E-PROJECTS Work Order Number: 1168092

Appropriation: MCON

PART SIX ATTACHMENTS

Design-Build RFP for the

SIMULATOR CENTER and RANGE CONTROL BUILDING

at

Marine Corps Base Camp Lejeune
North Carolina

FY'16 MCON PROJECT P-1346

PREPARED BY:

HBA Architecture and Interior Design
and
Hankins and Anderson Architects and Engineers,
A Joint Venture
One Columbus Center, Suite 1000
Virginia Beach, VA 23462
(A/E Contract N40082-10-D-5301, Task Order 0025)

REQUEST FOR PROPOSAL PREPARED BY:

Architectural: Thomas Ellis, AIA
Interior: Maxine Baer, NCIDQ
Civil: John Moore, P.E.
Structural: Dennis Claytor, P.E.
Geotechnical: Charles Crawley, P.E.
Surveying: Avolis Engineering
Mechanical: Scott O'Connell, P.E.
Electrical: Mike Lally, LEED AP BD+C
Plumbing: Michael Pearce, CPD
Fire Protection: Justin Wheeler, P.E.
Telecommunications: Kenny Shultz, P.E.,RCDD,CTS

Final Submission
20 November 2015

REQUEST FOR PROPOSAL APPROVED BY:

Submitted by: Joseph Bovee, AIA
For Commander, NAVFAC MID-ATLANTIC:
Date: November 20, 2015

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PART SIX – ATTACHMENTS

DEPARTMENT OF THE NAVY
THE ASSISTANT SECRETARY OF THE NAVY
(INSTALLATIONS AND ENVIRONMENT)
1000 NAVY PENTAGON
WASHINGTON, D.C. 20350-1000

NOV 16 2007

MEMORANDUM FOR DEPUTY CHIEF OF NAVAL OPERATIONS
(FLEET READINESS AND LOGISTICS)
DEPUTY COMMANDANT OF THE MARINE CORPS
(INSTALLATIONS AND LOGISTICS)

SUBJECT: Department of the Navy Low Impact Development (LID) Policy for Storm Water Management

References: (a) 33 United States Code 1251 (Clean Water Act)
(b) Title 40 Code of Federal Regulations 122, 130
(c) Department of Defense Unified Facilities Criteria 3-210-10 Design for Low Impact Development, October 2004
(d) Executive Order 13423 "Strengthening Federal Environmental, Energy, and Transportation Management", January 2007
(e) OPNAVINST 5090.1C, Clean Water Ashore Requirement, October 2007
(f) MCO P5090.2A, Water Quality Management, July 1998

BRAC 05 implementation, Department of Defense (DoD) Grow the Force Initiatives, and ongoing installation sustainment and modernization, have resulted in significant construction activity on Department of the Navy (DON) installations. New construction results in loss of natural vegetation cover and drainage capacity and increased storm water runoff. Conventional storm water collection and conveyance systems and storm water treatment options do not and can not replicate natural systems, thus increasing the volume and flow of storm water as well as sediment and nutrient loadings to streams, wetlands, and other receiving water bodies. Because of continuing water quality problems, States and the US Environmental Protection Agency are considering mandatory treatment and control of storm water. Conversely, low impact development (LID) techniques offer a suite of Best Management Practices that maintain or restore predevelopment hydrology. It mitigates the adverse effects of construction projects on water quality by cost effectively reducing the volume and pollutant loading of storm water before it reaches the receiving water bodies. LID utilizes strategies that infiltrate, filter, store, evaporate, and/or retain runoff close to its source. LID further reduces installation reliance on aging storm water management infrastructure. References (a) thru (f) provide requirements and guidance for LID.

This DON policy sets a goal of no net increase in storm water volume and sediment or nutrient loading from major renovation and construction projects[1]. In order to support this goal, as well as reduce reliance on conventional storm water collection systems and treatment options, this policy directs that LID be considered in the design for all projects that have a storm water management element. LID will be implemented where possible to assist DON installations in complying with references (a) and (b), as well as all applicable State and Federal requirements for sustainable development. In those infrequent situations where LID is not appropriate given the characteristics of the site, the Navy and Marine Corps are authorized to establish a waiver process that, if used, would include regional engineer level review and approval.

The Navy and Marine Corps are directed to immediately plan, program, and budget to meet the requirements of this policy starting in FY 2011. All efforts shall be made to incorporate LID practices in the fiscal years 08, 09, and 2010. The services are further directed to submit to my office an annual report that summarizes all projects that have a storm water component and identify how LID was implemented or waived. If waived, the report must identify the approving official. Naval Facilities Engineering Command, as the Department's expert in acquisition, construction, and environmental management, shall assist Navy and Marine Corps installations in meeting these policies. My point of contact for this matter is CAPT Robin Brake, robin.brake@navy.mil, (703) 693-2931.

BJ Penn

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[1] Major renovation projects are defined as having a storm water component and exceeding $5 million when initially approved by DASN (I&F). Major construction projects are defined as those exceeding $750K.

Low Impact Development Waiver Form

(Classification)

NAVY LOW IMPACT DEVELOPMENT WAIVER FORM	1. TODAY'S DATE	2. SUSPENSE DATE
3. PROJECT TITLE	3a. CONTRACT NUMBER	
	3b. MODIFICATION NUMBER	
4. DESIGN/CONSTRUCTION ORGANIZATION NAME(ES) AND ADDRESS(ES)	4a. NAME OF RESPONSIBLE PERSON/TITLE	
	4b. TELEPHONE NUMBER	
5. CONTRACT OFFICER NAME(ES) AND ADDRESS(ES)	5a. PROJECT NUMBER	
	5b. TASK NUMBER	
	5c. NAME OF RESPONSIBLE PERSON/TITLE OR RANK	
	5d. TELEPHONE NUMBER	
6. PROJECT DESCRIPTION		
6a. SUPPORTING DOCUMENTATION ☐ PLANS SUBMITTED ☐ STORM WATER CALCULATIONS SUBMITTED ☐ SUPPORTING DOCUMENTATION SUBMITTED		
7. WHY LID IS NOT PRACTICABLE FOR THIS PROJECT SITE		
7a. REASON NOT PRACTICABLE ☐ TECHNICAL ☐ ECONOMICAL ☐ OTHER		
8. PLANNED STORM WATER MANAGEMENT FEATURES (when LID is not practicable)		

9. SIGNATURES			COMMENTS
Project Manager (PM) Date	☐ APPROVED	☐ DISAPPROVED	
Design Manager (DM) Date	☐ APPROVED	☐ DISAPPROVED	
EV Department Eng (EDE) Date	☐ APPROVED	☐ DISAPPROVED	
FEAD/ROICC Date	☐ APPROVED	☐ DISAPPROVED	
Commanding Officer Date	☐ APPROVED	☐ DISAPPROVED	

WAIVER FORM INSTRUCTIONS

Parentheses at top of form: Fill in the classification (UNCLASSIFIED, CONFIDENTIAL, etc) in the parentheses at the top of the form.

Block 1. Enter today's date or due date of contract deadline. The Navy standard date format is YYYYMMDD. Example: 200070131.

Block 2. The format is YYMMDD. This suspense date should be completed by the Environmental Department Engineer (EDE) and/or Engineer In Charge (EIC). Enter the standard date the response is due to the contractor. (e.g. 30 days of receipt of contractors proposal) or Enter the date the response is due to the contractor if the review is time sensitive (e.g. 3, 10 days of receipt of contractor's proposal).

Block 3. Enter the Project Name and the LID technique or storm water Management feature.

Block 3a. Enter the contract number.

Block 3b. Enter the contract modification number.

Block 4. Enter the names and addresses of the engineering/design firm and the construction contractor.

Block 4a. - 4b. Enter the responsible performing organizations point of contact and position title (Lead Engineer, Manager, President, etc) and office phone number. This information is especially important to ensure any questions related to the project and site design can be quickly directed to the appropriate point of contact, avoiding delays in processing the action.

Block 5. Enter the Contract Agent Name and address.

Block 5a. Enter the project number.

Block 5b. Enter the task number (if applicable).

Block 5c -5d. Enter the responsible Contract Agent/Action officer's name, rank and/or position title, and office phone number. This information is especially important to ensure any questions related to the project and site design can be quickly directed to the appropriate point of contact, avoiding delays in processing the action.

Block 6. Provide a fact-filled background and summary of the project. Be sure to included details such as the project location, size, issues and the requirements. This discussion should tell the story of the planned project without "begging questions." The final approval authority should fully understand what the project is and why this project is necessary.

Block 6a. Select supporting documentation supporting the project. The site plans, storm water calculations and relevant supporting documentation for the selected LID design or the planned storm water management feature if LID is not selected, should be submitted along with the waiver form to ensure a thorough review.

Block 7. Explain which LID goals could not be achieved and why achieving LID goals was not practicable. Provide sufficient descriptions, drawings, and other necessary information to confirm the applicability of the Waiver. The final approval authority should fully understand the reasons LID is not practicable for the project(s). Submit supporting documentation.

Block 7a. Select a reason LID is not practicable for this project, (e.g., conflicts with existing State laws, policies or requirements, contaminated sites).

Block 8. Describe the planned storm water management features if LID is not selected. Provide sufficient descriptions, drawings, and other necessary information to evaluate the proposed project. Submit supporting documentation.

Block 9. All parties must review, approve/disapprove, and sign the form for a LID waiver.

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Low Impact Development (LID) Reporting Form
NAVFAC MIDLANT

Date: ____________

Project Name: ____________________

Project Location ____________________

Designer (A/E Firm) ____________________

Station Project Number ____________________

Instructions: Place a checkmark to the left of the appropriate items. Fill in quantities where needed.

Agency Sponsoring Project

	Marine Corps
	Navy
	Non-Federal Project
	Other DOD
	Other Federal Agency

Planning

Development Type

	New Development
	Redevelopment

Construction Project Over $750,000

	No
	Yes

Renovation Project over $5,000,000

	No
	Yes

Project Changes Land Cover > 5000 Square Feet

	No
	Yes

Stormwater Element Required

	No
	Yes

LID Estimate (from DD 1391) $ ____________

Notes: ____________________

Design

Actual Change to Land Cover in Sq Ft (increased or decreased) ____________

% Increase in Runoff ____________

EISA Technical Constraint(s)

	No Constraint
	Non-potable water demand (for irrigation, toilets, wash-water, etc.) is too small to warrant water harvesting and reuse systems
	Retaining storm water on site would adversely impact receiving water flows
	Site has shallow bedrock, contaminated soils, high groundwater, underground facilities or utilities
	Site is too small to infiltrate significant volume
	Soil infiltration capacity is limited
	State or local requirements restrict the use of green infrastructure/LID
	State or local requirements restrict water harvesting
	Structural, plumbing, or other modifications to existing buildings to manage storm water are infeasible

EISA Technical Constraint Approval Authority: Deb Brewster, P.E. (757) 341-0153 NAVFAC MIDLANT

Waiver Submitted and approved for LID Non-Compliance

	N/A
	No
	Yes

Waiver Authority: Regional Engineer

LID Cost Pre-Award Estimate/Award Actual ____________

LID Features Location

	Both
	On-Site
	Off-Site

LID Feature(s)

	Bioretention
	Dry Wells
	Filter Strips
	Grassed Swales
	Infiltration Trenches
	Inlet Pollution Removal Devices
	No LID
	Other, provide detail in Notes
	Permeable Pavement
	Permeable Pavers
	Rain Barrels and Cisterns
	Soil Amendments
	Tree Box Filters
	Vegetated Buffers
	Vegetated Roofs

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EMCS Equipment and Points Nomenclature for Camp Lejeune

No.	Nomenclature	Description
	EQUIPMENT	
1	AHU	Air Handling Unit
2	B	Heating Water Boiler
3	B	Steam Boiler
4	C	Chiller
5	CCC	Closed Circuit Cooler
6	CCT	Closed Circuit Tower
7	COM RM	Communication Room
8	CP	Condenser Water Pump
9	CRAC	Computer Room Air Conditioner
10	CT	Cooling Tower
11	CTP	Cooling Tower Pump
12	CTRL PNL	Control Panel
13	CU	Air Cooled Condensing Unit
14	CWP	Chilled Water Supply Pump
15	DECAHP	Defense Commissary Agency HP
16	DHW	Domestic Hot Water
17	DPR	Damper
18	DTS	Dual Temperature System
19	DWP	Domestic Hot Water Pump
20	ECT	Evaporative Cooling Tower
21	EF	Exhaust Fan
22	EST	Elevated Storage Tank
23	FCU	Fan Coil Unit
24	FLTR	Filter
25	GLBT	Ground Level Booster Tank
26	HP	Heat Pump (On Ground)
27	HWP	Hot Water Pump
28	HWT	Hot Water Tank
29	HV	Heating and Ventilating Unit
30	HX	Steam to Hot Water Converter
31	LS	Lift Station
32	LP-PMP	Loop Pump
33	MAD	Mixed Air Damper
34	MAU	Make-up Air Unit
35	MZ	Multizone Unit
36	OA	Outside Air
37	OAT	Outside Air Temperature
38	PACU	Package Unit
39	PHP	Packaged Heat Pump (On Ground)
40	PX	Plate Exchanger
41	RA	Return Air
42	RAF	Return Air Fan
43	RTHP	(RTU) Packaged Rooftop Heat Pump Unit
44	RTMZ	Rooftop Multizone Unit
45	RTU	Rooftop Unit (Packaged DX)
46	RVS-VLV	Reversing Valve
47	SA	Supply Air

EMCS Equipment and Points Nomenclature for Camp Lejeune		
No.	Nomenclature	Description
	EQUIPMENT	
48	STP	Secondary Treatment Plant
49	SV	Solenoid Valve/Steam Valve
50	TS	Temperature Sensor
51	TWAC	Thru-Wall Air Conditioner
52	TWHP	Thru-Wall Heat Pump
53	UH	Unit Heater
54	VAV	Variable Air Volume
55	WAC	Window Air Conditioner
56	WS	Work Station
57	WSHP	Water Source Heat Pump
58	WTP	Water Treatment Plant
59	WP	Well Pump
60	ZD	Zone Mixing Damper

EMCS Equipment and Points Nomenclature for Camp Lejeune

No.	Nomenclature	Description
	POINTS	
61	AHU-DHUM	Air Handling Unit Dehumidifier
62	AHU-OVRRD	Air Handling Unit Override
63	ALM-CMD	Alarm Command
64	ALM-HORN	Alarm Horn
65	ALM-RST	Alarm Reset
66	ALM-SIL	Alarm Silence
67	BLR-A	Boiler Alarm
68	BLR-C	Boiler Command
69	BLR-S	Boiler Start
70	BOILER-EN	Boiler Enable
71	BYPD-C	Bypass Damper Command
72	C-?	Chiller Status
73	CD-T	Cold Deck Temperature
74	CH-CMD	Chiller Command
75	CH-OVR	Chiller Override
76	CH-ALM	Chiller Alarm
77	CH-DP	Chiller Differential Pressure
78	CH-FLO-S	Chiller Flow Switch
79	CHILLER-EN	Chiller Enable
80	CHS-T	Chiller Supply Temperature
81	CHW-DP	Chilled Water Differential Pressure
82	CHW-FLOW	Chilled Water Flow
83	CHW-SYS ENABLE	Chilled Water System Enable
84	CLG-C	Cooling Command
85	CLGMAX	Cooling Maximum
86	CLG-NITE	Cooling Night Set Point
87	CLG-SP	Cooling Set Point
88	CLG-VLV	Chilled Water Valve Status
89	CLG-VLV	Chilled Water Valve Operation
90	COND1-S	Condenser 1 Status
91	COND2-S	Condenser 2 Status
92	COOL1-C	Cooling Stage 1 Command
93	COOL2-C	Cooling Stage 2 Command
94	CTFAN-C	Cooling Tower Fan Command
95	CTFAN-S	Cooling Tower Fan Status
96	CWR-T	Chilled Water Return Temperature
97	CWS-GPM	Chilled Water Supply GPM
98	CWS-T	Chilled Water Supply Temperature
99	DHW-SET	Domestic Hot Water Set Point
100	DHWS-T	Domestic Hot Water Supply Temperature
101	DHW-TANK	Domestic Hot Water Tank Temperature
102	DHW-VLV	Domestic Hot Water Steam Valve
103	ELEC-HEAT	Electric Heat
104	FLTR-DP	Filter Differential Pressure
105	FLTR-S	Air Filter Differential
106	HD-T	Hot Deck Temperature
107	HTG1-C	Heating Stage 1 Command

EMCS Equipment and Points Nomenclature for Camp Lejeune

No.	Nomenclature	Description
	POINTS	
108	HTG2-C	Heating Stage 2 Command
109	HTGMAX	Heating Maximum Set Point
110	HTG-NITE	Heating Night Set Point
111	HTG-SP	Heating Set Point
112	HTGV-CMD	Heating Command
113	HTG-VLV	Heating Valve
114	HUM-SPT	Humidity Set Point
115	HW-ENA	Hot Water Enable
116	HWP-1-C	Hot Water Pump 1 Command
117	HWP-SPT	Hot Water Pump Set Point
118	HWP-SS	Hot Water Pump Status
119	HWR-T	Hot Water Return Temperature
120	HW-SET	Hot Water Reset Set Point
121	HWS-FL	Hot Water Supply Flow
122	HWS-P	Hot Water Supply Pressure
123	HWS-SPT	Hot Water Supply Set Point
124	HWS-T	Hot Water Supply Temperature
125	HW-SYS ENABLE	Hot Water System Enable
126	HWVLV-C	Hot Water Valve Command
127	HX-VLV	Heat Exchanger Valve
128	IA-H	Indoor Humidity Sensor
129	INST-DMD	Instantaneous Demand
130	INTV-DMD	Interval Demand
131	LOOPR-T	Loop Return Temperature
132	LOOPS-T	Loop Supply Temperature
133	LPMP-1-C	Loop Pump 1 Command
134	MAD-CMD	Mixed Air Damper Command
135	MA-T	Mixed Air Temperature
136	MAX-CLG	Maximum Cooling Set Point
137	MAX-HTG	Maximum Heating Set Point
138	MIN-HTG	Minimum Heating Set Point
139	MIN-OAD	Minimum Outside Air Damper
140	OA-CFM	Outside Air Cubic Feet Per Minute
141	OAD-C	Outside Air Damper Position
142	OAD-SET	Outside Air Damper Set Point
143	OAF-C	Outside Air Fan Command
144	OAF-S	Outside Air Fan Status
145	OA-H	Outside Humidity Sensor
146	OA-RH	Outside Air Relative Humidity
147	OA-T	Outside Air Temperature
148	OCC-CLG	Occupied Cooling
149	OCC-HTG	Occupied Heating
150	OCCTIME	Occupied Time (Schedule)
151	OCCTIMER	Occupied Timer (Schedule)
152	OCLG-SP	Occupied Cooling Set Point
153	OHTG-SP]	Occupied Heating Set Point
154	OHWP-SPT	Occupied Hot Water Sump Set Point

EMCS Equipment and Points Nomenclature for Camp Lejeune		
No.	Nomenclature	Description
	POINTS	
155	PH-LEV	PH Level
156	PH-SET	PH Set Point
157	PWR-FAIL	Power Fail
158	PWR-MTR	Power Meter
159	RAD-C	Return Air Damper Position
160	RAF-C	Return Air Fan Command
161	RAF-S	Return Air Fan Status
162	RA-T	Return Air Temperature
163	REV-VLV	Reversing Valve
164	RM-T	Room Temperature
165	SA-SMKD-C	Smoke Detector Command
166	SA-SMK-S	Smoke Detector Status
167	SA-SP	Supply Air Set Point
168	SA-T	Supply Air Temperature
169	SETPNT1	Set Point 1
170	SETPNT2	Set Point 2
171	SF-C	Supply Fan Command
172	SF-S	Supply Fan Status
173	SF-VFD	Supply Fan Variable Frequency Drive
174	SHDN-CMD	Shutdown Command
175	SMK-S	Duct Smoke Detector
176	STM-C	Steam Command
177	STM-S	Steam Pressure
178	STM-T	Steam Temperature
179	STM-VLV	Steam Valve Operation
180	STM-VLV	Steam Valve Status
181	SUMMER	Summer Mode
182	SUMWIN-C	Summer/Winter Command
183	TANK-L-A	Tank Level
184	TOTAL-KW	Total Kilowatt (kW)
185	TOTLFLOW	Total Flow
186	TRIPLOCK	Trip Lock Out
187	TWR-CMD	Tower Command
188	UH-ENA	Unit Heater Enable
189	UH-SPT	Unit Heater Set Point
190	UNOCC-CLG	Unoccupied Cooling
191	UNOCC-HTG	Unoccupied Heating
192	VFD-S	Variable Frequency Drive Status
193	WINDO-AC	Window Air Conditioner
194	WINTER	Winter Mode
195	WSHP-SPT	Water Source Heat Pump Set Point
196	ZNHTG-SP	Zone Heating Set Point
197	ZN-T	Space/Zone Temperature

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Rev Aug 29, 2014
Previous 1.18.13

MCB CAMP LEJEUNE, N.C. MECHANICAL POLICIES

New revisions are bolded, new removals are lined through. Revisions since 10.14.08 are dated. Re-ordering of comments, grammer and typo corrections are not annotated.

GENERAL

1. All equipment shall be removable from the building without removing/displacing other equipment(8.8.12).
2. Isolate "steam" mechanical rooms from building. All steam equipment is more prone to leaking, thus making the room humidity saturated. Provide the steam room with an exterior door; do not provide a door(s) to adjacent spaces. Keep electrical equipment out of this room. If possible separate steam rooms from cold equipment rooms. Minimize controls in steam mechanical rooms. Only controls necessary for equipment in the room shall be allowed. If it is convenient put controls in adjacent room. It is preferable to keep air handlers out of this room also. Do not run high pressure steam outside the steam room(ie steam entrance should be directly into steam mechanical room). Separate building for steam equipment and pumps is good. Provide exhaust fan ventilation with 20ac/hr on cooling thermostat.
3. **If possible separate fuel fired equipment and other heat producing equipment from air handlers and other equipment that has a cool surface temperature into different mechanical rooms. Fuel fired equipment and other heat producing equipment require ventilation to meet building codes and for practical reasons. Air handlers, and chilled water pumps do not require ventilation. Rooms with only chilled/hot water air handlers are not classified as mechanical rooms by the international building code and therefore do not require ventilation.(8.29.14)**
4. Ventilate "hot" rooms and electrical rooms sufficient to mitigate heat gain
5. Do not ventilate cold equipment rooms. Cold equipment rooms are those rooms with chilled water pumping, cooling air handlers, ~~chillers,~~**(8.29.14)** etc. These rooms should be unvented and with small dehumidifier. Drain condensate to floor drain or other disposal location. Summer dew point ranges from low to high 70's at Camp Lejeune causing condensation on equipment and piping. Dehumidifier should be wall mounted with wheels removed and hard wired with disconnect (no pigtail with plug) to discourage theft/relocation. Dehumidifier should be hard piped to drain to avoid drainage blockage. (8.30.10)
6. Keep in mind fall hazards when locating equipment. Provide necessary fall protection.
7. **During renovations; remove unused pipe, duct, and equipment. It is not necessary to disassemble building components. Abandon in place piping sub slab or buried in a wall that is not getting demolished for other reasons. (8.29.14)**

8. **Install ice dams on metal roofs over or near outside mechanical equipment (8.29.14)**

HVAC: General

9. **Design conditions for Camp Lejeune are: 91/77F 1%DB/MCWB; 79/87F 1%WB/MCDB, 140 grains/lb and 84F MCDB. 26F 99% and 22F 99.6% heating conditions. Equipment selection shall meet all conditions. (8.29.14**)
10. Rooftop HVAC equipment should be used with discretion. Maintenance access is more difficult, controls and water piping are exposed to more extreme conditions and roof is exposed to more abuse and wear. Ladders permanent or temporary inhibit personnel, material and equipment access, and therefore stairways shall be provided to roof top equipment.
11. Avoid use of chilled water fan coil (FCU) systems due to the high maintenance associated with them. Coil condensate drain pans are especially problematic. If FCU's are used, ensure adequacy of the drain system.
12. HVAC equipment should not be installed in attics or above suspended ceilings, unless absolutely necessary. When placement in an attic is dictated by necessity, provide stairs to access the attic, and maintenance access to and space around equipment; ships ladders are undesirable. Provide drain pan float switch to shut down condensing unit or close chilled water valve to the coil. (6.26.9)
13. A/C terminal units with compressors shall be easily removed. On water source equipment that means unions on the equipment side of the service valves.
14. In refrigerated rooms/boxes: specify all evaporators on a condensing unit to defrost together, separate evaporator/condensing unit pairs should defrost non-concurrently.
15. Provide phase monitors on all 3 phase equipment. For chillers the following shall be included:
    a) phase unbalance protection
    b) over/under voltage protection
    c) phase loss protection
    d) Delay of break timer to delay automatic restarts
    e) non critical fault delay
    f) programmable auto/manual restart
    g) load and line side monitoring

    For all other equipment only phase loss, phase reversal, and phase unbalance need to be monitored. Standard internal functions of VFD are acceptable. Reset shall be automatic upon correction of the fault.
16. **When connecting to existing air or hydronic system; require contractor to test existing equipment or system to establish conditions. Be specific as to what needs to be tested and when. It may be necessary to adjust flow or static (head) pressures of new equipment and measuring before ordering new equipment will reduce contract modification costs.(8.29.14)**
17. In buildings where cooling is not available 12 months/year, consider the use of ductless split systems for conference rooms. Consider the use of Package Terminal Heat Pumps **or ductless split system (8.29.14)** for high internal heat spaces such as server rooms.

18. Geothermal coupled heat pump systems shall be designed and installed in accordance with NAVFAC MidAtlantic Policy (8.8.12).
19. Recommended HVAC system types are (8.8.12):
    a. All packaged units less than 120,000 Btu/hr shall be either heat pumps with auxiliary gas heat or heat pumps with auxiliary electric heat.
    b. All packaged units greater than 120,000 Btu/hr shall be either air conditioners with gas heat or heat pumps with auxiliary gas heat.
    c. All split systems less than 120,000 Btu/hr shall be either heat pumps with auxiliary electric heat or heat pumps with auxiliary gas heat.
    d. All split systems greater than 120,000 Btu/hr shall be heat pumps with auxiliary gas heat.
20. **VRF(Variable Refrigerant Flow): In most cases heat reclaim system is preferable to heat pump system. For systems with interior spaces and or rooms with significant internal heat gain specify that all interior units be capable of full heating capacity while other units are in the cooling mode(this requires a 3 pipe system), or schedule the minimum heating required for each indoor zone when outdoor unit is in the cooling(this allows a 2 pipe system, but sets minimum heating performance requirement). 8.29.14**
21. **Consider using gas fired unit heaters in boiler rooms in lieu of hot water unit heaters. These reduces the freezing risk if the boiler trips, but there is still gas and power. 8.29.14**

<u>HVAC: Pipes and Pumping</u>

22. Provide primary/secondary pumping systems on multiple building chiller systems and on systems larger 150 tons. Keep flow thru the chiller constant. Do not use variable primary flow (2.22.10). Ensure primary loop has sufficient thermal inertia. Be aware that the secondary loop has little influence on staging cycling during low load conditions. (6.20.8)
23. Do not use plastic preinsulated pipe for buried dual temperature water distribution; use preinsulated copper pipe. HDPE is acceptable for chilled water applications. (6.13.8)
24. Do not specify or permit mineral fiber on pipes cooler than 70F~~ or flexible unicellular insulation on chilled water pipes.~~(8.29.14) Cellular glass, **polystyrene(8.29.14),** or polyisocyanurate ~~up to 1-½ inches (40 mm) thick~~ is required on chilled water pipes and ~~preferred on other pipes below ambient temperature including~~ (8.29.14) domestic cold water. (1.25.10) **Allow flexible Unicellular when rigid insulation is not practical, such as small refrigerant lines sets, and tight piping.(8.29.14)**
25. Use rigid insulation on all pipes subject to being stepped on or damaged.
26. Use solids from water separators on all hydronic systems regardless of pipe material (steel or copper).
27. Do not specify or permit automatic flow control balancing valves (flow limiting valves). Specify manually TAB'd circuit setters. (1.18.13).
28. Design and specify bladder type expansion tanks with automatic air relief valve on air separator.
29. Paint all dual temp and chilled water steel pipe and equipment before insulation is installed. This in addition to shop primer and or mill coating. (1.28.10)

30. Do not permit grooved couplings in piping system other than the chiller connection. (6.13.8)
31. Extruded Tee's in copper piping are acceptable for mains 2" and larger with the branch ½ or less than the main. Joint must be brazed. (6.13.8)
32. Do not permit press type fittings in copper. (6.13.8)
33. Pump Packages: In general do not specify pump/heat exchanger packages. Most of our mechanical rooms are on the smallish side. Pump packages require maintenance space on all sides. If specifying a pump package, designer must work out general lay out of package and mechanical room to ensure maintenance access.
34. **Inline or close couple pumps are preferred for circulating pumps. Provide redundant system pumps; each pump shall carry the design flow, with the second pump as an alternating backup. A single pump is adequate for equipment pumps, such as a boiler pump. Inline and close coupled pumps do not have a coupling between the motor and the pump, do not require alignment or stringent grouting requirements and therefore cause less maintenance issues.(8.29.14)** For inline pumps 5 hp and larger, include rigging points for maintenance. ~~Circulating pumps for hot water, chilled water, or dual temperature shall be inline pumps when pumps are installed in noise sensitive areas or when redundant pumps are used. Otherwise, base mounted pumps shall be used.~~ (8.29.14)
35. When a partial renovation of a building HVAC system re-uses existing piping, specify the contractor to clean and flush the existing piping. (1.8.10)
36. Add valves, drains, and vents at each piece of equipment to aid servicing(8.31.11). All equipment including heat exchangers shall have P/T ports on inlet and discharge of all water connections(8.8.12). **Include in-situ thermometers in mechanical rooms to aid in onsite trouble shooting.(8.29.14)**
37. **Require balance valves of the venturi type where the throttling valve and the measuring station are separate. i.e. the pressure is not read across the valve. 8.29.14**
38. **Specify that all refrigerant piping be vacuum tested to 300 microns for 24 hours after the high pressure test. The system fails the test if with the vacuum pump disconnected from the system, the pressure rises above 300 microns after 24 hours.(8.29.14)**

<u>HVAC: Air Systems</u>

39. **Duct drawings shall be a minimum 3/16" scale.(8.29.14)**
40. Use the latest revision of ASHRAE 62 for guidance on indoor air quality. For the purposes of outside air ventilation only, typical occupancy is considered that which happens at least once a week for buildings that follow a regular schedule or at least 15 times a year for non-schedule type buildings.
41. **Buildings shall be kept at a slight positive pressure to reduce/avoid infiltration in the walls that can cause condensation. Consider the tightness of the building, also consider inaccuracies in TAB. Having outside volumes 10% in excess of exhaust volumes should be always be considered.(8.29.14)**
42. Chilled water VAV with zone reheat is the preferred HVAC system for offices and should be considered wherever appropriate. VAV zone boxes without fans are preferable to units with fans. In non-fan powered zone boxes, when specifying

minimum air flow the designer shall consider diffuser dumping. If a zone has a large variance of load profile from neighboring zones a fan powered box should be considered to avoid dumping of diffusers. Chilled water VAV with fan powered terminal units is the preferred HVAC system for BEQ/BOQ's. Zone reheat shall be as specified in the scope (10.14.08). VAV Fan powered terminal units shall have a fan volume of 50 cfm to 50% greater than the maximum primary air flow. (1.8.10) Minimum primary air flow ~~**should match**~~ **shall be the greater of the minimum controllable flow or (8.29.14)** the ventilation rate required. (5.12.10).

43. Particular attention should be given to humidity control by air conditioning equipment. **Constant volume (8.29.14)** cooling units 7.5 tons and smaller shall not have modulating water controls unless based on a constant 55 F supply temperature. Larger units may have split face coils to give capacity step control (progressive modulating chilled water valves may be used). Modulating face and bypass dampers are okay on any size equipment.
44. Avoid HVAC systems that modulate cooling supply air temperatures unless outside air is separately conditioned.
45. Air handling unit filter access doors should be specified as hinged with non-tool captive latching devices, i.e. captive thumb screws, quarter turn latches etc. Do not specify or approve access panels that are unhinged and/or retained by sheet metal screws.
46. Require contractors to provide a listing of the HVAC filters for each piece of equipment along with their dimensions (width, height and thickness) and types (permanent/washable, throwaway, etc)
47. **Require contractor to provide 2 extra complete sets of air filters to be left in the mechanical room at BOD. Require contractor to provide and change all air filters at second season TAB if included. In all, the contractor will provide up at least 5 sets of filters. 1 for startup, 1 at BOD, 2 in the box for government, 1 at 2nd season TAB.(8.29.14)**
48. Outside air intakes should be in compliance with force protection criteria, ie; minimum of 10' above finished grade.
49. DUCT WORK: specify and draw 45 degree expanded throat take offs with balance damper for all supply run outs to diffusers and grills. Do not permit flexible duct runs exceeding ~~**8'**~~ **5'(8.29.14)** long. Specify that all 90 degree turns be accomplished with hard metal elbows, such as on top of diffusers, and if top take off of trunk duct. **Show balance dampers on return systems with branches. Give return flows to TAB (8.29.10).**
50. Specification 23 05 93, Testing, Adjusting, and Balancing for HVAC: Change DALT requirement from 20% to 100% duct air leakage test on all projects. Specify on the drawings, duct seal class A for all ducts. (1.2.13) Specify the SMACNA leakage class (C_L) on the mechanical drawings: round and oval duct= 3, rectangular duct =6, test pressure of 1" (1.2.13). Contact Camp Lejeune project management concerning scope of work for existing ducts to be re-used. (9.8.10) Consider removing all insulation on existing duct and resealing and reinsulating it.
51. The use of ceiling return air plenums is discouraged and shall not be used in new
52. construction. (2.10.10)
53. Bull headed tees should be limited to below 900 fpm duct systems. (8.31.11)

54. Provide filters on upstream side of the wheel on the exhaust side of an energy recovery wheel. (8.31.11)
55. Fan powered VAV boxes: secondary air shall come directly from the conditioned space via a ducted return with a filter return grille. Secondary air shall not come from the closet. Closet returns shall direct air back to the air handler. (8.31.11)
56. ~~Series fan powered terminal units utilizing fractional and sub-fractional motors: Design around and size units so that PSC motors operate at full or near full load. Turning down PSC motors below full load is discouraged. Rather,~~ **(8.29.14)** Specify electronically commutated motors (ECM) for fan powered terminal units. Design consideration should be provided to address the degradation of power quality and potential problems with overheating of neutral wiring conductors, connectors, and transformers(8.31.11).
57. Interior duct liner shall not take the place of exterior duct insulation. All cooling supply duct shall be insulated including duct inside conditioned space (8.8.12).
58. Exterior duct shall be externally insulated with 1.5" thick foam rubber insulation with robust weather jacket. Insulation shall be 100% adhered to the duct. The weather jacket shall be either a sheet metal overlay or factory adhered multilayer (mylar and aluminum) covering. (1.18.13)
59. **Size cooling coils downstream of Enthalpy recovery wheels for degradation of wheel performance. For BEQ's, the EAT of the coil shall be schedule as though the coil has lost one half of its scheduled performance. This will aid in system recovery after outages, and in during periods of high shower use. For non-BEQ's, EAT of the coil shall be scheduled as though the enthalpy wheel has lost 15% of its scheduled performance. The economic analysis and energy study shall use the scheduled wheel effectiveness. Water flow and chiller sizing shall be based on the reduced wheel performance.(8.29.14)**
60. **Specify duct access doors at fire dampers and special duct mounted equipment requiring regular access such as duct mounted coils. Access doors are not desired at control dampers, manual dampers, and turning vanes. 8.29.14**

<u>HVAC: Chillers and outdoor equipment</u>

61. Provide aluminum fins on copper tubes or aluminum micro channel coils (8.8.12). **~~either with coating that passes the ASTM B117-90 3000 hour salt spray resistance test for~~ Require** coils on all outdoor equipment larger than 10 tons, and on DX, chilled water, and hot water coils with greater than 50% outside air regardless of capacity (8.31.11) **to pass ASTM B117 90 3000 hour salt spray resistance test as installed. For equipment within 1000 feet of the ocean, intracoastal waterway, New River, Wallace Creek require 6000 hour resistance.(8.29.14)** The heat transfer rating of phenolic-coated coils should be as installed (i.e. after coating).
62. Air cooled **~~chillers are~~ equipment is (8.29.14)** preferred to water cooled equipment for individual equipment smaller than 150 tons. Camp Lejeune weather is mild and humid which only gives slight efficiency advantage to water cooled equipment. Larger plants such as multiple 400 ton chillers should be water cooled. The efficiency advantage overcomes the additional maintenance of cooling towers.
63. Do not use steam absorption chillers. Helical screw compressors are desirable. Reciprocating and scroll compressors are acceptable. Where applicable on large

installations centrifugal equipment is acceptable, (greater than 150 tons). Oiless centrifugal is acceptable (1.25.10)~~**for water cooled applications.**~~ **Specify high lift compressors for air cooled oiless centrifugal chillers (8.29.14).**

64. Provide adequate thermal mass in chilled water systems to ensure proper control and longevity of chillers. Chiller manufacturers recommend 2 to 7 minute water loop return times; use a minimum of 5 minutes to size inertia tanks and/or increase pipe sizing/length.
65. Do not permit 400 series refrigerants except 407C and 410A. 400 series refrigerants are zeotropes and cause maintenance problems. Use of 407C is discouraged, as it is a short term stop gap measure that the manufacturers can drop into basically a R22 machine. Designer shall research the availability of 410A and/or 134A equipment. If sufficient competition is available with 410A and/or 134A, prohibit the use of 407C and R22. 5.22.09
66. Do not permit/specify engine driven refrigeration equipment.
67. On chillers and large condensing units; provide core filter dryer on suction line as available as standard option
68. On chillers and large condensing units; provide liquid and suction line service valves as available as standard option.
69. Do not permit welding on chillers. Water connections shall be by grooved coupling or flanges. Provide 16-20 mesh strainer on water inlet.
70. Require 5 year warranty on compressor parts. Require 5 year warranty on labor if available.

<u>GAS PIPING</u>

71. The design for LP gas tanks shall be as follows:
    a) construction contractor to provide:
        i. 6” thick concrete slab, 6’x8’ for 500 gallon tank, 6’x16’ for 1000 gallon tank (6.10.9)
        ii. Underground gas line to stub up through oversized sleeve in slab, 3”from edge
        iii. 1st stage regulator
        iv. Protective bollards, 7’long, 4” schedule 40 galvanized steel, concrete filled, 3’ bury with concrete encased, paint bright yellow/black with 4” stripes.
        v. Make tank hook up
        vi. Purchase at construction contractor’s expense, LP gas for startup, and construction period.
    b) Camp Lejeune will arrange rental, including placement, but not hook up, of the tank. Camp Lejeune will contract for tank fill up after BOD of project.
    c) Designer shall specify size of the tank (typical sizes are 123, 500, & 1000 gallon), size and location of the concrete pad, and placement/number of protective bollards. Bollards shall be placed to protect from the grass cutters (each open corner), and nearby traffic (may require intermediate bollard spacing). Design shall comply with all applicable codes. As a reminder, 500 gallon tank shall be minimum of 10’ from the building, 1000 gallon tank shall be minimum of 25’ from the building. The long axis of the tank shall be parallel with the building.

d) AROICC will notify Camp Lejeune metering & LP tank inspector (currently Rich Barnes @ 451-4785) of the need/timing of tank placement, and tank fill after BOD.

72. On LP systems, first stage regulator is located at the LP tank and should be set for 10 psig. The second stage regulator should be located on the exterior of the building wall in a protected location. Provide a building shut off valve on all systems. (1.19.2010).
73. Size interior gas piping with a 15% safety buffer. I.E. Size the piping for 15% more demand than anticipated. (1.28.10)
74. Common interior gas pressures are 7”, 2 psi, and 5 psi. Use 7” if 2” or smaller piping can serve the load, otherwise use 2psi with regulators at each appliance. (1.28.10)

CONTROLS

75. Avoid use of economizers (dry bulb or enthalpy). High humidity and poor control reliability prohibit success with economizers except in extremely high internal load buildings.
76. Direct Digital Control (DDC) systems are the preferred HVAC control systems for new and replacement control systems.
77. Where DDC is not practical, such as with small unitary equipment, use ~~**Smart**~~ ~~**Thermostats (SmartStat).**~~**standalone-programmable thermostats. (8.29.14)**
78. ~~SmartStats will be government provided equipment for contracts with less than 15 thermostats. Specify on the drawings, government furnished, contractor installed. Smartstat inventory is controlled and available at the Mechanical Section, Public Works Design, bldg. 1005. Government Construction Manager shall send email to Mechanical Section with general contractor, and mechanical contractor’s company names. (1.18.13~~**)(8.29.14)**
79. CO2 sensors and outside air modulation should be considered in facilities with highly varying occupancies.
80. Specify that pneumatic control devices be able to withstand 30 psi without damage.
81. Control valve actuators shall be spring return normally open on preheat coils and other coils subject to freezing, spring return closed on hot water converters, and spring return closed on outside air dampers. (10.22.08)
82. Specify individual scheduling for air handlers. Specify a gradual (progressive) startup and a gradual (progressive) shut down of air handlers. A sudden startup or shut down of the entire building is too fast for chiller controls to react and sometimes causes safety trips.
83. Do not specify or provide air filter status alarms. Filters are changed on a schedule and filter alarms cause nuisance reporting. (1.2.13)
84. **For Combined heating/cooling systems such as VAV with zone reheat; provide single heating-cooling global set point that is reset based on ambient conditions. For most applications, allow occupants to adjust the zone set point +/-3F from the global set point. Global set point shall be 70F at less than 50F ambient; and 76F at greater than 80F ambient. Between 50F and 80F, the global set point shall reset linearly or in no fewer than 3 steps. The single set point prevents the**

zone temperature from swinging between heating and cooling set points in low load conditions. (8.29.14)

PLUMBING

85. Lubrication oil lines should not be installed below building floor slabs. It is preferred that lubrication oil lines be installed overhead. If this is not possible or desirable by the customer, lines within service bays should be installed in trenches with removable tops. (6.26.9)
86. Install shop air compressors in accessible locations with appropriate space for periodic service. Shop air compressors are serviced by the building occupants and (6.26.09) should not be installed within mechanical rooms since occupant access is prohibited by base maintenance. Shop air compressors should be provided with sufficient cooling ventilation. Install air compressors associated with building HVAC controls within mechanical rooms.
87. Air compressor receivers over 5 cubic feet (37.4 gal) are unfired pressure vessels that must undergo hydrostatic and operational tests witnessed by the base boiler inspector. (5.19.8)
88. Air Compressors should be mounted on vibration pads/mounts. Specify/show flexible connectors on the piping. (10.22.08)
89. Where practical provide hose bibs near all HVAC coils for wash down/cleaning purposes.
90. Provide floor drains in all mechanical rooms.
91. Provide trap primers on all floor drains except locations that are expected to get regular use throughout the year. Trap primer shall be pressure type installed on a cold water line and shall not be installed on a flush valve.(2.27.9)
92. Provide sectional shut off valves for domestic hot & cold water for each bathroom (group).
93. Do not permit lever type control handles on pressure balance shower valves in BEQ's. This type of handle invites the user to pull for volume control, thereby breaking the handle.
94. Avoid frost proof hose bibs. **Use standard hose bibbs. Frost proof hose bibbs will break when they freeze, whereas standard hose bibbs are less likely to be damaged by freezing.(8.29.14)**
95. Provide strainers on RPZ back flow preventers.
96. Double Check and RPZ type back flow preventers (BFP) shall be tested/certified by the installing contractor prior to BOD. Add the following paragraph to any specification section that includes a BFP(10.22.08). "3.X Back Flow Preventer Certification: After installation all double check and reduce pressure zone type back flow preventers shall be inspected, tested and certified by a certified tester. Submit tester certification and Test Data Certification Sheet."
97. Extruded Tee's in copper piping are acceptable for mains 2" and larger with the branch ½ or less than the main. Joint must be brazed. (6.13.8)
98. Do not permit grooved connections in domestic water copper piping.
99. Do not permit press type fittings in copper. (6.13.8)
100. Combination waste & vent is discouraged and may be used only for floor drains and floor sinks when other venting methods are not possible. Venting lavatories and

sinks other than floor sinks is not permitted with combination waste & vent(8.8.12). Make use of circuit venting where appropriate.

101. Drain lines serving commercial dishwashers should be high silicone cast iron. Drains serving low temperature mild acid such as carbonated beverage machine drains should be PVC. Indicate on the drawings drain line material.

102. Domestic water piping shall be type L copper for above ground and type K copper for below grade. Do not permit press fittings. For O&M projects cross linked Polyethylene (PEX) is permitted when largest pipe can be served by 1" PEX. (5.19.8)

103. Domestic waste and vent drawings shall include a plan view of the plumbing fixtures and the waste piping serving those fixtures for each floor level, and an isometric view riser diagram. Vent piping does not need to be shown on the plan view; but do show the connection points to the waste piping. Waste piping shall be represented as a single continuous line. Vent piping shall be represented as a single dashed line. Indicate pipe sizing on the isometric riser diagram. (8.8.12)

104. Domestic hot and cold water drawings shall include a plan view of the plumbing fixtures and the water piping serving those fixtures for each floor level, and a riser diagram. The riser diagram may be an isometric view. The cold water shall be represented as a single line with a single dash. The hot water shall be represented as a single line with a double dash. (8.8.12)

105. Do not combine waste/vent drawings with hot/cold water drawings. Waste/vent plans, hot/cold plans, and riser diagrams may be **~~combined~~ included (8.29.14)**on the same sheet if project size and space permits. (8.8.12)

106. For domestic hot water system heated by geothermal heat pumps **that do not output 140F in a single pass(8.29.14);** do not install whole building tempering valve. Store the hot water at 130-140 degrees, and deliver at the storage temperature. (1.18.13)

107. **Provide pre-heat tank on solar hot water systems. Tank shall be sized for 1 day worth of peak heat production (60F to 180F) for BEQs and 3 day's worth of peak heat production for other buildings, but not more than 1 day's use of hot water. (8.29.14)**

FUEL FIRED DOMESTIC WATER HEATERS, WATER BOILERS and SMALL STEAM BOILERS (8.30.10)

108. Boilers 399,000 btu/hr and smaller are heating appliances. Boilers 400,000 btu/hr and larger are utility boilers and have increased surveillance, inspection, and maintenance requirements. Utility boilers are serviced, inspected, and operated by Utilities Department. Heating appliances are serviced and maintained by the Base Maintenance Contractor. Use multiple condensing boilers under 400,000 btu/hr input for applications where the total load is less than 2,200,000 btu/hr **for heating, and 1,440,000 btu/hr for domestic water.**(8.29.14) Size the boilers for N+1 of 75% of the peak load, and all boilers no less than 100% of the peak demand. Where N equals the number of boilers to produce 75% peak demand (8.8.12).

109. Dining Facilities: Provide separate steam boilers for the process loads (dishwashers, steam kettles etc). Size each boiler for 110% of the process load in an N+1 configuration. Boilers shall be 150psig maximum allowable working pressure,

wet back fire tube. Operate boiler at 50psig with a minimum pressure of 25psig (accounting for dead band during burner cycling). Burner shall be modulating type or two firing rate (hi/low fire) type. Provide steam pressure reducing station in a 1/3-2/3 configuration to reduce pressure to operating pressure of the equipment. (8.8.12)

110. Specify emergency gas shutoff. This is a remotely operated shut off valve. The labeled red mushroom valve shall be located next to the exit door.
111. Specify Gas pressure gage.
112. Specify lockable disconnect.
113. All boiler controls shall meet CSD-1. Show on the drawings the emergency shutdown switch required by CSD-1 CE 110 (a). The preferred method is a single illuminated 50mm dia mushroom switch with one set of normally open contacts on the inside of the exit door. On single boiler installations this switch shall trip a shunt trip breaker for the boiler. On multiple boiler installations this switch shall trip a shunt trip breaker that energizes a normally open contactor. (i.e. when shunt trip breaker trips, it no longer holds the contactor closed). Contactor shall have one set of contacts for each boiler circuit. The idea is to require a manual reset of the shut trip breaker after an emergency activation. Provide appropriate signage (1.2.13)
114. Specify service valves on inlet and outlet connections.
115. Boilers and tankless domestic water heaters shall have a minimum 30” piping and maintenance clearance on all sides. At least every other side shall have 30” clear floor space for personnel access (8.8.12). **Do not stack boilers. All boilers shall sit on housekeeping pad on floor. Pumps may be stacked. (8.29.14)**
116. Tank type domestic water heaters shall have 15” clearance to the sides and rear, and minimum 30” piping and maintenance clearance to the front (8.8.12).
117. Provide condensate neutralization kit for each boiler/water heater. Tank shall hold at least ¼ cubic foot of limestone and be rechargeable without disconnecting piping or brackets (8.8.12).
118. Exhaust vents shall be vertical discharge for environmental reasons, even with sidewall penetrations. i.e. no rain caps. (1.2.13)
119. For Fuel Gas fired water and steam boilers provide a gas shutoff valve within 30 feet of the mechanical room exit door and on the same or adjacent wall to the exit door. i.e. valve shall be easily accessible in direct route from door with no more than one 90 degree turn. This valve shall be quick operating type valve such as a ¼ turn ball valve. (1.18.13)

STEAM: Camp Lejeune is in the process of closing down the existing central steam distribution systems. New and renovated facilities are to use other sources of heating unless otherwise noted by the project manager (8.8.12).

120. Meters are required for steam, ~~water~~(8.30.10) and electrical service to MWR facilities and all other reimbursable customers.
121. Avoid (5.19.8) steam pits within mechanical rooms. Steam lines should be counter flowed from an exterior manhole.
122. Steam condensate receiver pumps should be steam pressure powered. Do not use electric duplex condensate pumps.
123. Minimize use of steampits. Those required must be raised 18 inches (450 mm) above finish grade and equipped with a full grated top. Steampits are required for the

connection and valving of building service lines. Drip legs can be direct buried with steam trap above ground in a "doghouse" if the steam pit is not required for other reasons. Steampits are required at low points and end of mains in order to gravity drain condensate for cold start up of distribution system.

124. Do not use FRP pipe for buried steam condensate lines. Use schedule 80 black steel pipe in condensate systems.
125. Steam tunnels and trenches are preferred by base utilities over direct buried preinsulated steam and condensate systems. Trench tops may double as a sidewalk where appropriate.
126. Direct buried steam and condensate piping shall be drainable, dryable, testable. Do not include thermal performance testing or sensors (i.e. Delete from guide specification). Edit the testing specification as follows: Socket welded pipe does not need to be tested. As an alternative to radiographic testing, the butt welds may be ultrasonically tested. The report shall be similar to that of the radiographic exam, i.e., examiner shall sign and date report, defects and location shall be noted, weld shall be graded acceptable or unacceptable, etc. Welded connections shall not be covered until the government selects 10% of the connections to be tested. (5.26.09)
127. Use externally pressurized bellows expansion joints when inline expansion in steam lines is required and where loops cannot be utilized. Slip tube expansion joints are acceptable but not preferred over externally pressurized bellows joints.
128. Provide check valves and test valves at all steam condensate drip stations.
129. Base operating steam pressures are as follows:

Steam Plant	Steam Pressure
Plant 1700	150 psi (1034 kPa)
Plant AS4151	**50 psi (345 kPa)(8.29.14)**
Plant G650	**50 psi (345 kPa)(8.29.14)**
Plant M625	**50 psi (345 kPa)(8.29.14)**
Plant RR15	50 psi (345 kPa)
~~Plant PP2615~~	~~50 psi (345 kPa)~~(decommissioned 8.30.10)
~~Plant M230~~	~~50 psi (345 kPa)~~(decommissioned)
Plant BB9	100 psi (690 kPa)
Plant NH100	100 psi (690 kPa)

130. Specify steam control valve actuators that can withstand heat conducted from steam lines and equipment. Do not specify, or approve, hydraulic powered actuators in steam applications.
131. Install blow down valves on all strainers.
132. It is preferred to distribute hot water throughout building or building complex for heating in lieu of direct steam heat.
133. Specify flange gaskets to be metal spiral wound ASME B16.20.
134. All steam pressure powered pumps (PPP) shall have a direct acting pressure regulator on the motive steam. Provide pressure gages on the motive steam line and the condensate collection system. Regulator to be set for 20 psi higher than the condensate back pressure. Regulator shall be 20' from PPP, or the line between the regulator and the pump shall be oversized. (12.31.07) If the steam distribution

pressure exceeds pump body pressure rating, a safety relief valve must be installed in the steam supply. (8.30.10)

135. Ensure that all steam heated equipment with modulating steam control valves have vacuum breakers, air vents, and gravity drain to a condensate receiver. Show sufficient details to ensure contractor pipes accordingly. The mechanical room plan shall also allow for this. If a pumping trap is required, show it on the drawing. (12.31.07)

136. Valves for 100psi and greater steam shall be steel bodied valves. (1.28.10)

137. Camp Lejeune has introduced flooded vertical heat exchangers that use line pressure steam and a control valve on the condensate discharge in lieu of a steam control valve thereby omitting the need for a steam pressure regulator, steam pressure safety valve, steam control valve and a condensate pump. Contact the Public Works project manager to coordinate the use of the traditional steam system or the flooded vertical heat exchanger on each project. Contact the mechanical branch manager to get the standard detail and about application. (1.28.10)

SWIMMING POOLS (5.10.09)

138. Swimming pool chemistry and filters are monitored by PW Utilities and pools shall be equipped as followings.

139. Pool shall have pool controller that automatically monitors and feeds sodium hypochlorite and sulfuric acid, and backwashes the filter.
    a) Controller shall read ORP or free chlorine, and PH.
    b) Controller shall transmit free chlorine, and PH values to the corresponding water plant via radio.
    c) Pool water temperature shall also be sensed and transmitted on indoor pools.
    d) Controller shall transmit a master alarm to the corresponding water plant via radio in the event of high or low ORP or PH levels, no sensor water flow, and elapsed chemical feed alarm.
    e) Chemical feed system shall be interlocked to shut off in the event of no pool circulation water flow.
    f) The preferred pool controller is Bec System 7.
    g) Electronics shall have a 60 minute battery backup.

140. Filter backwash shall have manual over-ride such that the filters can be backwashed in the event of controller failure.

141. Normal pool water waste shall be to the sanitary sewer, with a bypass to the storm sewer. This can be used to empty pool after dechlorination. A dechlorinator shall be installed. (7.2.09)

142. A normally energized duplex receptacle needs to be installed near the chemical feed pumps to manually feed chemicals in the event of pool controller failure. If chemical feed is controlled by energizing/de-energizing the receptacle supplying the feed pumps, each pump shall have a separate, independent, and labeled receptacle. (7.2.09)

143. Minimum chemical storage for an indoor Olympic size pool shall be 300 gallons of sodium hypochlorite, and 150 gallons of sulfuric acid. Chemical storage shall be proportional to pool size. Outdoor pools require increased storage capacity. All chemical storage tanks shall have secondary containment. Chemical rooms shall be

mechanically vented, dedicated to chemical storage and large enough to increase the storage by 50%. Chemical rooms shall be located with easy access by delivery tanker truck. Entrances to chemical room shall be labeled with Hazmat Placard. (7.2.09)

144. Do not use brass saddles at chemical injection points. Use PVC.

145. Do not locate normally serviced equipment such as pumps, backflow preventers, lint traps, etc in pits. Equipment that requires regular operation, service, or maintenance shall not be located in confined spaces. (7.2.09)

146. The contractor shall modify the front end software at the water plant to receive and display the new pool.
   a) Wallace creek recreation center shall transmit to the building 20 water plant.
   b) The wounded warrior pool shall transmit to the building 670 water plant.

147. Swimming pools shall comply with 15A NCAC 18.A2500, (North Carolina Rules for Public Swimming Pools), with the following exception: Do not provide an integral vacuum system as called for in 15A NCAC 18A.2518(g). The pool chemistry is maintained by the PW Utilities. The cleaning is done by the pool operators. We do not want pool operators to have access to the pump room, which would be necessary if an integral vacuum system were installed.

148. Filter rooms should have a pedestrian door and an 8'x8' roll up door for forklift and pallet access. Provide differential pressure gage across each filter to be easily read while standing in front of filter. (7.2.09)

<u>ENERGY</u>

149. **For partial renovation/repair projects, energy modelling may not be practical or in the design scope of work. To comply with the intended goal of 20% better than ASHRAE, specify individual assembly performance to be 20% better than the ASHRAE prescriptive requirement. (8.29.14)**

150. Building thermal envelope assemblies shall at a minimum meet the prescriptive requirements of ASHRAE 90.1 with the following exceptions. (2.10.10)

151. Metal and wood studs walls shall be 6" with R19 insulation. (2.10.10)

152. Mass walls shall have a minimum of R10 rigid insulation between wythes of masonry or on the exterior of the massive layer. Insulation in the cells of CMU does not fill this requirement. (2.10.10)

153. ~~Roof insulation shall be R30, except for metal panel construction where blanket insulation is placed between purlins and metal panels the insulation may be R19.~~ (2.10.10)

154. Windows shall meet ATFP requirements, laminated, meet ASHRAE 90.1 prescriptive requirements. No tilting sashes are permitted. (2.10.10)

155. Water meters are required on all new buildings. Preferred location is in mechanical room and shall report thru the DDC to the EMCS. (8.30.10)

156. Return duct to ERV's shall be insulated when passing thru unconditioned spaces. (8.8.12)

157. Equipment energy efficiencies shall meet the Federal Energy Management Program (FEMP) and Energy Star minimum efficiencies. Refer to FEMP or Energy Star documentation for greater detail. The minimum efficiencies are listed below (8.8.12). **Consider raising these standards when 3 manufacturers are available (8.29.14)**.

a. Hot water, gas fired, condensing boilers over 300 MBH: 94% or greater AFUE
b. Hot water, gas fired, condensing boilers under 300 MBH: 94% or greater AFUE
c. Hot water, gas fired, non-condensing boilers over 300 MBH: 84% or greater AFUE
d. Hot water, gas fired, non-condensing boilers under 300 MBH: 85% or great AFUE
e. Gas fired steam boiler, 300 MBH-10,000 MBH: 80% or greater AFUE
f. Domestic hot water gas fired heater with storage, over 75 MBH: 94% or greater AFUE
g. Domestic hot water gas fired instantaneous, over 200 MBH: 94% or greater AFUE
h. Domestic hot water gas fired supply boiler, 300 MBH – 12,500 MBH: 945 or greater AFUE
i. Air-source heat pump, 3 phase, packaged unit, <65,000 Btu/hr: 14 SEER; 11 EER; 8.0 HSPF
j. Air-source heat pump, 3 phase, split system, <65,000 Btu/hr: 14 SEER; 11 EER; 8.2 HSPF
k. Air-source heat pump, 3 phase, ≥65,000 Btu/hr - <135,000 Btu/hr: 11.3 EER; 11.4 IEER; 3.35 COP at 47°F
l. Air-source heat pump, 3 phase, ≥135,000 Btu/hr - <240,000 Btu/hr: 10.9 EER; 11 IEER; 3.25 COP at 47°F
m. Air-source air conditioner, 3 phase, packaged unit, <65,000 Btu/hr: 14 SEER; 11 EER
n. Air-source air conditioner, 3 phase, split system, <65,000 Btu/hr: 14 SEER; 12 EER
o. Air-source air conditioner, 3 phase, w/electric resistance heating, ≥65,000 Btu/hr - <135,000 Btu/hr: 11.7 EER; 11.8 IEER
p. Air-source air conditioner, 3 phase, with other heating, ≥65,000 Btu/hr - <135,000 Btu/hr: 11.5 EER; 11.6 IEER
q. Air-source air conditioner, 3 phase, w/electric resistance heating, ≥135,000 Btu/hr - <240,000 Btu/hr: 11.7 EER; 11.8 IEER
r. Air-source air conditioner, 3 phase, with other heating, ≥135,000 Btu/hr - <240,000 Btu/hr: 11.5 EER; 11.6 IEER
s. Air Source, 1 phase, split system, heat pump and air conditioner, <65,000 Btu/hr: 15 SEER; 12 EER; 8.5 HSPF (HSPF for heat pumps only)
t. Air Source, 1 phase, packaged unit, heat pump and air conditioner, <65,000 Btu/hr: 14.25 SEER; 11 EER; 8.2 HSPF (HSPF for heat pumps only.
u. Gas fired furnace, 225,000 Btu/hr: 90% or greater AFUE

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NAVFAC Naval Facilities Engineering Command
NAVFAC MID-ATLANTIC

Design Strategies for Energy Use Reduction to Consider During DD Form 1391 And Development of Construction Solicitation Documents

Criteria:

1. ASHRAE/IESNA Standard 90.1-2007 "Energy Standard for Buildings Except Low-Rise Residential Buildings"
2. UFC 3-400-01 dated 5 July 2002 Including Change 4, August 2008 "ENERGY CONSERVATION".
3. COMNAVREGMIDLANTINST 4100.1, REGIONAL ENERGY MANAGEMENT PROGRAM, Dated 28 Sept 2009
4. ECB 2008-03, Acceptance Testing of Critical Systems
5. NAVFAC Engineering and Construction Bulletin (ECB) 2008-01, Energy Policy Act of 2005 Implementation and USGBC LEED® Certification

NAVFAC tools:

Utilize the NAVFAC tools from the NAVFAC web site: See NAVFAC Sustainable Development Program - Tools at: http://www.wbdg.org/references/pa_dod_sust_tools.php

This site covers 6 tools: Here are the two most important tools:

Navy 1391 Sustainable Design Cost Tool: http://www.wbdg.org/docs/navy_1391_leed.xls

The primary use of this tool is to identify sustainable features and their costs to achieve the requirements of the Energy Policy Act 2005, Executive Order 13423 (implements Federal Leadership in High Performance and Sustainable Buildings MOU), Energy Independence and Security Act 2007 (EISA) and a minimum LEED® Silver-level rating certified by USGBC, to include in the Budget Estimate Summary Sheet of the DD Form 1391. The total cost of these items will be carried over to the EPAct2005/LEED® Silver line item in Block 9 of DD Form 1391.

Energy Conservation tool: http://www.wbdg.org/docs/energy_conserve_measure_toolkit.xls

This tool is intended to be a companion tool to the Navy 1391 Sustainable Design Cost Tool and has been expanded to include worksheets for seven facility types common to the Department of Defense. Each facility worksheet recommends Energy Conservation Measures (ECMs) for building components and systems which are identified for specific climate zones.

1. Commissioning:

Provide Enhanced Commissioning.

The change to Enhanced Commissioning is located at LEED-NC (latest version) EA Credit 3. Enhanced commissioning requires the involvement of the Commissioning Agent (CA) to review the building operation for 10 months and resolve the issues. NAVFAC MIDLANT's policy is for the Contractor and the CA to optimize all of the electrical and mechanical systems to the system peak operating efficiencies as an Energy feature, however, *change the time from 10 months to 12 months*. Enhanced commissioning resolves by keeping the project on design target and goals, keeps construction from deviating from design, fine tunes systems, ensures that operators are trained, ensures that systems are maintained, and improves energy efficiency.

2. ECB 2008-03 Acceptance Testing of Critical Systems, dated 25 Sept 08:

Incorporate the requirements of the engineering Construction Bulletin ECB 2008-03 in the acceptance testing of critical systems. Why?

The ECB requires focus towards NAVFAC's technical oversight of acceptance testing during construction of five critical areas (electrical, fire and life safety, mechanical, roofing, and underwater structures) to ensure the constructed facility performs as intended and meets the needs of the supported commands; to define the use of Post Construction Award Services (PCAS) funding as it applies to the Capital Improvements Business Line (CIBL) in-house acceptance testing and technical support efforts. This supplements the Enhanced Commissioning. Here is the link for the ECB: https://portal.navfac.navy.mil/portal/page/portal/docs/doc_store_pub/ecb2008-03.pdf

3. ENERGY STAR ® Labeled facility:

Provide ENERGY STAR® Label facility. Why?

This is a major energy feature. This feature registers the project as an ENERGY STAR® Label facility. It offers national recognition and a posting on the Department of Energy (DOE) web site. NAVFAC MIDLANT proposes that the Contractor and A/E provide facilities that meet or are better than the Department of Energy' s requirements for ENERGY STAR® Label for Commercial Buildings. Provide for a minimum target overall rating of 90. After one year of operation the Contractor, CA and the A/E shall accumulate the required energy usage data and submit applications to obtain the Energy Star® label for each facility. The Contractor shall apply the label to each facility and register the facility as an ENERGY STAR® Label facility. A copy of 2009 Professional Engineer's Guide to the ENERGY STAR® Label for Commercial Buildings is available on the DOE web site. All equipment provided shall have the ENERGY STAR® Label. The A/E shall obtain an Energy Star® labeled design for each facility.

What it means:

a. A 90 rating means this in the top 10% of all similar facilities having energy saving features

b. National Recognition with a DOE posting

c. A building with an Energy Star® Label

d. Requires all equipment and systems to have the Energy Star® Label

e. Design shall be an Energy Start® Label design

f. Requires 12 months of energy monitoring.

g. Using Enhanced LEED® Commissioning for 12 months, the contractor, CA, and A/E shall monitor the building to make sure it keeps on the Energy Target. If the building is off-Target, the Contractor, A/E, and the CA shall resolve issues to bring the facility back on Target.

4. ASHRAE 90.1-2007:

Incorporate the latest ASHRAE 90.1 standard. Why? The project scope may have been previously defined to meet ASHRAE 90.1-2004.

The new standard raises the energy savings requirement. Design the facility to have energy usage of 40% less than ASHRAE 90.1-2007. This is the current requirement that NAVFAC MIDLANT is incorporating on current design projects. The 30% standard was changed to 40%.

Provide facility envelope improvements, interior and exterior lighting improvements, HVAC system and equipment efficiency improvements, building control system improvements, and other energy saving improvements to reduce annual energy consumption to 40% minimum below ASHRAE 90.1-2007 The 40% shall be calculated using the methodology outlined in the UFC 3-400-01.

5. Optimize the Building Envelope:

Optimize the exterior building envelope to reduce energy. This goes hand in hand with ASHRAE 90.1. Increase the wall insulation and roof insulation. Exceed the latest ASHRAE 90.1 requirements. NAVFAC MIDLANT is incorporating this on current design projects.

6. Optimize the Window Requirements:

Optimize the window strategy to reduce energy even further. Utilize latest version of ASHRAE 90.1 requirements and exceed them. Consider additional thermal insulation capabilities, insulated frames, shading effects, and consider shading devices such as overhangs to reduce the solar load on the windows.

NAVFAC MIDLANT is incorporating this on current design projects. Consider reducing window size *unless* it impacts LEED® factors for daylighting.

7. Radiant Barriers in the Walls:

Incorporate radiant barriers in the wall systems to reduce the radiant heat transfer, and reduce the energy transfer through the walls. NAVFAC MIDLANT is incorporating this on current design projects.

8. Radiant Barriers in the Roof

Incorporate radiant barriers in the roof system to reduce the radiant heat transfer, and reduce the energy transfer through the roof. This will require a major attention to the attic and roof design. The roof materials must be considered because the radiant barrier will increase the roof temperature.

9. Increase Building Envelope Tightness

Incorporate building envelope-tightness building design to reduce air infiltration by providing sealing throughout the envelope. This requires specific details on the drawings as well as specifications for the sealing and testing techniques. Provide building air tightness by reducing the air infiltration through the envelope to 0.25 CFM per envelope area (square feet) at 0.3 inches water gauge pressure. This reduces the effect of energy from reducing infiltration. See the attached Building envelope air tightness requirement.

10. Water Heater Efficiencies:

Consider 80% to 90% or greater. Current design is based on 80% combustion efficiency, which is standard. Changing the water heater design to a condensing type will increase the efficiency to 90% or greater.

11. Supplement Hot Water with Energy Recovery

Provide energy recovery with hot water – utilize the hot water storage tank. Recover energy from the Chiller condenser to supplement the hot water storage heating source.

12. Hot Water Distribution System:

Provide Variable Speed pumping for hot water pumps

Provide high efficiency pumps and motors.

13. Chiller:

Optimize the chiller plant, including the chilled water pump.

a. Look at increasing the chiller efficiency. Increase the Chilled Water temperature difference from 10 degree rise to 11 or 12 degrees. For Constant speed chillers, for every 1 degree increase in chilled water temperature can increase the chiller energy efficiency by 1 to 2%.
b. Increase the pump efficiency and motor efficiency.
c. Consider variable speed primary pumps for chilled water.
d. Optimize the chilled water plant operation via DDC.
e. If the Public Works Department agrees, use water cooled chiller instead of an air cooled chiller.

14. Interior Room Design Condition:

Change the design from 75^{o} F dry bulb as shown on Drawing M1-001 to 76^{o} F dry bulb as required by UFC 3-400-10N, Paragraph 3-2.1.3, Cooling Indoor Design Conditions.

15. Apply the requirements of 2007 Energy Independence and Security Act.

Optimize the lighting efficiencies as well as meet new ASHRAE 90.1-2007

Optimize equipment efficiencies to improve to beat the EISA 2007act.

Solar Hot Water – EISA 2007: requires 30% minimum of the hot water demand to be provided by solar water heating system, if life cycle cost effective. Payback period is considered to be *40* years. (Note: some clients may require this feature even if the payback is greater than 40 years.) Consider 100% of the hot water demand as well.

Provide solar water heating – Develop the hot water system design in conjunction with the HVAC systems, in meeting EPACT 2005. Evaluate the domestic hot water system types or combination of types, in view of meeting the EPACT 2005, EISA 2007 and the LEED® requirements for this project. Perform a life cycle cost analysis on these systems and include with the EPACT 2005 calculations. Submit calculations at the 35% design submittal. Select a hot water service system based on fully meeting the EPACT 2005 and EISA 2007 goals. Provide analysis for using energy reclamation from chillers and/or geothermal heating, natural gas storage type heaters, natural gas storage heaters supplemented by solar water heating system, and supplemented by solar-assisted water source heat pumps in view of achieving LEED® credits under EA Credit 1 (Optimize Energy Performance). EISA 2007 requires that 30% of the hot water demand shall be provided by solar water heating system if life cycle cost effective. Provide energy calculations, system design and life cycle cost calculations.

16. Optimize the HVAC Systems:

Evaluate three general HVAC system types in view of meeting EPACT 2005, UFC 3-400-01 and the LEED® requirements for this project. The following four HVAC systems are those that have been found to be used the most. Prepare a life-cycle cost analysis for these three HVAC systems and the two heat distribution systems. Select an HVAC system based upon fully-meeting EPACT 2005, UFC 3-400-01 requirements and the LEED® requirements. UFC 3-400-01 dated 5 July 2002, including Change 4 dated August 2008, "ENERGY CONSERVATION" – use latest versions. Base the life cycle cost on first cost, yearly maintenance cost, energy costs, operating costs, and system/equipment replacement costs. The Designer of Record shall select an HVAC system type based upon fully meeting the energy conservation requirements and the overarching LEED® Silver requirement, and favoring the most life-cycle cost effective system. The systems shall be evaluated on the basis of life cycle cost on the following factors over a time period of *40* years:

1. First cost or cost of installation and materials
2. Cost of maintenance and repair
3. Cost of operation
4. Energy usage and cost
5. Energy Savings and Cost in savings
6. Cost of replacement

The four systems to be evaluated vary in first cost, operation cost, maintenance cost, replacement cost, life cycle cost, and energy costs, and offer corresponding increases in energy efficiency, and the systems are as follows:

The four HVAC systems vary in first cost and offer corresponding increases in energy efficiency, and they are as follows:

a. VAV Systems: High efficiency air-cooled chiller(s) and natural gas. Consider using Chilled water with variable primary pumping and hot water loops with variable flow. System shall consist of VAV air handling units serving VAV fan powered terminal units throughout the facility and a dedicated outdoor air system with 100% exhaust air energy recovery using total enthalpy heat wheel(s). Perform life cycle cost calculations.

b. Variable refrigerant flow (VRF) cooling and heating systems using multiple packaged outdoor heat recovery units with digital variable speed scroll compressors, and multiple split indoor evaporators with simultaneous heating and cooling capability using heat recovery and supplemental hot water coil. Include primary/secondary pumping for hot water loops. Provide a separate and dedicated 100% outdoor air conditioning system feeding neutral air to each individual zone/space using direct expansion (DX) cooling, hot water heating, pre-heat and reheat using hot water, and energy recovery from exhaust air using total enthalpy heat wheel. Hot water heating will be from the hot water supply via natural gas. VRF systems shall meet ASHRAE 15 and 34 standards. Refrigerant systems shall meet ASHRAE 15 and 34 standards, International Mechanical Code, and Local and/or State Mechanical Codes, as required. System design shall ensure the refrigerant volume of a system does not exceed the refrigerant concentration limit per unit volume as defined in ASHRAE 34 and the local and State Mechanical Codes for the smallest occupied space. In addition, and if used, VRF systems shall be designed and installed in accordance with the detailed requirements as attached.

c. Ground Source Heat Pumps (GSHPs): Geothermal well field with condenser water loop serving ground-source heat pumps (GSHP) located throughout the facility. Consider supplemental energy such as steam heated hot water or hot water from other energy sources such as gas, electric, etc as required to support condenser water temperatures during the heating season, if required and backed up by analyses.   Analyze best heat source if required using life cycle cost analysis. Consider utilizing a closed circuit cooling tower to supplement the ground source condenser water during the cooling season if required. Provide a separate and dedicated 100% outdoor air conditioning system feeding neutral air to each individual zone/space using GSHP, hot water heating, pre-heat and reheat using hot water, and energy recovery from exhaust air using total enthalpy heat wheel.

d. Water Source Heat Pumps (WSHPs): Closed-circuit cooling tower(s) with condenser water loop serving water-source heat pumps (WSHP) located throughout the facility. Supplemental heating to condenser loop will be from the available energy supply using hot water. Dedicated 100% outdoor air conditioning system feeding neutral air to the individual WSHP units using direct expansion (DX) cooling, hot water heating, and energy recovery from exhaust air using total enthalpy heat wheel. Hot water heating will be from the available energy supply.

Ground source heat pumps and associated systems shall meet Unified Facilities Guide Specifications (UFGS) Section 23 81 47 "WATER-LOOP AND GROUND-LOOP HEAT PUMP SYSTEMS." The geothermal well field and GSHP systems is suggested to be designed 15% oversized using software specifically designed to simulate this system type. The contractor shall follow the requirements of UFGC specification UFGS 23 81 47 Water-Loop and Ground-Loop Heat Pump Systems for geothermal well field and the ground source heat pump system. The contractor shall perform tests at the site to evaluate the conductivity and performance of the soil for geothermal heat exchange. The contractor shall determine the general geothermal well field size and location that best meet the site requirements and shall come up with their own estimates of well field size for the purpose of bidding. The well field shall fit within the site and not impede on adjacent sites or future development planned for those sites. As a minimum, the ground source heat pump well shall meet the local and state well requirements and shall be fully permitted. Each well shall have its own Local and/or State well permit, as required. Each well shall be full grout from top to bottom in accordance with local and or State requirements and the well depth shall be of a depth that is no deeper than allowed by State regulation (for example 150 feet or less in North Carolina), depending on the local and State well requirements – Verify depth with the local and State requirements. Each well shall have a minimum thermal diameter influence of 20 feet, meaning the well spacing between wells shall be a minimum of 20 feet Each well shall not exceed one ton of cooling. Contractor shall provide in-Situ testing to determine heat transfer characteristics of the soil and potential well output. Provide a minimum of 4 in-situ test locations per building. Suggest to provide a separate and dedicated outdoor air system to each space and room.

17. Provide heat recovery from shower drains. Provide this strategy where there are a large number of showers.

18. Lighting Power densities:

Optimize the lighting power densities. Must exceed ASHRAE 90.1-2007 requirements.

Provide daylighting strategy.

19. Demand Control Ventilation:

Provide Demand Control Ventilation utilizing either CO2 or infrared room sensors. If room infrared sensors are used, they can reduce the outside air demand to rooms, when rooms are unoccupied. With demand control ventilation utilize variable speed controls on outside air fan, exhaust air fan, and heat wheel to vary outside air in accordance to demand and still meet ASHRAE 62 requirements.

20. Ventilation: Provide ventilation that meets ASHRAE 62. Calculate the ventilation effectiveness. Strive for 100% effectiveness by requiring ducted exhaust from each room

20. Room Sensor: Along with demand control ventilation, consider utilizing a room sensor that will engage the room lights, room power, exhaust, increase the room supply from minimum, HVAC, etc. The room sensor can be infrared.

21. Room Card Reader System: In lieu of a room sensor, consider a room card or CAC card for use rooms such as quarters. As in a BEQ or BOQ: when the occupant is in the room, the room energy systems would be engage by the card reader system. When the occupant leaves the quarters the room energy would be reduced to a minimum value when the card is removed.

22. UFC 3-400-01, Energy Conservation

Use the latest edition. Except utilize 40% less than ASHRAE 90.1-2007.

23. Duct Seal Class:

Increase the duct seal to reduce the duct losses – Use max seal class, A.

24. Mechanical System Insulation:

Increase thermal insulation on mechanical systems and utilize radiant barriers to reduce thermal losses.

25. DX Systems

Minimize the use of DX systems. Consider using Variable refrigerant flow (VRF) cooling and heating systems. See Item 16 above

For split DX systems: Use where they are required. Specify high efficiency split system units. Use at least 13 SEER.

Prefer high efficient heat pump systems.

When required using Centralized Direct Expansion (DX): Consider packaged cooling with VAV and heating from the available energy supply. Primary/secondary pumping for hot water loops. VAV air handling units serving VAV terminals throughout the facility. Dedicated 100% outdoor air conditioning system feeding neutral air to the VAV air handlers using direct expansion (DX) cooling, hot water heating, and energy recovery from exhaust air using total enthalpy heat wheel. Hot water heating will be from the available energy supply. This approach has to beat the other four systems above in item 16.

26. Optimize the Boiler sizing.

Use 85% combustion efficiency or higher, may have to change boiler type. In optimizing the boiler efficiency include some form of burner control which allows for fully modulating burners with variable frequency drives and fans. Provide for low NOx emissions. Consider multiple packaged boilers for higher operation efficiency. Multiple boilers are better able to match the current load with boiler capacity and cycle on and off less frequently. Utilize controls to stage the boilers on as required to match the load. Utilize boilers with powered or forced draft burners, instead of atmospheric burners. Consider re-circulating flue gases for optimal combustion with minimal excess air. Utilize electronic control systems that monitor flue-gas components and adjust fuel and air as needed. Provide greatly improved turndown ratios to improve efficiency at less than peak load. Review flue gas temperatures – may require stainless steel flues.

27. Provide Renewable sources

Provide Photovoltaic power See CNRMA Energy Instruction for minimum requirements.

Provide Solar Hot Water Heating (See item 15 on EISA 2007 above)

Get half the power at Navy shore installations from alternative energy sources - including wind or solar - by 2020, and where possible, supply energy back to the grid.

28. Provide high efficiency motors.

29. Consider ultra high efficiency motors

These motors have very high efficiency with power unloading very close to the centrifugal blower’s power and speed cubic relationship, lowering operating costs significantly at reduced speeds. These motors are called Electronically Commutated Motors (ECM) and are DC motors, with a permanent magnet rotor and ball bearings and an internal microcontroller.

30. Provide digital ballast for light fixtures

31. Ensure the project includes Rainwater harvesting. Goal to save the use of domestic water – Provide water usage reduction: 2% per year with a total reduction of 16% by 2015. This is also covered in CNRMA Energy Instruction.

32. Meet the requirements of the MOU – Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding (MOU), dated 24 January 2006

33. Metering: All incoming utilities shall be metered and monitored via the DDC. All utilities shall be metered is required by EISA 2007 and EPACT 2005. Metering shall be used for the purposes of efficient energy use and reduction in the cost of the utility. Provide utility grade meters that data at least daily and measure the consumption of electricity at least hourly. Utilize advanced metering, which consists of sub-metering. The metering will be part of the EMCS/DDC controls. Consider meter data transfer to GIS via EMCS/DDC.

34. Minimize Energy usage, maximize efficiency, consider life-cycle costs and utilize the referenced criteria requirements when acquiring new equipment or systems, as well as vendors' efficiency or energy policies.

35. EMCS/DDC: Consider utilizing Energy Monitoring Control System (EMCS) and Direct Digital Control (DDC). EMCS and DDC can provide energy savings by monitoring and control of utilities, advanced metering such as sub-metering, HVAC, etc. See attached Energy Monitoring Control System/Direct Digital Control Systems (EMCS/DDC) Strategy (First Draft)

DEPARTMENT OF THE NAVY
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TELEPHONE NO:

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11000
CIME/tjh
01 March 2005

From: Commander, Naval Facilities Engineering Command, Capitol Improvements
To: Distribution

Subj: INTERIM TECHNICAL GUIDANCE (ITG) FY05-2, NAVFAC HUMID AREA HVAC DESIGN CRITERIA

Ref: (a) ITG FY03-4, "NAVFAC Mold Response Manual"
(b) Engineering Technical Letter (ETL) 04-3: Design Criteria for Prevention of Mold in Air Force Facilities, dtd 6 April 6 2004
(c) Engineering Technical Letter (ETL) 03-2: Design Criteria for Prevention of Mold in Air Force Facilities, dtd 12 August 2003

Encl: (1) "NAVFAC Humid Area HVAC Design Criteria," dtd 31 January 2005
(2) "Bachelor Housing 1 + 1E Apt Example"

1. Purpose. The purpose of this guide is to provide revised basic criteria and information concerning the design of facilities located in Humid Areas, with the intent to prevent the occurrence of mold and mildew growth.

2. Discussion. Reference (a) provides guidance on mold remediation and abatement, based upon increasing incidence of mold and mildew occurrence within Navy facilities. References (b) and (c) address prevention of similar problems within Air Force facilities. Enclosure (1) of this ITG incorporates substantial portions of the Air Force ETL, and supplements it with some additional information.

3. Action.

a. Design. All projects, located in Humid Areas, starting design 90 days after the effective date of this ITG will comply with enclosure (1). Projects currently under design shall be revised to comply, where schedule and funds permit.

b. Criteria. NAVFAC CI will coordinate the revision of existing and the drafting of new Unified Facilities Criteria (UFC) documents to incorporate the provisions of enclosure (1).

c. References to ITG FY05-02 have been added by changes to the following documents:

- UFC 1-200-01, *Design: General Building Requirements*
- UFC 3-410-0-02N, *Design: HVAC Systems*
- UFC 3-100-10N, *Architectural*
- UFC 3-400-10N, *Mechanical*

Upon incorporation of Humid Area Design Criteria into existing and new documents, the above ITG FY05-02 and references to it will be cancelled.

4. Point of Contact. For clarification or additional information related to this subject, please contact Mr. Thomas J. Harris, PE, DSN 262-4206, Comm (757) 322-4206, email thomas.j.harris@navy.mil

S. P. GEUSIC
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01 March 2005

NAVFAC HUMID AREA HVAC DESIGN CRITERIA

1-1 Purpose. This guide provides design criteria for preventing mold inside Navy facilities.

1-2 "Humidity Control Basics." Successful control of humidity within Naval facilities, in order to prevent mold, requires the efforts of the several entities involved in the life cycle of the facility. The User must "Define the purpose of the project." The Architect must "Design a tight building." The HVAC designer must "Control the outdoor air." The Contractor must "Build low-leakage building and tight duct work." And the Building Operations Staff must "Maintain correct internal air pressure." Only then may the building meet the needs throughout the life cycle at minimum life cycle costs. The quotes courtesy of ASHRAE *Humidity Control Design Guide for Commercial and Institutional Buildings, Chapter 2,* see paragraph 3-1.4, below.

2-1 Application. This guide applies to new or renovated Navy facility projects that start design 90 days after the effective date of the ITG. Projects currently under design shall be revised to comply, where schedule and funds permit.

3-1 Referenced Publications:

3-1.2 Unified Facilities Criteria (UFC):
- UFC 3-400-02, *Design: Engineering Weather Data*
- UFC 3-400-10N, *Design: General Mechanical Requirements*
- UFC 4-721-10, *Design: Navy and Marine Corps Bachelor Housing,*

3-1.3 Unified Facilities Guide Specifications (UFGS):
- UFGS 15080, *Thermal Insulation for Mechanical Systems*
- UFGS 15950N, *Testing, Adjusting, and Balancing of HVAC Systems,*

3-1.4 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):
- ASHRAE 52.2-1999, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*
- ANSI/ASHRAE 55-2004, *Thermal Environmental Conditions for Human Occupancy*
- ASHRAE 62.1-2004, *Ventilation for Acceptable Indoor Air Quality*
- ASHRAE 90.1-2004, *Energy Standard for Buildings Except Low-Rise Residential Buildings*
- Standard 90.1-2004 *User's Manual*
- *ASHRAE Fundamentals Handbook*
- ASHRAE *Humidity Control Design Guide for Commercial and Institutional Buildings*

3-1.5 Other Industry:
- National Roofing Contractors Association (NRCA) *Roofing and Waterproofing Manual* (fifth edition)
- International Code Council (ICC) *International Building Code 2003* (IBC)

4-1 Acronyms:

ANSI - American National Standards Institute
CFM - cubic feet per minute
CMS - cubic meter per second
F - Fahrenheit
HVAC - heating, ventilating, and air conditioning
ICC - International Code Council
MERV - Minimum Efficiency Reporting Value

5-1 Definitions:

5-1.1 Sensible Cooling Load: Heat gain that causes a change in dry bulb temperature at a constant humidity ratio.

5-1.2 Latent Cooling Load: The portion of the cooling load attributed to a change in the humidity ratio at a constant dry bulb temperature.

5-1.3 Humidity Ratio: The ratio of the mass of water vapor to the mass of dry air contained in a given moist air sample.

5-1.4 Humid Area (HA): Geographic location where UFC 3-400-02, Data Table (Page 1 of 18), Other Site Data, entry titled "Ventilation Cooling Load Index" indicates the annual latent cooling load (Ton-hr/cfm/yr) of outside (ventilation) air equals or exceeds three times the outside (ventilation) sensible cooling load, AND the monthly latent load exceeds the monthly sensible load, as evaluated by inspection of the graph (Page 14 of 18), titled "Average Ventilation and Infiltration Loads", for two or more consecutive months of the year.

6-1 Requirements.

6-1.1 Introduction. Navy facilities have experienced damage from moisture and/or mold, especially in locations within humid areas. The high ambient moisture and temperature common in high-humidity areas reverses vapor flow through building components and increases the latent cooling load on HVAC equipment, when compared to the design conditions for most other continental United States locations. These unique conditions require design criteria differing from the conventional wisdom used in other areas.

6-1.2 Site Drainage. Grade/slope building sites to drain away from buildings.

6-1.3 Building Envelopes. For new construction or renovation involving roofs and/or exterior walls, design and construction at all Navy locations in humid areas must comply with the following:

6-1.3.1 Continuous Air Barrier. Provide a continuous air barrier (vapor retarder, the least permeable material) on the exterior side of the building insulation and place only more-permeable materials on the interior side of the building insulation. For double-wythe walls, place the continuous air barrier on the exterior side of the inner wythe. Provide drainage from the continuous air barrier to the exterior (i.e., weep holes in the base of the exterior brick veneer wythe, protected from accumulation of mortar droppings).

6-1.3.2 Moisture Seal. Seal all seams in the continuous air barrier, and seal all openings around doors and windows, lintels, utility penetrations, and at intersections of walls, roofs, floors, and foundation walls. Install non-permeable sill gaskets between floors and the bottom plate of exterior walls. Flash all windows and exterior doors with corrosion-resistant flashing to prevent water intrusion into the wall cavity. Provide design details in design drawings for these requirements. Provide details to minimize thermal bridging, especially at door and window frames and the intersections of walls and roofs. Refer to *Humidity Control Design Guide for Commercial and Institutional Buildings,* Chapter 2, "Humidity Control Basics" for more information.

6-1.3.3 Provide roof/ceiling/insulation systems complying with the following principles:

6-1.3.3.1 Install the continuous air barrier (vapor retarder) in accordance with guidance in the *NRCA Roofing and Waterproofing Manual* (fifth edition).

6-1.3.3.2 Ventilate spaces created outside the roof/ceiling continuous air barrier (vapor retarder). For sloped roofs, ventilation must comply with the *International Building Code 2003* (IBC), Section 1202.2. Ensure that moisture transfer from ventilated attics into the building is minimized the same as for walls.

6-1.3.3.3 Prohibit entry of unconditioned outside air into all spaces inside the thermal envelope. Ventilation of such spaces, if required, must use air from conditioned spaces.

Exception: Mechanical, Electrical, Elevator Machine, and similar rooms, provided with louvers or other intended means of outside air entry, shall have all the interior surfaces provided with a continuous air barrier, except the interior face of the exterior walls. Walls and ceilings may be painted with vapor retardant paint, and above-grade floors may be seal-coated concrete.

6-1.3.3.4 On the interior face of exterior walls, use only interior wall finishes that allow water vapor within the wall to escape into the conditioned space, such as latex paint. Vinyl wall coverings, oil-based paint, and other vapor-resistant materials will not be used as interior finishes for exterior walls.

6-1.3.4 Envelope Design Analysis. For swimming pool enclosures, museums, and other highly-humidified buildings, the designer must perform a moisture/vapor diffusion analysis for exterior walls and roof structures, using the dew point method as shown in American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) *Fundamentals Handbook* (Fundamentals), 2001, Chapter 23 using design weather conditions as stated in paragraph 6-1.4.1.1 of this document. The wall analysis must indicate any planes of condensation. Acceptable wall design shall either NOT contain any planes of condensation or the walls SHALL have the capability to drain/vent the moisture to the exterior (i.e., weep holes). Corrective action (i.e., redesign) must occur if the design fails to meet these requirements.

6-1.4 HVAC Systems:

6-1.4.1 HVAC System Cooling/Dehumidification Capability. For facilities authorized air conditioning, HVAC system cooling/dehumidification capacity must be designed to meet the following:

6-1.4.1.1. Outside Design Conditions for all locations. Refer to UFC 3-400-02 and utilize the Design Criteria Data available from the referenced Air Force Combat Climatology Center website. For Design/Build projects, the data may be defined in the RFP documents.

6-1.4.1.1.1. Cooling Systems:

Humid Area Facilities, Specialized De-humidification Systems, and 100% Outside Air Systems: For design, use the "1% Occurrence" value of outside air "Dry Bulb Temperature (T)" "Design Value (°F)" and the "Mean Coincident (Average) Values" "Wet Bulb Temperature (°F)" for the Design Cooling Day. Also, design for Maximum Humidity conditions, using the "1.0% Occurrence" value of outside air "Humidity Ratio (HR)" "Design Value (gr/lb)" and the "Mean Coincident (Average) Values" "Dry Bulb Temperature (°F)." For Mission-Critical Facilities in Humid Areas, use the "0.4% Occurrence" values instead of the "1% Occurrence"values above.

Mission-Critical Facilities (not HA), where equipment failure due to high heat would be unacceptable: For design use the "0.4% Occurrence" value for outside air "Dry Bulb Temperature (T)" "Design Value (°F)" and the "Mean Coincident (Average) Values" "Wet Bulb Temperature (°F)" for the Design Cooling Day.

Other Typical Facilities and Systems (not HA): For design, use the "1% Occurrence" value of outside air "Dry Bulb Temperature (T)" "Design Value (°F)" and the "Mean Coincident (Average) Values" "Wet Bulb Temperature (°F)" for the Design Cooling Day.

Cooling Towers or Evaporative Cooling Equipment: For sizing, use the "0.4% Occurrence" (for Mission-Critical Facilities) or the "1.0% Occurrence" (for Other Typical Facilities) value for outside air "Wet Bulb Temperature (T)" "Design Value (°F)" and the "Mean Coincident (Average) Values" "Dry Bulb Temperature (T)" for the Design Cooling Day.

6-1.4.1.1.2 Heating Systems:

Mission-Critical Facilities: For design, use the "99.6% Occurrence" value for outside air "Dry Bulb Temperature (T)" "Design Value (°F)."

Other Typical Facilities: For design, use the "99.0% Occurrence" value for outside air "Dry Bulb Temperature (T)" "Design Value (°F)."

6-1.4.1.2 Inside Design Conditions for Bachelor Housing, Administrative Spaces, and Family Housing:

6-1.4.1.2.1. Cooling Systems:

Space Design conditions shall be 76 Fdb (24.4 Cdb) & 50% RH, during the Design Cooling Day outside air conditions. At all other than design day, occupied times, maintain the space within the "Summer" conditions shown in ASHRAE *Handbook of Fundamentals – 2001*, Chapter 8, Figure 5, but not less than 76 Fdb (24.4 Cdb). Space thermostat typically set at 76 Fdb +/- 2 Fdb dead band (24.5 Cdb +/- 1 Cdb). 100% Outside Air systems shall operate continuously in Humid Areas, to prevent mold growth.

Admin spaces with Process cooling; Space Design conditions are to be determined by the requirements of the respective processes to be utilized within.

Note: Spaces authorized comfort cooling shall be designed for inside temperatures no lower than 76 Fdb (24.4 Cdb). During unoccupied hours, cooling systems shall be secured where appropriate. [IAW OPNAVINST 4100.5D]

6-1.4.1.2.2. Heating Systems:

Space Design conditions shall be 70 Fdb (21.1 Cdb) during the Design Heating Day outside air conditions. At all other than design day, occupied times, maintain the space within the "Winter" conditions shown in ASHRAE *Handbook of Fundamentals – 2001*, Chapter 8, Figure 5, but not more than 70 Fdb (21.1 Cdb). Space thermostat typically set at 70 Fdb +/- 2 Fdb dead band (21.1 Cdb +/- 1 Cdb).

Admin spaces with Process heating; Space Design conditions are to be determined by the requirements of the respective processes to be utilized within.

Note: Spaces requiring comfort heating shall be maintained at temperatures no higher than 70 Fdb (21.1 Cdb). During unoccupied hours, temperatures shall be set no higher than 55 Fdb (12.8 Cdb). [IAW OPNAVINST 4100.5D]

6-1.4.1.3. Inside Design Conditions for Laboratories, Shops, Warehouses, etc:

Space Design conditions, during the Design Heating Day outside air conditions, shall be 65 Fdb (18.3 Cdb) for areas with moderate activity employment, 60 Fdb (15.5 Cdb) for areas with heavy activity employment, and 50 Fdb (10 Cdb) for storage areas.

Spaces with Process heating; Space Design conditions are to be determined by the requirements of the respective processes utilized within.

Note: Temperatures shall be maintained to minimize energy consumption, with 55 Fdb (12.8 Cdb) being the maximum for heating purposes in storage spaces. [IAW OPNAVINST 4100.5D]

6-1.4.2. System Design. Provide HVAC systems to separately dehumidify and precondition ventilation air if the latent cooling load at the design weather condition causes a system reheat requirement to maintain space conditions (if total dehumidification were to be accomplished by the system cooling coil). The HVAC systems must provide the capability to condition ventilation air and maintain space relative humidity less than 60 percent over the full range of cooling load. Where a separate system is provided to treat outdoor air, the system must comply with 6-1.4.8.1.2 below.

6-1.4.3 Psychrometric Design Analysis. The HVAC design analysis for new facilities or renovation of existing facilities must include a psychrometric analysis of each system, documenting that the system design meets the criteria in paragraph 6-1.4.1. The analysis must provide calculations of system cooling loads (sensible and latent); coil selections; fan selections; chiller or refrigeration system selections; and a system psychrometric diagram and table, indicating state point conditions of dry bulb, wet bulb, and dew point temperatures, humidity ratios, enthalpy, and relative humidity of outside air, mixed air, supply air, and return air flow streams.

6-1.4.4 Equipment Compliance. Construction specifications will require HVAC equipment submittals documenting that proposed equipment is in compliance with the design.

6-1.4.5 Ventilation Air. Supply ventilation air to satisfy ASHRAE 62-2004, *Ventilation for Acceptable Indoor Air Quality*, for the number of occupants, or as required to meet exhaust air requirement plus 15 percent for pressurization, whichever is larger. Ventilation air must be 115 +/- 5 percent of exhaust air for all spaces with direct mechanical exhaust.

Exception: Ventilation for military family housing is normally satisfied by infiltration or natural ventilation, and is designed per Energy Star requirements.

6-1.4.6 Filtering. Filter ventilation air before it enters an air handler, heat recovery equipment, or preconditioning equipment. Use extended media filters with a Minimum Efficiency Reporting Value (MERV) of 7 or greater, in accordance with ASHRAE 52.2-1999, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.*

6-1.4.7 Duct Seal. Seal all ducts to SMACNA Seal Class B, and leak test in accordance with UFGS 15950N, *Duct Air Leakage Testing (DALTS).* Ducts shall also be sealed at all penetrations through the building enclosure and continuous air barrier, and at all connections to equipment, louvers, registers, and grills. Registers and grills shall also be sealed to the space interior wall surfaces. Louvers shall be sealed to exterior wall surfaces. Seal all seams within the air paths, including within air moving equipment. Where units or ducts penetrate the exterior wall, seal all thru-wall sleeves between the exterior wall and the sleeve at both the exterior and interior wall surfaces. Also, seal all thru-wall sleeves between the units and ducts and the sleeve, at the exterior end of the sleeve. Seal all curb-mounted rooftop HVAC equipment to the roof curbs, and seal the roof curbs to the roofing membrane. Seal all HVAC equipment mounted within the building envelope to the supply and return ducts, to prevent leakage from or into the building cavities. Duct insulation must be external; duct board or internal duct liner are not allowed. Use only metal ductwork for the central ventilation and exhaust systems.

Supply air duct leakage into the building cavities causes condensation, leading to mold growth within the cavities, and reduced cooling to the spaces. Exhaust air duct leakage depressurizes the building cavities, increasing infiltration of moisture laden outside air into the building cavities, leading to mold growth within the cavities, and reduced removal of moisture laden or pollution laden air intended to be exhausted.

6-1.4.8 Bachelor Housing and Navy Lodge Facilities.

6-1.4.8.1 New Facilities. The design must provide sufficient floor-to-floor height, vertical distribution space, and mechanical equipment space to accommodate ducted systems to supply preconditioned ventilation air, and ducted systems for exhaust air. **In these types of facilities, do not use the space above the ceiling as an HVAC plenum.**

6-1.4.8.1.1 Within bathrooms, the substrate beneath ceramic tile, plastic tile, or plastic finished wall panels in areas exposed to water (e.g., tub and shower enclosures) must be made of cement, fiber cement, or composite materials manufactured specifically for use in high-moisture locations.

6-1.4.8.1.2 Ventilation Air Supply (VAS) Systems. New facilities must employ separate, dedicated, constant-volume, central ventilation air supply systems that continuously supply dehumidified and reheated (tempered) 100 percent outside air to all occupied spaces. The design intent of these systems is not to provide total space heating and cooling, but to provide total ventilation load and space latent load cooling, and to capture any available VAS sensible cooling to meet a portion of the space sensible cooling load; systems must continuously condition and deliver ventilation air to each occupied space. The ventilation air must be dehumidified to maintain a 55 F dew point (Fdpt) (12.8 C dew point (Cdpt)) and reheated (tempered) enough to maintain ventilation air supply relative humidity less than 70% within VAS ducts. This reheat is to reduce potential for mold growth within the VAS ducts due to moisture carryover from the cooling coil. VAS supply air temperature must not be at or below room design dew point temperature, to avoid condensation on the supply air registers. VAS supply air dew point temperature must be below room design dew point temperature, in order to meet the room latent load. Humidification of ventilation air during periods of low ambient humidity is not required, unless otherwise indicated. Facility central VAS systems must not be subject to intermediate season (no-heat/no-cool) shutdown, or any other non-emergency shutdown. Individual room heating/cooling equipment must have occupant control, but may be subject to intermediate season heating/cooling curtailment as directed by local command. Systems must be designed to minimize the transmission of sound between apartments. The designer will provide a psychrometric analysis documenting that the system is designed to properly maintain the space temperature and relative humidity, at the required "0.4% or 1 % Occurrence" Outside Design Conditions. The system must provide the capability to condition ventilation air and maintain space relative humidity less than 60 percent over the full range of cooling load.

Note: Conditioning of ventilation air is not required for facilities not otherwise air-conditioned.

6-1.4.8.1.3 Exhaust Systems. A central ducted bathroom exhaust system will be used instead of individual exhaust fans for each space. The exhaust system must run continuously and be interlocked with the building supply air system. The exhaust duct for each space must have a manual volume damper accessible from the space for proper balancing. Install an exhaust grille, constructed of corrosion-resistant material, just outside each shower stall and bathtub. Exhaust systems must be designed to minimize the transmission of sound between apartments. Exhaust from moisture-producing equipment (i.e., clothes dryers) must be vented to the exterior. Take advantage of the ASHRAE allowed reduced bathroom (toilet) ventilation requirements due to provision of continuous operation; see 2001 ASHRAE Handbook Fundamentals, Chapter 26, Table 3.

Note: Vent-less Clothes Dryers are not acceptable in Humid Area locations.

6-1.4.8.1.4 Air Balance for Bachelor Housing. Continuous VAS of 15 cfm (0.007 cms) per person for 4 persons (maximum) wartime loading will be 60 cfm (0.0028 cms). Continuous bathroom exhaust of 20 cfm (0.009 cms) (ASHRAE recommendation) will allow the remaining 40 cfm (0.019 cms) to pressurize the spaces to reduce infiltration. The bathroom will dry a little more slowly with the continuous exhaust airflow, but the VAS at 55Fdpt (12.8 Cdpt) will ensure that it dries satisfactorily. Bedrooms and kitchen spaces will remain dry due to pressurization reducing infiltration loads from humid outside air during door openings. Clothes dryer operation (if provided) will temporarily create an additional 150 cfm (0.071 cms) exhaust flow, which will be satisfied by the 40 cfm (0,019 cms) VAS pressurization air flow plus 110 cfm (0.052 cms) of infiltration, during the approximately one hour drying cycle. The other 23 hours of 40 cfm (0.019 cfm) exfiltration of VAS will transport the infiltrated moisture back outside the space, thereby protecting these spaces from moisture accumulation and resultant mold growth.

6-1.4.8.1.5 Heat Recovery. Use heat recovery from exhaust air, or from VAS refrigeration equipment, to provide the VAS reheat and reduce the energy consumption necessary to condition ventilation air, where savings from heat recovery results in a life cycle cost payback for the heat recovery equipment.

6-1.4.8.1.6 Economizer Cycle. Economizer cycle will not be used in Navy construction, unless required by ASHRAE Standard 90.1 (STD 90.1). Full use of the STD 90.1 Economizer Requirements Exceptions shall be taken, to avoid economizer use, where allowed. These exceptions are detailed in the 90.1 User's Manual, Section 6.3.1. They include the weather & capacity exception (Table 6.3.1); the residential exception, the envelope-dominated exception; the High efficiency exception, and others. STD 90.1, Table 6.3.1, lists 1% Cooling Design Wet Bulb Temperature (CDwbt) ranges and the Number of Hours the Outside Air Design Dry Bulb Temperature is between 55 Fdb (12.8 Cdb) and 69 Fdb (20.5 Cdb), during the time period of 8 AM to 4 PM. The tabulated value is the minimum system size that **will** require an economizer. STD 90.1, Appendix D-1, lists values for the 1% CDwbt and No. of Hours for many locations. Engineering Weather Data (EWD) lists the 1% Cooling Wet Bulb Temperature, on page 1 of 18, and lists the Dry Bulb Temperature Hours For An Average Year, on page 9 of 18. The column labeled "Hour Group (LST) 09 to 16" may be used to obtain the number of hours for use in STD 90.1, Table 6.3.1. The difference between the STD 90.1, Appendix D-1 data and the EWD is small, and is due to the difference in hours included in the data. STD 90.1 uses 0800 through 1559; EWD uses 0900 through 1659. Use the EWD data where available.

6-1.4.8.1.7 Storage Spaces. Closets and storage or utility rooms smaller than 4.64 square meters (50 square feet) of floor space within conditioned spaces must have undercut and overcut doors allowing airflow through these spaces. Closets and storage or utility spaces larger than 4.64 square meters of floor space must be supplied with conditioned air.

6-1.4.8.2 Existing Facilities. Existing facilities being renovated must incorporate ventilation air supply systems as described for new facilities in paragraph 6-1.4.8.1.2. Where the facility structure (i.e., floor-to-floor height) prohibits dedicated central ventilation air systems, alternative system (package unit) designs must have separate, dedicated, and continuous conditioning of ventilation air. The designer will perform a psychrometric analysis documenting that the system is designed to maintain space humidity with entering ventilation air at the 1 percent humidity ratio design weather condition. The system must provide the capability to condition ventilation air and maintain space relative humidity over the full range of cooling load.

6-1.4.9 HVAC Equipment Selection.

6-1.4.9.1 For VAS cooling coils, typically with a depth of 4 or more rows, indicate the design coil fin density on the equipment schedules, not to exceed a maximum of 8 fins per inch (8 fins per 25.4 millimeters), to ensure a cleanable coil and competitive bidding. For other than VAS cooling coils, with typical depth of less than 4 rows, indicate the cooling coil fin density on equipment schedules at a maximum of 14 fins per inch (14 fins per 25.4 millimeters). To preclude moisture carryover, coil face velocities must not exceed 550 feet per minute (167.6 meters per minute). Ultraviolet lights may be considered to control growth of mold within the coil, air-handling unit, and ductwork, and may be especially suitable for use with deep (4 row or more) cooling coils.

6-1.4.9.2 Specify the minimum number of cooling coil rows in the equipment schedules. The number of rows will be based on a comparison of data from at least three manufacturers and must ensure that latent cooling loads can be met or exceeded.

6-1.4.9.3 Cooling coil design entering and leaving air conditions must be specified (wet and dry bulb temperatures) at the design airflow rate.

6-1.4.9.4 Select equipment with a cooling capacity closest to the design load (no safety factors) meeting the conditions of paragraph 6-1.4.1. Over-sizing the cooling equipment inhibits dehumidification capability. (Heating equipment capacity SHOULD INCLUDE appropriate safety factors.)

6-1.4.9.5 Several options for equipment types are available to accomplish dehumidification. Select equipment that will meet the design requirements and provide the lowest life cycle cost and energy consumption.

6-1.4.10 HVAC System Layout.

6-1.4.10.1 To the maximum extent possible, chilled water piping must be routed through pipe chases and hallways. Avoid concealing piping in the walls or ceilings of occupied spaces. Provide access for maintenance.

6-1.4.10.2 Insulate piping with an operating temperature below dew point with jacketed insulation meeting the cold piping requirements of UFGS 15080, *Thermal Insulation for Mechanical Equipment.* The insulation jacket must be sealed to provide an exterior vapor barrier.

6-1.4.10.3 Sufficiently sized, safe access must be provided for the maintenance of valves, variable air volume (VAV) boxes, dampers, controls, and other HVAC components.

6-1.4.10.4 Ductwork must not be installed within or beneath slab-on-grade floors.

6-1.4.11 Design Analysis Submittal. The designer shall provide a single submittal package, for approval of the Contracting Officer, including each of the following applicable Design Analysis (DA):

ITG Paragraph 6-1.3.4.	Envelope DA
ITG Paragraph 6-1.4.3.	Psychrometric DA
ITG Paragraph 6-1.4.8.1.2.	VAS Psychrometric DA
ITG Paragraph 6-1.4.8.2	Existing Facility Alternative System Psychrometric DA

7-1 Testing, Adjusting, and Balancing (TAB). HVAC systems will be tested, adjusted, and balanced to verify and document actual performance of the systems and evaluate conformity with the design intent. UFGS 15950N will be used to develop the contract requirements for TAB.

8-1 Point of Contact. Recommendations for improvements to this ITG are encouraged and should be furnished to:

Commander, Naval Facilities Atlantic,
Engineering and Criteria Office (Code CI),
6506 Hampton Blvd., Norfolk, Virginia 23508-1278,
Attn: Mr. Thomas J. Harris

Or contact Mr. Harris at DSN 262-4206, (757) 322-4206, Fax (757) 322-4416

Or email to thomas.j.harris@navy.mil

BACHELOR HOUSING
1 + 1 E Apt
Example

Design Space Conditions: 76 Fdb, 50%RH, 56 Fdpt, 67 grHR (Design values underlined)

Occupancy: 2 + 2 persons, per UFC 4-721-10, Chap. 4-6 and 10-33.

Minimum Outside Air = 4 persons X 15 CFM/person = 60 CFM, per ASHRAE STD 62

Exhaust Air (EA) Reqmts: Bathroom – 20 CFM continuous, per ASHRAE Fund C26, Table 3
Or Bathroom – 50 CFM intermittent, per ASHRAE Fund C26, Table 4
And Clothes Dryer – 150 CFM intermittent, per ASHRAE Fund C26.18

Ventilation Air Supply (VAS) = greater of Minimum Outside Air for occupants (60 CFM)
Or 115% of Exhaust Air (20 CFM X 115% = 23 CFM), per UFC 4-721-10, Chap. 6.4.5
Or 115% of Exhaust Air (50 CFM X 115% = 57.5 CFM), per UFC 4-721-10, Chap. 6.4.5

Choose VAS = 60 CFM and Continuous Bathroom Exhaust = 20 CFM

This leaves 40 CFM available for pressurization, to reduce infiltration, and to dissipate, during 23 hours per day of exfiltration, the moisture infiltrated when the clothes dryer operates for say 1 hour per day.

Calculate Space Latent Load and Sensible Load due to occupants; all other sensible loads to be taken by the space cooling and heating equipment:

Male seated typing 4 persons X 255 BTUHL = 1020 BTUHL
4 persons X 255 BTUHS = 1020 BTUHS

Latent Load (BTUHL) = 0.68 X CFM X Δ grHR; rearranging to Δ grHR = BTUHL/ 0.68 CFM

Therefore: Δ grHR = 1020 BTUHL / (0.68 X 60 CFM) = 25 grHR

VAS HR Conditions must be Space HR (67 gr) – (25 gr) = 42 grHR

Therefore: The VAS cooling coil leaving conditions are about 47.7 Fdb, 46.3 Fwb, 45.1 Fdpt, & 42 grHR.

To maintain the VAS 70% RH in ductwork requirement of the ITG, Encl. (1), 6.4.7.1.1, reheat is needed to obtain a VAS reheat coil leaving conditions of 54.6 Fdb, 70 %RH, 49.5Fwb, 45.1 Fdpt, & 42 grHR.

Sensible Load (BTUHS) = 1.08 X CFM X Δt Fdb; rearranging to Δt Fdb = BTUHS/1.08 X CFM

Therefore: Δt Fdb = 1020 BTUHS / (1.08 X 60 CFM) = 15.75 Fdb

Therefore: Space temperature without other sensible loads would be VAS reheat coil leaving conditions of 54.6 Fdb + 15.75 Fdb = 70.35 Fdb.

Adding in the estimated sensible load from the refrigerator of 375 BTUHS raises the room temperature as follows:

Δt Fdb = BTUHS/1.08 X CFM = 375 BTUHS / (1.08 X 60 CFM) = 5.75 Fdb

Therefore: Space temperature with the 4 persons and the refrigerator will be 70.35 Fdb + 5.75 Fdb = 76.1 Fdb.

All other sensible loads will be taken by the space HVAC equipment, such as the outside wall load, the interior corridor or mechanical chase load, the fenestration load, and the various internal loads, such as lights, cook-top, microwave, ceiling fan motor, washer/dryer, and personal items such a televisions, computers, etc.

Consider now only 2 persons in the apartment:

VAS still 60 CFM; Space Latent Load = 510 BTUHL, Space Sensible Load = 510 BTUHS

Δ grHR = BTUHL/ 0.68 CFM = 510 BTUHL / (0.68 X 60 CFM) = 12.5 grHR

Δt Fdb = BTUHS/1.08 X CFM = 510 BTUHS / (1.08 X 60 CFM) = 7.9 Fdb

VAS HR Conditions must be Space HR (67 gr) – (12.5 gr) = 54.5 grHR

Therefore: The VAS cooling coil leaving conditions are about 52.8 Fdb, 51.4 Fwb, 50.4 Fdpt, & 54.5 grHR.

To maintain the VAS 70% RH in ductwork requirement of the ITG, Encl. (1), 6.4.7.1.1, reheat is needed to obtain a VAS reheat coil leaving conditions of 62.4 Fdb, 70 %RH, 55.4 Fwb, 50.3 Fdpt, & 54.5 grHR.

Therefore: Space temperature without other sensible loads would be VAS reheat coil leaving conditions of 62.4 Fdb + 7.9 Fdb = 70.3 Fdb; with refrigerator heat added, it will be 70.3 Fdb + 5.75 Fdb = 76.1 Fdb.

Therefore, the VAS/Exhaust systems need to sense the building room average conditions, and reset the VAS cooling coil and VAS reheat coil-leaving conditions, based upon occupancy.

Consider a Relative Humidity or Dew point sensor sensing the building total bathroom EA airflow dew point, and averaging it over several hours, and controlling the VAS cooling coil control valve to open upon a rise in EA dew point, and to close upon a fall in EA dew point. By averaging over a long period of time, the influence of showers, and clothes washing are damped out, and the system responds to the long-term building occupancy driven latent load. This will maintain the VAS cooling coil-leaving dew point at the desired value to maintain the space conditions.

Consider a Thermostat sensing the building total bathroom EA temperature, and averaging it over several hours, and controlling the reheat coil control valve to close upon a rise in EA temperature, and to open upon a fall in EA temperature. By averaging over a long period of time, the influence of showers, and clothes washing are damped out, and the system responds to the long-term building occupancy driven sensible load. This will maintain the VAS reheat coil leaving temperature at the desired value to avoid overcooling the spaces under low load conditions.

This control scheme attempts to minimize the VAS cooling use of new energy while protecting the building and contents from mold. It also attempts to use the reheat to minimize new energy use in the space cooling equipment, while not over-cooling the spaces under low load.

Both the VAS and EA Systems must run continuously in order to protect the building from mold and mildew growth. Even if the building is to be vacated, these systems still need to run continuously. However, with no occupancy, it may be possible to slow down the VAS and EA system fan speeds, so as to deliver less airflow to the building, without losing control of the space dew point.

BUILDING AIR LEAKAGE:

From UFC 4-721-10, Design: Navy and Marine Corps Bachelor Housing, Chapter 4, Para. 4-3, the Gross Building Area per Apartment = 710 sq. ft. Assuming a minimum height of 9 feet from top of floor to top of floor, and a three-floor building, the volume of the building may be approximated by the following:

Bldg. Volume = Area x Height = 710 sq. ft. x 100 units x 9 ft. high = 639,000 cubic feet.

The design VAS (outside air) volume to be delivered is 60 cubic feet per minute (CFM) per unit. Therefore, the total VAS is as follows:

VAS vol. = 60 CFM x 100 units x 60 min. per hour = 360,000 cubic feet per hour (CFH)

The design Exhaust Air (EA) volume to be removed by the toilet exhaust is 20 CFM per unit. Therefore, the total EA is as follows:

EA vol. = 20 CFM x 100 units x 60 minutes per hour = 120,000 CFH

Therefore, the design air change rate, available to offset building air leakage, is the (VAS volume minus EA volume) divided by the building volume, as follows:

(VAS – EA) / Bldg. Vol. = (360,000 – 120,000) CFH / 639,000 cubic feet
= 0.38 Air Changes/ hour

Per the ASHRAE *Humidity Control Design Guide for Commercial and Institutional Buildings,* Chapter 16, Building Pressure Management, based upon a field investigation survey of 70 commercial buildings in the southern U. S., these buildings leaked an average of 0.4 AC/hr when the HVAC systems were OFF, and an average of 0.9 AC/hr when the HVAC systems were ON. It is easy to see that the available 0.38 AC/hr will not be enough to positively pressurize the building with properly dehumidified VAS, unless and until we construct a building envelope tighter than the average, and we construct the HVAC system ductwork tighter than average. Additionally, the 60 CFM per unit was based upon 4 persons per unit, not the normal 2 persons per unit, therefore, the design VAS volume is ample, and the design EA volume is as low as allowed by ASHRAE.

The only other means to keep the moisture that leads to mold and mildew out of the building is to increase the VAS CFM enough to offset the leakage. This requires larger, more expensive HVAC equipment, greater energy consumption, and greater maintenance costs, for the life of the building.

Investing in sealing the building enclosure, and sealing the HVAC system, will avoid these increased life cycle costs.

May 2002

Seismic Design for Mechanical Systems

The forces exerted by an earthquake on a structure, or, more specifically, the mechanical systems within a building can be in any direction. However, since every building, and mechanical system support, is designed to take care of the vertical, or gravity, loads, the main emphasis for seismic design is in the control of horizontal forces exerted during a seismic event. The vertical load component for equipment is its operating weight. For ducts and pipes, the vertical load component includes the weight of the duct or pipe and the contained fluid.

The design of structural seismic restraints for mechanical systems assumes the building is designed to respond safely during earthquake events. The restraints' primary function is to insure the mechanical systems do not break away, but move with the building during an earthquake.

Because the direction of forces during an earthquake are unpredictable, and can be in any direction, it is important to provide restraint in the X, Y, and Z directions; vertically, laterally (transverse), and longitudinally. Together, transverse and longitudinal bracing with vertical (gravity) supports will resist seismic loads in all directions. The bracing that will be referenced in this guidance will provide for the additional members required to resist the horizontal forces during an earthquake.

Code references in this guidance are based on the policy established by Planning and Design Policy Statement 95-02, which adopted the International Mechanical Code (IMC) as NAVFAC's sole mechanical code. The IMC is published by three entities in the United States including: the Building Officials and Code Administrators International, Inc. (BOCA), the International Conference of Building Officials (ICBO), and the Southern Building Code Congress International, Inc. (SBCCI). Use of these U.S. Codes for projects outside the continental U.S. is contingent upon the engineer to determine it to be more strict than what the local requires; standard procedure requires the engineer to apply the strictest of U.S. and local codes in foreign countries.

• Seismic Bracing for Pipe and Duct

All building codes, including BOCA, require most structures to be designed for a horizontal seismic force. The formulas to determine the horizontal seismic force are in the form of:

$$Fp = Cs * Wp$$

where:

where:	Fp	=	seismic force
	Cs	=	seismic coefficient
	Wp	=	weight of the ducts or pipes

Horizontal seismic forces may also is expressed as a percentage of the weight of the elements being braced. It is this percentage that correlates to a designation utilized by SMACNA called the "Seismic Hazard Level" (SHL) that will be addressed later and is fully explained in "Appendix A" of the <u>SMACNA Restraint Manual, Second Edition</u>. The codes have formulas for calculating the <u>percentage horizontal seismic force</u> based on the seismic zone, the importance factor, and the type construction.

The <u>percent horizontal seismic factor</u> is expressed as:

$$\%F = [Fp \div Wp] * 100$$

and: Cs = [Fp ÷ Wp]

= Cs * 100

More specifically, the formula in the IMC and used in the Building Officials and Code Administrators International, Inc. (BOCA), National Building Code, 1996, Chapter 16 to determine the seismic force is:

$$Fp = Av * Cc * P * Ac * Wc$$

where: Av = Figure 1610.1.3(1)
Cc = Figure 1610.6.4(1)
P = Figure 1610.6.4(1); requires determination of "SHEG"
SHEG = Seismic Hazard Exposure Group, Table 1610.1.5
Ac = Figure 1610.6.4(2)

Conveniently, the percent horizontal seismic factor is expressed as:

$$\%F = [Fp \div Wc] * 100$$

$$= [Av * Cc * P * Ac] * 100$$

The "Seismic Hazard Level", SHL, designation was developed specifically for the SMACNA Restraint Manual, Second Edition. It is a designation of "A", "B", or "C" that combines several building codes, seismic zones, and other factors into a single system for determining appropriate restraints. SHL's are established by prescribed limits of resistive force as a percentage of weight of the ducts and pipes and correlate to the percent horizontal seismic factors, (%F), determined by building code formulas. The prescribed limits for the SHL's are with "A" being the most stringent, and "C" the least:

- Most stringent; covers buildings most vulnerable due to the strength of seismic events. The bracing for SHL "A" is designed to resist 48% of the weight of the ducts or pipes. If %F is = 48, then use SHL "A". If %F is > 48, the SMACNA Restraint Manual, Second Edition, cannot be used.

- The bracing for SHL "B" is designed to resist 30% of the weight of the ducts or pipes. If %F is = 30, then use SHL "B".

- Least stringent; covers buildings least vulnerable due to the strength of seismic events. The bracing for SHL "C" is designed to resist 15% of the weight of the ducts or pipes. If %F is = 15, then use SHL "C".

Determination of the SHL for a specific project is fundamental, and indeed the first step in the use of the SMACNA Restraint Manual, Second Edition. The bracing detailed in the SMACNA Restraint Manual, Second Edition provides for the additional members needed to resist horizontal forces in pipe and duct systems. It does not cover seismic restraints for equipment. All in-line equipment must be braced independently of all the ducts or pipes and in conformance with all applicable building codes. Additionally, SMACNA does not consider forces due to thermal expansion; seismic bracing referenced here is not intended to handle forces imposed by thermal expansion.

<u>Steps in the Use of SMACNA Sizing Tables</u>:

Step 1. Determine the Seismic Hazard Level (SHL). *The determination of the SHL requires familiarity with the earthquake design portion of the building codes, and* ***<u>shall not</u>*** *be left up to a contactor to establish; the design engineer* ***<u>must</u>*** *specify the SHL in the contract documents.*

The SHL for each Seismic Hazard Exposure Group (see Table 1610.1.5, <u>National Building Code</u>, 1996, Chapter 16) within a specific geographic location in the LANTNAVFACENGCOM jurisdiction are presented in Table 1, entitled "SHL Factors".

Table 1

Seismic Hazard Level (SHL) Factors

Geographic Location	Seismic Hazard Exposure Group (SHEG) (Note 1)	Factors					Seismic Hazard Level (SHL)	
		Av	Cc		P	Ac		
			Duct & Non-Haz Pipe	Gas & Haz Pipe Boilers (Note 2)			Duct & Non-Hazardous Pipe	Gas & Hazardous Pipe
Tidewater Virginia	I	0.05	0.67	2.0	0.5	1.0	C	B
	II	0.05	0.67	2.0	1.0	1.0	C	B
	III	0.05	0.67	2.0	1.5	1.0	C	B
MCAS Cherry Point	I	0.10	0.67	2.0	0.5	1.0	C	B
MCB Camp Lejeune	II	0.10	0.67	2.0	1.0	1.0	C	B
MCAS New River	III	0.10	0.67	2.0	1.5	1.0	C	B
Sugar Grove, WVA	I	0.05	0.67	2.0	0.5	1.0	C	B
	II	0.05	0.67	2.0	1.0	1.0	C	B
	III	0.05	0.67	2.0	1.5	1.0	C	B
Puerto Rico	I	0.20	0.67	2.0	0.5	1.0	C	(Note 3)
	II	0.20	0.67	2.0	1.0	1.0	C	(Note 3)
	III	0.20	0.67	2.0	1.5	1.0	B	(Note 3)
Naples, Italy	I	0.15	0.67	2.0	0.5	1.0	C	A
	II	0.15	0.67	2.0	1.0	1.0	C	A
	III	0.15	0.67	2.0	1.5	1.0	B	A
Sigonella, Italy	I	0.40	0.67	2.0	0.5	1.0	C	(Note 3)
	II	0.40	0.67	2.0	1.0	1.0	B	(Note 3)
	III	0.40	0.67	2.0	1.5	1.0	A	(Note 3)
Aviano AFB, Italy	I	0.15	0.67	2.0	0.5	1.0	C	A
	II	0.15	0.67	2.0	1.0	1.0	C	A
	III	0.15	0.67	2.0	1.5	1.0	B	A
Iceland	I	0.40	0.67	2.0	0.5	1.0	C	(Note 3)
	II	0.40	0.67	2.0	1.0	1.0	B	(Note 3)
	III	0.40	0.67	2.0	1.5	1.0	A	(Note 3)

Notes:

(1) See Table 1610.1.5, the BOCA National Building Code f or Seismic Hazard Exposure Group classifications
(2) Includes boilers, furnaces, incinerators, water heaters, and other equipment utilizing combustible energy sources
(3) The horizontal seismic factor percentage exceeds 50%; SMACNA Restraint Manual, Second Edition, cannot be used.

Step 2. Check the structural system to determine the type structure from which ducts and pipes are supported. If SHL "A" has been specified, determine the connection level.

- When working in SHL "A", one of two con nection levels to the supporting structure must be selected.
    - Connection Level "2" is the most strict condition.
        - Must be used in the State of California within the jurisdiction of OSHPD (California hospitals) and the Office of the State Architect (OSA)(California schools).
        - Conservatively, use this connection level for any area of structural concrete.
    - Use of Connection Level "1" may be used if it is substantiated. May be used anywhere except when connecting into concrete within the jurisdiction of OSHOD (California hospitals) and the Office of the State Architect (OSA)(California schools).

Step 3. Find the detail in the SMACNA Restraint Manual, Second Edition (Chapter 4), which corresponds to the type duct or pipe restraint required. Notes in the detail will refer to the table where member sizes and connections can be found.

Step 4. Determine which chapter of the SMACNA Restraint Manual, Second Edition provides the table for the SHL for your specific project.

- For SHL "A", use Chapter 5.
- For SHL "B", use Chapter 6.
- For SHL "C", use Chapter 7.

Step 5. In the chapter determined by Step 4, find the table referred to in the detail from Chapter 4 of the SMACNA Restraint Manual, Second Edition by Step 3.

Step 6. In the first column, find the duct or pipe size. If the exact size is not liste d, use the next larger size. Ducts are assumed to be of SMACNA standard construction and pipes are assumed to be Schedule 40 water pipes. If pipes are insulated or of heavy construction, the weight of the duct or pipe must be determined and the "weight column" in the tables must be used to select the proper braces.

Step 7. Once the appropriate row in the table has been found, move to the right to read the size requirements for the hangers, braces and bolts.

Step 8. In the same row, under the column "Connection Type to Structural Member", find the connection type designated by a capital letter (A through H). For SHL "A", use the connection level determined in Step 2 to find the connection type.

Step 9. Find the connection type in the first column in Table 8-1 in Chapter 8 of the SMACNA Restraint Manual, Second Edition. Move to the right in the same row to find sizes for the expansion anchors, bolts, spreader sizes, and angle connectors for connecting to the supporting structure.

Step 10. Find a detail in Chapter 8 of the SMACNA Restraint Manual, Second Edition that corresponds to your connection type and to your type of supporting structural system. Install transverse and longitudinal seismic braces at the intervals specified in the general requirements for ducts in Chapter 3 or the tables for pipes in Chapters 5, 6, or 7 of the SMACNA Restraint Manual.

• Seismic Bracing for HVAC Equipment

As with the design of seismic bracing of pipe and duct, the initial step to design restraints for HVAC equipment is to consult the appropriate code. Here, the same code references apply, specifically, Chapter 16 of the Building Officials and Code Administrators International, Inc. (BOCA), National Building Code, 1996.

The BOCA Code provides a seismic force formula to determine the horizontal seismic static force acting at the center of gravity of HVAC equipment. That formula takes the form of:

$$Fp = Av * Cc * P * Ac * Wc$$

where:	Av	=	Figure 1610.1.3(1)
	Cc	=	Figure 1610.6.4(1)
	P	=	Figure 1610.6.4(1); requires determination of "SHEG"
	SHEG	=	Seismic Hazard Exposure Group, Table 1610.1.5
	Ac	=	Figure 1610.6.4(2)

Once the seismic force (Fp) is determined, the seismic loads at the connection between the equipment and the building must be resolved. Static load calculations will be required and examples showing how to compute the loads may be found in the ASHRAE Handbook, HVAC Applications and the ASHRAE, A Practical Guide to Seismic Restraint.

Seismic restraint of HVAC equipment will depend on how the equipment is isolated and whether it is supported on the floor, or from the wall, or overhead.

• Seismic Design Requirements

- **General Requirements:**

  Use either cable or solid bracing for all situations. Do not mix bracing types.

  All runs must have a minimum of two transverse braces and on longitudinal brace. A run is defined as a length of duct or pipe without any change in direction except as allowed by offsets (see Chapter 4 of the SMACNA Restraint Manual, Second Edition).

- **Duct Bracing:**

  Brace all ducts with a cross-sectional area of 0.56 sm (6 ft²), or greater; Rectangular ductwork less than 0.56 sm (6 ft²) in cross-section does not require seismic restraint.

  Round duct less than 710 mm (28") diameter does not require seismic restraint.

  Brace flat oval ducts in the same manner as rectangular ducts.

  No bracing is required if the duct is suspended by hangers 305 mm (12"), or less, in length, as measured from the top of the duct to the bottom of the support where the hanger is attached.

  Hangers must be attached to the duct within 50 mm (2") of the top of the duct with a minimum of two M5 x 0.8 (#10) sheet metal screws.

  Transverse bracing must occur at intervals specified in tables in Chapters 5, 6, and 7, of the SMACNA Restraint Manual, Second Edition or at both ends if the duct run is less than the specified interval. Transverse bracing will be installed at each duct turn and at each end of the duct run, with a minimum of one brace at each end.

  Longitudinal bracing must occur at the interval specified in tables in Chapters 5, 6, and 7 of the SMACNA Restraint Manual, Second Edition, with at least one brace per duct run. Transverse bracing for one duct section may also act as a longitudinal brace for a duct section at 90º turns if the bracing is installed within two times the duct width of the intersection of both ducts and the bracing is sized for the larger duct (see Figure 4-1, Chapter 4 of the SMACNA Restraint Manual, Second Edition).

  A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.

  Example: To brace a 760 mm x 760 mm (30"x30") duct adjacent to a 1370 mm x 710 mm (54"x28") duct, select bracing for an 2134 mm x 1067mm (84"x42") duct. The horizontal dimension of the 2134 mm x 1067 mm (84"x42") duct is equal to that of the combined ducts and its weight is greater than their combined weights.

  Walls, including gypsum board non-load bearing partitions that have ducts running through them, may replace a typical transverse brace. Provide solid blocking around duct penetrations at all stud wall construction.

  Unbraced ducts must be installed with a 150 mm (6") minimum clearance to vertical ceiling hanger wires.

- **Pipe Bracing:**

  Brace all fuel oil, natural gas, medical gas, and compressed air piping in accordance with local codes.

  Brace all piping located in boiler, mechanical equipment, and refrigeration mechanical rooms that is 32 mm (1¼") nominal diameter and greater.

  Brace all pipes 65 mm (2½") nominal diameter and greater.

Piping suspended by individual hangers 305 mm (12"), or less, in length (as measured from the top of the pipe to the bottom of the support where the hanger is attached) need not be braced. For pipes on a trapeze, the 305 mm (12") exception is measured from the upper face of the horizontal structure member (or the bottom of the pipe).

Transverse bracing must be at 12-meter (40 ft) minimum intervals, except where a lesser spacing is indicated in the tables for pipe bracing.

Longitudinal bracing must be at 24-meter (80 ft) minimum intervals, except where a lesser spacing is indicated in the tables.

For gas piping, the bracing details, schedules, and notes may be used, except that transverse and longitudinal bracing will be at one-half the spacing shown in the tables in Chapter 5 of the SMACNA Restraint Manual, Second Edition. Provide seismic automatic shut-off valves where required by NAVFAC Specifications 15195N, Natural Gas Piping, and 02556a, Gas Distribution Systems.

Transverse bracing for one pipe section may also act as the longitudinal brace for a pipe section of the same size at a 90º turn if the bracing is installed within 610 mm (24") of the elbow as long as the brace is sized as a longitudinal brace (see Figure 4-1 of the SMACNA Restraint Manual, Second Edition).

Provide joints capable of accommodating seismic movements where pipes pass through building seismic or expansion joints or where rigidly supported pipes connect to equipment with vibration isolators. The joints must allow movement in all directions.

Branch lines may not be used to brace main lines.

Cast iron pipe of all types, glass pipe, and any other pipe joined with a shield and clamp assembly, where the top of the pipe is 610 mm (24"), or more, from the supported structure, must be braced on each side of the change in direction of 90º or more. Riser joints must be braced or stabilized between floors.

Vertical risers not specifically engineered must be laterally supported with a riser clamp at each floor. For buildings greater than six floors, all risers must be engineered individually. For risers in hubless piping systems where the riser joints are unsupported between floors, see Figure 9-10 of the SMACNA Restraint Manual, Second Edition for brace.

- **HVAC Equipment Bracing:**

  Mechanical equipment less than 181 kg (400 lbs) does not require seismic restraint.

  - **Seismic Restraint of Equipment without Vibration Isolators:**

    Seismic restraint of floor-mounted equipment without vibration isolation is most straightforward and easiest to address. Such equipment, like tube heat exchangers and storage tanks, without moving parts are simply bolted to the floor. Equipment, such as exhaust fans and small pumps, mounted in non-vibration sensitive locations may also be simply bolted to the floor or slab. The calculated seismic force determines the specific means of anchorage. The engineered anchorage must address the type and size of the anchor bolts, with particular attention given to the clearance around the bolt. Excessive clearances between bolts and equipment may lead to anchor failure due to shear during earthquakes. Neoprene grommets or epoxy fillers should be used fill the clearances. Anchorage to steel, wood and concrete requires additional considerations:

- Anchorage to steel: Consult the "American Institute of Steel Construction Manual" for the actual strength of the anchor bolts.

- Anchorage to wood: The strength of an anchor to wood depends on the type and grade of wood as well as the embedment. Generally, a 15 mm (1/2") to 20 mm (3/4") diameter lag bolt with a depth of 50 mm (2") to 75 mm (3") provides adequate anchorage.

- Anchorage to concrete: Set-in-concrete anchor bolts are not practical. Use post drill anchors where practical. ASHRAE, A Practical Guide to Seismic Restraint provides specific information on their use. Anchorage for large equipment (>11 metric tons) in high seismic zones may make the use of numerous post drill anchors impractical. Other solutions may include the connection of embedment plates to structural elements of a reinforced slab.

Bracing of non-vibration isolated, suspended equipment such as small in-line pumps, fan coils, mixing boxes, water source heat pumps and the like, involves nothing more than to keep the equipment from swaying into adjacent equipment, pipes, ducts or structure. Anti-sway bracing may be accomplished by use of slack cables or steel struts. ASHRAE recommends use of prestretched aircraft quality cable. Additional information can be found in ASHRAE, A Practical Guide to Seismic Restraint.

- **Seismic Restraint of Equipment with Vibration Isolators:**

Seismic restraint for equipment mounted on vibration isolators is more complex since the isolators tend to amplify seismic forces. Amplification occurs because vibration isolators usually have the same natural resonant frequency as an earthquake energy peak. To quell the amplified movement of equipment on vibration isolators, snubbing devices or sway braces are employed. Considerations on the use of snubbers and sway braces include:

- Clearances around snubbers should be about 6 mm (1/4"). Larger gaps will permit high inertia forces that will increase load on equipment. Smaller gaps could hinder the effectiveness of vibration isolators.

- Chillers and boilers, etc. can be directly mounted on seismic snubbers with built-in vibration isolators.

- Floor mounted, lightweight equipment not having adequate stiffness may require supplemental structural bases to prevent buckling at snubbers. Most airside equipment falls in this category.

- Floor mounted pumps may require concrete bases to control distortion to bearings, couplings and seals when point mounted on vibration isolators.

- For adequate stiffness, concrete base thickness should be 1/12th of the maximum span between isolators, but no less than 150 mm (6"). The depth of structural members in steel bases should be 1/10th of the maximum span between isolators, but no less than 100 mm (4").

- Many manufacturers employ internal isolators in their equipment. Because the unit casings are commonly lightweight sheet metal, they are not structurally adequate to incorporate snubbing devices, or there is not adequate clearance within the case to prevent contact between components. ASHRAE recommends cautious use of internal seismic mountings and snubbers and only with written guarantees from the equipment manufacturer or from an independent certified test.

- Use snubber devices on wall-mounted equipment such as propeller fans, some air handling units and exhaust fans, if equipped with vibration isolators.

- Sway bracing consisting of slack cable is required for suspended HVAC equipment to prevent the pendulum effect; a rigid sway brace of channel or angle steel would cause transfer of vibration to the structure.

  Sway bracing cable may be attached to the top of bottom of the unit and at least for cables per unit will be required for proper seismic restraint.

  When employing the sway bracing cable system, particular attention must be paid to the cable connection to the building structure. Consult ASHRAE, A Practical Guide to Seismic Restraint for specific guidance.

- **Drawing Requirements**

Seismic restraint detailing for mechanical and plumbing systems, complete and appropriate for the project location and seismic hazard exposure group, shall be provided on the contract drawings. It shall be incumbent upon the A& E to determine the Seismic Hazard Level (SHL) factor and to clearly indicate the determination on the mechanical and plumbing contract drawings.

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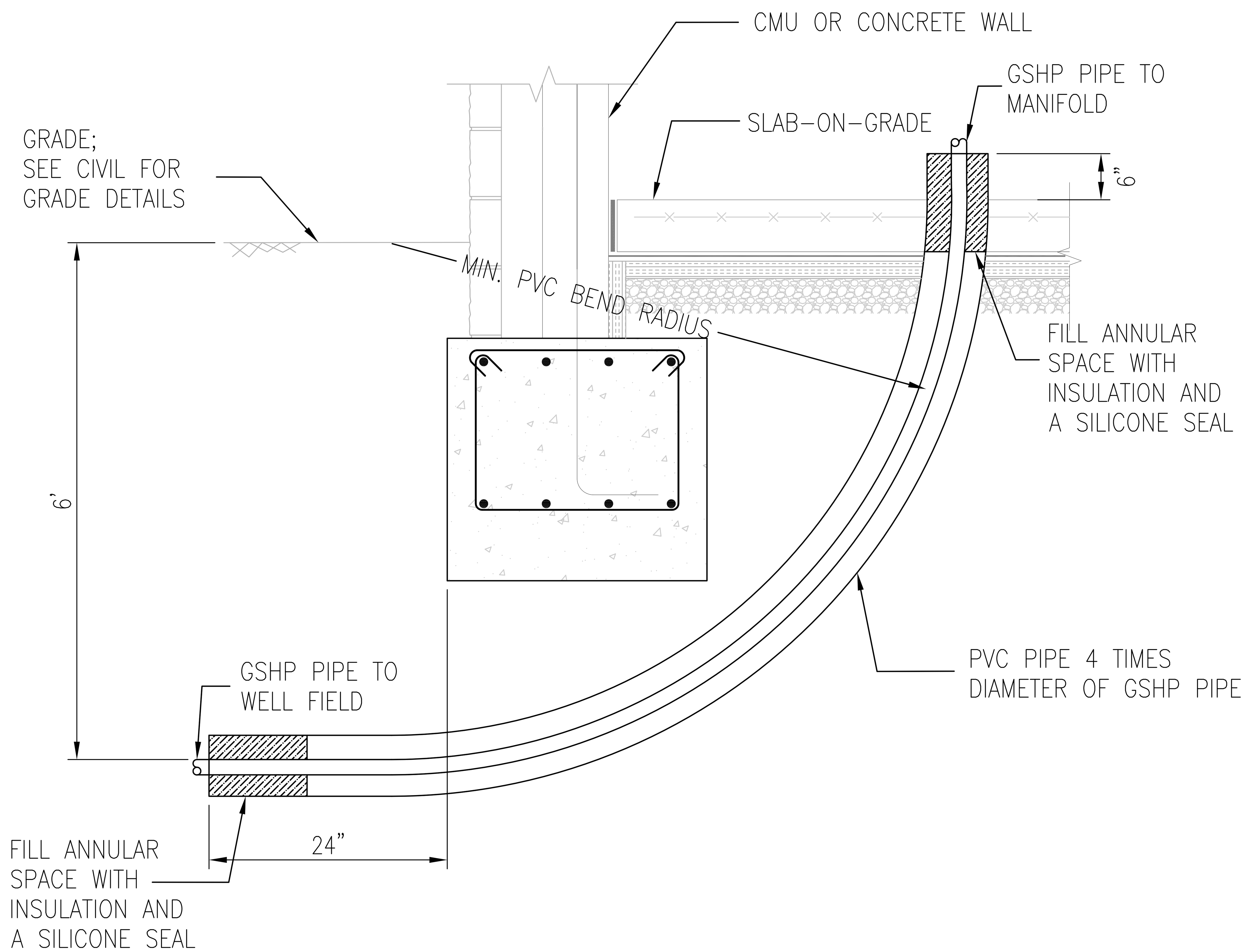
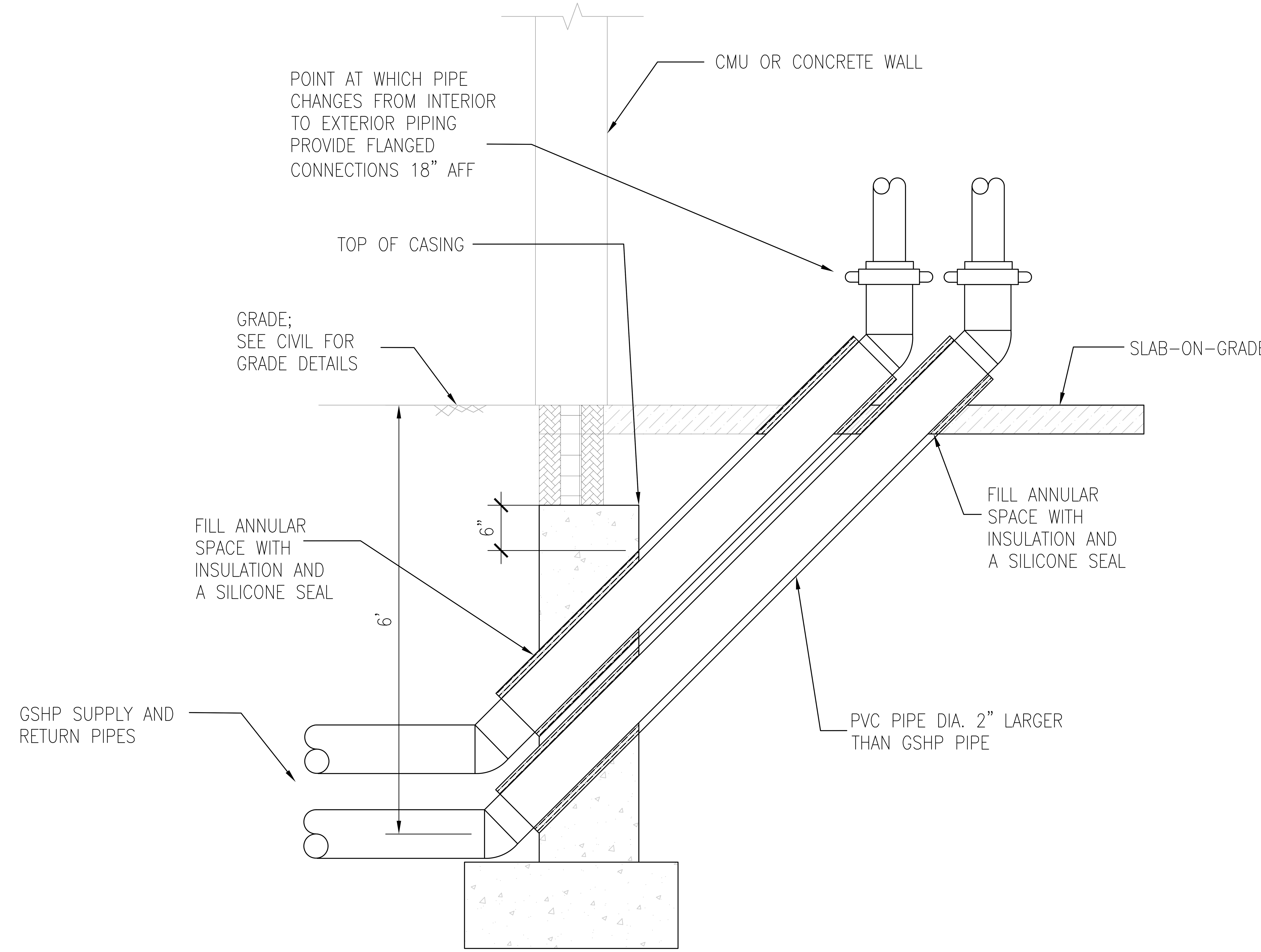


NOTE: ONLY FOR GSHP PIPES 2" OR SMALLER



NOTE: ONLY FOR GSHP PIPES LARGER THAN 2"

GEOEXCHANGER PIPE CASING THRU SLAB

NOT TO SCALE

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SECTION 22 14 00.00 22

RAINWATER HARVESTING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22/CSA 4.4	(1999; Addenda A 2000, Addenda B 2001; R 2004) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

AMERICAN SOCIETY OF SANITARY ENGINEERING (ASSE)

ASSE 1001	(2008) Performance Requirements for Atmospheric Type Vacuum Breakers (ANSI approved 2009)
ASSE 1003	(2009) Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems - (ANSI approved 2010)
ASSE 1011	(2004; Errata 2004) Performance Requirements for Hose Connection Vacuum Breakers (ANSI approved 2004)
ASSE 1012	(2009) Performance Requirements for Backflow Preventer with an Intermediate Atmospheric Vent - (ANSI approved 2009)
ASSE 1013	(2011) Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Principle Backflow Preventers - (ANSI approved 2010)
ASSE 1020	(2004; Errata 2004; Errata 2004) Performance Requirements for Pressure Vacuum Breaker Assembly (ANSI Approved 2004)

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA 10084	(2005) Standard Methods for the Examination of Water and Wastewater
AWWA B300	(2010; Addenda 2011) Hypochlorites
AWWA B301	(2010) Liquid Chlorine
AWWA C651	(2005; Errata 2005) Standard for Disinfecting Water Mains
AWWA C652	(2011) Disinfection of Water-Storage Facilities
AWWA C700	(2009) Standard for Cold Water Meters - Displacement Type, Bronze Main Case
AWWA C701	(2012) Standard for Cold-Water Meters - Turbine Type for Customer Service

ASME INTERNATIONAL (ASME)

ASME A112.1.2	(2012) Standard for Air Gaps in Plumbing Systems (For Plumbing Fixtures and Water-Connected Receptors)
ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC	(2010) Boiler and Pressure Vessels Code

ASTM INTERNATIONAL (ASTM)

ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B370	(2012) Standard Specification for Copper Sheet and Strip for Building Construction
ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D2822/D2822M	(2005; E 2011; R 2011) Asphalt Roof Cement
ASTM E1	(2013) Standard Specification for ASTM Liquid-in-Glass Thermometers
ASTM E2129	(2010) Standard Practice for Data Collection for Sustainability Assessment of Building Products

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR Manual	(10th Edition) Manual of Cross-Connection Control

INTERNATIONAL CODE COUNCIL (ICC)

ICC IPC	(2012) International Plumbing Code

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2008) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA MG 1	(2011; Errata 2012) Motors and Generators
NEMA MG 11	(1977; R 2012) Energy Management Guide for Selection and Use of Single Phase Motors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

NSF INTERNATIONAL (NSF)

NSF/ANSI 61	(2013) Drinking Water System Components - Health Effects

PLASTIC PIPE AND FITTINGS ASSOCIATION (PPFA)

PPFA Fire Man	(2010) Firestopping: Plastic Pipe in Fire Resistive Construction

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J1508	(2009) Hose Clamp Specifications

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED	(2002; R 2005) Leadership in Energy and Environmental Design(tm) Green Building Rating System for New Construction (LEED-NC)

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

40 CFR 50.12	National Primary and Secondary Ambient Air Quality Standards for Lead
PL 109-58	Energy Policy Act of 2005 (EPAct05)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

[SD-02 Shop Drawings

Rainwater harvesting System; G

Detail drawings consisting of schedules, performance charts, instructions, diagrams, and other information to illustrate the requirements and operations of systems that are not covered by the Plumbing Code. Detail drawings for the complete rainwater harvesting system including piping layouts and locations of connections; dimensions for roughing-in, foundation, and support points; schematic diagrams and wiring diagrams or connection and interconnection diagrams. Detail drawings shall indicate clearances required for maintenance and operation. Where piping and equipment are to be supported other than as indicated, details shall include loadings and proposed support methods. Mechanical drawing plans, elevations, views, and details, shall be drawn to scale.]

[Modular Storage Tank; G

Detail drawings showing the size, configuration, and other information to illustrate the requirements and assembly of the storage tank modules and all required accessories. Provide storage tank drawing plans, elevations, views, and details drawn to scale.]

[Fiberglass Reinforced Plastic Storage Tank; G

Detail drawings showing the size, configuration, and other information to illustrate the requirements and assembly of the storage tank modules and all required accessories. Provide storage tank drawing plans, elevations, views, and details drawn to scale.]

SD-03 Product Data

[Local/Regional Materials

Documentation indicating distance between manufacturing facility and the project site. Indicate distance of raw material origin from the project site. Indicate relative dollar value of local/regional materials to total dollar value of products included in project.]

[Environmental Data]

Materials

Documentation indicating percentage of post-industrial and post-consumer recycled content per unit of product. Indicate relative dollar value of recycled content products to total dollar value of products included in project.

Fixtures; (LEED)

List of installed fixtures with manufacturer, model, and flow rate.

Rainwater Control System[; G]

[Modular Storage Tank; G]

[Fiberglass Reinforced Plastic Storage Tank; G]

Submersible Feed Pump[; G]

Debris Filter[; G]

Initial Runoff Filter[; G]

Rainwater Sediment Filters[; G]

Rainwater Ultraviolet Purification System[; G]

[Dye Injection System[; G]]

[Chlorine Injection System[; G]]

[Unpressurized Holding Tank[; G]]

[Booster Pump[; G]]

[Packaged Pump System[; G]]

Hydropneumatic Tank[; G]

Backflow prevention assemblies; G

Domestic Water Service Meters[; G]

Vibration-Absorbing Features[; G]

Details of vibration-absorbing features, including arrangement, foundation plan, dimensions and specifications.

Rainwater Harvesting System; G

Diagrams, wiring diagrams for power, signal, and control wiring, dimensioned outline drawings of equipment and system, instructions, and other sheets proposed for posting. Manufacturer's recommendations for the installation of the rainwater harvesting system including piping, tanks, pumps, and controls.

SD-06 Test Reports

Tests, Flushing and Disinfection

Test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, completion and testing of the installed system. Each test report shall indicate the final position of controls.

Test of Backflow Prevention Assemblies; G.

Certification of proper operation shall be as accomplished in accordance with state regulations by an individual certified by the state to perform such tests. If no state requirement exists, the Contractor shall have the manufacturer's representative test the device, to ensure the unit is properly installed and performing as intended. The Contractor shall provide written documentation of the tests performed and signed by the individual performing the tests.

SD-07 Certificates

Materials and Equipment

Where equipment is specified to conform to requirements of the ASME Boiler and Pressure Vessel Code, the design, fabrication, and installation shall conform to the code.

SD-10 Operation and Maintenance Data

Rainwater Harvesting System; G

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and 01 78 24.05 20 FACILITY OPERATION AND MAINTENANCE SUPPORT INFORMATION.

1.3 STANDARD PRODUCTS

Specified materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacture of such products. Specified equipment shall essentially duplicate equipment that has performed satisfactorily at least two years prior to bid opening. Standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year use shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2 year period. Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS applies to this section, with additions and modifications specified herein.

1.3.1 Alternative Qualifications

Products having less than a two-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturer's factory or laboratory tests, can be shown.

1.3.2 Service Support

The equipment items shall be supported by service organizations. Submit a certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. These service organizations shall be reasonably convenient to the equipment installation and able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3.3 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

1.3.4 Modification of References

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction", or words of similar meaning, to mean the Contracting Officer.

1.3.4.1 Definitions

For the International Code Council (ICC) Codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall." Reference to the "code official" shall be interpreted to mean the "Contracting Officer." For Navy owned property, references to the "owner" shall be interpreted to mean the "Contracting Officer." For leased facilities, references to the "owner" shall be interpreted to mean the "lessor." References to the "permit holder" shall be interpreted to mean the "Contractor."

1.3.4.2 Administrative Interpretations

For ICC Codes referenced in the contract documents, the provisions of Chapter 1, "Administrator," do not apply. These administrative requirements are covered by the applicable Federal Acquisition Regulations (FAR) included in this contract and by the authority granted to the Officer in Charge of Construction to administer the construction of this project. References in the ICC Codes to sections of Chapter 1, shall be applied appropriately by the Contracting Officer as authorized by his administrative cognizance and the FAR.

1.4 DELIVERY, STORAGE, AND HANDLING

Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.5 REGULATORY REQUIREMENTS

Unless otherwise required herein, all work shall be in accordance with ICC IPC. Energy consuming products and systems shall be in accordance with PL 109-58 and ASHRAE 90.1 - IP. In addition, energy consuming equipment shall have the Energy Star label.

1.6 PROJECT/SITE CONDITIONS

The Contractor shall become familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.7 INSTRUCTION TO GOVERNMENT PERSONNEL

When specified in other sections, furnish the services of competent instructors to give full instruction to the designated Government personnel in the adjustment, operation, and maintenance, including pertinent safety requirements, of the specified equipment or system. Instructors shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work.

Instruction shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. The number of man-days (8 hours per day) of instruction furnished shall be as specified in the individual section. When more than 4 man-days of instruction are specified, use approximately half of the time for classroom instruction. Use other time for instruction with the equipment or system.

When significant changes or modifications in the equipment or system are made under the terms of the contract, provide additional instruction to acquaint the operating personnel with the changes or modifications.

1.8 ACCESSIBILITY OF EQUIPMENT

Install all work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install concealed valves, expansion joints, controls, dampers, and equipment requiring access, in locations freely accessible through access doors.

1.9 SUSTAINABLE DESIGN REQUIREMENTS

1.9.1 Local/Regional Materials

Use materials or products extracted, harvested, or recovered, as well as manufactured, within a [500][_____] mile radius from the project site, if available from a minimum of three sources.

1.9.2 Environmental Data

[Submit Table 1 of ASTM E2129 for the following products: [_____].]

1.9.3 Rainwater Harvesting System

Provide a sustainable design technique of rainwater harvesting. To achieve Low Impact Development (LID) and LEED credit(s), provide a complete rainwater harvesting and management system complete ready for use. The system shall be complete and shall serve plumbing fixtures within the facility in accordance with LEED guidance. The system shall collect, treat, store, and distribute rainwater as "non-potable water" in sufficient capacity to achieve the corresponding water efficiency reduction for LEED credit(s). The system shall be provided in accordance with the most stringent requirements from the applicable government criteria, including the requirements/recommendations of the following:

o EPA Manual "EPA/625/R-04/108 September 2004, Guidelines for Water Reuse" Web link is http://www.epa.gov/nrmrl/pubs/625r04108/625r04108.pdf

o NCDENR Technical Guidance Stormwater Treatment Credit for Rainwater Harvesting Systems, web link is http://h2o.enr.state.nc.us/su/documents/RainwaterHarvesting_Approved.pdf

o The Texas Manual on Rainwater Harvesting, latest edition, web link is www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf

North Carolina Rules Regarding Water Reuse, See North Carolina ADMINISTRATIVE CODE Effective April 1, 2001. Pages 31 - 36 of 44. See also ENR-ENVIRONMENTAL MANAGEMENT COMMISSION T15A: 02H .0200.

All of the water closets, urinals[,_____], and hose bibbs shall be served by non-potable water. To distinguish non-potable water from potable water, the non-potable water shall be [dyed with a purple color (Pantone 522) and]embossed or integrally stamped or painted "CAUTION: RECLAIMED WATER - DO NOT DRINK". Provide this notice at all hose bibbs connected to the rainwater harvesting system. The non-potable water piping system shall have its own particular identification color and pipe ID code/name. The identification color shall be in accordance with local codes. The non-potable water system shall have a potable water back-up for supplement during dry spells. Provide potable water back-up via air gap or reduced pressure back-flow preventer and a pressure reducing station with level controls in accordance with the plumbing codes, NC building code, NCDENR requirements, North Carolina Administrative Code, and EPA requirements.[Provide drainage of cooled condensate to rainwater collection system.]

PART 2 PRODUCTS

2.1 MATERIALS

The requirements for pressure piping and fittings are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Material or equipment containing lead shall not be used in the rainwater harvesting system. Rainwater collection piping located outside the building shall be as specified in Section 33 40 00 STORM DRAINAGE UTILITIES.

2.1.1 Miscellaneous Materials

Miscellaneous materials shall conform to the following:

a. Copper, Sheet and Strip for Building Construction: ASTM B370.

b. Asphalt Roof Cement: ASTM D2822/D2822M.

c. Hose Clamps: SAE J1508.

d. Hypochlorites: AWWA B300.

e. Liquid Chlorine: AWWA B301.

f. Gauges - Pressure and Vacuum Indicating Dial Type - Elastic Element: ASME B40.100.

g. Thermometers: ASTM E1. Mercury shall not be used in thermometers.

2.1.2 Pipe Insulation Material

Insulation shall be as specified in Section [23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS][23 07 00.00 22 MECHANICAL INSULATION].

2.2 PIPE HANGERS, INSERTS, AND SUPPORTS

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69.

2.3 VALVES

Valves shall be provided on supplies to equipment. Except as specified herein, valves are specified in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Pressure ratings shall be based upon the application. Valves shall conform to the following standards:

Description	Standard
Ball Valves Threaded, Socket-Welding, Solder Joint Ends	MSS SP-110
Bronze Gate, Globe, Angle, and Check Valves	MSS SP-80
Vacuum Relief Valves	ANSI Z21.22/CSA 4.4
Water Pressure Reducing Valves	ASSE 1003

2.4 BACKFLOW PREVENTERS

Backflow preventers shall be approved and listed by the Foundation For Cross-Connection Control & Hydraulic Research. Provide reduced pressure principle type assembly backflow preventers on each in-coming potable service water line to the rain water harvesting system. In addition, provide backflow preventers in accordance to the North Carolina Building Code and the Water Supply permit. All backflow preventers shall be accessible. Reduced pressure principle assemblies, double check valve assemblies, atmospheric (nonpressure) type vacuum breakers, and pressure type vacuum breakers shall be tested, approved, and listed in accordance with FCCCHR Manual. Backflow preventers with intermediate atmospheric vent shall conform to ASSE 1012. Reduced pressure principle backflow preventers shall conform to ASSE 1013. Hose connection vacuum breakers shall conform to ASSE 1011. Pipe applied atmospheric type vacuum breakers shall conform to ASSE 1001. Pressure vacuum breaker assembly shall conform to ASSE 1020. Air gaps in plumbing systems shall conform to ASME A112.1.2.

2.5 RAINWATER HARVESTING SYSTEM

Provide the rainwater harvesting system complete with all components necessary to provide a complete system to collect, store, and process rainwater for use in situ; including water treatment as appropriate to intended service. System shall include the following items:

2.5.1 Rainwater Control System

Provide a rainwater control system capable of monitoring and controlling the entire rainwater harvesting system. The system shall be able to monitor the water level in the cistern storage tank, the status of the filters, and the purification system. The system shall control the cistern pump and the bypass connection to the potable water supply to ensure a continuous water supply to the building fixtures connected to the system.

2.5.2 Modular Storage Tank

Storage tank shall be composed of interlocking modular sections arranged in the configuration shown on the civil drawings. The modules shall be assembled from injection molded plastic top, bottom, and side panels of the manufacturers standard size. The top and bottom panels shall be connected by either extruded rigid PVC columns or internal baffles. The tank structure shall be capable of withstanding HS-20 surface loads as defined by AASHTO. Provide inspection ports, inlets, outlet, and overflow connections as shown on the Plumbing and Civil drawings. Tank shall be vented to atmospheric pressure.

2.5.3 Fiberglass Reinforced Plastic Storage Tank

Storage tank shall be fiber glass reinforced plastic (FRP) Underground Storage tank. Provide a polyester resin chemical rated coating on the tank (interior and exterior). Tanks shall be capable of handling internal pressure loads of 5 psig pressure with a 5:1 safety ratio. The tank size shall be as indicated on the Plumbing and Civil drawings. Tank shall be leaked test in the factory at 5 psig. The tank shall be capable of withstanding a vacuum test to 11.5 inches of mercury. The tank shall be capable of withstanding surface loads from H-20 axle loads. The tank shall be capable of handling external hydrostatic pressure loads from being buried in the ground up to seven feet overburden with a safety factor of 5:1 against general buckling. Tank shall be designed, rated, and ASME BPVC code stamped. The tank and all components, and accessories shall be manufactured with materials conforming to the requirements of NSF standard 61

Provide the tank with a vent to the atmosphere. The tank shall be manufactured with 100% resin and glass fiber reinforcement. Provide FRP anchor straps. Provide as recommended and specified by the tank manufacturer all the required types and number of anchors, strap locations, strap sizes, and number of straps.

With the tank provide the following FRP accessories with all necessary supports: Internal pump platforms, drop and fill downcomer tubes, submersible pumps[and ladders], flanged manways[(minimum of two)], Manway extensions, and covers.

2.5.4 Submersible Feed Pump

Provide a submersible pump for the rainwater storage tank. The pump shall be capable of providing the flow quantities at the conditions indicated on the drawings. Pump motor shall be the high efficiency type. The pump shall be rated for potable water and shall have the required certifications and shall be NSF listed for the service intended. All components of the sump pump that come in contact with liquid shall be constructed of non-ferrous or stainless steel materials. Provide the pump with a floating type extractor with screen and a float type level control to shut down the pump when tank level is below safe level for pump operation.

2.5.5 Debris Filter

Provide a self cleaning type debris filter to remove trash before rainwater is delivered to the storage tank. The filter is to be provided as a self contained unit with inlet, outlet, and overflow pipe connections, and removable stainless steel 0.35 mm mesh[basket] strainer. Provide an adjustable dome shaft with pedestrian load rated cover. Provide the cover with a child proof closure.

2.5.6 Initial Runoff Filter (Water Diverter)

Provide an initial runoff filter (water diverter) to remove water borne contaminants. The filter shall consist of a horizontal underground chamber sized as indicated on the Plumbing drawings, to hold the initial water runoff from the roof. Provide a floating ball at the filter inlet to divert water to the storage tank once the chamber of the initial runoff filter is full. At the outlet end of the filter provide an adjustable orifice that slowly allows the water in the chamber to drain out over time. The orifice shall be removable for servicing.

2.5.7 Rainwater Sediment Filters

Provide 50 and 10 micron sediment filters, and a 10 micron carbon filter sized for the service intended and located as shown on the drawings. The filters shall have removable filter housings with replaceable cartridge type filters and shall be NSF listed for the service intended.

2.5.8 Rainwater Ultraviolet Purification System

Provide a ultraviolet water purifier sized for the service intended and located as shown on the drawings. The unit shall be NSF listed for the service intended.

[2.5.9 Dye Injection System

Add description here.

][2.5.10 Chlorine Injection System

Add description here.

][2.5.11 Unpressurized Holding Tank

Provide a free standing [____] gallon water storage tank. Tank shall be commercial grade constructed of FDA approved Polyethylene that is UV stabilized for long term service and for potable water storage. Tank walls shall be translucent for level viewing and equipped with gallon indicators. Provide tank with a minumum 16 inch vented lid/access manway, connections for inlet, outlet, drain and overflow piping, and provisions for low and high water float switches..

][2.5.12 Booster Pump

Pumps shall be electrically driven, single-stage, centrifugal, with mechanical seals, suitable for the intended service. Pump and motor shall be[integrally mounted on a cast-iron or steel subbase,][close-coupled with an overhung impeller,][and][supported by the piping on which it is installed]. The shaft shall be one-piece, heat-treated, corrosion-resisting steel with impeller and smooth-surfaced housing of bronze. All components of the pump that come in contact with liquid shall be constructed of non-ferrous or stainless steel materials. The pump shall be UL listed, rated for potable water, shall have the required certifications, and shall be NSF listed for the service intended and meet the requirements of NSF/ANSI 61. The pumps shall be selected for maximum energy efficiency.

Motor shall be high efficiency type and totally enclosed, fan-cooled and shall have sufficient horsepower for the service required. Each pump motor shall be equipped with an across-the-line magnetic controller in a NEMA 250, Type 1 enclosure with "START-STOP" switch in cover.

Integral size motors shall be premium efficiency type in accordance with NEMA MG 1. Pump motors smaller than 1 hp Fractional horsepower pump motors shall have integral thermal overload protection in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Guards shall shield exposed moving parts.

][2.5.13 Packaged Pump System

The package pump system for the rainwater harvesting shall be a dual vertical multistage pump system with variable frequency drives (VFD), electronic controller to maintain a constant discharge pressure, pump control valves, and pressure reducing valves. All components of the pump that come in contact with liquid shall be constructed of non-ferrous or stainless steel materials. The pumps shall be selected for maximum energy efficiency. The electronic controller shall be a programmable controller with keypad and LCD display. Programmable functions shall include but not limited to: Pump status, Standby designation, elapsed running hours, system pressure set point, actual system pressure, VFD pump speed percent, VFD pump min and max speed, system faults, pump priority, pump rotation order, friction loss compensation, high and low discharge pressure shut down limits and alarms, low suction pressure shut-down limit and alarm, clock program, DDC control input and output for connection into the DDC system. Pump package shall be UL listed. Components shall be certified with manufacturer certified ratings. All electrical components, devices, and accessories of the pump package shall be listed and labeled as given in NFPA 70. Pump motors shall be high efficiency type and totally enclosed fan cooled. The pump shall be rated for potable water and shall have the required certifications and and shall be NSF listed for the service intended.

]2.5.14 Hydropneumatic Tank

Provide Tank specifically designed for use on potable water systems with size and acceptance volume shall be as indicated on the drawings. Construct of steel for minimum working pressure of125 psig. Tank shall have polypropylene or butyl lined diaphragm which keeps the air charge separated from the water. Provide ASME code stamped tank in accordance with ASME BPVC.

2.6 DOMESTIC WATER SERVICE METERS

Cold water meters 2 inches and smaller shall be positive displacement type conforming to AWWA C700. Cold water meters 2-1/2 inches and larger shall be turbine type conforming to AWWA C701. Meter register may be round or straight reading type, indicating with totalizer. Meter shall be provided with a pulse generator, remote readout register and all necessary wiring and accessories. The water meters shall be connected to the DDC system for remote reading of all water usage. Provide water meters for the make-up water to the rainwater harvesting system and the rainwater supply to the water distribution system in the locations as shown on the Plumbing drawings.

2.7 ELECTRICAL WORK

Provide electrical motor driven equipment specified complete with motors, motor starters, and controls as specified herein and in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide internal wiring for components of packaged equipment as an integral part of the equipment. Provide[high efficiency type,] single-phase, fractional-horsepower alternating-current motors, including motors that are part of a system, corresponding to the applications in accordance with NEMA MG 11.[In addition to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, provide polyphase, squirrel-cage medium induction motors with continuous ratings, including motors that are part of a system, that meet the efficiency ratings for premium efficiency motors in accordance with NEMA MG 1.] Provide motors in accordance with NEMA MG 1 and of sufficient size to drive the load at the specified capacity without exceeding the nameplate rating of the motor.

Motors shall be rated for continuous duty with the enclosure specified. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of the enclosure.

Controllers and contactors shall have auxiliary contacts for use with the controls provided. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided. For packaged equipment, the manufacturer shall provide controllers, including the required monitors and timed restart.

Power wiring and conduit for field installed equipment shall be provided under and conform to the requirements of Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.8 MISCELLANEOUS PIPING ITEMS

2.8.1 Escutcheon Plates

Provide one piece or split hinge metal plates for piping entering floors, walls, and ceilings in exposed spaces. Provide chromium-plated on copper alloy plates or polished stainless steel finish in finished spaces. Provide paint finish on plates in unfinished spaces.

2.8.2 Pipe Sleeves

Provide where piping passes entirely through walls, ceilings, roofs, and floors.

2.8.2.1 Sleeves in Masonry and Concrete

Provide schedule 40 steel or PVC plastic pipe sleeves. Core drilling of masonry and concrete may be provided in lieu of pipe sleeves when cavities in the core-drilled hole are completely grouted smooth.

2.8.2.2 Sleeves Not in Masonry and Concrete

Provide 26 gage galvanized steel sheet or PVC plastic pipe sleeves.

2.8.3 Pipe Hangers (Supports)

Provide MSS SP-58 and MSS SP-69, Type 1 with adjustable type steel support rods, except as specified or indicated otherwise. Attach to steel joists with Type 19 or 23 clamps and retaining straps. Attach to Steel W or S beams with Type 21, 28, 29, or 30 clamps. Attach to steel angles and vertical web steel channels with Type 20 clamp with beam clamp channel adapter. Attach to horizontal web steel channel and wood with drilled hole on centerline and double nut and washer. Attach to concrete with Type 18 insert or drilled expansion anchor. Provide Type 40 insulation protection shield for insulated piping.

2.8.4 Nameplates

Provide 0.125 inch thick melamine laminated plastic nameplates, black matte finish with white center core, for equipment, gages, thermometers, and valves; valves in supplies to faucets will not require nameplates. Accurately align lettering and engrave minimum of 0.25 inch high normal block lettering into the white core. Minimum size of nameplates shall be 1.0 by 2.5 inches. Key nameplates to a chart and schedule for each system. Frame charts and schedules under glass and place where directed near each system. Furnish two copies of each chart and schedule.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

Piping located in air plenums shall conform to NFPA 90A requirements. Piping located in shafts that constitute air ducts or that enclose air ducts shall be noncombustible in accordance with NFPA 90A. Installation of plastic pipe where in compliance with NFPA may be installed in accordance with PPFA Fire Man. The rainwater harvesting system shall be installed complete with necessary equipment, fittings, valves, and accessories. Rainwater harvesting system piping shall be extended 5 feet outside the building, unless otherwise indicated. Piping shall be connected to the exterior service lines or capped or plugged if the exterior service is not in place. Rainwater harvesting system pipes shall be laid in separate trenches, except when otherwise shown. Exterior underground utilities shall be at least 12 inches below the[average local frost depth][finish grade] or as indicated on the drawings. If trenches are closed or the pipes are otherwise covered before being connected to the service lines, the location of the end of each plumbing utility shall be marked with a stake or other acceptable means. Valves shall be installed with control no lower than the valve body. All piping located below the building shall be supported from above by the floor slab. Provide adequate working space around all equipment in accordance with manufacturers written requirements. Working space shall allow room to perform maintenance functions as well as to pull coils, pumps, heat transfer surfaces, valves and valve operators, dampers, controls, control wiring, conduit fans, motors, etc.

3.1.1 Water Pipe, Fittings, and Connections

Water pressure piping, fitting and connections to the rainwater harvesting system and equipment shall be made in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE. Rainwater collection piping located outside the building shall be connected in accordance with Section 33 40 00 STORM DRAINAGE UTILITIES.

3.1.1.1 Utilities

The piping shall be extended to all fixtures and equipment. The rainwater harvesting piping system shall be arranged and installed to permit draining. The supply line to each item of equipment or fixture, except flush valves, or other control valves which are supplied with integral stops, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to fixtures, hydrants, and flushing devices shall be anchored to prevent movement.

3.1.1.2 Cutting and Repairing

The work shall be carefully laid out in advance, and unnecessary cutting of construction shall be avoided. Damage to building, piping, wiring, or equipment as a result of cutting shall be repaired by mechanics skilled in the trade involved.

3.1.1.3 Protection of Fixtures, Materials, and Equipment

Pipe openings shall be closed with caps or plugs during installation. Equipment shall be tightly covered and protected against dirt, water, chemicals, and mechanical injury. Upon completion of the work, the materials and equipment shall be thoroughly cleaned, adjusted, and operated. Safety guards shall be provided for exposed rotating equipment.

3.1.1.4 Mains, Branches, and Runouts

Piping shall be installed as indicated. Pipe shall be accurately cut and worked into place without springing or forcing. Structural portions of the building shall not be weakened. Aboveground piping shall run parallel with the lines of the building, unless otherwise indicated. Branch pipes from service lines may be taken from top, bottom, or side of main, using crossover fittings required by structural or installation conditions. Supply pipes, valves, and fittings shall be kept a sufficient distance from other work and other services to permit not less than 1/2 inch between finished covering on the different services. Bare and insulated water lines shall not bear directly against building structural elements so as to transmit sound to the structure or to prevent flexible movement of the lines. Water pipe shall not be buried in or under floors unless specifically indicated or approved. Changes in pipe sizes shall be made with reducing fittings. Use of bushings will not be permitted except for use in situations in which standard factory fabricated components are furnished to accommodate specific accepted installation practice. Change in direction shall be made with fittings, except that bending of pipe 4 inches and smaller will be permitted, provided a pipe bender is used and wide sweep bends are formed. The center-line radius of bends shall be not less than six diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be acceptable.

3.1.1.5 Expansion and Contraction of Piping

Allowance shall be made throughout for expansion and contraction of water pipe. Risers shall be securely anchored as required or where indicated to force expansion to loops. Branch connections from risers shall be made with ample swing or offset to avoid undue strain on fittings or short pipe lengths. Horizontal runs of pipe over 50 feet in length shall be anchored to the wall or the supporting construction about midway on the run to force expansion, evenly divided, toward the ends. Sufficient flexibility shall be provided on branch runouts from mains and risers to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that piping will spring enough to allow for expansion without straining.

3.1.2 Joints

Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints shall be made up with fittings of compatible material and made for the specific purpose intended.

3.1.2.1 Threaded

Threaded joints shall have American Standard taper pipe threads conforming to ASME B1.20.1. Only male pipe threads shall be coated with graphite or with an approved graphite compound, or with an inert filler and oil, or shall have a polytetrafluoroethylene tape applied.

3.1.2.2 Unions and Flanges

Unions, flanges and mechanical couplings shall not be concealed in walls, ceilings, or partitions. Unions shall be used on pipe sizes 2-1/2 inches and smaller; flanges shall be used on pipe sizes 3 inches and larger.

3.1.3 Dissimilar Pipe Materials

Connections between ferrous and non-ferrous copper water pipe shall be made with dielectric unions or flange waterways. Dielectric waterways shall have temperature and pressure rating equal to or greater than that specified for the connecting piping. Waterways shall have metal connections on both ends suited to match connecting piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways. Connecting joints between plastic and metallic pipe shall be made with transition fitting for the specific purpose.

3.1.4 Pipe Sleeves and Flashing

Pipe sleeves shall be furnished and set in their proper and permanent location.

3.1.4.1 Sleeve Requirements

Unless indicated otherwise, provide pipe sleeves meeting the following requirements:

Secure sleeves in position and location during construction. Provide sleeves of sufficient length to pass through entire thickness of walls, ceilings, roofs, and floors.

A modular mechanical type sealing assembly may be installed in lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve. The seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve using galvanized steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe and sleeve involved.

Sleeves shall not be installed in structural members, except where indicated or approved. Rectangular and square openings shall be as detailed. Each sleeve shall extend through its respective floor, or roof, and shall be cut flush with each surface, except for special circumstances. Pipe sleeves passing through floors in wet areas such as mechanical equipment rooms, lavatories, kitchens, and other plumbing fixture areas shall extend a minimum of 4 inches above the finished floor.

Unless otherwise indicated, sleeves shall be of a size to provide a minimum of [1/4 inch][one inch] clearance between bare pipe or insulation and inside of sleeve or between insulation and inside of sleeve. Sleeves in bearing walls and concrete slab on grade floors shall be steel pipe or cast-iron pipe. Sleeves in nonbearing walls or ceilings may be steel pipe, cast-iron pipe, galvanized sheet metal with lock-type longitudinal seam, or plastic.

Except as otherwise specified, the annular space between pipe and sleeve, or between jacket over insulation and sleeve, shall be sealed as indicated with sealants conforming to ASTM C920 and with a primer, backstop material and surface preparation as specified in Section 07 92 00 JOINT SEALANTS. The annular space between pipe and sleeve, between bare insulation and sleeve or between jacket over insulation and sleeve shall not be sealed for interior walls which are not designated as fire rated.

Sleeves through below-grade walls in contact with earth shall be recessed 1/2 inch from wall surfaces on both sides. Annular space between pipe and sleeve shall be filled with backing material and sealants in the joint between the pipe and[concrete][masonry] wall as specified above. Sealant selected for the earth side of the wall shall be compatible with dampproofing/waterproofing materials that are to be applied over the joint sealant. Pipe sleeves in fire-rated walls shall conform to the requirements in Section 07 84 00 FIRESTOPPING.

3.1.4.2 Flashing Requirements

The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Pipes, up to and including 10 inches in diameter, passing through floor waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing-clamp device, and pressure ring with brass bolts. Flashing shield shall be fitted into the sleeve clamping device. Pipes passing through wall waterproofing membrane shall be sleeved as described above. A waterproofing clamping flange shall be installed.

3.1.4.3 Pipe Penetrations of Slab on Grade Floors

Where pipes, or similar items penetrate slab on grade floors, except at penetrations of floors with waterproofing membrane as specified in paragraphs Flashing Requirements and Waterproofing, a groove 1/4 to 1/2 inch wide by 1/4 to 3/8 inch deep shall be formed around the pipe, fitting or drain. The groove shall be filled with a sealant as specified in Section 07 92 00 JOINT SEALANTS.

3.1.4.4 Pipe Penetrations

Provide sealants for all pipe penetrations. All pipe penetrations shall be sealed to prevent infiltration of air, insects, and vermin.

3.1.5 Fire Seal

Where pipes pass through fire walls, fire-partitions, fire-rated pipe chase walls or floors above grade, a fire seal shall be provided as specified in Section 07 84 00 FIRESTOPPING.

3.1.6 Supports

3.1.6.1 General

Hangers used to support piping 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement when operating temperatures exceed ambient temperatures shall be supported by variable spring hangers and supports or by constant support hangers. In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run. Threaded sections of rods shall not be formed or bent.

3.1.6.2 Pipe Supports and Structural Bracing, Seismic Requirements

Piping and attached valves shall be supported and braced to resist seismic loads as specified in Section 23 05 48 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT. Structural steel required for reinforcement to properly support piping, headers, and equipment, but not shown, shall be provided. Material used for supports shall be as specified in[Section 05 12 00 STRUCTURAL STEEL][Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS][Section 05 51 33 METAL LADDERS][Section 05 52 00 METAL RAILINGS][Section 05 51 00 METAL STAIRS].

3.1.6.3 Pipe Hangers, Inserts, and Supports

Installation of pipe hangers, inserts and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein.

a. Types 5, 12, and 26 shall not be used.

b. Type 3 shall not be used on insulated pipe.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and shall have both locknuts and retaining devices furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron steel plate or adapter.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Type 39 saddles shall be used on insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher. Type 39 saddles shall be welded to the pipe.

h. Type 40 shields shall:

(1) Be used on insulated pipe less than 4 inches.

(2) Be used on insulated pipe 4 inches and larger when the temperature of the medium is 60 degrees F or less.

(3) Have a high density insert for all pipe sizes. High density inserts shall have a density of 8 pcf or greater.

i. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves. Operating temperatures in determining hanger spacing for PVC pipe shall be 120 degrees F for PVC. Horizontal pipe runs shall include allowances for expansion and contraction.

j. Vertical pipe shall be supported at each floor, except at slab-on-grade, at intervals of not more than 15 feet nor more than 8 feet from end of risers. Vertical pipe risers shall include allowances for expansion and contraction.

k. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided to allow longitudinal pipe movement. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered. Lateral restraints shall be provided as needed. Where steel slides do not require provisions for lateral restraint the following may be used:

(1) On pipe 4 inches and larger when the temperature of the medium is 60 degrees F or higher, a Type 39 saddle, welded to the pipe, may freely rest on a steel plate.

(2) On pipe less than 4 inches a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

(3) On pipe 4 inches and larger carrying medium less that 60

degrees F a Type 40 shield, attached to the pipe or insulation, may freely rest on a steel plate.

l. Pipe hangers on horizontal insulated pipe shall be the size of the outside diameter of the insulation. The insulation shall be continuous through the hanger on all pipe sizes and applications.

m. Where there are high system temperatures and welding to piping is not desirable, the type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches or by an amount adequate for the insulation, whichever is greater.

n. Hangers and supports for plastic pipe shall not compress, distort, cut or abrade the piping, and shall allow free movement of pipe except where otherwise required in the control of expansion/contraction.

3.1.6.4 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Supports shall not be attached to the underside of concrete filled floor or concrete roof decks unless approved by the Contracting Officer. Masonry anchors for overhead applications shall be constructed of ferrous materials only.

3.2 RAINWATER HARVESTING SYSTEM

Follow the drawings and manufacturer's written instructions for installation of the rainwater harvesting system. All aboveground piping, valves, fittings, and accessories shall be as specified for domestic water supply. Underground piping from the [fiberglass reinforced plastic][modular] storage tank to the rainwater harvesting system shall be installed in accordance with Section 33 11 00 WATER DISTRIBUTION.

[3.2.1 Modular Storage Tank

Prepare the area where the tank is to be installed in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL. Install the tank in accordance with the tank manufacturer's written instructions. Provide the required types and number modules, inspection ports, inlets, outlet, and overflow connections, and accessories as recommended by the tank manufacturer. Tank shall be vented to atmospheric pressure.

][3.2.2 Fiberglass Reinforced Plastic Storage Tank

Install the tank in accordance with the tank manufacturer's written instructions. Provide the required types and number of anchors, strap sizes and number of straps, and strap locations, as recommended by the tank manufacturer. Tank shall be vented to atmospheric pressure.

]3.2.3 Submersible Feed Pump

Follow the drawings and the manufacturer's written instructions for installation of the submersible feed pump. Connect the pump controls to the rainwater control system.

3.2.4 Debris Filter

Install the debris filter in accordance with the filter manufacturer's written instructions. Install such that the top cover shall be flush with finish grade after installation is complete.

3.2.5 Initial Runoff Filter

Install the debris filter in accordance with the filter manufacturer's written instructions. Install such that the top cover shall be flush with finish grade after installation is complete.

3.2.6 Rainwater Filter, Purification, and Controls

Follow the drawings and the manufacturer's written instructions for installation of the rainwater filters, purification system and controls.

3.2.7 [Dye][and][Chlorine]Injection System

Follow the drawings and the manufacturer's written instructions for installation of the [dye][and][chlorine]injection system.

[3.2.8 Booster Pump

Follow the drawings and the manufacturer's written instructions for installation of the booster pump. Connect the pump controls to the rainwater control system.

][3.2.9 Packaged Pump System

Follow the drawings and the manufacturer's written instructions for installation of the packaged pump system. Connect the pump controls to the rainwater control system.

]3.2.10 Hydropneumatic Tank

Follow the drawings and the manufacturer's written instructions for installation of the rainwater filters, purification system and controls.

3.3 FIXTURES AND FIXTURE TRIMMINGS

Polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view. Angle stops, straight stops, stops integral with the faucets, or concealed type of lock-shield, and loose-key pattern stops for supplies with threaded, sweat or solvent weld inlets shall be furnished and installed with fixtures. Where connections between copper tubing and faucets are made by rubber compression fittings, a beading tool shall be used to mechanically deform the tubing above the compression fitting. Exposed supply pipes for fixtures and equipment shall be connected to the rough piping systems at the wall, unless otherwise specified under the item. Floor and wall escutcheons shall be as specified. Drain lines and hot water lines of fixtures for handicapped personnel shall be insulated and do not require polished chrome finish. Plumbing fixtures and accessories shall be installed within the space shown.

[3.3.1 Backflow Prevention Devices

Plumbing fixtures, equipment, and pipe connections shall not cross connect or interconnect between a potable water supply and any source of nonpotable water. Backflow preventers shall be installed where indicated and in accordance with [ICC IPC][and the North Carolina Building Codes] at all other locations necessary to preclude a cross-connect or interconnect between a potable water supply and any nonpotable substance. Backflow preventers shall be located so that no part of the device will be submerged. Backflow preventers shall be of sufficient size to allow unrestricted flow of water to the equipment, and preclude the backflow of any nonpotable substance into the potable water system. Bypass piping shall not be provided around backflow preventers. Access shall be provided for maintenance and testing. Each device shall be a standard commercial unit.

]3.3.2 Access Panels

Access panels shall be provided for concealed valves and controls, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced, maintained, or replaced. Access panels shall be as specified in Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.

3.4 VIBRATION-ABSORBING FEATURES

Mechanical equipment, including pumps, shall be isolated from the building structure by approved vibration-absorbing features, unless otherwise shown. Each foundation shall include an adequate number of standard isolation units. Each unit shall consist of machine and floor or foundation fastening, together with intermediate isolation material, and shall be a standard product with printed load rating. Isolation unit installation shall limit vibration to [_____] percent of the lowest equipment rpm.

3.5 WATER METER REMOTE READOUT REGISTER

The remote readout register shall be provided thru the DDC for remote reading.

3.6 IDENTIFICATION SYSTEMS

3.6.1 Identification Tags

Identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and valve number shall be installed on valves. Tags shall be 1-3/8 inch minimum diameter, and marking shall be stamped or engraved. Indentations shall be black, for reading clarity. Tags shall be attached to valves with No. 12 AWG, copper wire, chrome-plated beaded chain, or plastic straps designed for that purpose. All hose bibbs connected to the rainwater harvesting system shall be identified with signs that say "CAUTION: RECLAIMED WATER - DO NOT DRINK". The letters on the sign shall be at least 1/2" high.

3.6.2 Pipe Color Code Marking

Color code marking of piping shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.6.3 Color Coding Scheme for Locating Hidden Utility Components

Scheme shall be provided in buildings having suspended grid ceilings. The color coding scheme shall identify points of access for maintenance and operation of operable components which are not visible from the finished space and installed in the space directly above the suspended grid ceiling. The operable components shall include valves and switches. The color coding scheme shall consist of a color code board and colored metal disks. Each colored metal disk shall be approximately 3/8 inch in diameter and secured to removable ceiling panels with fasteners. The fasteners shall be inserted into the ceiling panels so that the fasteners will be concealed from view. The fasteners shall be manually removable without tools and shall not separate from the ceiling panels when panels are dropped from ceiling height. Installation of colored metal disks shall follow completion of the finished surface on which the disks are to be fastened. The color code board shall have the approximate dimensions of 3 foot width, 30 inches height, and 1/2 inch thickness. The board shall be made of wood fiberboard and framed under glass or 1/16 inch transparent plastic cover. Unless otherwise directed, the color code symbols shall be approximately 3/4 inch in diameter and the related lettering in 1/2 inch high capital letters. The color code board shall be mounted and located in the mechanical or equipment room. The color code system shall be as determined by the Contracting Officer. The color code shall meet base requirements.

3.7 ESCUTCHEONS

Escutcheons shall be provided at finished surfaces where bare or insulated piping, exposed to view, passes through floors, walls, or ceilings, except in boiler, utility, or equipment rooms. Escutcheons shall be fastened securely to pipe or pipe covering and shall be satin-finish, corrosion-resisting steel, polished chromium-plated zinc alloy, or polished chromium-plated copper alloy. Escutcheons shall be either one-piece or split-pattern, held in place by internal spring tension or setscrew.

3.8 PAINTING

Painting of pipes, hangers, supports, and other iron work, either in concealed spaces or exposed spaces, is specified in Section 09 90 00 PAINTS AND COATINGS.

3.8.1 PAINTING OF NEW EQUIPMENT

New equipment painting shall be factory applied or shop applied, and shall be as specified herein, and provided under each individual section.

3.8.1.1 Factory Painting Systems

Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall withstand 3000 hours in a salt-spray fog test. Salt-spray fog test shall be in accordance with ASTM B117, and for that test the acceptance criteria shall be as follows: immediately after completion of the test, the paint shall show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen shall show no signs of rust creepage beyond 0.125 inch on either side of the scratch mark.

The film thickness of the factory painting system applied on the equipment shall not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120 degrees F, the factory painting system shall be designed for the temperature service.

3.8.1.2 Shop Painting Systems for Metal Surfaces

Clean, pretreat, prime and paint metal surfaces; except aluminum surfaces need not be painted. Apply coatings to clean dry surfaces. Clean the surfaces to remove dust, dirt, rust, oil and grease by wire brushing and solvent degreasing prior to application of paint, except metal surfaces subject to temperatures in excess of 120 degrees F shall be cleaned to bare metal.

Where more than one coat of paint is specified, apply the second coat after the preceding coat is thoroughly dry. Lightly sand damaged painting and retouch before applying the succeeding coat. Color of finish coat shall be aluminum or light gray.

a. Temperatures Less Than 120 Degrees F: Immediately after cleaning, the metal surfaces subject to temperatures less than 120 degrees F shall receive one coat of pretreatment primer applied to a minimum dry film thickness of 0.3 mil, one coat of primer applied to a minimum dry film thickness of one mil; and two coats of enamel applied to a minimum dry film thickness of one mil per coat.

b. Temperatures Between 120 and 400 Degrees F: Metal surfaces subject to temperatures between 120 and 400 degrees F shall receive two coats of 400 degrees F heat-resisting enamel applied to a total minimum thickness of 2 mils.

c. Temperatures Greater Than 400 Degrees F: Metal surfaces subject to temperatures greater than 400 degrees F shall receive two coats of 600 degrees F heat-resisting paint applied to a total minimum dry film thickness of 2 mils.

3.9 TESTS, FLUSHING AND DISINFECTION

3.9.1 Rainwater Harvesting System

The following tests shall be performed on the rainwater harvesting system in accordance with [ICC IPC] and [North Carolina Building Codes][_______].

a. Rainwater Harvesting system Test.

b. Water Supply Systems Tests.

3.9.1.1 Test of Backflow Prevention Assemblies

Backflow prevention assembly shall be tested using gauges specifically designed for the testing of backflow prevention assemblies. Gauges shall be tested annually for accuracy in accordance with the University of Southern California's Foundation of Cross Connection Control and Hydraulic Research or the American Water Works Association Manual of Cross Connection (Manual M-14). Report form for each assembly shall include, as a minimum, the following:

Data on Device	Data on Testing Firm
Type of Assembly	Name
Manufacturer	Address
Model Number	Certified Tester
Serial Number	Certified Tester No.
Size	Date of Test

Location
Test Pressure Readings Serial Number and Test Data of Gauges

If the unit fails to meet specified requirements, the unit shall be repaired and retested.

3.9.2 Defective Work

If inspection or test shows defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests shall be repeated. Repairs to piping shall be made with new materials. Caulking of screwed joints or holes will not be acceptable.

3.9.3 System Flushing

3.9.3.1 During Flushing

Before operational tests or disinfection, potable and non-potable water piping system shall be flushed with potable water. Sufficient water shall be used to produce a water velocity that is capable of entraining and removing debris in all portions of the piping system. This requires simultaneous operation of all fixtures on a common branch or main in order to produce a flushing velocity of approximately 4 fps through all portions of the piping system. In the event that this is impossible due to size of system, the Contracting Officer (or the designated representative) shall specify the number of fixtures to be operated during flushing. Contractor shall provide adequate personnel to monitor the flushing operation and to ensure that drain lines are unobstructed in order to prevent flooding of the facility. Contractor shall be responsible for any flood damage resulting from flushing of the system. Flushing shall be continued until entrained dirt and other foreign materials have been removed and until discharge water shows no discoloration.

3.9.3.2 After Flushing

System shall be drained at low points. Strainer screens shall be removed, cleaned, and replaced. After flushing and cleaning, systems shall be prepared for testing by immediately filling water piping with clean, fresh potable water. Any stoppage, discoloration, or other damage to the finish, furnishings, or parts of the building due to the Contractor's failure to properly clean the piping system shall be repaired by the Contractor. Automatic control systems shall be adjusted for proper operation according to manufacturer's instructions. Comply with ASHRAE 90.1 - IP for minimum efficiency requirements. Unless more stringent local requirements exist, lead levels shall not exceed limits established by 40 CFR 50.12 Part 141.80(c)(1). The water supply to the building shall be tested separately to ensure that any lead contamination found during potable water system testing is due to work being performed inside the building.

3.9.4 Operational Test

Upon completion of flushing and prior to disinfection procedures, the Contractor shall subject the rainwater harvesting system to operating tests to demonstrate satisfactory installation, connections, adjustments, and functional and operational efficiency. Such operating tests shall cover a period of not less than 8 hours for each system and shall include the following information in a report with conclusion as to the adequacy of the system:

a. Time, date, and duration of test.

b. Water pressures at the most remote and the highest fixtures.

c. Operation of each fixture and fixture trim.

d. Operation of each valve, hydrant, and faucet.

e. Pump suction and discharge pressures.

f. Operation of each vacuum breaker and backflow preventer.

g. Complete operation of the rainwater harvesting system. This shall include operation under all conditions such as loss of power and low water levels in the storage tank.

3.9.5 Disinfection

After operational tests are complete, the entire domestic non-potable and cold-water distribution system shall be disinfected. System shall be flushed as specified, before introducing chlorinating material. The chlorinating material shall be hypochlorites or liquid chlorine. Except as herein specified, water chlorination procedure shall be in accordance with AWWA C651 and AWWA C652. The chlorinating material shall be fed into the water piping system at a constant rate at a concentration of at least 50 parts per million (ppm). A properly adjusted hypochlorite solution injected into the main with a hypochlorinator, or liquid chlorine injected into the main through a solution-feed chlorinator and booster pump, shall be used. If after the 24 hour and 6 hour holding periods, the residual solution contains less than 25 ppm and 50 ppm chlorine respectively, flush the piping with potable water, and repeat the above procedures until the required residual chlorine levels are satisfied. The system shall then be flushed with clean water until the residual chlorine level is reduced to less than one part per million. During the flushing period each valve shall be opened and closed several times. Samples of water in disinfected containers shall be obtained from several locations selected by the Contracting Officer.

The samples of water shall be tested for total coliform organisms (coliform bacteria, fecal coliform, streptococcal, and other bacteria) in accordance with AWWA 10084. The testing method used shall be EPA approved for drinking water systems and shall comply with applicable local and state requirements.

Disinfection shall be repeated until tests indicate the absence of coliform organisms (zero mean coliform density per 100 milliliters) in the samples for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

3.10 WASTE MANAGEMENT

Place materials defined as hazardous or toxic waste in designated containers. Return solvent and oil soaked rags for contaminant recovery and laundering or for proper disposal. Close and seal tightly partly used sealant and adhesive containers and store in protected, well-ventilated, fire-safe area at moderate temperature. Place used sealant and adhesive tubes and containers in areas designated for hazardous waste. Separate copper and ferrous pipe waste in accordance with the Waste Management Plan and place in designated areas for reuse.

3.11 POSTED INSTRUCTIONS

Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above for the wiring and control diagrams and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

-- End of Section --

SECTION 22 33 30.00 10

SOLAR WATER HEATING EQUIPMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22/CSA 4.4	(1999; Addenda A 2000, Addenda B 2001; R 2014) Relief Valves for Hot Water Supply Systems

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 93	(2010; Errata 2013l Errata 2014) Methods of Testing to Determine the Thermal Performance of Solar Collectors

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C606	(2011) Grooved and Shouldered Joints

AMERICAN WELDING SOCIETY (AWS)

AWS B2.1/B2.1M	(2014) Specification for Welding Procedure and Performance Qualification
AWS D1.2/D1.2M	(2014) Structural Welding Code - Aluminum

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(2013) Pipe Threads, General Purpose (Inch)
ASME B16.15	(2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2012) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.24	(2011) Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500
ASME B16.26	(2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes

ASME B16.39	(2009) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 19.3 TW	(2010) Thermowells Performance Test Codes

ASTM INTERNATIONAL (ASTM)

ASTM A183	(2014) Standard Specification for Carbon Steel Track Bolts and Nuts
ASTM A536	(1984; R 2014) Standard Specification for Ductile Iron Castings
ASTM B152/B152M	(2013) Standard Specification for Copper Sheet, Strip, Plate, and Rolled Bar
ASTM B209	(2014) Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B32	(2008; R 2014) Standard Specification for Solder Metal
ASTM B62	(2009) Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM B75/B75M	(2011) Standard Specification for Seamless Copper Tube
ASTM B828	(2002; R 2010) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
ASTM B88	(2014) Standard Specification for Seamless Copper Water Tube
ASTM C1048	(2012; E 2012) Standard Specification for Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass
ASTM D2000	(2012) Standard Classification System for Rubber Products in Automotive Applications
ASTM F1199	(1988; R 2010) Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(2010) Ball Valves Threaded,

	Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-58	(1993; Reaffirmed 2010) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-72	(2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service
MSS SP-80	(2013) Bronze Gate, Globe, Angle and Check Valves

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(2011; Errata 2012) Motors and Generators

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-310-04	(2013) Seismic Design for Buildings

1.2 SOLAR ENERGY SYSTEM

a. Provide a solar energy system arranged for preheating of service (domestic and/or process) water using flat plate liquid solar collectors. Include in the system components a solar collector array, storage tank, pump[s], automatic controls, instrumentation, interconnecting piping and fittings, [uninhibited food-grade propylene-glycol and water heat transfer fluid in a closed loop], [potable water heat transfer fluid in an open loop], [heat exchanger], [expansion tank], and accessories required for the operation of the system.

b. Submit manufacturer's descriptive and technical literature; performance chart and curves; catalog cuts; and installation instructions. Proposed diagrams, instructions, and other sheets, prior to posting. A copy of the posted instructions proposed to be used, including a system schematic, wiring and control diagrams, and a complete layout of the entire system. Include with the instructions, in typed form, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system, methods of balancing and testing flow in the system, and methods of testing for control failure and proper system operation.

c. Submit drawings containing a system schematic; a collector layout and roof plan noting reverse-return piping for the collector array; a system elevation; an equipment room layout; a schedule of operation and installation instructions; and a schedule of design information including collector height and width, recommended flow rate and pressure drop at that flow rate, and number of collectors to be grouped per bank.

d. Include on the drawings complete wiring and schematic diagrams and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout and anchorage of equipment and appurtenances, and equipment relationship to other parts of the work, including clearances for maintenance and operation.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Solar Energy System
As-Built Drawings

SD-03 Product Data

Spare Parts
Solar Energy System
Welder Qualifications

SD-06 Test Reports

Inspection and Testing

SD-10 Operation and Maintenance Data

Operation and Maintenance Procedures; G

1.4 WELDER QUALIFICATIONS

Qualify procedures and welders in accordance with the code under which the welding is specified to be accomplished. Submit, prior to welding operations, [_____] copies of qualified procedures and lists of names and identification symbols of qualified welders and welding operators.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and excessive temperature variation, and dirt and dust or other contaminants.

1.6 WARRANTY

Provide a minimum 10-year warranty against the following: failure of manifold or riser tubing, joints or fittings; degradation of absorber plate selective surface; rusting or discoloration of collector hardware; and embrittlement of header manifold seals. Include in the warranty full repair or replacement of defective materials or equipment.

1.7 SPARE PARTS

Submit data for each different item of material and equipment listed, including a complete list of parts and supplies, with current unit prices and source of supply; a list of parts and supplies that are either normally furnished at no extra cost with the purchase of equipment, or specified to be furnished as part of the contract; and a list of additional items recommended by the manufacturer to ensure efficient operation for a period of 120 days.

PART 2 PRODUCTS

2.1 GENERAL EQUIPMENT REQUIREMENTS

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

Each major item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.3 Identical Items

Items of the same classification shall be identical, including equipment, assemblies, parts, and components.

2.1.4 Equipment Guards [and Access]

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting set-screws, keys, and other rotating parts so located that any person may come in close proximity. High-temperature equipment and piping so located as to endanger personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. [Provide catwalk, ladder, and guard rails where shown and in accordance with Section 05 50 13 MISCELLANEOUS METAL FABRICATIONS.]

2.1.5 Special Tools

Provide one set of special tools, calibration devices, and instruments required for operation, calibration, and maintenance of the equipment.

2.2 PIPING SYSTEM

Piping system shall be complete with pipe, pipe fittings, valves, strainers, expansion loops, hangers, inserts, supports, anchors, guides, sleeves, and accessories. System materials shall conform to the following:

2.2.1 Copper Tubing

ASTM B88, Type K where buried, Type L otherwise. Collector risers Type L or M.

2.2.2 Solder

ASTM B32, Type Sb5, Sn94, Sn95, or Sn96.

2.2.3 Joints and Fittings for Copper Tubing

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B75/B75M. Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18 and ASTM B828. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Cast bronze threaded fittings shall conform to ASME B16.15. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used. Grooved mechanical joints and fittings shall be designed for not less than 125 psig service and shall be the product of the same manufacturer. Grooved fitting and mechanical coupling housing shall be ductile iron conforming to ASTM A536. Gaskets for use in grooved joints shall be molded synthetic polymer of pressure responsive design and shall conform to ASTM D2000 for circulating medium up to 230 degrees F. Grooved joints shall conform to AWWA C606. Coupling nuts and bolts for use in grooved joints shall be steel and shall conform to ASTM A183.

2.2.4 Flanges

Bronze, Class 125 or 150 as applicable, ASME B16.24.

2.2.5 Dielectric Waterways and Flanges

Waterways and flanges shall conform to the requirements of ASME B16.39. Dielectric waterways shall have metal connections at both ends suited to match connecting piping. Ends shall be threaded or soldered to match adjacent piping. Dielectric waterways shall be internally lined with an insulator specifically designed to prevent current flow between dissimilar metals. Dielectric waterways and flanges shall be suitable for the temperatures, pressures, and antifreeze encountered. Dielectric flanges shall meet the performance requirements described herein for dielectric waterways.

2.2.6 Bronze Gate, Globe, Angle, and Check Valves

MSS SP-80, Type 1 (or nonslam, spring type), Class 125 or 150.

2.2.7 Ball Valves

[MSS SP-72] [or] [MSS SP-110], Class 125 or 150.

2.2.8 Relief Valves, Pressure and Temperature

ANSI Z21.22/CSA 4.4. Pressure relief valves located on the solar collector array upper manifold and on the expansion tank shall open and discharge the collector fluid [into drain indicated] [into drain tank] when fluid pressure rises above 125 psig. Pressure and temperature relief valves located on the solar storage tank shall open and discharge water [into drain indicated] [into drain tank] when fluid pressure rises above [125] [_____] psig or when fluid temperature rises above [210] [_____] degrees F.

2.2.9 Calibrating Balancing Valves

Calibrated balancing valves shall be suitable for 125 psig and 250 degrees F service. Calibrated balancing valves shall be of bronze body/brass ball construction with seat rings compatible with system fluid and shall have differential readout ports across valve seat area. Readout ports shall be fitted with internal insert of compatible material and check valve. Calibrated balancing valves shall have memory stop feature to allow valve to be closed for service and reopened to set point without disturbing balance position, and shall have calibrated nameplate to assure specific valve settings.

2.2.10 Air Vents

Brass or bronze valves or cocks suitable for 125 psig service. Air vents shall be provided with threaded plugs or caps.

2.2.11 Strainers

ASTM F1199, removable basket and screen, Y pattern, cast iron strainer with pressures to 125 psig, simplex type; or a combination elbow-strainer with straightening vanes and strainer arranged for horizontal flow.

2.2.12 Pressure Gauges

ASME B40.100. Pressure gauges shall be provided with throttling type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 3-1/2 inch.

2.2.13 Thermometers

ASME PTC 19.3 TW, Type I, Class 3. Thermometers shall be supplied with wells and separable bronze sockets.

2.2.14 Pipe Threads

ASME B1.20.1.

2.2.15 Pipe Supports

MSS SP-58. Metal insulation shield shall be stainless steel.

2.2.16 Aluminum Sheets

ASTM B209, Alloy 3003.

2.2.17 Copper Sheets Copper Alloy 110

ASTM B152/B152M.

2.3 ELECTRICAL WORK

Electric motor-driven equipment specified shall be provided complete with motor, motor starters, and controls. Electrical equipment and wiring shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Electrical characteristics shall be as specified or indicated. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control specified. Each motor shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

2.4 COLLECTOR SUBSYSTEM

2.4.1 Solar Collector Construction

Collectors shall be of the flat plate, liquid, internally manifolded type. Each collector shall be provided with cover glazing, an absorber plate, heat transfer liquid flow tubes, internal headers, weep holes, insulation, and a casing. Collectors shall be of weather-tight construction. Solar collectors shall withstand a stagnation temperature of 350 degrees F and a working pressure of 125 psig without degrading, out-gassing, or warping. Collector net aperture area shall be as shown and shall be a minimum of 28 square feet. Collector length, width, and volume shall be as shown.

2.4.2 Absorber Plate and Flow Tubes

Absorber sheet or plate shall be copper. Top of absorber plate shall be coated with selective surface of black chrome and shall have an emissivity less than 0.2 and absorptivity greater than 0.9. Flow tubes shall be Type L or Type M copper, and shall be soldered, brazed, or mechanically bonded to the absorber plate. Tubes shall be installed on the absorber plate so that they drain by gravity.

2.4.3 Cover Glazing

Each collector shall have a single layer of cover glazing made of clear float, water white or low iron type tempered glass. Glass shall meet ASTM C1048. Cover glazing shall be completely replaceable from the front of the collector without disturbing the piping or adjacent collectors. Cover glazing shall be separated from the collector by a continuous gasket made of EPDM rubber.

2.4.4 Insulation

Back and sides of the absorber plate shall be insulated. Insulation shall fill space between absorber plate and casing and shall have an R value of 4 minimum. Insulation shall conform to EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING and shall be fibrous glass, polyisocyanurate, urethane foam, or other material suitable for the intended purpose, and shall withstand the moisture, sun exposure, and stagnation temperature limitations of the solar collector. Polyisocyanurate insulation shall not come in contact with the absorber plate.

2.4.5 Casing

Casing shall be aluminum. Finish shall be mill finish or factory applied baked enamel, embossed or bronze anodized aluminum. Cover glazing shall be separated from the casing by an EPDM rubber gasket or equivalent material. Allowance shall be made for thermal expansion between the cover and absorber plates and the casing, and for drainage of moisture through weep holes.

2.4.6 Mounting and Assembly Hardware

Mounting brackets and hinges shall be aluminum or stainless steel. Assembly hardware including all bolts, washers, and nuts shall be stainless steel.

2.4.7 Solar Collector Performance

Thermal performance shall be plotted on the thermal efficiency curve in accordance with ASHRAE 93. The y-intercept shall be equal to or greater than 0.68, and the numerical value of the slope of the curve (FRUL) shall be between 0 and minus 1.0 Btu per hour per square foot per degree F. Manufacturer's recommended volumetric flow rate and the design pressure drop at the recommended flow rate shall be as shown. Manufacturer's recommendations shall allow at least seven collectors to be joined per bank while providing for balanced flow and for thermal expansion considerations.

2.5 Solar Collector Array

2.5.1 Net Absorber Area and Array Layout

Array shall consist of an assembly of solar collectors as shown with a minimum total array aperture area of [_____] square feet. Solar collectors shall be assembled as shown in banks of equal number of collectors. Banks shall consist of no less than 4 and no more than 7 collectors each. Collector array shall be oriented so that all collectors face the same direction and are oriented within 20 degrees of true south and with respect to true south as indicated. Collectors arranged in multiple rows shall be spaced so that no shading from other collectors is evident between 1000 hours and 1400 hours solar time on December 21. Minimum spacing between rows shall be as shown.

2.5.2 Piping

The array piping shall include interconnecting piping between solar collectors, and shall be connected in a reverse-return configuration as indicated with approximately equal pipe length for any possible flow path. Flow rate through the collector array shall be as indicated. Automatic pressure relief valves shall be provided in the array piping system as indicated, and shall be adjusted to open when the pressure within the solar array rises above 125 psig. Each collector bank shall be capable of being isolated by valves, and each bank capable of being separated shall have a pressure relief valve installed and shall be capable of being drained. Manually operated air vents shall be located at system high points, and all array piping shall be pitched a minimum of 0.25 inch/foot as shown so that piping can be drained by gravity. Calibrated balancing valves shall be supplied at the outlet of each collector bank as indicated.

2.5.3 Supports for Solar Collector Array

Support structure for collector array shall be aluminum and shall be in accordance with Section [05 50 13 MISCELLANEOUS METAL FABRICATIONS][05 50 14 STRUCTURAL METAL FABRICATIONS]. Support structure shall secure collector array at the tilt angle with respect to horizontal and orientation with respect to true south as shown. Support structure shall withstand static weight of filled collectors and piping, wind, snow, seismic, and other loads as indicated. Seismic details shall [conform to UFC 3-310-04 and Sections 13 48 00 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 13 48 00.00 10 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT] [be as shown on the drawings]. Support structure shall allow access to all equipment for maintenance, repair, and replacement.

2.6 STORAGE TANK

Solar system hot water storage tank shall have a storage volume between

[_____] and [_____] gallons and shall be as shown. Solar system storage tank shall conform to specifications for hot water storage tanks in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Insulation shall be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except that insulation shall have an R value of not less than 30. Tank penetrations shall be designed to allow for connections to copper piping without risk of corrosion due to dissimilar metals, and shall be factory installed as indicated.

2.7 TRANSPORT SUBSYSTEM

2.7.1 Heat Exchanger

The heat exchanger construction and testing shall be in accordance with ASME BPVC SEC VIII D1. Minimum design pressure rating shall be 125 psig. Heat exchanger shall be capable of returning a hot-side exit temperature of [120] [_____] degrees F or less given a hot-side approach temperature of 140 degrees F and a cold-side approach temperature of 100 degrees F. Heat exchanger shall be capable of withstanding temperatures of at least 240 degrees F. Heat exchanger shall be capable of operation at the flow rates as shown.

2.7.1.1 Plate Heat Exchanger

Heat exchanger shall be constructed of multiple plates of 316 stainless steel, titanium, copper, copper-nickel, or brass. Plates shall be frame-mounted, mechanically bonded, welded, or brazed at edges. Plate-type heat exchanger shall be able to be cleaned. Gaskets shall be of EPDM rubber or Viton. All plate heat exchanger characteristics shall be as indicated.

2.7.1.2 Tube-in-Shell Heat Exchanger

Heat exchanger shall be [fixed] [removable] bundle, shell-and-tube type. Shell, tube sheets, and end plates shall be constructed of nonferrous, brass, copper-nickel, or 316 stainless steel. Shell insulation shall be in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS, except that insulation shall have a minimum R value of not less than 12. Tubes shall be seamless copper or copper alloy and shall be mechanically bonded, welded, or brazed to the end tube plates. Tubes shall be straight and supported by tube sheets which maintain the tubes in alignment. [Straight tube heat exchanger shall be arranged for mechanical cleaning.] All tube-in-shell heat exchanger characteristics shall be as indicated.

2.7.2 Pumps

Circulating pumps shall be electrically-driven, single-stage, centrifugal type. The pumps shall be supported [on a concrete foundation] [or] [by the piping on which installed]. The pumps shall have a capacity not less than that indicated and shall be either integrally-mounted with the motor or direct-connected by a flexible-shaft coupling on a cast-iron or steel subbase. The pump shaft shall be constructed of corrosion resistant alloy steel, sleeve bearings and glands of bronze designed to accommodate a mechanical seal. Pumps shall have stainless steel impellers and casings of bronze. The motors shall have sufficient power for the service required, shall be of a type approved by the manufacturer of the pump, shall be suitable for the available electric service and for the heat transfer fluid used, and shall conform to the requirements specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. The motors shall be controlled by suitable switches that can be activated by either the differential temperature controller or by manual override (Hand-Off-Automatic). Each pump suction and discharge connection shall be provided with a pressure gauge as specified.

2.7.3 Pipe Insulation

Pipe insulation and coverings shall be applied in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS as called out for steam piping to 15 psig. Array piping insulation shall be capable of withstanding 250 degrees F, except that piping within 1.5 feet of collector connections shall be capable of withstanding 400 degrees F.

2.7.4 Expansion Tank

Expansion tank shall be constructed and tested in accordance with ASME BPVC SEC VIII D1 and as applicable for a working pressure of 125 psig. Tank shall be provided with an elastomeric EPDM bladder which separates the system fluid from the tank walls and is suitable for a maximum operating temperature of 240 degrees F. Expansion tank acceptance volume shall be a minimum of [_____] gallons as shown. Total tank size and arrangement shall be as shown. Tank shall be provided with 125 psi pressure relief valve. Tank shall be provided with precharge pressure of [_____] psi as shown.

2.7.5 Heat Transfer Fluid

[Solar collector loop fluid shall be uninhibited USP/food-grade propylene-glycol and shall be mixed with distilled or demineralized water to form a [30] [50] percent by volume propylene-glycol solution as shown]. [Solar collector loop fluid shall be potable water.]

2.8 CONTROL AND INSTRUMENTATION SUBSYSTEM

2.8.1 Differential Temperature Control Equipment

Differential temperature control equipment shall be supplied as a system by a single manufacturer. Controller shall be solid-state electronic type complete with an integral transformer to supply low voltage, shall allow a minimum adjustable temperature differential (on) of 8 to 20 degrees F, a minimum adjustable temperature differential (off) of 3 to 5 degrees F, and shall include a switching relay or solid state output device for pump control. Thermostat shall operate in the on-off mode. Controller accuracy shall be plus or minus 1 degree F. Controller shall be compatible with 10-kOhm thermistor temperature sensors. Differential control shall provide direct digital temperature readings of all temperatures sensed. Control shall indicate visually when pumps are energized. Control ambient operating range shall be a minimum of 32 to 120 degrees F.

2.8.2 Thermistor Temperature Sensors

Temperature sensors shall be 10-kOhm thermistors supplied by the differential temperature controller manufacturer, with an accuracy of plus or minus 1 percent at 77 degrees F. Model supplied must have passed an accelerated life test conducted by subjecting thermistor assemblies to a constant temperature of 400 degrees F or greater for a period of 1000 hours minimum. Accuracy shall have remained within plus or minus 1 percent as stated above. Thermistors shall be hermetically sealed glass type. Operating range shall be minus 40 to plus 400 degrees F. Immersion wells or watertight threaded fittings shall be provided for temperature sensors.

2.8.3 Sensor and Control Wiring

18 AWG minimum twisted and shielded 2, 3, or 4 conductor to match analog function hardware. Control wiring shall have 600 volt insulation. Multiconductor wire shall have an outer jacket of PVC.

2.8.4 Flowmeters

Flowmeters shall consist of a venturi, 6 inch dial differential pressure meter, valved pressure taps, and bar stock needle valves. Venturi flow nozzle shall have threaded bronze ends for pipe sizes up to 2 inches and flanged ends for pipe sizes 2-1/2 inches and above. Venturi length shall not be less than 1.6 times the pipe size. Venturi shall be selected to read differential pressure corresponding to 0.5 to 1.5 times the system flow rate. Venturi shall have an accuracy of plus or minus 1 percent of the range. Meter shall have an accuracy of plus or minus 2 percent of the full scale range.

2.8.5 Sight Flow Indicators

Sight flow indicators shall consist of a clear glass window or cylinder and a nonferrous or 316 stainless steel body and impeller. Indicator shall have threaded ends for pipe sizes up to 2 inches and flanged ends for pipe sizes 2-1/2 inches and above. Maximum operating pressure shall be no less than 125 psi. Maximum operating temperature shall be no less than 250 degrees F.

2.9 PAINTING AND FINISHING

Equipment and component items, when fabricated from ferrous metal and located inside the building, shall be factory finished with the manufacturer's standard finish.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming thoroughly familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

3.2.1 Collector Subsystem

3.2.1.1 Collector Array

Solar collector array shall be installed at the tilt angle, orientation, and elevation above roof as indicated. [For installation on flat roofs with rack type collector mounting or for ground mounted collectors, bottom of collector shall be a minimum of 18 inches from roof or ground surface.] [For mounting on pitched roofs, back of collectors shall be installed a minimum of 2 inches above roof surface.] Each solar collector shall be removable for maintenance, repair, or replacement. Solar collector array shall not impose additional loads on the structure beyond the loads scheduled on the structural drawings.

3.2.1.2 Array Piping

Collector array piping shall be installed in a reverse-return configuration so that path lengths of collector supply and return are of approximately equal length. All piping must be coded with fluid type and flow direction labels in accordance with Section 09 90 00 PAINTS AND COATINGS.

3.2.1.3 Array Support

Array support shall be installed in accordance with the recommendations of the collector manufacturer. Structural members requiring welding shall be welded in accordance with AWS D1.2/D1.2M for aluminum and welders should be qualified according to AWS B2.1/B2.1M.

3.2.2 Storage Subsystem

Solar storage tank penetrations shall be installed as shown so that cold water inlet to storage tank and outlet from storage tank to collector array are located near the bottom of the tank, and inlet from collector array and outlet to load are located near the top of the tank.

3.2.3 Transport Subsystem

3.2.3.1 Flow Rates

[Flow rate in the collector loop shall be based on recommended collector flow rate, and shall be as shown. Storage loop flow rate shall be 1.25 times the collector loop flow rate.] [System flow rate shall be based on recommended collector flow rate, and shall be as indicated.] All flow rates shall be below 5 feet/second.

3.2.3.2 Pumps

[Pumps shall be installed on foundations, leveled, grouted, and realigned before operation in accordance with manufacturers instructions.] [Additional pipe supports shall be provided for close-coupled in-line pumps.] [All base mounted pumps shall have a straight pipe between the suction side of the pump and the first elbow. The length of this pipe shall be a minimum of five times the diameter of the pipe on the suction side of the pump, or a suction diffuser of the proper size shall be attached to the suction side of the pump.] [All in-line pumps shall have straight pipe between the suction side of the pump and the first elbow. The length of this pipe shall be a minimum of five times the diameter of the pipe size on the suction side of the pump.] Drain line sizes from the pumps shall not be less than the drain trap or the pump dirt pocket, but in no case shall the drain line be less than 1/2 inch iron pipe size. Drain lines shall terminate to spill over the nearest floor or open sight drain.

3.2.3.3 Expansion Tank

Expansion tank shall be installed on suction side of pump as shown.

3.2.3.4 Piping, Valves, and Accessories

Piping shall be installed in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE, except where noted otherwise. Solders used on piping shall be as shown. Piping shall be coded with fluid type and flow direction labels in accordance with Section 09 90 00 PAINTS AND COATINGS. When a food-grade uninhibited propylene-glycol solution is used to heat potable service water, tamper resistant seals must be attached to all fill ports. All propylene-glycol circuits must be labeled "CONTAINS UNINHIBITED FOOD-GRADE PROPYLENE-GLYCOL: INTRODUCTION OF ANY NONAPPROVED FLUID MAY CONSTITUTE A HEALTH HAZARD." All tamper resistant seals must carry the name of the registered engineer or licensed plumber who certifies that only a [30] [50] percent food-grade uninhibited propylene-glycol and water solution has been installed in the system. Air vents shall be installed at the high points of the collector array and in the equipment room.

3.2.3.5 Pipe Expansion

Expansion of supply and return pipes shall be provided for by changes in the direction of the run of pipe or by expansion loops as indicated. Expansion loops shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. Loops shall be cold-sprung and installed where indicated. Pipe guides shall be provided as indicated. Expansion joints shall not be used in system piping.

3.2.3.6 Valves

Valves shall be installed at the locations indicated and where required for the proper functioning of the system. Valves shall be installed with their stems horizontal or above. Gate or ball valves shall be installed at the inlet and outlet of each bank of internally manifolded collectors. Calibrated balancing valves with integral pressure taps shall be installed at the outlet of each bank and at the pump discharge. Final setting for each valve shall be marked on each valve. Ball valves shall be installed with a union immediately adjacent. Gate valves shall be installed at the inlet and outlet of each pump and also at the inlet and outlet of each heat exchanger. A check valve shall be installed at pump discharges. Discharges of relief valves shall be piped to the nearest floor drain or as indicated on system drawings.

3.2.3.7 Foundations

Concrete foundations or pads for storage tanks, heat exchangers, pumps, and other equipment covered by this specification shall be constructed in accordance with manufacturer's recommendations and be a minimum of 6 inches high with chamfered edges.

3.2.3.8 Grooved Mechanical Joints

Grooves shall be prepared according to the coupling manufacturer's instructions. Grooved fittings, couplings, and grooving tools shall be the products of the same manufacturer. Pipe and groove dimensions shall comply with the tolerances specified by the coupling manufacturer. The diameter of grooves made in the field shall be measured using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer, or other method specifically approved by the coupling manufacturer for the intended application. Grooved width and dimension of groove from end of pipe shall be measured and recorded for each change in grooving tool setup to verify compliance with the coupling manufacturer's tolerances. Grooved joints shall not be used in concealed locations.

3.2.4 Control Subsystem

3.2.4.1 Differential Temperature Controller

Automatic control equipment shall be installed at the location shown in accordance with the manufacturer's instructions. Control wiring and sensor wiring shall be installed in conduit. [Collector temperature sensor shall be mounted in a temperature sensor well in the fluid stream along the top manifold of a bank between two adjacent collector units.] [Collector temperature sensor shall be provided by differential temperature controller manufacturer and mounted directly on the absorber plate by the manufacturer.] Unless otherwise indicated, operators, controllers, sensors, indicators, and like devices when installed on equipment casings and pipe lines shall be provided with stand-off mounting brackets, bases, nipples, adapters, or extended tubes to provide clearance, not less than the thickness of the insulation, between the surface and the device. These stand-off mounting items shall be integral with the devices or standard accessories of the controls manufacturer unless otherwise approved. Clamp-on devices or instruments where direct contact with pipe surface is required shall be exempted from the use of the above mounting items. All control wiring shall be color coded and identified with permanent numeric or alphabetic codes.

3.2.4.2 Sequence of Operation

The differential temperature controller sensing temperature difference between the fluid in a solar collector and water in the storage tank shall start solar collector loop [and storage loop] pumps[s] when the temperature differential (Delta T - ON) rises above [15] [_____] degrees F, and shall stop the pump when the differential (Delta T - OFF) falls below [5] [_____] degrees F.

3.3 INSPECTION AND TESTING

Submit an independent testing agency's certified reports of inspections and laboratory tests, including analysis, position of flow-balancing equipment, and interpretation of test results. Each report shall be properly identified. Describe test methods used and compliance with recognized test standards.

3.3.1 Inspection

Make system available for inspection at all times.

3.3.2 Testing Prior to Concealment

3.3.2.1 Hydrostatic Test

Demonstrate to Contracting Officer that all piping has been hydrostatically tested, at a pressure of 125 psi for a period of time sufficient for inspection of every joint in the system and in no case less than 2 hours, prior to installation of insulation. Expansion tank and relief valves shall be isolated from test pressure. No loss of pressure shall be allowed. Leaks found during tests shall be repaired by replacing pipe or fittings and the system retested. Caulking of joints shall not be permitted.

3.3.2.2 Cleaning of Piping

System piping shall be flushed with clean, fresh water prior to concealment of any individual section and prior to final operating tests. Prior to flushing piping, relief valves shall be isolated or removed. Solar collectors shall be covered to prevent heating of cleaning fluid, unless cleaning is performed during hours of darkness. The solution shall be circulated through the section to be cleaned at the design flow rate for a minimum of 2 hours.

3.3.3 Posting Framed Instructions

Framed instructions under glass or in laminated plastic shall be posted where directed. These instructions shall include a system schematic, and wiring and control diagrams showing the complete layout of the entire system. Condensed operating instructions explaining preventative maintenance procedures, balanced flow rates, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above, and posted beside the diagrams. Proposed diagrams, instructions, and other sheets shall be submitted for approval prior to posting. The framed instructions shall be posted before acceptance testing of the system.

3.3.4 Acceptance Testing and Final Inspection

Notify the Contracting Officer 7 calendar days before the performance and acceptance tests are to be conducted. Tests shall be performed in the presence of the Contracting Officer. Furnish all instruments and personnel required for the tests. Electricity and water will be furnished by the Government. A written record of the results of all acceptance tests shall be maintained, to be submitted in booklet form. The tests shall be as follows:

3.3.4.1 As-Built Drawings

Submit, as a condition of final acceptance, a complete set of as-built system drawings. Drawings shall clearly indicate the actual condition of the installed solar energy system at the time of the final test.

3.3.4.2 Final Hydrostatic Test

Demonstrate to Contracting Officer that all piping has been hydrostatically tested at a pressure of 125 pounds per square inch for a period of time sufficient for inspection of every joint in the system and in no case less than 2 hours. Expansion tank and relief valves shall be isolated from test pressure. Gauges used in the test shall have been calibrated within the 6-month period preceding the test. Test shall be witnessed by Contracting Officer. No loss of pressure shall be allowed. Leaks found during tests shall be repaired by replacing pipe or fittings and the system retested. Caulking of joints shall not be permitted.

3.3.4.3 System Flushing

For the final inspection, the system shall be thoroughly flushed, in no case for less than 2 hours,of all foreign matter until a white linen bag installed in a strainer basket shows no evidence of contamination. The white linen bag shall be in the strainer basket during the entire flushing operation prior to its being presented to the Contracting Officer for approval. The Contracting Officer will inspect the linen bag prior to completion of flushing and approve the flushing operation. System shall be drained prior to final filling.

3.3.4.4 System Filling

System shall be filled through indicated connections with [propylene-glycol solution. Solution shall be mixed externally to the solar system and consist of [30] [50] percent propylene-glycol and [70] [50] percent distilled water by volume] [distilled water]. Air shall be vented from the system after filling. System pressure at the high point on the roof shall be 10 psig minimum.

3.3.4.5 Operational Test

Operational test shall occur over a period of 48 consecutive hours with sufficient solar insulation to cause activation of the solar energy system during daylight hours. With system fully charged so that pressure at the high point on the roof or the lowest system pressure is a minimum of 10 psig and with fluid and pump[s] energized, [sight flow indicator must indicate flow] [flowmeter must indicate flow as indicated]. Calibrated balancing valves with pressure taps shall indicate bank flow rate as shown.

3.3.4.6 Control Logic

By substituting variable resistors for collector and storage tank temperature sensors, demonstrate the differential temperature controller correctly energizes the system pump[s] when the collector sensor indicates a temperature of [15] [_____] degrees F greater than the storage tank temperature, as indicated on the controller display panel. The differential temperature controller shall de-energize the system pump[s] when the displayed temperature of the solar collectors is [5] [_____] degrees F greater than the displayed temperature of the storage tank.

3.3.4.7 Temperature Sensor Diagnostics

Demonstrate that the controller will correctly identify open and short circuits on both the solar collector temperature sensor circuit and the storage tank sensor circuit.

3.3.4.8 Overall System Operations

Demonstrate that the solar energy system will operate properly while unattended for a period of at least 72 hours and that the controller will start pump[s] after being warmed by the sun, and that it will properly shut down during cloudy weather or in the evening over a minimum of three complete cycles. Contractor is permitted to manipulate the temperature of the storage tank by the introduction of cold water at local groundwater temperature.

3.4 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members. Training shall be provided for a minimum period of [_____] hours of normal working time and shall start after the system is functionally complete but prior to final acceptance tests. The training shall include discussion of the system design and layout and demonstrations of routine operation and maintenance procedures. This training shall include: normal system operation and control; flow balancing; detection of a nonfunctioning system due to sensor, controller, and/or mechanical failure; filling, draining, and venting of the collector array; replacement of sensors, collectors, and collector components; collector cleaning and inspection for leaks; and heat exchanger cleaning and expansion tank charging if applicable. Submit [6] [_____] copies of operation and [6] [_____] copies of maintenance manuals for the equipment furnished. One complete set prior to performance testing and the remainder upon acceptance. Manuals shall be approved prior to the field training course.

Operating manuals shall detail the step-by-step procedures required for system filling, startup, operation, and shutdown. Operating manuals shall include the manufacturer's name, model number, service manual, parts list, and brief descriptions of all equipment and their basic operating features. Maintenance manuals shall list routine maintenance procedures, possible breakdowns and repairs, troubleshooting guides, piping and equipment layout, balanced fluid flow rates, and simplified wiring and control diagrams of the system as installed.

-- End of Section --

SECTION 22 33 30.05 22

INTEGRATED SOLAR WATER HEATING EQUIPMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE 93	(2010; Errata 2013l Errata 2014) Methods of Testing to Determine the Thermal Performance of Solar Collectors
ASHRAE 96	(1980; R 1989) Methods of Testing to Determine the Thermal Performance of Unglazed Flat-Plate Liquid-Type Solar Collectors

AMERICAN WELDING SOCIETY (AWS)

AWS A5.8/A5.8M	(2011; Amendment 2012) Specification for Filler Metals for Brazing and Braze Welding

ASME INTERNATIONAL (ASME)

ASME A13.1	(2007; R 2013) Scheme for the Identification of Piping Systems
ASME B16.39	(2009) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2014; INT 1-47) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC VIII D1	(2010) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

ASTM INTERNATIONAL (ASTM)

ASTM A193/A193M	(2014) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications

ASTM A194/A194M	(2014) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
ASTM A216/A216M	(2014) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
ASTM A351/A351M	(2014) Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM B32	(2008) Standard Specification for Solder Metal
ASTM B763/B763M	(2014) Standard Specification for Copper Alloy Sand Castings for Valve Application
ASTM B88	(2009) Standard Specification for Seamless Copper Water Tube
ASTM F1199	(1988; R 2010) Cast (All Temperatures and Pressures) and Welded Pipe Line Strainers (150 psig and 150 degrees F Maximum)
ASTM F876	(2013a) Crosslinked Polyethylene (PEX) Tubing
ASTM F877	(2011a) Crosslinked Polyethylene (PEX) Plastic Hot- and Cold-Water Distribution Systems

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-110	(2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
MSS SP-25	(2013) Standard Marking System for Valves, Fittings, Flanges and Unions
MSS SP-58	(2009) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-69	(2003; Notice 2012) Pipe Hangers and Supports - Selection and Application (ANSI Approved American National Standard)

SOLAR RATING AND CERTIFICATION CORPORATION (SRCC)

SRCC CSCWHSR	(ongoing online) SRCC Ratings Pages (http://www.solar-rating.org/ratings/index.html)
SRCC OG-100	(1995) Operating Guidelines for Certifying Solar Collectors

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-59617	(Basic) Unions, Brass or Bronze, Threaded Pipe Connections and Solder-Joint Tube Connections

1.2 SYSTEM DESCRIPTION

Provide a solar energy collecting system arranged for preheating of service (domestic and/or process) water using solar collectors hidden from view, mounted beneath the standing seam roof. Include in the system components a solar collector array, storage tanks, pumps, automatic controls, instrumentation, interconnecting piping and fittings, USP/food-grade propylene-glycol and water heat transfer fluid in a closed loop, heat exchanger, expansion tank, and accessories required for the operation of the system. The system must not add to wind profile and the total weight must not exceed five (5) pounds per square foot.

1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES Section 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Solar energy collecting system[; G]

As-Built Drawings[; G]

Include collector structural supports, solar collector control sequences, and instrument mounting and interconnections.

SD-03 Product Data

Piping[; G]

Instrumentation[; G]

Valves[; G]

Piping specialties[; G]

Pumps[; G]

Solar hot water storage tanks[; G]

Solar collectors[; G]

Heat exchangers[; G]

Solar-boosted domestic water heaters[; G]

Collector heat transfer fluid[; G]

SD-06 Test Reports

Inspection and Testing[; G]

Submit a factory holiday test certificate for all required system equipment and instrument.

SD-07 Certificates

Solar energy collecting system installation[; G]

Submit technical representative's certification that the solar energy system installation has been done as recommended by the manufacturer.

SD-08 Manufacturer's Instructions

Solar energy collecting system[; G]

SD-10 Operation and Maintenance Data

Solar energy collecting system, Data Package 5[; G]

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

SD-11 Closeout Submittals

Posted operating instructions for solar energy system[; G]

1.4 QUALITY ASSURANCE

For brazing and soldering procedure qualification, conform to ASME B31.1; for preparation and procedures for joints, conform to ASME B31.1.

1.4.1 Operation and Maintenance Data

Submit solar energy collecting system data package for the following items in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA Section 01 78 24.05 20 FACILITY OPERATION AND MAINTENANCE SUPPORT INFORMATION.

a. Troubleshooting guide for solar energy systems

b. Solar collector warranty

c. Operation instructions

d. Preventive maintenance and inspection data, including a schedule for system operators.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, excessive humidity and excessive temperature variation, and dirt and dust or other contaminants.

1.6 SOLAR COLLECTOR SYSTEM WARRANTY

Provide a minimum 25-year warranty against defects in materials and workmanship.

1.7 POSTED OPERATING INSTRUCTIONS

Provide for piping identification codes and diagrams of solar energy systems, operating instructions, control matrix, and trouble shooting instructions.

PART 2 PRODUCTS

2.1 SOLAR ENERGY COLLECTING SYSTEM

Provide the necessary materials to fabricate solar energy collecting systems in accordance with this section. At the Contractor's option, provide factory-prefabricated solar equipment packages which include heat exchanger, storage tanks, pumps and controls and which meet the requirements of this section. The solar energy collecting system shall be valved to provide for shut-off from the service water supply without interrupting normal cold water service to the residence.

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 PIPING SYSTEM

Piping system shall be complete with pipe, pipe fittings, valves, hangers, inserts, supports, anchors, guides, sleeves, and accessories. System materials shall conform to manufacturer's requirements. The piping from the manifold to hot water heaters will be cooper.

2.1.2.1 PEX-AL-PEX Piping

Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) piping used for collector array. Piping and fittings shall conform to ASTM F876 and ASTM F877. Make all mechanical joints visible.

2.1.2.2 Copper Tubing

ASTM B88, minimum Type L, hard drawn copper tubing, except that the connection tubes of collectors may be soft-drawn. Make all mechanical joints visible.

2.1.2.3 Hangers and Supports

MSS SP-58, as required by MSS SP-69.

2.1.2.4 Unions

CID A-A-59617, solder joint.

2.1.2.5 Strainers

ASTM F1199, removable basket and screen, Y pattern, cast bronze strainer with pressures to 125 psig, simplex type; or a combination elbow-strainer with straightening vanes and strainer arranged for horizontal flow.

2.1.2.6 Pressure Gauges

ASME B40.100. Pressure gauges shall be provided with throttling type needle valve or a pulsation dampener and shutoff valve. Minimum dial size shall be 3-1/2 inch.

2.1.2.7 Thermostats

The system shall include temperature gauges so that an observer can determine if the system is operating properly and is providing solar heated water.

2.1.2.8 Dielectric Union

Provide insulated union with a galvanized steel female pipe-threaded end and a copper solder joint end conforming to ASME B16.39, Class 1. Provide a dry insulation barrier, impervious to water and capable of withstanding a 600 volt breakdown test and limiting galvanic current to one percent of the short circuit current in a corresponding bimetallic joint.

2.1.2.9 VALVES

Ensure all valves comply with solar energy collecting system manufacturer and solar energy collecting system requirements. ASTM B763/B763M for brass valves and ASTM A216/A216M or ASTM A351/A351M. Provide end connections as indicated. Unless otherwise indicated, valves shall open when turned counterclockwise. In some cases, provide valves actuated by electric motors. Provide valve construction with rating indicated, MSS SP-25 marking modulating, brass or steel body construction, provide nonferrous or stainless steel valve seats and moving parts exposed to fluid, compatible with the operating conditions, and thermostatically controlled. Construct valves to permit replacing valve seals without draining the system. MSS SP-110 for threaded, socket-welding, solder joint, grooved and flanged ends.

2.2 PIPING SPECIALTIES

2.2.1 Bolts and Nuts

Stainless steel; ASTM A193/A193M for bolts and ASTM A194/A194M for nuts.

2.2.2 Gaskets, Sealants and Couplings

Use fluorinated elastomers, ethylene-propylene-diene-terpolymer (EPDM) or silicone gaskets for system compatibility. Gaskets, sealants, and coupling hoses shall not be adversely affected by contact with fluids or the environment to an extent that will significantly impair their ability to function.

2.2.3 Brazing Metal

AWS A5.8/A5.8M, 15 percent silver-base alloy, minimum melting point 1,500 degrees F, for copper pipes rated at maximum 125 psi and 350 degrees F. Provide cadmium free filler metals.

2.2.4 Solder Metal

ASTM B32, Alloy Grade Sb5, Sn95, or Sn96, with minimum melting 430 degrees F.

2.2.5 Piping Identification Labels

Plastic slip-on or adhesive backed labels conforming to ASME A13.1.

2.3 CIRCULATING PUMPS

A variable or multiple speed AC or DC pump as designed and furnished by the manufacturer as part of the balance of system. The motors shall have sufficient power for the service required and be suitable for the available electric service and for the heat transfer fluid used, and shall conform to the requirements specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Circulating pumps shall be electrically-driven, single-stage, centrifugal type. The pumps shall be supported on a concrete foundation. The pumps shall have a capacity not less than that indicated. The pump shaft shall be constructed of corrosion resistant alloy steel, sleeve bearings and glands of bronze designed to accommodate a mechanical seal. Pumps shall have stainless steel impellers and casings of bronze. The motors shall be controlled by suitable switches that can be activated by either the differential temperature controller or by manual override (Hand-Off-Automatic). Each pump suction and discharge connection shall be provided with a pressure gauge as specified.

2.4 SOLAR HOT WATER STORAGE TANKS

The solar hot water tanks shall be sized to accommodate the thermal systems output and furnished by the manufacturer as part of the balance of system. The two ([__]) solar system hot water storage tank shall have a storage volume of [_____] gallons and shall be as shown. Solar system storage tank shall conform to specifications for hot water storage tanks in Section 22 00 00 PLUMBING, GENERAL PURPOSE. Tank penetrations shall be designed to allow for connections to copper piping without risk of corrosion due to dissimilar metals, and shall be factory installed as indicated.

2.4.1 Tank Insulations and Jackets

Comply with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Separate aboveground tanks from supports with insulation.

2.4.2 Mounting and Assembly Hardware

Mounting brackets and hinges shall be aluminum or stainless steel. Assembly hardware including all bolts, washers, and nuts shall be stainless steel.

2.5 SOLAR COLLECTORS

Site built collectors shall be designed to occupy a one (1) inch of space between the waterproof roofing underlayment and the roofing material. The collector will allow fastening of the roofing material directly to the roof deck. Collector should comply to ASHRAE 93, ASHRAE 96, SRCC OG-100 and SRCC CSCWHSR. Supply with all materials necessary for integration into building's envelope. Include the following design features:

2.5.1 SOLAR COLLECTOR PERFORMANCE

Thermal performance shall be plotted on the thermal efficiency curve in accordance with ASHRAE 93. Manufacturer's recommended volumetric flow rate and the design pressure drop at the recommended flow rate shall be as shown. Manufacturer's recommendations shall allow for balanced flow and for thermal expansion considerations.

2.5.2 Collector Sizes

Maximum filled weight not to exceed 5 pounds per square foot of gross collector area.

2.5.3 Array Layout

Array shall consist of an assembly of solar collectors as shown. Solar collectors shall be assembled as shown. Minimum spacing between rows shall be as shown.

2.5.4 Array Piping

The array piping shall include interconnecting piping and manifolds between solar collectors, and shall be connected in a configuration as indicated with approximately equal pipe length for any possible flow path. Flow rate through the collector array shall be as indicated. Each collector bank shall be capable of being isolated by valves. Manually operated air vents shall be located at system high points.

2.6 Supports for Solar Collector Array

Array support shall be provided by a pre-engineered sub purlin system on a properly prepared metal roof and installed in accordance with the recommendations of the collector manufacturer. Support structures provided by the collector manufacturer may be used if they meet the stated specification. Support structure shall secure collector array at roof pitch angle with respect to horizontal and orientation with respect to true south as shown. Support structure shall withstand static weight of filled collectors and piping, wind, snow, seismic, and other loads as indicated. Seismic details shall be as shown on the drawings. Support structure shall allow access to all equipment for maintenance, repair, and replacement.

2.7 HEAT EXCHANGERS

The heat exchanger construction and testing shall be in accordance with ASME BPVC SEC VIII D1. Minimum design pressure rating shall be as shown. Provide relief vent with a visual indicator to detect leaks by the change of coloring in the heat transfer fluid.

2.8 SOLAR-BOOSTED DOMESTIC WATER HEATERS

ASHRAE 90.1 - IP and UL listed. Provide built-in, double wall heat exchanger and factory insulation jacket.

2.9 PIPE INSULATION

Pipe insulation and coverings shall be applied in accordance with Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS as called out for steam piping to 15 psig. Array piping insulation shall be capable of withstanding 250 degrees F, except that piping within 1.5 feet of collector connections shall be capable of withstanding 360 degrees F.

2.10 EXPANSION TANK

Expansion tank, fill and drain assemblies, mechanical thermostats, air scoops and vents in compliance with best practices as described by solar energy collecting system manufacturer. Expansion tank shall be constructed and tested in accordance with ASME BPVC SEC VIII D1 and as applicable for a working pressure of 125 psig. Expansion tank acceptance volume, total tank size and arrangement shall be as shown. Tank shall be provided with pressure relief valve. Tank shall be provided with precharged pressure as shown.

2.11 HEAT TRANSFER FLUID

Solar collector loop fluid shall be uninhibited USP/food-grade propylene-glycol and shall be mixed with distilled or demineralized water to form a 50 percent by volume propylene-glycol solution as shown.

Conform to the following:

a. Liquid useful temperature range of -40 to 400 degrees F.

b. Non-ionic, high dielectric, non-aqueous, non-reactive, stable fluid which does not corrode copper, aluminum, iron, or steel, or attack plastics.

c. Flash point exceeding 380 degrees F.

d. Fluid stability of ten years.

e. Maximum acute oral toxicity of 5000 ppm.

2.12 CONTROL AND INSTRUMENTATION SUBSYSTEM

2.12.1 Solar Differential Control Equipment

A differential controller will operate the solar circulator based on a difference in temperature between the roof collector and the bottom of the solar storage tank. This temperature differential will be adjustable in the field. This unit will be furnished by the manufacturer as part of the balance of system and include an Energy Monitoring System. Differential temperature control equipment shall include a switching relay or solid state output device for pump control. Thermostat shall operate in the on-off mode. Controller accuracy shall be plus or minus 1 degree F. Controller shall be compatible with manufacturer supplied thermistor temperature sensors. Differential control shall provide direct digital temperature readings of all temperatures sensed. Control shall indicate visually when pumps are energized. Control ambient operating range shall be indicated by solar energy collecting system manufacturer.

2.12.2 Solar Energy Monitoring System

The solar energy monitoring system consist of a large graphic display with backlight that accommodates several languages, temperature sensors, variable speed pump control, manual test mode, easy to use interface with 1 GB SD card permanent memory storage. The system will record and view system data for energy, pump operation etc., with SD card interface. The system also provides a graphic view for 5 system configurations with extra functions, 2 Pump outputs, 2 Analog sensor inputs for flow and pressure, 1 Impulse flow meter input, pump exercise function. System capabilities include monitoring for errors such as short or open circuits to sensors, pump failure. Collector sensor location can be external or internal to collector.

2.13.3 Sensor and Control Wiring

Install in accordance with manufacturer's instructions, and applicable electrical and plumbing code standards. The control subsystem shall include such provision for bypass, adjustment or override controls as are required to facilitate installation, startup, operation, shutdown and maintenance of the system. Safety controls shall not have provision for bypass or override. All switches and their function shall be labeled and easily accessible.

2.12.3 Thermistor Temperature Sensors

Temperature sensors shall be multiple 1k type thermistor's units supplied by the differential temperature controller manufacturer, with an accuracy of plus or minus 1 percent at indicated temperature. Quantities will vary as a function of overall size.

2.13 MANIFOLD

Provide supply and return manifold sets as part of each solar energy collecting system. Manifold seta may include actuators, balancing valves, flow rate indicators, pressure test assembly and other related accessories. Check and balance flow rates as needed. Verify that the manifold is mounted properly and fasteners are tight.

2.14 PAINTING AND FINISHING

Equipment and component items, when fabricated from ferrous metal and located inside the building, shall be factory finished with the manufacturer's standard finish.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming thoroughly familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

3.2 INSTALLATION

3.2.1 Collector Subsystem

Collectors, tanks, pumps, valves, heat exchangers, piping, hoses and other components shall be capable of operating within design pressure and temperature ranges and withstanding environmental extremes anticipated in actual service without significantly reducing system design life. A rating for 180° F at 100 psi should be sufficient for all components located beneath the roof collector area.

3.2.1.1 Collector Array

Solar collector array shall be installed in accordance to the manufacturer's specifications. For mounting on pitched roofs, back of collectors shall be installed at 1 inches above roof surface. Each solar collector shall be removable for maintenance, repair, or replacement. Solar collector array shall not impose additional loads on the structure beyond the loads scheduled on the structural drawings.

3.2.1.2 Array Piping

Collector array piping shall be installed in a reverse-return configuration so that path lengths of collector supply and return are of approximately equal length. All piping must be coded with fluid type and flow direction labels in accordance with Section 09 90 00 PAINTS AND COATINGS.

3.2.1.3 Array Support

Array support shall be provided by a pre-engineered sub purlin system on a properly prepared metal roof and installed in accordance with the recommendations of the collector manufacturer.

3.2.2 Storage Subsystem

Solar storage tank penetrations shall be installed as shown so that cold water inlet to storage tank and outlet from storage tank to collector array are located near the bottom of the tank, and inlet from collector array and outlet to load are located near the top of the tank.

3.2.3 Transport Subsystem

3.2.3.1 Flow Rates

Flowmeters will be used for displaying and setting flow rate. System flow rate shall be based on recommended collector flow rate, and shall be as indicated. All flow rates shall be below 5 feet/second.

3.2.3.2 Pumps

Pumps shall be installed on foundations, leveled, grouted, and realigned before operation in accordance with solar energy collecting system manufacturer instructions. Additional pipe supports shall be provided as indicated. Drain line sizes from the pumps shall not be less than the drain trap or the pump dirt pocket, but in no case shall the drain line be less than 1/2 inch iron pipe size. Drain lines shall terminate to spill over the nearest floor or open sight drain.

3.2.3.3 Expansion Tank

Expansion tank shall be installed on suction side of pump as shown.

3.2.3.4 Piping, Valves, and Accessories

Piping shall be installed in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE, except where noted otherwise. Solders used on piping shall be as shown. Piping shall be coded with fluid type and flow direction labels in accordance with Section 09 90 00 PAINTS AND COATINGS. When a food-grade uninhibited propylene-glycol solution is used to heat potable service water, tamper resistant seals must be attached to all fill ports. All propylene-glycol circuits must be labeled "CONTAINS UNINHIBITED FOOD-GRADE PROPYLENE-GLYCOL: INTRODUCTION OF ANY NONAPPROVED FLUID MAY CONSTITUTE A HEALTH HAZARD." All tamper resistant seals must carry the name of the registered engineer or licensed plumber who certifies that only a 50 percent food-grade uninhibited propylene-glycol and water solution has been installed in the system. Air vents shall be installed at the high points of the collector array and in the equipment room.

3.2.3.5 Pipe Expansion

Expansion of supply and return pipes shall be provided for by changes in the direction of the run of pipe or by expansion loops as indicated. Expansion loops shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. Pipe guides shall be provided as indicated. Expansion joints shall not be used in system piping.

3.2.3.6 Valves

Valves shall be installed at the locations indicated and where required for the proper functioning of the system. Valves shall be installed with their stems horizontal or above. Ball valves shall be installed in flow and return in combination with check valves to prevent gravity and thermo circulation. Safety relief valves will be used to prevent over pressure.

3.2.3.7 Foundations

Concrete foundations or pads for storage tanks, heat exchangers, pumps, and other equipment covered by this specification shall be constructed in accordance with manufacturer's recommendations and be a minimum of 6 inches high with chamfered edges.

3.2.4 Control Subsystem

3.2.4.1 Differential Temperature Controller

Automatic control equipment shall be installed at the location shown in accordance with the solar energy collecting system manufacturer instructions. Control wiring and sensor wiring shall be installed in conduit. Unless otherwise indicated, operators, controllers, sensors, indicators, and like devices when installed on equipment casings and pipe lines shall be provided with stand-off mounting brackets, bases, nipples, adapters, or extended tubes to provide clearance, not less than the thickness of the insulation, between the surface and the device. These stand-off mounting items shall be integral with the devices or standard accessories of the controls manufacturer unless otherwise approved. Clamp-on devices or instruments where direct contact with pipe surface is required shall be exempted from the use of the above mounting items. All control wiring shall be color coded and identified with permanent numeric or alphabetic codes.

3.2.4.2 Sequence of Operation

The differential temperature controller sensing temperature difference between the fluid in a solar collector and water in the storage tank shall start and stop solar collector loop and storage loop pumps when the temperature differential (Delta T - ON) rises above manufacturer temperature specified.

3.3 INSPECTION AND TESTING

3.3.1 Inspection

Make system available for inspection at all times.

3.3.2 Testing Prior to Concealment

3.3.2.1 Hydrostatic Test

Demonstrate to Contracting Officer that all piping has been hydrostatically tested, at a pressure of indicated by solar energy collecting system manufacturer for a period of time sufficient for inspection of every joint in the system and in no case less than 2 hours, prior to installation of insulation. Expansion tank and relief valves shall be isolated from test pressure. No loss of pressure shall be allowed. Leaks found during tests shall be repaired by replacing pipe or fittings and the system retested. Caulking of joints shall not be permitted.

3.3.2.2 Cleaning of Piping

System piping shall be flushed with clean, fresh water prior to concealment of any individual section and prior to final operating tests. Prior to flushing piping, relief valves shall be isolated or removed. Solar collectors shall be covered to prevent heating of cleaning fluid, unless cleaning is performed during hours of darkness. The solution shall be circulated through the section to be cleaned at the design flow rate for a minimum of 2 hours.

3.3.3 Posting Framed Instructions

Framed instructions under glass or in laminated plastic shall be posted where directed. These instructions shall include a system schematic, and wiring and control diagrams showing the complete layout of the entire system. Condensed operating instructions explaining preventative maintenance procedures, balanced flow rates, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed as specified above, and posted beside the diagrams. Proposed diagrams, instructions, and other sheets shall be submitted for approval prior to posting. The framed instructions shall be posted before acceptance testing of the system.

3.3.4 Acceptance Testing and Final Inspection

Notify the Contracting Officer 7 calendar days before the performance and acceptance tests are to be conducted. Tests shall be performed in the presence of the Contracting Officer. Furnish all instruments and personnel required for the tests. Electricity and water will be furnished by the Government. A written record of the results of all acceptance tests shall be maintained, to be submitted in booklet form. The tests shall be as follows:

3.3.4.1 As-Built Drawings

Provide as a condition of final acceptance a complete set of as-built system drawings. Drawings shall clearly indicate the actual condition of the installed solar energy system at the time of the final test.

3.3.4.2 Final Hydrostatic Test

Demonstrate to Contracting Officer that all piping has been hydrostatically tested at a pressure indicated by manufacturer for a period of time sufficient for inspection of every joint in the system and in no case less than 2 hours. Expansion tank and relief valves shall be isolated from test pressure. Gauges used in the test shall have been calibrated within the 6-month period preceding the test. Test shall be witnessed by Contracting Officer. No loss of pressure shall be allowed. Leaks found during tests shall be repaired by replacing pipe or fittings and the system retested. Caulking of joints shall not be permitted.

3.3.4.3 System Flushing

For the final inspection, the system shall be thoroughly flushed, in no case for less than 2 hours, of all foreign matter until a white linen bag installed in a strainer basket shows no evidence of contamination. The white linen bag shall be in the strainer basket during the entire flushing operation prior to its being presented to the Contracting Officer for approval. The Contracting Officer will inspect the linen bag prior to completion of flushing and approve the flushing operation. System shall be drained prior to final filling.

3.3.4.4 System Filling

System shall be filled through indicated connections with propylene-glycol solution. Solution shall be mixed externally to the solar system and consist of 50 percent propylene-glycol and 50 percent distilled water by volume. Air shall be vented from the system after filling. System pressure at the high point on the roof shall be as indicated by solar energy collecting system manufacturer.

3.3.4.5 Operational Test

Operational test shall occur over a period of 48 consecutive hours with sufficient solar isolation to cause activation of the solar energy system during daylight hours. With system fully charged so that pressure at the high point on the roof or the lowest system pressure set by manufacturer and with fluid and pumps energized, flowmeter must indicate flow. Calibrated balancing valves with pressure taps shall indicate bank flow rate as shown.

3.3.4.6 Control Logic

By substituting variable resistors for collector and storage tank temperature sensors, demonstrate the differential temperature controller correctly energizes the system pumps when the collector sensor indicates a temperature indicated on the controller display panel. The differential temperature controller shall de-energize the system pumps when the displayed temperature of the solar collectors reaches the displayed temperature of the storage tank.

3.3.4.7 Temperature Sensor Diagnostics

Demonstrate that the controller will correctly identify open and short circuits on both the solar collector temperature sensor circuit and the storage tank sensor circuit.

3.3.4.8 Overall System Operations

Demonstrate that the solar energy system will operate properly while unattended for a period of at least 72 hours and that the controller will start pumps after being warmed by the sun, and that it will properly shut down during cloudy weather or in the evening over a minimum of three complete cycles. Contractor is permitted to manipulate the temperature of the storage tank by the introduction of cold water at local groundwater temperature.

3.4 FIELD TRAINING

Provide a field training course for designated operating and maintenance staff members. The training period shall consist of a total [___] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests. Training shall be provided in accordance with solar energy collecting system manufacturer's requirements and shall start after the system is functionally complete but prior to final acceptance tests. The training shall include discussion of the system design and layout and demonstrations of routine operation and maintenance data and procedures. This training shall include: normal system operation and control; flow balancing; detection of a nonfunctioning system due to sensor, controller, and/or mechanical failure; filling, draining, and venting of the collector array; replacement of sensors, collectors, and collector components; collector cleaning and inspection for leaks; and heat exchanger cleaning and expansion tank charging if applicable.

-- End of Section --

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This specification section applies to MCB Camp Lejeune and MCAS New River projects only.
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SECTION 23 09 23.13 22

BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL (AMCA)

AMCA 500-D	(2012) Laboratory Methods of Testing Dampers for Rating

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 135	(2012; Errata 1 2013; INT 1-9 2013; Errata 2 2013; INT 10-12 2014; Errata 3 2014) BACnet—A Data Communication Protocol for Building Automation and Control Networks

ASME INTERNATIONAL (ASME)

ASME B16.34	(2013) Valves - Flanged, Threaded and Welding End
ASME B16.5	(2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B31.1	(2014; INT 1-47) Power Piping

ASTM INTERNATIONAL (ASTM)

ASTM A126	(2004; R 2014) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.45	(2002; R 2008) Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000v and less)AC Power Circuits

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 8802-3	(2000) Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD)Access Method and Physical Layer Specifications

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code
NFPA 72	(2013) National Fire Alarm and Signaling Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition

UNDERWRITERS LABORATORIES (UL)

UL 1449	(2014) Surge Protective Devices
UL 506	(2008; Reprint Oct 2013) Specialty Transformers
UL 508A	(2013; Reprint Jan 2014) Industrial Control Panels
UL 916	(2007; Reprint Aug 2014) Standard for Energy Management Equipment

1.2 DEFINITIONS

1.2.1 ANSI/ASHRAE Standard 135

ANSI/ASHRAE Standard 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks, referred to as "BACnet". ASHRAE developed BACnet to provide a method for diverse building automation devices to communicate and share data over a network.

1.2.2 BACnet

Building Automation and Control Network; the common name for the communication standard ASHRAE 135. The standard defines methods and protocol for cooperating building automation devices to communicate over a variety of LAN technologies.

1.2.3 BACnet/IP

An extension of BACnet, Annex J, defines this mechanism using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number. See also "BACnet Broadcast Management Device".

1.2.4 BACnet Internetwork

Two or more BACnet networks, possibly using different LAN technologies, connected with routers. In a BACnet internetwork, there exists only one message path between devices.

1.2.5 BACnet Network

One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.

1.2.6 BACnet Segment

One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.

1.2.7 BBMD

BACnet Broadcast Management Device (BBMD). A communications device, typically combined with a BACnet router. A BBMD forwards BACnet broadcast messages to BACnet/IP devices and other BBMDs connected to the same BACnet/IP network. Every IP subnetwork that is part of a BACnet/IP network must have only one BBMD. See also "BACnet/IP".

1.2.8 BAS

Building Automation Systems, including DDC (Direct Digital Controls) used for facility automation and energy management.

1.2.9 BIBBs

BACnet Interoperability Building Blocks. A collection of BACnet services used to describe supported tasks. BIBBs are often described in terms of "A" (client) and "B" (server) devices. The “A” device uses data provided by the "B" device, or requests an action from the “B” device.

1.2.10 BI

BACnet International, formerly two organizations: the BACnet Manufacturers Association (BMA) and the BACnet Interest Group - North America (BIG-NA).

1.2.11 BI/BTL

BACnet International/BACnet Testing Laboratories (Formerly BMA/BTL). The organization responsible for testing products for compliance with the

BACnet standard, operated under the direction of BACnet International.

1.2.12 Bridge

Network hardware that connects two or more network (or BACnet internetwork) segments at the physical and data link layers. A bridge may also filter messages.

1.2.13 Broadcast

A message sent to all devices on a network segment.

1.2.14 DADMS

DON Application and Database Management System, (DADMS) is a listing of digital applications approved for purchase and use.

1.2.15 Device

Any control system component, usually a digital controller, that contains a BACnet Device Object and uses BACnet to communicate with other devices. See also "Digital Controller".

1.2.16 Device Object

Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.

1.2.17 Device Profile

A collection of BIBBs determining minimum BACnet capabilities of a device, defined in ASHRAE 135, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing BIBBs supported and must be tested and listed by BACnet Testing Laboratory (BTL).

1.2.18 Digital Controller

An electronic controller, usually with internal programming logic and digital and analog input/output capability, which performs control functions. In most cases, synonymous with a BACnet device described in this specification. See also "Device". There are different levels of controllers, with varying levels or complexity and flexibility.

1.2.18.1 Terminal Device Controllers

Terminal device controllers typically are controllers with less control features, may have integrated actuators, and may be mounted directly on equipment (with enclosures).

1.2.18.2 Field Controllers

Field controllers typically have a greater capability for input/output and customization, do not have integral actuators, are mounted in an enclosure not on the equipment and are used for equipment such as VAV air handlers.

1.2.18.3 Plant Controllers

Plant Controllers are typically used to control various equipment in mechanical rooms such as pumps, heat exchangers, and chillers.

1.2.18.4 Supervisory Controllers

Supervisory Controller is used to coordinate all equipment in a building, input scheduling, and is often used as a connection point for transferring configuration files to the other controllers.

1.2.18.5 Supervisory Building Controller (SBC)

Supervisory Building Controller (SBC) is used to connect the building's DDC system (MS/TP) to Camp Lejeune's EMCS (TC/IP). Depending on approvals and capabilities, the SBC and supervisory controller may be combined into the same piece of hardware.

1.2.19 Direct Digital Control (DDC)

Digital controllers performing control logic. Usually the controller directly senses physical values, makes control decisions with internal programs, and outputs control signals to directly operate switches, valves, dampers, and motor controllers.

1.2.20 DDC System

A distribution network of digital controllers, communication architecture, and user interfaces. A DDC system may include programming, sensors, actuators, switches, relays, factory controls, operator workstations, and various other devices, components, and attributes.

1.2.21 DITSCAP

Department of Defense Information Technology Security Certification and Accreditation Process (DITSCAP). DISCAP and DIACAP are processes that approve IP base equipment that is connected and communicates on the base Ethernet network. All devices using TCP/IP or Ethernet connectivity require prior approval to be listed in the DITSCAP and SSA document.

1.2.22 EMCS

Energy Management & Control System. The EMCS at Camp Lejeune is an enterprise system that actively receives energy and building condition information from multiple sources and provides load shedding, electric metering, alarming, trending, scheduling, set point adjustment and device status of all supervisory building controllers for maintenance personnel. The EMCS receives real time electrical utility pricing data and automatically manages to Camp Lejeune's energy target. The existing Camp Lejeune EMCS is manufactured by Johnson Controls and incorporates the Metasys extended architecture system that communicates over the MRAN.

1.2.23 EMCS Owner

The regional or local user responsible for managing all aspects of the BAS operation, including: network connections, workstation management, submittal review, technical support, control parameters, and daily operation. The BAS

Owner for this project is Utility Monitoring & Control (UMAC) Director

1.2.24 Ethernet

A family of local-area-network technologies providing high-speed networking features over various media. Base Telephone manages all Ethernet connections to the IP networks.

1.2.25 Firmware

Software programmed into read only memory (ROM), flash memory, electrically erasable programmable read only memory (EEPROM), or erasable programmable read only memory (EPROM) chips.

1.2.26 Gateway

Communication hardware connecting two or more different protocols, similar to human language translators. The Gateway translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.

1.2.27 Half Router

A device that participates as one partner in a BACnet point-to-point (PTP) connection. Two half-routers in an active PTP connection combine to form a single router.

1.2.28 Hub

A common connection point for devices on a network.

1.2.29 Internet Protocol (IP, TCP/IP, UDP/IP)

A communication method, the most common use is the World Wide Web. At the lowest level, it is based on Internet Protocol (IP), a method for conveying and routing packets of information over various LAN media. Two common protocols using IP are User Datagram Protocol (UDP) and Transmission Control Protocol (TCP). UDP conveys information to well-known "sockets" without confirmation of receipt. TCP establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

1.2.30 Input/Output (I/O)

Physical inputs and outputs to and from a device, although the term sometimes describes software, or "virtual" I/O. See also "Points".

1.2.31 I/O Expansion Unit

An I/O expansion unit provides additional point capacity to a digital controller.

1.2.32 IP subnet

Internet protocol (IP) identifies individual devices with a 32-bit number divided into four groups from 0 to 255. Devices are often grouped and share some portion of this number. For example, one device has IP address 209.185.47.68 and another device has IP address 209.185.47.82. These two devices share Class C subnet 209.185.47.00

1.2.33 Local-Area Network (LAN)

A communication network that spans a limited geographic area and uses the same basic communication technology throughout.

1.2.34 MAC Address

Media Access Control address. The physical node address that identifies a device on a Local Area Network.

1.2.35 Master-Slave/Token-Passing (MS/TP)

ISO 8802-3. The standard LAN for BACnet. MSTP uses twisted-pair wiring for relatively low speed and low cost communication (up to 4,000 ft at 76.8K bps).

1.2.36 Native BACnet Device

A device that uses BACnet as its primary, if not only, method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.

1.2.37 Network

Communication technology for building network data communications. BACnet approved network types are Point to Point (PTP) Ethernet, and MS/TP. BACnet over Internet Protocol is not an approved method for building level controls.

1.2.38 Network Number

A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.

1.2.39 Object

The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

1.2.40 Object Identifier

An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

1.2.41 Object Properties

Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.

1.2.42 Peer-to-Peer

Peer-to-peer refers to devices where any device can initiate and respond to communication with other devices.

1.2.43 Performance Verification Test (PVT)

The procedure for determining if the installed BAS meets design criteria prior to final acceptance. The PVT is performed after installation, testing, and balancing of mechanical systems. Typically the PVT is performed by the Contractor in the presence of the Government.

1.2.44 PID

Proportional, integral, and derivative control; three parameters used to control modulating equipment to maintain a setpoint. Derivative control is often not required for HVAC systems (leaving "PI" control).

1.2.45 PICS

Protocol Implementation Conformance Statement (PICS), describing the BACnet capabilities of a device. See BACnet, Annex A for the standard format and content of a PICS statement.

1.2.46 Points

Physical and virtual inputs and outputs. See also "Input/Output".

1.2.47 PTP

Point-to-Point protocol connects individual BACnet devices or networks using serial connections.

1.2.48 Repeater

A network component that connects two or more physical segments at the physical layer.

1.2.49 Router

A BACnet router is a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.

1.2.50 Stand-Alone Control

Refers to devices performing equipment-specific and small system control without communication to other devices or computers for physical I/O, excluding outside air and other common shared conditions. Devices are located near controlled equipment, with physical input and output points limited to 64 or less per device, except for complex individual equipment or systems. Failure of any single device will not cause other network devices to fail. BACnet "Smart" actuators (B-SA profile) and sensors (B-SS profile) communicating on a network with a parent device are exempt from stand-alone requirements.

1.2.51 SSAA

System Security Authorization Agreement. The SSAA is a local document authorizing the use of the IP networks on Camp Lejeune.

1.2.52 Supervisory Controller

Supervisory Controller is the upper level controller on the building's MS/TP bus. It provides building wide points, scheduling, and interface with programming tools.

1.2.53 Supervisory Building Controller (SBC)

The Supervisory Building Controller is the point of connection between the Camp Lejeune EMCS network (IP) and the building level control network (MS/TP). The hardware at this location, that provides the connection is referred to as the SBC. Since the EMCS network uses the Marine Air-Ground Task Force Regional Area Network (MRAM) Ethernet network using TCP/IP, any equipment connecting to the Camp Lejeune EMCS must be listed in the approved DITSCAP or DIACAP equipment list and must be Marine Corps DADMS listed and approved.

1.3 [SUBCONTRACTOR SPECIAL REQUIREMENTS

Perform all work in this section in accordance with the paragraph entitled "Subcontractor Special Requirements" in Section 01 30 00 ADMINISTRATIVE REQUIREMENTS. The paragraph specifies that all contract requirements of this section shall be accomplished directly by a first tier subcontractor. No work required shall be accomplished by a second tier subcontractor.]

a. The controls sub-contractor for this project shall be regularly engaged in the design and installation of BACnet DDC systems (for building HVAC systems) similar to the size and scope of this project, shall have been a representative of the proposed control system manufacturer for a minimum of two years, have a staffed office within a 50-mile radius of the project location, and shall have performed design and installation of DDC systems for a minimum of 5 years.

b. The controls sub-contractor shall ensure that their installing electricians have a copy of, read, and understand the mechanical sheets of the contract's design construction drawings, in addition to the control drawings prepared by the sub-contractor. Provide the DDC programming and graphics using Standard English units of measure, not metric.

1.4 BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC DESCRIPTION

a. [Remove existing and] [provide new BACnet] [and] [modify existing] [and merge with existing non-BACnet] [and merge with existing BACnet] DDC systems including associated equipment and accessories.[The existing DDC system is manufactured by [_____].]

b. Provide a networked DDC system for stand alone control in compliance with the latest revision of the ASHRAE 135 BACnet standard. Include all programming, objects, and service required to meet the sequence of control. Provide BACnet communication between the DDC system and the native BACnet devices furnished with HVAC equipment, and plant equipment including boilers, chillers, and variable frequency drives. Devices provided shall be BACnet Testing Laboratories (BTL) product listing certified. Interface the new DDC system with Camp Lejeune's existing EMCS. Provide a Supervisory Building Controller (SBC) that shall communicate with the field DDC controllers via the MS/TP bus using BACnet, and with the EMCS via the Marine Air-Ground Task Force

Regional Area Network (MRAM) Ethernet network using TCP/IP. Provide interface with the existing EMCS including graphic creation, scheduling, alarming, load management scheduling and trending.

c. Authority to Operate/Authority to Connect: Prior approval to communicate on the base MRAN is a requirement on this project. Supervisory Building Controllers (SBC) and any other device communicating on the MRAN without being DADMS listed and approved and approval from the Designated Approving Authority based on DITSCAP or DIACAP efforts will not be permitted.

d. Only technicians authorized by the Camp Lejeune utilities department and factory trained on Metasys extended architecture are approved to add, manage or revise data in the EMCS. Authorization shall require a unique username and password managed by the Utilities Department. All equipment listed as being part of the DDC system shall have a defined energy load value and be entered into the base load rolling program. Graphics, naming, trending and overall user views shall be added to the EMCS. All points added shall be consistent with previously installed buildings.

1.4.1 Design Requirements

1.4.1.1 Control System Drawings Title Sheet

Provide a title sheet for the control system drawing set. Include the project title, project location, contract number, the controls contractor preparing the drawings, an index of the control drawings in the set, and a legend of the symbols and abbreviations used throughout the control system drawings.

1.4.1.2 List of I/O Points

Also known as a Point Schedule, provide for each input and output point physically connected to a digital controller: point name, point description, point type (Analog Output (AO), Analog Input (AI), Binary Output (BO), Binary Input (BI)), point sensor range, point actuator range, point address, BACnet object, associated BIBBS (where applicable), and point connection terminal number. Typical schedules for multiple identical equipment are allowed unless otherwise requested in design or contract criteria. All points shall adhere to the Camp Lejeune standard naming conventions.

1.4.1.3 Control System Components List

Provide a complete list of control system components installed on this project. Include for each controller and device: control system schematic name, control system schematic designation, device description, manufacturer, and manufacturer part number. For sensors, include point name, sensor range, and operating limits. For valves, include body style, Cv, design flow rate, pressure drop, valve characteristic (linear or equal percentage), and pipe connection size. For actuators, include point name, spring or non-spring return, modulating or two-position action, normal (power fail) position, nominal control signal operating range (0-10 volts DC or 4-20 milliamps), and operating limits.

1.4.1.4 Control System Schematics

Provide control system schematics. Typical schematics for multiple identical equipment are allowed unless otherwise requested in design or contract criteria. Include the following:

a. Location of each input and output device

b. Flow diagram for each piece of HVAC equipment

c. Name or symbol for each control system component, such as V-1 for a valve

d. Setpoints, with differential or proportional band values

e. Written sequence of operation for the HVAC equipment

f. Valve and Damper Schedules, with normal (power fail) position

1.4.1.5 HVAC Equipment Electrical Ladder Diagrams

Provide HVAC equipment electrical ladder diagrams. Indicate required electrical interlocks.

1.4.1.6 Component Wiring Diagrams

Provide a wiring diagram for each type of input device and output device. Indicate how each device is wired and powered; showing typical connections at the digital controller and power supply. Show for all field connected devices such as control relays, motor starters, actuators, sensors, and transmitters.

1.4.1.7 Terminal Strip Diagrams

Provide a diagram of each terminal strip. Indicate the terminal strip location, termination numbers, and associated point names.

1.4.1.8 BACnet Communication Architecture Schematic

Provide a schematic showing the project's entire BACnet communication network, including addressing used for LANs, LAN devices including routers and bridges, gateways, controllers, workstations, and field interface devices. If applicable, show connection to existing networks.

1.5 SUBMITTALS

Submit detailed and annotated manufacturer's data, drawings, and specification sheets for each item listed, that clearly show compliance with the project specifications.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control Approval. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Include the following in the project's control system drawing set:

Control system drawings title sheet; G

List of I/O Points; G

Control System Components List; G

Control system schematics; G

HVAC Equipment Electrical Ladder diagrams; G

Component wiring diagrams; G

Terminal strip diagrams; G

BACnet communication architecture schematic; G

SD-03 Product Data

Direct Digital Controllers; G

Include BACnet PICS for each controller/device type, including smart sensors (B-SS) and smart actuators (B-SA).

BACnet Gateways; G

Include BACnet and workstation display information; bi-directional communication ability; compliance with interoperability schedule; expansion capacity; handling of alarms, events, scheduling and trend data; and single device capability (not depending on multiple devices for exchanging information from either side of the gateway).

Notebook Computer; G

Sensors and Input Hardware; G

Output Hardware; G

Surge and transient protection; G

[Duct smoke detectors; G]

[Variable frequency (motor) drives; G]

SD-05 Design Data

Performance Verification Testing Plan; G

Pre-Performance Verification Testing Checklist; G

SD-06 Test Reports

Performance Verification Testing Report; G

SD-07 Certificates

Contractor's Qualifications; G

SD-09 Manufacturer's Field Reports

Pre-PVT Checklist; G

SD-10 Operation and Maintenance Data

Comply with requirements for data packages in Section 01 78 23 OPERATION AND MAINTENANCE DATA and 01 78 24.00 20 FACILITY ELECTRONIC OPERATION AND MAINTENANCE SUPPORT INFORMATION (eOMSI), except as supplemented and modified in this specification.

BACnet Direct Digital Control Systems, Data Package 4; G

Controls System Operators Manuals, Data Package 4; G

VFD Service Manuals, Data Package 4; G

SD-11 Closeout Submittals

DDC Software; G

Training documentation; G

1.6 QUALITY ASSURANCE

1.6.1 Standard Products

Provide material and equipment that are standard manufacturer's products currently in production and supported by a local service organization.

1.6.2 Delivery, Storage, and Handling

Handle, store, and protect equipment and materials to prevent damage before and during installation according to manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6.3 Operating Environment

Protect components from humidity and temperature variation, dust, and contaminants. If components are stored before installation, keep them within the manufacturer's limits.

1.6.4 Finish of New Equipment

New equipment finishing shall be factory provided. Manufacturer's standard factory finishing shall be proven to withstand 125 hours in a salt-spray fog test. Equipment located outdoors shall be proven to withstand 3000 hours in a salt-spray fog test.

Salt-spray fog test shall be according to ASTM B117, with acceptance criteria as follows: immediately after completion of the test, the finish shall show no signs of degradation or loss of adhesion beyond 0.125 inch on either side of the scratch mark.

1.6.5 Verification of Dimensions

The contractor shall verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing work.

1.6.6 Contractor's Qualifications

Submit documentation certifying the controls Contractor performing the work has completed at least three DDC systems installations of a similar design to this project, and programmed similar sequences of operation for at least two years. Submit the name of the technician proposed to make additions/alterations to the EMCS servers. Submit supporting documentation demonstrating their qualifications.

1.6.7 Modification of References

The advisory provisions in ASME B31.1 and NFPA 70 are mandatory. Substitute "shall" for "should" wherever it appears and interpret all references to the "authority having jurisdiction" and "owner" to mean the Contracting Officer.

1.6.8 Project Sequence

The control system work for this project shall proceed in the following order:

a. Submit and receive approval on the Shop Drawings, Product Data, and Certificates specified under the paragraph entitled "SUBMITTALS."

b. Perform the control system installation work, including all field check-outs and tuning.

c. Provide support to TAB personnel as specified under the paragraph "TEST AND BALANCE SUPPORT."

d. Submit and receive approval of the Controls System Operators Manual specified under the paragraph "CONTROLS SYSTEM OPERATORS MANUALS."

e. Submit and receive approval of the Performance Verification Testing Plan and the Pre-PVT Checklist specified under the paragraph "PERFORMANCE VERIFICATION TESTING."

f. Perform the Performance Verification Testing.

g. Submit and receive approval on the PVT Report.

h. Submit and receive approval on the Training Documentation specified under the paragraph "INSTRUCTION TO GOVERNMENT PERSONNEL"[and "VFD Service Support"]. Submit at least 30 days before training.

i. Deliver the final Controls System Operators Manuals[and VFD Service Manuals].

j. Conduct the Phase I Training[and VFD on-site/hands-on training].

k. Conduct the Phase II Training.

l. Submit and receive approval of Closeout Submittals.

PART 2 PRODUCTS

2.1 DDC SYSTEM

Provide a networked DDC system for stand-alone control in compliance with the latest revision of the ASHRAE 135 BACnet standard. Include all programming, objects, and services required to meet the sequence of control. Provide BACnet MSTP communications between the DDC system and native BACnet devices furnished with HVAC equipment, and plant equipment such as boilers, and chillers when provided with BACnet MSTP communications. DDC controllers provided shall be certified in the BACnet Testing Laboratories (BTL) Product Listing. BACnet over IP is not permitted.

2.1.1 Supervisory Building Controller (SBC)

Provide an SBC that communicates between the DDC system and the Camp Lejeune EMCS server. Provide all necessary hardware, drivers, software, material and equipment which shall allow communication and control between the SBC and the field DDC controllers using BACnet on the MS/TP bus. The SBC shall be capable of upload/download to and from the EMCS server. All SBC information shall transfer back to the EMCS system via the Ethernet TCP/IP level 1 network. All IP addresses and network drops shall be furnished by base telephone. Supervisory Building Controllers (SBC) must be listed and approved on the Marine Corps DADMS and listed in the sites DITSCAP SSAA documents. When the SBC is disconnected from the enterprise system for maintenance, access to the SBC shall be via a laptop computer with Internet Explorer and not require any proprietary licensed software or license key.

2.1.2 Direct Digital Controllers

Direct digital controllers shall be UL 916 rated.

2.1.2.1 I/O Point Limitation

The total number of I/O hardware points used by a single stand-alone digital controller, including I/O expansion units, shall not exceed 64. Place I/O expansion units in the same cabinet as the digital controller.

2.1.2.2 Environmental Limits

Controllers shall be suitable for, or placed in protective enclosures suitable for the environment (temperature, humidity, dust, and vibration) where they are located.

2.1.2.3 Stand-Alone Control

Provide stand-alone digital controllers capable of meeting the complete sequence of operation with and without network connectivity (being connected to the EMCS).

2.1.2.4 Internal Clock

Provide internal clocks for all BACnet Building Controllers (B-BC) and BACnet Advanced Application Controllers (B-AAC) using BACnet time synchronization services. Automatically synchronize system clocks daily from an operator-designated controller. The system shall automatically adjust for daylight saving time.

2.1.2.5 Memory

Provide sufficient memory for each controller to support the required control, communication, trends, alarms, and messages. Protect programs residing in memory with EEPROM, flash memory, or by an uninterruptible power source (battery or uninterruptible power supply). The backup power source shall have capacity to maintain the memory during a 72-hour continuous power outage. Rechargeable power sources shall be constantly charged while the controller is operating under normal line power. Batteries shall be replaceable without soldering. Trend and alarm history collected during normal operation shall not be lost during power outages less than 72 hours long.

2.1.2.6 Immunity to Power Fluctuations

Controllers shall operate at 90 percent to 110 percent nominal voltage rating.

2.1.2.7 Transformer

The controller power supply shall be fused or current limiting and rated at 125 percent power consumption.

2.1.2.8 Wiring Terminations

Use screw terminal wiring terminations for all field-installed controllers. Provide field-removable modular terminal strip or a termination card connected by a ribbon cable for all controllers other than terminal units.

2.1.2.9 Input and Output Interface

Provide hard-wired input and output interface for all controllers as follows:

a. Protection: Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with sources up to 24 volts AC or DC for any duration shall cause no controller damage.

b. Binary Inputs: Binary inputs shall monitor two state devices.

c. Pulse Accumulation Inputs: Pulse accumulation inputs shall conform to binary input requirements and accumulate pulses at a resolution suitable to the application.

d. Analog Inputs: Analog inputs shall monitor low-voltage (0-10 VDC), current (4-20 mA), or resistance (thermistor or RTD) signals.

e. Binary Outputs: Binary outputs shall have a toggle switch and send a pulsed 24 VDC low-voltage signal for modulation control, or provide a maintained open-closed position for on-off control. For HVAC equipment and plant controllers, provide for manual overrides, either with three-position (on-off-auto) override switches and status lights, or with an adjacent operator display and interface. Where appropriate, provide a method to select normally open or normally closed operation.

f. Analog Outputs: Analog outputs shall send modulating 0-10 VDC or 4-20 mA signals to control output devices.

g. Tri-State Outputs: Tri-State outputs shall provide three-point floating control of terminal unit electronic actuators.

2.1.2.10 Digital Controller Cabinet

Provide each digital controller as factory mounted or in a factory fabricated cabinet enclosure. Cabinets located indoors shall protect against dust and have a minimum NEMA 1 rating, except where indicated otherwise. Cabinets located outdoors or in damp environments shall protect against all outdoor conditions and have a minimum NEMA 4 rating. Mechanical rooms that contain steam service or equipment are considered damp environments. Outdoor control panels and controllers must be able to withstand extreme ambient conditions, without malfunction or failure, whether or not the controlled equipment is running. If necessary, provide a thermostatically controlled panel heater in freezing locations, and an internal ventilating fan in locations exposed to direct sunlight. Cabinets shall have a hinged lockable door and an offset removable metal back plate, except controllers integral with terminal units, like those mounted on VAV boxes. Provide like-keyed locks for all hinged panels provided and a set of two keys at each panel, with one key inserted in the lock.

2.1.2.11 Main Power Switch and Receptacle

Provide each control cabinet with a main external power on/off switch located inside the cabinet. Also provide each cabinet with a separate 120 VAC duplex receptacle.

2.1.2.12 DSL Modems

DSL modems and Rate Adaptive Asymmetric Digital Subscriber Line (RADSL) modems are provided by the government. Telephone modems are not permitted for any other communication with the DDC system.

2.1.2.13 BACnet Gateways

Provide gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC controlled plant equipment, only when specifically requested and approved by the Government, and shown on the Government approved BACnet Communication Architecture Schematic. Communication shall be MS/TP. Communication using IP is not permitted. Provide with each gateway an interoperability schedule [Use gateway interoperability schedules shown on design drawings or other project documents], showing each point or event on the legacy side that the BACnet "client" will read, and each parameter that the BACnet network will write to. Describe this interoperability in terms of BACnet services, or Interoperability Building Blocks (BIBBS), defined in ASHRAE 135 Annex K. Provide two-year minimum warranty for each gateway, including parts and labor.

The following minimum capabilities are required:

a. Gateways shall be able to read and view all readable object properties listed in the interoperability schedule on the non-BACnet network to the BACnet network and vice versa where applicable.

b. Gateways shall be able to write to all writeable object properties listed in the interoperability schedule on the non-BACnet network from the BACnet network and vice versa where applicable.

c. Gateways shall provide single-pass (only one protocol to BACnet without intermediary protocols) translation from the non-BACnet protocol to BACnet and vice versa.

d. Gateways shall meet the requirements of Data Sharing Read Property (DS-RP-B), Data Sharing Write Property (DS-WP-B), Device Management

Dynamic Device Binding-B (DM-DDB-B), and Device Management Communication Control (DM-DCC-B) BIBBs, in accordance with ASHRAE 135.

e. Gateways shall include all hardware, software, software licenses, and configuration tools for operator-to-gateway communications. Provide backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.1.3 Notebook Computer

Provide a notebook computer, complete with the project's installed DDC software, configuration files and, applications database, to fully troubleshoot and program the project's devices. Provide the notebook computer with ballistic nylon carrying case with shoulder strap with all necessary cables and interface hardware needed for setup and communication with the controllers and control system components.

At a minimum the notebook computer shall include: Common Access Card reader, a Microsoft Windows 7 operating system, processor with capability and speed required by application software, 40 giga-byte hard drive, 512 mega-byte RAM, 2 USB 2.0 ports, 10/100 network interface card, internal V.92 modem, 15-inch display, keyboard, 3-hour battery with charger, 52X internal CD-RW drive with CD creator software, and Microsoft Office bundled software. Provide all original licenses, installation media, documentation, and recovery CDs capable of restoring the original configuration. Provide the manufacturer's 3-year next business day on-site warranty with the Government listed as the warranty owner. Provide a CAC card access port.

2.1.4 DDC Software

2.1.4.1 Programming

Provide programming to execute the sequence of operation indicated. Provide all programming, programming software tools, and programming hardware tools to configure and program all controllers. If the laptop computer provided elsewhere is used as a programming tool, provide all necessary accessories for full functionality. All software shall be licensed to Marine Corps Base, Camp Lejeune Complex for unrestricted use on Camp Lejeune Complex and reproduction for use on Camp Lejeune Complex. Software keys and "dongles" are not permitted. Provide sequence of operation routines in simple, easy-to-follow logic with detailed text comments describing what the logic does and how it corresponds to the project's written sequence of operation.

a. Graphic-based programming shall use a library of function blocks made from pre-programmed code designed for BAS control. Function blocks shall be assembled with interconnecting lines, depicting the control sequence in a flowchart. If providing a computer with device programming tools as part of the project, graphic programs shall be viewable in real time showing present values and logical results from each function block.

b. Menu-based programming shall be done by entering parameters, definitions, conditions, requirements, and constraints.

c. For line-by-line and text-based programming, declare variable types (local, global, real, integer, etc.) at the beginning of the program. Use descriptive comments frequently to describe the programming.

d. If providing a computer with device programming tools as part of the project, provide a means for detecting program errors and testing software strategies with a simulation tool. Simulation may be inherent within the programming software suite, or provided by physical controllers mounted in a NEMA 1 test enclosure. The test enclosure shall contain one dedicated controller of each type provided under this contract, complete with power supply and relevant accessories.

2.1.4.2 Parameter Modification

All writeable object properties, and all other programming parameters needed to comply with the project specification shall be adjustable for devices at any network level, including those accessible with web-browser communication, and regardless of programming methods used to create the applications.

2.1.4.3 Short Cycling Prevention

Provide setpoint differentials and minimum on/off times to prevent equipment short cycling.

2.1.4.4 Equipment Status Delay

Provide an adjustable delay from when equipment is commanded on or off and when the control program looks to the status input for confirmation.

2.1.4.5 Run Time Accumulation

Use the Elapsed Time Property to provide re-settable run time accumulation for each Binary Output Object connected to mechanical loads greater than 1 HP, electrical loads greater than 10 KW, or wherever else specified.

2.1.4.6 Timed Local Override

Provide a non-cumulative adjustable override time for the push of a local override button.

2.1.4.7 Time Synchronization

Provide time synchronization, including adjustments for leap years, daylight saving time, and operator time adjustments.

2.1.4.8 Scheduling

Provide operating schedules as indicated, with equipment assigned to groups. Changing the schedule of a group shall change the operating schedule of all equipment in the group. Groups shall be capable of operator creation, modification, and deletion. Provide capability to view and modify schedules in a seven-day week format. Provide capability to enter holiday and override schedules one full year at a time.

2.1.4.9 Object Property Override

Allow writeable object property values to accept overrides to any valid value. Where specified or required for the sequence of control, the Out Of Service property of Objects shall be modifiable using BACnet's write property service. When documented, exceptions to these requirement are allowed for life, machine, and process safeties.

2.1.4.10 Alarms and Events

Alarms and events shall be capable of having programmed time delays and high-low limits. All alarms/events shall report to the EMCS server. Alarms/events shall be stored within the Site Building Controller (SBC). Provide alarms/events in agreement with the point schedule, sequence of operation, and the BAS Owner. At a minimum, provide programming to initiate alarms/events any time a piece of equipment fails to operate, a control point is outside normal range or condition shown on schedules, communication to a device is lost, a device has failed, or a controller has lost its memory.

2.1.4.11 Trending

Provide BACnet trend services capable of trending all object present values set points, and other parameters indicated for trending on project schedules. Trends may be associated into groups, and a trend report may be set up for each group. Trends are stored within a device on the BACnet network, with operator selectable trend intervals from 10 seconds up to 60 minutes. The minimum number of consecutive trend values stored at one time shall be 100 per variable. When trend memory is full, the most recent data shall overwrite the oldest data.

The SBC shall upload trends automatically upon reaching 3/4 of the device buffer limit (via Notification_Threshold property), by operator request, or by time schedule for archiving. Archived and real-time trend data shall be available for viewing numerically and graphically for at the workstation and connected notebook computers.

2.1.4.12 Device Diagnostics

Each controller shall have diagnostic LEDs for power, communication, and device fault condition. The DDC system shall recognize and report a non-responsive controller.

2.1.4.13 Power Loss

Upon restoration of power, the DDC system shall perform an orderly restart and restoration of control.

2.1.4.14 Access Control

Provide at least five levels of password protection for operator interfaces. The lowest level only allowing viewing of graphics. The second level allows viewing graphics and changing space temperature setpoints. The third level allows the previous level's capability, plus changing operating schedules. The fourth level allows access to all functions except passwords. The highest level provides all administrator rights and allows full access to all programming, including setting new passwords and access levels. Provide the BAS Owner with the highest level password access. Provide automatic log out if no keyboard or mouse activity is detected after a user-defined time delay.

2.1.4.15 Configuration Tool

Provide the software with the manufacturer's installation CDs and licenses. Licenses shall allow unrestricted use and reproduction for use at the Camp Lejeune Complex. Software shall not require the use of software keys or "dongles" Configure the software according to the DDC system manufacturer's specifications and in agreement with BACnet standards found in ASHRAE 135, Annex L.

The software shall permit complete monitoring, modification, and troubleshooting interface with the DDC system. The operator interface with the software shall be menu-driven with appropriate displays and menu commands to manipulate the DDC system's objects, point data, operating schedules, control routines, system configuration, trends, alarms, messages, graphics, and reports. Trends shall be capable of graphic display in real time, with variables plotted as functions of time. Each alarmed point shall be capable of displaying its alarm history, showing when it went into alarm, if and when it was acknowledged, and when it went out of alarm. The modification of DDC system parameters and object properties shall be accomplished with "fill in the blank" and/or "point and drag" methods. Modifications shall download to the appropriate controllers at the operator's request.

2.1.4.16 Graphics Software

Provide web-based system graphics viewable on browsers compatible with MS Internet Explorer 6.X or greater using an industry-standard file format such as HTML, BMP, JPEG, or GIF. Graphics for new projects must be consistent with base standards including layout and device naming. Contractor shall install this graphics package on the EMCS Server, bind all points, and demonstrate operability.

Graphic displays shall have full-screen resolution when viewed on the workstation and notebook computers. Dynamic data on graphics pages shall refresh within 10 seconds using an Internet connection, or 30 seconds using a dial-up modem connection. Graphics viewing shall not require additional "plug-in" software like Java, Shockwave and Flash applications unless the software is readily available for free over the Internet, and certified for use with Government provided personal computers.

The graphics shall show the present value and object name for each of the project's I/O points on at least one graphic page. Arrange point values and names on the graphic displays in their appropriate physical locations with respect to the floor plan or equipment graphic displayed. Graphics shall allow the operator to monitor current status, view zone and equipment summaries, use point-and-click navigation between graphic pages, and edit setpoints and parameters directly from the screens. Items in alarm shall be displayed using a different color or other obvious visual indicator. Provide graphics with the following:

a. Graphic Types: Provide at least one graphic display for each piece of HVAC equipment, building floor, and controlled zone. Indicate dynamic point values, operating statuses, alarm conditions, and control setpoints on each display. Provide summary pages where appropriate.

    (1) Building Floor Plans: Provide a floor plan graphic for each of the building's floors [and roof] with dynamic display of space temperature and other important data. If used, indicate and provide links to sub-plan areas. If possible, use the project's electronic drawing files for the graphic backgrounds. Provide clear names for important areas, such as "Main Conference Room." Include room names and numbers where applicable. Include features such as stairwells, elevators, and main entrances. Where applicable, include the mechanical room, HVAC equipment, and

control component locations, with corresponding links to the equipment graphics.

(2) Sub-plan Areas: Where a building's floor plan is too large to adequately display on the screen, sub-divide the plan into distinct areas, and provide a separate graphic display for each area. Provide same level of detail requested in building floor plan section above.

(3) HVAC Equipment: Provide a graphic display for each piece of HVAC equipment, such as a fan coil unit, VAV terminal, or air handling unit. Equipment shall be represented by a two or three-dimensional drawing. Where multiple pieces of equipment combine to form a system, such as a central chiller plant or central heating plant, provide one graphic to depict the entire plant. Indicate the equipment, piping, ductwork, dampers, and control valves in the installed location. Include labels for equipment, piping, ductwork, dampers, and control valves. Show the direction of air and water flow. Include dynamic display of applicable object data with clear names in appropriate locations.

(4) Sequence of Operation: Provide a graphic screen displaying the written out full sequence of operation for each piece of HVAC equipment. Provide a link to the sequence of operation displays on their respective equipment graphics.[Include dynamic real-time data within the text for setpoints and variables.]

b. Graphic Title: Provide a prominent, descriptive title on each graphic page.

c. Dynamic Update: When the workstation is on-line, all graphic I/O object values shall update with change-of-value services, or by operator selected discrete intervals.

d. Graphic Linking: Provide forward and backward linking between floor plans, sub-plans, and equipment.

e. Graphic Editing: Provide installed software to create, modify, and delete the DDC graphics. Include the ability to store graphic symbols in a symbol directory and import these symbols into the graphics.

f. Dynamic Point Editing: Provide full editing capability for deleting, adding, and modifying dynamic points on the graphics.

2.2 SENSORS AND INPUT HARDWARE

Coordinate sensor types with the BAS Owner to keep them consistent with existing installations.

2.2.1 Field-Installed Temperature Sensors

Where feasible, provide the same sensor type throughout the project. Avoid using transmitters unless absolutely necessary.

2.2.1.1 Thermistors

Precision thermistors may be used in applications below 200 degrees F. Sensor accuracy over the application range shall be 0.36 degree F or less between 32 to 150 degrees F. Stability error of the thermistor over five years shall not exceed 0.25 degrees F cumulative. A/D conversion resolution error shall be kept to 0.1 degrees F. Total error for a thermistor circuit shall not exceed 0.5 degrees F.

2.2.1.2 Resistance Temperature Detectors (RTDs)

Provide RTD sensors with platinum elements compatible with the digital controllers. Encapsulate sensors in epoxy, series 300 stainless steel, anodized aluminum, or copper. Temperature sensor accuracy shall be 0.1 percent (1 ohm) of expected ohms (1000 ohms) at 32 degrees F. Temperature sensor stability error over five years shall not exceed 0.25 degrees F cumulative. Direct connection of RTDs to digital controllers without transmitters is preferred. When RTDs are connected directly, lead resistance error shall be less than 0.25 degrees F. The total error for a RTD circuit shall not exceed 0.5 degrees F. Allow an additional 0.5 percent accuracy for averaging sensors.

2.2.1.3 Temperature Sensor Details

a. Room Type: Provide the sensing element components within a decorative protective cover suitable for surrounding decor. [Provide room temperature sensors with timed override button, setpoint adjustment lever, digital temperature display.] Provide a communication port for a portable operator interface like a notebook computer or PDA.

b. Duct Probe Type: Ensure the probe is long enough to properly sense the air stream temperature.

c. Duct Averaging Type: Continuous averaging sensors shall be one foot in length for each 4 square feet of duct cross-sectional area, and a minimum length of 6 feet.

d. Pipe Immersion Type: Provide minimum three-inch immersion. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel when used in steel piping, and brass when used in copper piping. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior.

e. Outside Air Type: Provide the sensing element on the building's north side with a protective weather shade that positions the sensor approximately 3 inches off the wall surface, does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain.

2.2.2 Transmitters

Provide transmitters with 4 to 20 mA or 0 to 10 VDC linear output scaled to the sensed input. Transmitters shall be matched to the respective sensor, factory calibrated, and sealed. Size transmitters for an output near 50 percent of its full-scale range at normal operating conditions. The total transmitter error shall not exceed 0.1 percent at any point across the measured span. Supply voltage shall be 12 to 24 volts AC or DC. Transmitters shall have non-interactive offset and span adjustments. For temperature sensing, transmitter drift shall not exceed 0.03 degrees F a year.

2.2.2.1 Relative Humidity Transmitters

Provide transmitters with an accuracy equal to plus or minus 3 [2] [5] percent from 0 to 90 percent scale, and less than one percent drift per year. Sensing elements shall be the polymer type.

2.2.2.2 Pressure Transmitters

Provide transmitters integral with the pressure transducer.

2.2.3 Current Transducers

Provide current transducers to monitor motor amperage. Current switches may be used to indicate on/off status.

[2.2.4 Pneumatic to Electric Transducers

Pneumatic to electronic transducers shall convert a 0 to 20 psig signal to a proportional 4 to 20 mA or 0 to 10 VDC signal (operator scaleable). Supply voltage shall be 24 VDC. Accuracy and linearity shall be 1.0 percent or better.

]2.2.5 Air Quality Sensors

Provide power supply for each sensor.

2.2.5.1 CO2 Sensors

Provide photo-acoustic type CO2 sensors with integral transducers and linear output. The devices shall read CO2 concentrations between 0 and 2000 ppm with full scale accuracy of at least plus or minus 100 ppm.

2.2.5.2 Air Quality Sensors

Provide full spectrum air quality sensors using a hot wire element based on the Taguchi principle. The sensor shall monitor a wide range of gaseous volatile organic components common in indoor air contaminants like paint fumes, solvents, cigarette smoke, and vehicle exhaust. The sensor shall automatically compensate for temperature and humidity, have span and calibration potentiometers, operate on 24 VDC power with output of 0-10 VDC, and have a service rating of 32 to 140 degrees F and 5 to 95 percent relative humidity.

2.2.6 Input Switches

2.2.6.1 Timed Local Overrides

Provide buttons or switches to override the DDC occupancy schedule programming for each major building zone during unoccupied periods, and to return HVAC equipment to the occupied mode. This requirement is waived for zones clearly intended for 24 hour continuous operation.

2.2.7 Freeze Protection Thermostats

Provide special purpose thermostats with flexible capillary elements 20 feet in length for coil face areas up to 40 square feet. Provide additional thermostats for larger coils. Provide switch contacts rated for the respective motor starter's control circuit voltage. Include auxiliary contacts for the switch's status condition. A freezing condition at any

18-inch increment along the sensing element's length shall activate the switch. The thermostat shall be equipped with a manual push-button reset switch so that when tripped, the thermostat requires manual resetting before the HVAC equipment can restart.

2.2.8 Air Flow Measurement Stations

Air flow measurement stations shall have an array of velocity sensing elements and straightening vanes inside a flanged sheet metal casing. The velocity sensing elements shall be the RTD or thermistor type, traversing the ducted air in at least two directions. The air flow pressure drop across the station shall not exceed 0.1 inch water gage at a velocity of 2,000 fpm. The station shall be suitable for air flows up to 2500 fpm, and a temperature range of 0 to 140 degrees F. The station's measurement accuracy over the range of 125 to 2,500 fpm shall be plus or minus 3 percent of the measured velocity. Station transmitters shall provide a linear, temperature-compensated 4 to 20 mA or 0 to 10 VDC output. The output shall be capable of being accurately converted to a corresponding air flow rate in cubic feet per minute. Transmitters shall be a 2-wire, loop powered device. The output error of the transmitter shall not exceed 0.5 percent of the measurement.

2.2.9 Air Flow Measurement For Terminal Devices

Air flow measurement for terminal devices such as variable air volume boxes, with or without fan power shall have an array of pressure sensing elements that sense total pressure and static pressure. The flow measurement shall be integral to the device controller and shall be by differential pressure sensor. The air flow shall measure flows down to 300 fpm with an accuracy of 5 percent of reading.

2.2.10 Energy Metering

Provide energy meters to collect steam and water consumption, and hot water solar collector generation for the facility and report to the EMCS database.

2.2.10.1 Steam Meters

Steam meters shall be the vortex type, with pressure compensation, a minimum turndown ratio of 10 to 1. Output signal shall be 4-20 ma, pulsed, or BACnet (MS/TP), all compatible with installed DDC system.

2.2.10.2 Water meters

Water meters 1" and smaller shall be positive displacement nutating disk. Water meters larger than 1" shall be compound type. Output signal shall be 4-10 ma, pulse, or BACnet(MS/TP).

2.2.10.3 Hot Water Solar Collector Meters

Meters for hot water solar collectors may be an integrated BTU meter with a BACnet output or may be a combination of temperature sensors and water flow meter monitored by a DDC controller with the DDC system calculating the BTU transfer. Water flow can be measured by orifice or venturi meter selected for the anticipated system flow rate. Temperature sensors shall be placed in both the supply to and the return from the solar collector array.

2.3 OUTPUT HARDWARE

2.3.1 Control Dampers

Provide factory manufactured aluminum blade/galvanized steel frame dampers where indicated. Control dampers shall comply with SMACNA 1966 except as modified or supplemented by this specification. Published damper leakage rates and respective pressure drops shall have been verified by tests in compliance with AMCA 500-D requirements.

Provide damper assembly frames constructed of 13 gauge minimum thickness galvanized steel channels with mitered and welded corners. Damper axles shall be 0.5 inches minimum diameter plated steel rods supported in the damper frame by stainless steel or bronze bearings. Blades mounted vertically shall be supported by thrust bearings.

Dampers shall be rated for not less than 2000 fpm air velocity. The pressure drop through each damper when full-open shall not exceed 0.04 inches water gage at 1000 fpm face velocity. Damper assemblies in ductwork subject to above 3-inch water gauge static air pressure shall be constructed to meet SMACNA Seal Class "A" construction requirements.

Provide the damper operating linkages outside of the air stream, including crank arms, connecting rods, and other hardware that transmits motion from the damper actuators to the dampers, shall be adjustable. Additionally, operating linkages shall be designed and constructed to have a 2 to 1 safety factor when loaded with the maximum required damper operating force. Linkages shall be brass, bronze, galvanized steel, or stainless steel.

Provide access doors or panels in hard ceilings and walls for access to all concealed damper operators and damper locking setscrews.

For field-installed control dampers, a single damper section shall have blades no longer than 48 inches and no higher than 72 inches. The maximum damper blade width shall be 12 inches. Larger sized dampers shall be built using a combination of sections.

Frames shall be at least 2 inches wide. Flat blades shall have edges folded for rigidity. Blades shall be provided with compressible gasket seals along the full length of the blades to prevent air leakage when closed.

The damper frames shall be provided with jamb seals to minimize air leakage. Seals shall be suitable for an operating temperature range of minus 40 degrees F to 200 degrees F.

The leakage rate of each damper when full-closed shall be no more than 2 cfm per sq. foot of damper face area at 1.0 inches water gage static pressure.

2.3.2 Control Valves

2.3.2.1 Valve Assembly

Valve bodies shall be designed for 125 psig minimum working pressure or 150 percent of the operating pressure, whichever is greater. Valve stems shall be Type 300 series stainless steel. Valve leakage ratings shall be 0.01 percent of rated Cv value. Class 125 copper alloy valve bodies and Class 150 steel or stainless steel valves shall meet the requirements of ASME B16.5. Cast iron valve components shall meet the requirements of

ASTM A126 Class B or C.

2.3.2.2 Butterfly Valves

Butterfly valves shall be the threaded lug type suitable for dead-end service and for modulation to the fully-closed position, with stainless steel shafts supported by bearings, non-corrosive discs geometrically interlocked with or bolted to the shaft (no pins), and EPDM seats suitable for temperatures from minus 20 degrees F to plus 250 degrees F. Valves shall have a means of manual operation independent of the actuator.

2.3.2.3 Two-Way Valves

Two-way modulating valves shall have an equal percentage characteristic.

2.3.2.4 Three-Way Valves

Three-way valves shall have an equal percentage characteristic.

2.3.2.5 Valves for Chilled Water, Condenser Water, and Glycol Fluid Service

a. Bodies for valves 1-1/2 inches and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 2 inches to 3 inches inclusive shall be of brass, bronze, or iron. Bodies for 2 inch valves shall have threaded connections. Bodies for valves from 2-1/2 to 3 inches shall have flanged connections.

b. Internal valve trim shall be brass or bronze, except that valve stems shall be stainless steel.

c. Unless indicated otherwise, provide modulating valves sized for 2 psi minimum and 4 psi maximum differential across the valve at the design flow rate.

d. Valves 4 inches and larger shall be butterfly valves, unless indicated otherwise.

2.3.2.6 Valves for Hot Water Service

Valves for hot water service below 250 Degrees F:

a. Bodies for valves 1-1/2 inches and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 2 inches to 3 inches inclusive shall be of brass, bronze, or iron. Bodies for 2 inch valves shall have threaded connections. Bodies for valves from 2-1/2 to 3 inches shall have flanged connections.

b. Internal trim (including seats, seat rings, modulation plugs, valve stems, and springs) of valves controlling water above 210 degrees F shall be Type 300 series stainless steel.

c. Internal trim for valves controlling water 210 degrees F or less shall be brass or bronze. Valve stems shall be Type 300 series stainless steel.

d. Non-metallic parts of hot water control valves shall be suitable for a minimum continuous operating temperature of 250 degrees F or 50 degrees F above the system design temperature, whichever is higher.

e. Unless indicated otherwise, provide modulating valves sized for 2 psi minimum and 4 psi maximum differential across the valve at the design flow rate.

f. Valves 4 inches and larger shall be butterfly valves, unless indicated otherwise.

2.3.2.7 Valves for High Temperature Hot Water Service

Valves for hot water service 250 Degrees F above:

a. Valve bodies shall conform to ASME B16.34 Class 300. Valve and actuator combination shall be normally closed. Bodies shall be carbon steel, globe type with welded ends on valves 1 inch and larger. Valves smaller than 1 inch shall have socket-weld ends. Packing shall be virgin polytetrafluoroethylene (PTFE).

b. Internal valve trim shall be Type 300 series stainless steel.

c. Unless indicated otherwise, provide modulating valves sized for 2 psi minimum and 4 psi maximum differential across the valve at the design flow rate.

2.3.2.8 Valves for Steam Service

The entire body for valves 1-1/2 inches and smaller shall be brass or bronze, with threaded or union ends. Bodies for valves from 2 to 3 inches inclusive shall be of brass, bronze, or carbon steel. Bodies for valves 4 inches and larger shall be carbon steel. Bodies for 2 inch valves shall have threaded connections. Bodies for valves 2-1/2 inches and larger shall have flanged connections. Steam valves shall be sized for [15 psig] [_____] inlet steam pressure with a maximum [13 psi] [_____] differential through the valve at rated flow, except where indicated otherwise. Internal valve trim shall be Type 300 series stainless steel.

2.3.3 Actuators

Provide direct-drive electric actuators for all control applications, except where indicated otherwise.

2.3.3.1 Electric Actuators

Each actuator shall deliver the torque required for continuous uniform motion and shall have internal end switches to limit the travel, or be capable of withstanding continuous stalling without damage. Actuators shall function properly within 85 to 110 percent of rated line voltage. Provide actuators with hardened steel running shafts and gears of steel or copper alloy. Fiber or reinforced nylon gears may be used for torques less than 16 inch-pounds. Provide two-position actuators of single direction, spring return, or reversing type. Provide modulating actuators capable of stopping at any point in the cycle, and starting in either direction from any point. Actuators shall be equipped with a switch for reversing direction, and a button to disengage the clutch to allow manual adjustments. Provide the actuator with a hand crank for manual adjustments, as applicable. Actuators without spring-return may only be used on terminal fan coil units, terminal VAV units, convectors, and unit heaters. Spring return actuators shall be provided on all control dampers and all control valves except terminal fan coil units, terminal VAV units, convectors, and unit heaters; unless indicated otherwise. Each actuator shall have distinct markings indicating the full-open and full-closed position, and the points in-between.

2.3.4 Output Signal Conversion

2.3.4.1 Electronic-to-Pneumatic Transducers

Electronic to pneumatic transducers shall convert a 4 to 20 mA or 0 to 10 VDC digital controller output signal to a proportional 0 to 20 psig pressure signal (operator scaleable). Accuracy and linearity shall be 1.0 percent or better. [Transducers shall have feedback circuit that converts the pneumatic signal to a proportional 4 to 20 mA or 0 to 10 VDC signal.]

2.3.5 Output Switches

2.3.5.1 Control Relays

Field installed and DDC panel relays shall be double pole, double throw, UL listed, with contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light shall be lit when the coil is energized and off when coil is not energized. Relays shall be the socket type, plug into a fixed base, and replaceable without tools or removing wiring. Encapsulated "PAM" type relays may be used for terminal control applications.

2.4 ELECTRICAL POWER AND DISTRIBUTION

2.4.1 Transformers

Transformers shall conform to UL 506. For control power other than terminal level equipment, provide a fuse or circuit breaker on the secondary side of each transformer.

2.4.2 Surge and Transient Protection

Provide each digital controller with surge and transient power protection. Surge and transient protection shall consist of the following devices, installed externally to the controllers.

2.4.2.1 Power Line Surge Protection

Provide surge suppressors on the incoming power at each controller or grouped terminal controllers. Surge suppressors shall be rated in accordance with UL 1449, have a fault indicating light, and conform to the following:

a. The device shall be a transient voltage surge suppressor, hard-wire type individual equipment protector for 120 VAC/1 phase/2 wire plus ground.

b. The device shall react within 5 nanoseconds and automatically reset.

c. The voltage protection threshold, line to neutral, shall be no more than 211 volts.

d. The device shall have an independent secondary stage equal to or greater than the primary stage joule rating.

e. The primary suppression system components shall be pure silicon avalanche diodes.

f. The secondary suppression system components shall be silicon avalanche diodes or metal oxide varistors.

g. The device shall have an indication light to indicate the protection components are functioning.

h. All system functions of the transient suppression system shall be individually fused and not short circuit the AC power line at any time.

i. The device shall have an EMI/RFI noise filter with a minimum attenuation of 13 dB at 10 kHz to 300 MHz.

j. The device shall comply with IEEE C62.41.1 and IEEE C62.41.2, Class "B" requirements and be tested according to IEEE C62.45.

k. The device shall be capable of operating between minus 20 degrees F and plus 122 degrees F.

2.4.3 Wiring

Provide complete electrical wiring for the DDC System, including wiring to transformer primaries. Unless indicated otherwise, provide all normally visible or otherwise exposed wiring in conduit. Where conduit is required, control circuit wiring shall not run in the same conduit as power wiring over 100 volts. [Circuits operating at more than 100 volts shall be in accordance with Section 26 20 00, INTERIOR DISTRIBUTION SYSTEM.] Run all circuits over 100 volts in conduit, metallic tubing, covered metal raceways, or armored cable. Use plenum-rated cable for circuits under 100 volts in concealed accessible spaces. Examples of these spaces include HVAC plenums, within walls, above suspended ceilings, in attics, and within ductwork. All wiring in mechanical rooms and mezzanines shall be run in conduit.

2.4.3.1 Power Wiring

The following requirements are for field-installed wiring:

a. Wiring for 24 V circuits shall be insulated copper 18 AWG minimum and rated for 300 VAC service.

b. Wiring for 120 V circuits shall be insulated copper 14 AWG minimum and rated for 600 VAC service.

2.4.3.2 Analog Signal Wiring

Field-installed analog signal wiring shall be in accordance with manufacturer's installation instructions. Each cable shall be 100 percent shielded and have a 20 AWG drain wire. Each wire shall have insulation rated for 300 VAC service. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape.

2.5 FIRE PROTECTION DEVICES

2.5.1 Duct Smoke Detectors

Provide duct smoke detectors in HVAC ducts in accordance with NFPA 72 and NFPA 90A, except as indicated otherwise. Provide UL listed or FM approved detectors, designed specifically for duct installation.

[Furnish detectors under Section 28 31 76.00 20 INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM and install under this section. Connect new detectors to the building fire alarm panel.]

[Provide photoelectric type detectors. Detectors shall detect both visible and invisible particles of combustion, and shall not be susceptible to undesired operation by changes to relative humidity. Provide each detector with an approved duct housing mounted exterior to the duct, and an integral perforated sampling tube extending across the width of the duct. The detector housing shall have indicator lamps that light when the detector is powered and when the detector is activated. Each detector shall have an integral test port and test switch. Connect new detectors to the building's existing fire alarm control panel. Provide control and power modules required for the operation of the detectors in their own new control unit or integral with the existing fire alarm panel. A ground fault, break, or open condition in the electrical circuitry to any detector or its control or power unit shall cause activation of a trouble signal at the building fire alarm panel. Electrical supervision of wiring used exclusively for air-handling unit shutdown is not required, provided a break in the wiring would cause shutdown of the associated unit. Equipment and devices shall be compatible and operable in all respects with, and shall in no way impair the reliability or operational functions of, the existing fire alarm system. The building's existing fire alarm control panel was manufactured by [_____]. Provide descriptive zone labels at the existing fire alarm panel indicating which new air-handling unit detectors they serve and their location. Label zones modified in order to accomplish the work.]

[Provide photoelectric type detectors. Detectors shall detect both visible and invisible particles of combustion, and shall not be susceptible to undesired operation by changes to relative humidity. Provide each detector with an approved duct housing mounted exterior to the duct, and an integral perforated sampling tube extending across the width of the duct. The detector housing shall have indicator lamps that light when the detector is powered and when the detector is activated. Each detector shall have an integral test port and test switch. Provide a 115 VAC power supply unit integral with the detector's duct housing. Provide power to the detector from [the air-handling unit or air-handling unit controls] [the location indicated]. Provide the detectors with a remote alarm indicator device at the location indicated. Activation of a detector shall cause immediate shutdown of the associated air-handling unit and the closing of its dampers and shall activate the remote alarm indicator.]

[Provide smoke control systems with a provision for manual operation by means of a key-operated switch to override the duct smoke detector shutdowns. Locate the override switch [adjacent to the building's fire alarm system control panel][as indicated].]

2.6 VARIABLE FREQUENCY (MOTOR) DRIVES

Provide variable frequency drives (VFDs) as indicated. VFDs shall convert 240 or 460 volt (plus or minus 10 percent), three phase, 60 hertz (plus or minus 2Hz), utility grade power to adjustable voltage/frequency, three phase, AC power for stepless motor control from 5 percent to 105 percent of base speed. VFDs shall be UL listed as delivered to the end user. The VFD shall meet the requirements specified in the most current National Electrical Code. Each VFD shall also meet the following:

a. The VFD shall use sine coded Pulse Width Modulation (PWM) technology. PWM calculations shall be performed by the VFD microprocessor.

b. The VFD shall be capable of automatic control by a remote 4-20 mA 0 to 10 VDC signal, BACnet interface, or manually by the VFD control panel.

2.6.1 VFD Quality Assurance

VFDs shall be the manufacturer's current standard production unit with at least 10 identical units successfully operating in the field.

2.6.2 VFD Service Support

a. Warranty: Provide the VFDs with a minimum 24-month full parts and labor warranty. The warranty shall start when the contract's HVAC system is accepted by the Government. Include warranty documentation, dates, and contact information with the VFD on-site service manuals.

b. VFD Service Manuals: Provide the VFDs with all necessary installation, operation, maintenance, troubleshooting, service, and repair manuals in English including related factory technical bulletins. Provide the documents factory bound, in sturdy 3-ring binders, or hard bound covers. Provide a title sheet on the outside of each binder indicating the project title, project location, installing contractor, contract number, and the VFD manufacturer, address, and telephone number. Each binder shall include a table of contents and tabbed dividers, with all material neatly organized. The documentation provided shall be specifically applicable to this project, shall be annotated to reflect the actual project conditions, and shall provide a complete and concise depiction of the installed work.[Provide a storage cabinet on or near the VFD large enough to hold all of the documentation. Have the cabinet's proposed installation site approved in advance by the Contracting Officer. Prominently label the cabinet "VFD OPERATION AND MAINTENANCE MANUALS." Clearly label each manual with the wording "MECHANICAL ROOM COPY - DO NOT REMOVE".]

c. Technical Support: Provide the VFDs with manufacturer's technical telephone support in English, readily available during normal working hours, and free of charge for the life of the equipment.

d. Initial Start-Up: Provide the VFDs with factory-trained personnel for the on-site start-up of the HVAC equipment and associated VFD. The personnel shall be competent in the complete start-up, operation, and repair of the particular model VFD installed. The factory start-up representative shall perform the factory's complete recommended start-up procedures and check-out tests on the VFD. Include a copy of the start-up test documentation with the VFD on-site service manuals.

e. Provide the VFDs with on-site/hands-on training for the user and maintenance personnel. Provide a capable and qualified instructor with minimum two years field experience with the operation and maintenance of similar VFDs. The training shall occur during normal working hours and last not less than 2 hours. Coordinate the training time with the Contracting Officer and the end user. The VFD service manuals shall be used during the training. The contractor shall ensure the manuals are on-site before the start of training. The training shall cover all operational aspects of the VFD.

2.6.3 VFD Features

VFDs shall have the following features:

a. A local operator control keypad capable of:

(1) Remote/Local operator selection with password access.

(2) Run/Stop and manual speed commands.

(3) All programming functions.

(4) Scrolling through all display functions.

b. Digital display capable of indicating:

(1) VFD status.

(2) Frequency.

(3) Motor RPM.

(4) Phase current.

(5) Fault diagnostics in descriptive text.

(6) All programmed parameters.

c. Standard PI loop controller with input terminal for controlled variable and parameter settings.

d. User interface terminals for remote control of VFD speed, speed feedback, and an isolated form C SPDT relay, which energizes on a drive fault condition.

e. An isolated form C SPDT auxiliary relay which energizes on a run command.

f. A metal NEMA 1 enclosure for indoors, NEMA 4 with heater for outdoors.

g. An adjustable carrier frequency with 16 KHz minimum upper limit.

h. A built in or external line reactor with 3 percent minimum impedance to protect the VFDs DC buss capacitors and rectifier section diodes.

2.6.4 Programmable Parameters

VFDs shall include the following operator programmable parameters:

a. Upper and lower limit frequency.

b. Acceleration and Deceleration rate.

c. Variable torque volts per Hertz curve.

d. Starting voltage level.

e. Starting frequency level.

f. Display speed scaling.

g. Enable/disable auto-restart feature.

h. Enable/disable soft stall feature.

i. Motor overload level.

j. Motor stall level.

k. Jump frequency and hysteresis band.

l. PWM carrier frequency.

2.6.5 Protective Features

VFDs shall have the following protective features:

a. An electronic adjustable inverse time current limit with consideration for additional heating of the motor at frequencies below 45Hz, for the protection of the motor.

b. An electronic adjustable soft stall feature, allowing the VFD to lower the frequency to a point where the motor will not exceed the full-load amperage when an overload condition exists at the requested frequency. The VFD will automatically return to the requested frequency when load conditions permit.

c. A separate electronic stall at 110 percent VFD rated current, and a separate hardware trip at 190 percent current.

d. Ground fault protection that protects the output cables and motor from grounds during both starting and continuous running conditions.

e. The ability to restart after the following faults:

(1) Overcurrent (drive or motor).

(2) Power outage.

(3) Phase loss.

(4) Over voltage/Under voltage.

f. The ability shut down if inadvertently started into a rotating load without damaging the VFD or the motor.

g. The ability to keep a log of a minimum of four previous fault conditions, indicating the fault type and time of occurrence in descriptive text.

h. The ability to sustain 110 percent rated current for 60 seconds

i. The ability to shutdown safely or protect against and record the following fault conditions:

(1) Over current (and an indication if the over current was during acceleration, deceleration, or running).

(2) Over current internal to the drive.

(3) Motor overload at start-up.

(4) Over voltage from utility power.

(5) Motor running overload.

(6) Over voltage during deceleration.

(7) VFD over heat.

(8) Load end ground fault.

(9) Abnormal parameters or data in VFD EEPROM.

2.6.6 Minimum Operating Conditions

VFDs shall be designed and constructed to operate within the following service conditions:

a. Ambient Temperature Range, 0 to 120 degrees F.

b. Non-condensing relative humidity to 90 percent.

2.6.7 Additional Features

Provide VFDs with the following additional features:

a. BACnet MS/TP communication interface port

b. RFI/EMI filters

c. One spare VFD of each model provided, fully programmed and ready for back-up operation when connected.

PART 3 EXECUTION

3.1 INSTALLATION

Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems.

3.1.1 BACnet Naming and Addressing

Coordinate with the EMCS Owner and provide naming and addressing consistent with existing buildings already loaded on the EMCS server. All DDC controllers shall have a Camp Lejeune unique instance number and all Site Building Controllers shall have a Camp Lejeune unique name.

a. MAC Address

Every BACnet device shall have an assigned and documented MAC Address unique to its network. For Ethernet networks, document the MAC Address assigned at its creation. For ARCNET or MS/TP, assign from 4 to 128.

b. Network Numbering

Assign unique numbers to each new network installed on the BACnet internetwork. Provide ability for changing the network number; either by device switches, network computer, or field operator interface. The BACnet internetwork (all possible connected networks) can contain up to 65,534 possible unique networks.

c. Device Object Identifier Property Number

Assign unique Device "Object_Identifier" property numbers or device instances for each device on the BACnet internetwork. Provide for future modification of the device instance number; either by device switches, network computer, or field interface. BACnet allows up to 4,194,302 possible unique devices per internetwork.

d. Device Object Name Property Text

The Device Object Name property field shall support 32 minimum printable characters. Assign unique Device "Object_Name" property names with plain-English descriptive names for each device
For example, the Device Object Name for the device controlling the first floor air handler unit at Building AS4035 would be:

Name=Air Station.AS4035.First Floor.Air Handling Unit.AHU-1-A

e. Object Name Property Text (Other than Device Objects)

The Object Name property field shall support 32 minimum printable characters. Assign Object Name properties with plain-English names descriptive of the application. Examples include "Zone 1 Temperature" and "Fan Start/Stop".

f. Object Identifier Property Number (Other than Device Objects)

Assign Object Identifier property numbers according to design drawings or tables if provided. If not provided, Object Identifier property numbers may be assigned at the Contractor's discretion but must be approved by the Government. In this case they must be documented and unique for like object types within the device.

3.1.2 Minimum BACnet Object Requirements

a. Use of Standard BACnet Objects in accordance with existing Camp Lejeune standards

For the following points and parameters, use standard BACnet objects, where all relevant object properties can be read using BACnet's Read Property Service, and all relevant object properties can be modified using BACnet's Write Property Service:
all device physical inputs and outputs, all set points, all PID tuning parameters, all calculated pressures, flow rates, and consumption values, all alarms, all trends, all schedules, and all equipment and lighting circuit operating status.

b. BACnet Object Description Property

The Object Description property shall support 32 minimum printable characters. For each object, complete the description property field using a brief, narrative, plain English description specific to the object and project application. For example: "HW Pump 1 Proof." Document compliance, length restrictions, and whether the description is writeable in the device PICS.

c. Analog Input, Output, and Value Objects

Support and provide Description and/or Device_Type text strings matching signal type and engineering units shown on the points list.

d. Binary Input, Output, and Value Objects

Support and provide Inactive_Text and Active_Text property descriptions matching conditions shown on the points list.

e. Calendar Object

For devices with scheduling capability, provide at least one Calendar Object with ten-entry capacity. All operators may view Calendar Objects; authorized operators may make modifications from a workstation. Enable the writeable Date List property and support all calendar entry data types.

f. Schedule Object

Use Schedule Objects for all building system scheduling. All operators may view schedule entries; authorized operators may modify schedules from a workstation.

g. Loop Object or Equal

Use Loop Objects or equivalent BACnet objects in each applicable field device for PID control. Regardless of program method or object used, allow authorized operators to adjust the Update Interval, Setpoint, Proportional Constant, Integral Constant, and Derivative Constant using BACnet read/write services.

3.1.3 Minimum BACnet Service Requirements

a. Command Priorities

Use commandable BACnet objects to control machinery and systems, providing the priority levels listed below. If the sequence of operation requires a different priority, obtain approval from the Contracting Officer.

Priority Level	Application
1	Manual-Life Safety
2	Automatic-Life Safety
3	(User Defined)
4	(User Defined)
5	Critical Equipment Control
6	Minimum On/Off
7	(User Defined)
8	Manual Operator
9	(User Defined)
10	(User Defined)
11	Load Shedding
12	(User Defined)
13	(User Defined)
14	(User Defined)

Priority Level	Application
15	(User Defined)
16	(User Defined)

b. Alarming

(1) Alarm Priorities - Coordinate alarm and event notification with the BAS Owner.

(2) Notification Class - Enable writeable Priority, Ack Required, and Recipient List properties of Notification Class objects.

(3) Event Notification Message Texts - Use condition specific narrative text and numerical references for alarm and event notification.

c. Updating Displayed Property Values

Allow workstations to display property values at discrete polled intervals, or based on receipt of confirmed and unconfirmed Change of Value notifications. The COV increment shall be adjustable by an operator using BACnet services, and polled intervals shall be adjustable at the operator workstation.

3.1.4 Local Area Networks

Obtain Government approval before connecting new networks with existing networks. Network numbers and device instance numbers shall remain unique when joining networks. Do not change existing network addressing without Government approval. See also "BACnet Naming and Addressing".

3.1.5 BACnet Routers, Bridges, and Switches

Provide the quantity of BACnet routers, bridges, and switches necessary for communications shown on the BACnet Communication Architecture schematic. Provide BACnet routers with BACnet Broadcast Message Device (BBMD) capability on each BACnet internetwork communicating across an MS/TP network. Configure each BACnet device and bridge, router, or switch to communicate on its network segment. All switches provided by the contractor shall be approved by base telephone.

3.1.6 Wiring Criteria

a. Run circuits operating at more than 100 volts in rigid or flexible conduit, metallic tubing, covered metal raceways, or armored cable.

b. Do not run binary control circuit wiring in the same conduit as power wiring over 100 volts. Where analog signal wiring requires conduit, do not run in the same conduit with AC power circuits or control circuits operating at more than 100 volts.

c. Provide circuit and wiring protection required by NFPA 70.

d. Run all wiring located inside mechanical rooms in conduit.

e. Do not bury aluminum-sheathed cable or aluminum conduit in concrete.

f. Input/output identification: Permanently label each field-installed wire, cable, and pneumatic tube at each end with descriptive text using a commercial wire marking system that fully encircles the wire, cable, or tube. Locate the markers within 2 inches of each termination. Match the names and I/O number to the project's point list. Similarly label all power wiring serving control devices, including the word "power" in the label. Number each pneumatic tube every six feet. Label all terminal blocks with alpha/numeric labels. All wiring and the wiring methods shall be in accordance with UL 508A.

g. For controller power, provide new 120 VAC circuits, with ground, if not defined on the electrical drawings. Provide each circuit with a dedicated breaker, and run wiring in its own conduit, separate from any control wiring. Connect the controller's ground wire to the electrical panel ground; conduit grounds are not acceptable.

h. Surge Protection: Install surge protection according to manufacturer's instructions. Multiple controllers fed from a common power supply may be protected by a common surge protector, properly sized for the total connected devices.

i. Grounding: Ground controllers and cabinets to a good earth ground as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Conduit grounding is not acceptable; all grounding shall have a direct path to the building earth ground. Ground sensor drain wire shields at the controller end.

j. The Contractor shall be responsible for correcting all associated ground loop problems.

k. Run wiring in panel enclosures in covered wire track.

3.1.7 Accessibility

Install all equipment so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible. Install digital controllers, data ports, and concealed actuators, valves, dampers, and like equipment in locations freely accessible through access doors.

3.1.8 Digital Controllers

a. Install as stand alone control devices (see definitions).

b. Locate control cabinets at the locations shown on the drawings. If not shown on the drawings, install in the most accessible space, close to the controlled equipment.

3.1.9 Hand-Off-Auto Switches

Wire safety controls such as smoke detectors and freeze protection thermostats to protect the equipment during both hand and auto operation.

3.1.10 Temperature Sensors

Install temperature sensors in locations that are accessible and provide a good representation of sensed media. Installations in dead spaces are not acceptable. Calibrate sensors according to manufacturer's instructions. Do not use sensors designed for one application in a different application.

3.1.10.1 Room Temperature Sensors

Mount the sensors on interior walls to sense the average room temperature at the locations indicated. Avoid locations near heat sources such as copy machines or locations by supply air outlet drafts. Mount the center of the sensor [5 feet above the finished floor][54 inches above the floor to meet ADA requirements][at the height[s] indicated].

3.1.10.2 Duct Temperature Sensors

a. Probe Type: Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration air tight. Seal the duct insulation penetration vapor tight.

b. Averaging Type (and coil freeze protection thermostats): Weave the capillary tube sensing element in a serpentine fashion perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports. Prevent contact between the capillary and the duct or air handler internals. Provide a duct access door at the sensor location. The access door shall be hinged on the side, factory insulated, have cam type locks, and be as large as the duct will permit, maximum 18 by 18 inches. For sensors inside air handlers, the sensors shall be fully accessible through the air handler's access doors without removing any of the air handler's internals.

3.1.10.3 Immersion Temperature Sensors

Provide thermowells for sensors measuring piping, tank, or pressure vessel temperatures. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells shall not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide thermal conductivity material within the well to fully coat the inserted sensor.

3.1.10.4 Outside Air Temperature Sensors

Provide outside air temperature sensors in weatherproof enclosures on the north side of the building, away from exhaust hoods and other areas that may affect the reading. Provide a shield to shade the sensor from direct sunlight.

3.1.11 Energy Meters

Locate energy meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous and accumulated energy usage.

3.1.12 Damper Actuators

Where possible, mount actuators outside the air stream in accessible areas.

3.1.13 Thermometers and Gages

Mount devices to allow reading while standing on the floor or ground, as applicable.

3.1.14 Pressure Sensors

Locate pressure sensors as indicated.

3.1.15 Component Identification Labeling

Using an electronic hand-held label maker with white tape and bold black block lettering, provide an identification label on the exterior of each new control panel, control device, actuator, and sensor. Also provide labels on the exterior of each new control actuator indicating the (full) open and (full) closed positions. For labels located outdoors, use exterior grade label tape, and provide labels on both the inside and outside of the panel door or device cover. Acceptable alternatives are white plastic labels with engraved bold black block lettering permanently attached to the control panel, control device, actuator, and sensor. Have the labels and wording approved by the BAS Owner prior to installation.

3.1.16 Network and Telephone Communication Lines

When telephone lines or network connections by the Government are required, provide the Contracting Officer at least 60 days advance notice of need. Provide 1 inch conduit and Cat 5 cable from the Supervisory Building controller (SBC) to the network connection (most likely in the telephone equipment room).

3.2 INTERFACE WITH EXISTING EMCS

Interface the new DDC system with Camp Lejeune's existing EMCS. Obtain Government approval before connecting new DDC system to the EMCS. Any device connected directly to the EMCS must be approved by the Designated Approving Authority by following procedures listed in the DIACAP instruction. Complete installation and programming includes graphic creation, scheduling, alarming, lard management scheduling and trending. The server is located in Building 24: workstations are located at Buildings 1005, 1023, and 1202. Only Johnson Controls factory trained technicians, approved by the EMCS Engineer will be allowed to program the EMCS.

3.3 TEST AND BALANCE SUPPORT

The controls contractor shall coordinate with and provide on-site support to the test and balance (TAB) personnel [specified under Section 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC.] This support shall include:

a. On-site operation and manipulation of control systems during the testing and balancing.

b. Control setpoint adjustments for balancing all relevant mechanical systems, including VAV boxes.

c. Tuning control loops with setpoints and adjustments determined by TAB personnel.

3.4 CONTROLS SYSTEM OPERATORS MANUALS

Provide five electronic and three printed copies of a Controls System Operators Manual. The manual shall be specific to the project, written to actual project conditions, and provide a complete and concise depiction of the installed work. Provide information in detail to clearly explain all operation requirements for the control system.

Provide with each manual: CDs of the project's control system drawings, control programs, data bases, graphics, and all items listed below. Include gateway back-up data and configuration tools where applicable. Provide CDs in jewel case with printed and dated project-specific labels on both the CD and the case. For text and drawings, use Adobe Acrobat or MS Office file types. When approved by the Government, AutoCAD and Visio files are allowed. Give files descriptive English names and organize in folders.

Provide printed manuals in sturdy 3-ring binders with a title sheet on the outside of each binder indicating the project title, project location, contract number, and the controls contractor name, address, and telephone number. Each binder shall include a table of contents and tabbed dividers, with all material neatly organized. Manuals shall include the following:

a. A copy of the as-built control system (shop) drawings set, with all items specified under the paragraph "Submittals." Indicate all field changes and modifications.

b. A copy of the project's mechanical design drawings, including any official modifications and revisions.

c. A copy of the project's approved Product Data submittals provided under the paragraph "Submittals."

d. A copy of the project's approved Performance Verification Testing Plan and Report. Test report shall be a 48 hour trend report verifying all temperature setpoints listed in the sequence of operation. The trend report should be printed from the EMCS server. All systems (AHU's, ERV's, CHWS, HWS) should be part of this section.

e. A copy of the project's approved final TAB Report. (Added by the Mechanical Contractor (Division 23)).

f. Printouts of all control system programs, including controller setup pages if used. Include plain-English narratives of application programs, flowcharts, and source code.

g. Printouts of all physical input and output object properties, including tuning values, alarm limits, calibration factors, and set points.

h. A table entitled "AC Power Table" listing the electrical power source for each controller. Include the building electrical panel number, panel location, and circuit breaker number.

i. The DDC manufacturer's hardware and software manuals in both print and CD format with printed project-specific labels. Include installation and technical manuals for all controller hardware, operator manuals for all controllers, programming manuals for all controllers, operator manuals for all workstation software, installation and technical manuals for the workstation and notebook, and programming manuals for the workstation and notebook software.

j. A list of qualified control system service organizations for the work provided under this contract. Include their addresses and telephone numbers.

k. A written statement entitled "Technical Support" stating the control system manufacturer or authorized representative will provide toll-free telephone technical support at no additional cost to the Government for a minimum of two years from project acceptance, will be furnished by experienced service technicians, and will be available during normal weekday working hours. Include the toll-free technical support telephone number.

l. A written statement entitled "Software Upgrades" stating software and firmware patches and updates will be provided upon request at no additional cost to the Government for a minimum of two years from contract acceptance. Include a table of all DDC system software and firmware provided under this contract, listing the original release dates, version numbers, part numbers, and serial numbers.

3.4.1 Storage Cabinets

In one project mechanical room, provide a wall-mounted metal storage cabinet with hinged doors. Provide cabinets large enough to hold the entire set of Controls System Operators Manuals, and the HVAC operation and maintenance manuals [provided under Division 23 HVAC.] Locate cabinets adjacent to DDC control panels where applicable. Have each cabinet's proposed installation site approved in advance by the Contracting Officer and the BAS Owner. Prominently label each cabinet with the wording "OPERATION AND MAINTENANCE MANUALS." Place one of the three hard copies of the Operators Manual in this cabinet. Prominently label each binder with the wording "MECHANICAL ROOM COPY - DO NOT REMOVE."

3.5 PERFORMANCE VERIFICATION TESTING (PVT)

3.5.1 General

The PVT shall demonstrate compliance of the control system work with the contract requirements. The PVT shall be performed by the Contractor and witnessed and approved by the Government. If the project is phased, provide separate testing for each phase. A Pre-PVT meeting to review the Pre-PVT Checklist is required to coordinate all aspects of the PVT and shall include the Contractor's QA representative, the Contractor's PVT administrator, the Contracting Officer's representative, and the EMCS Owner.

3.5.2 Performance Verification Testing Plan

Submit a detailed PVT Plan of the proposed testing for Government approval. Develop the PVT Plan specifically for the control system in this contract. The PVT Plan shall be a clear list of test items arranged in a logical sequence. Include the intended test procedure, the expected response, and the pass/fail criteria for every component tested.

The plan shall clearly describe how each item is tested, indicate where assisting personnel are required (like the mechanical contractor), and include what procedures are used to simulate conditions. Include a separate column for each checked item and extra space for comments. Where sequences of operations are checked, insert each corresponding routine from the project’s sequence of operation. For each test area, include signature and date lines for the Contractor's PVT administrator, the Contractor's QA representative, the Contracting Officer's representative, and the EMCS Owner to acknowledge successful completion.

3.5.3 PVT Sample Size

Test all central plant equipment, primary air handling unit controllers, and fan coil unit controllers unless otherwise directed. Use the DDC system to verify all VAV boxes are controlling as specified. The Government may require testing of like controllers beyond a statistical sample if sample controllers require retesting or do not have consistent results.

The Government may witness all testing, or random samples of PVT items. When only random samples are witnessed, the Government may choose which ones.

3.5.4 Pre-Performance Verification Testing Checklist

Submit the following as a list with items checked off once verified. Provide a detailed explanation for any items that are not completed or verified.

a. Verify all required mechanical installation work is successfully completed, and all HVAC equipment is working correctly (or will be by the time the PVT is conducted).

b. Verify HVAC motors operate below full-load amperage ratings.

c. Verify all required control system components, wiring, and accessories are installed.

d. Verify the installed control system architecture matches approved drawings.

e. Verify all control circuits operate at the proper voltage and are free from grounds or faults.

f. Verify all required surge protection is installed.

g. Verify the A/C Power Table specified in "CONTROLS SYSTEM OPERATORS MANUALS" is accurate.

h. Verify all DDC network communications with the EMCS function properly, including commanding set points, and load shedding.

i. Verify air handling unit and VAV box coil performance by commanding all valves 100 percent open in both heating and cooling. Record the entering and leaving air temperatures. Record the entering water temperature. This data shall be printed, stored, and saved for future reference.

j. Verify each digital controller’s programming is backed up.

k. Verify all wiring, components, and panels are properly labeled.

l. Verify all required points are programmed into devices.

m. Verify all TAB work affecting controls is complete.

n. Verify all valve and actuator zero and span adjustments are set properly.

o. Verify all sensor readings are accurate and calibrated.

p. Verify each control valve and actuator goes to normal position upon loss of power.

q. Provide 48 hours of trend data to verify all systems are functioning as specified. Trend reports will verify control set point adjustment per the temperature re-set schedules (as required by sequence of operation).

Provide the following Trends:

(1) Chilled water System: supply temperature (actual), return temperature (actual)

(2) Hot Water System: supply temperature (actual), return temperature (actual), supply temperature set point.

(3) Air Handling Unit: discharge air temperature set point, return air temperature set point, discharge air temperature (actual), return air temperature (actual), valve command position.

(4) VAV Box (10 percent of VAV's): room temperature set point, room temperature (actual), associated AHU discharge air temperature (actual).

(5) Energy Recovery Unit: Wheel status, wheel discharge air temperature (actual), wheel discharge air humidity (actual), unit discharge air temperature set point, unit discharge air temperature (actual).

(6) Fan Coil Unit: valve command position, room temperature set point, room temperature (actual).

r. Verify each controller works properly in stand-alone mode.

s. Verify all safety controls and devices function properly, including freeze protection and interfaces with building fire alarm systems.

t. Verify all electrical interlocks work properly.

u. Verify all workstations, notebooks and maintenance personnel interface tools are delivered, all system and database software is installed, and graphic pages are created for each device controlled by the DDC system.

v. Verify the as-built (shop) control drawings are completed.

w. Verify all required alarms are identified at the EMCS server and proper notification is setup for each alarm condition.

3.5.5 Conducting Performance Verification Testing

a. Provide trend report for each HVAC system that is part of the buildings DDC system. The trend report shall include a value for each set point listed in the sequence of operation.

b. Identify any values that do not meet the sequence of operation requirements, make repairs (re-program) and run a new trend for the system. Document each deficiency and corrective action taken.

c. If re-testing is required, follow the procedures for the initial PVT. The Government may require re-testing of any control system components affected by the original failed test.

3.5.6 Controller Capability and Labeling

Test the following for each controller:

a. Memory: Demonstrate that programmed data, parameters, and trend/ alarm history collected during normal operation is not lost during power failure.

b. Direct Connect Interface: Demonstrate the ability to connect directly to each type of digital controller with a portable electronic device like a notebook computer or PDA. Show that maintenance personnel interface tools perform as specified in the manufacturer's technical literature.

c. Stand Alone Ability: Demonstrate controllers provide stable and reliable stand-alone operation using default values or other method for values normally read over the network. Building DDC system shall function to the project's specifications if connection to the EMCS server is lost.

d. Wiring and AC Power: Demonstrate the ability to disconnect any controller safely from its power source using the AC Power Table. Demonstrate the ability to match wiring labels easily with the control drawings. Demonstrate the ability to locate a controller's location using the BACnet Communication Architecture Schematic and floor plans.

e. Nameplates and Tags: Show the nameplates and tags are accurate and permanently attached to control panel doors, devices, sensors, and actuators.

3.5.7 EMCS Server Operation

a. Show points lists agree with naming conventions.

b. Show that graphics are complete.

c. Show the UPS operates as specified.

3.5.8 BACnet Communications and Interoperability at the EMCS Server

Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. If available or required in this specification, use a BACnet protocol analyzer to assist with identifying devices, viewing network traffic, and verifying interoperability. These requirements must be met even if there is only one manufacturer of equipment installed. Testing includes the following:

a. Data Presentation: On each BACnet Operator Workstation, demonstrate graphic display capabilities.

b. Reading of Any Property: Demonstrate the ability to read and display any used readable object property of any device on the network.

c. Setpoint and Parameter Modifications: Show the ability to modify all setpoints and tuning parameters in the sequence of control or listed on project schedules. Modifications are made with BACnet messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.

d. Peer-to-Peer Data Exchange: Show all BACnet devices are installed and configured to perform BACnet read/write services directly (without the need for operator or workstation intervention), to implement the project sequence of operation, and to share global data.

e. Alarm and Event Management: Show that alarms/events are installed and prioritized according to the BAS Owner. Demonstrate time delays and other logic is set up to avoid nuisance tripping, e.g., no status alarms during unoccupied times or high supply air during cold morning start-up. Show that operators with sufficient privilege can read and write alarm/event parameters for all standard BACnet event types. Show that operators with sufficient privilege can change routing (BACnet notification classes) for each alarm/event including the destination, priority, day of week, time of day, and the type of transition involved (TO-OFF NORMAL, TO-NORMAL, etc.).

f. Schedule Lists: Show that schedules are configured for start/stop, mode change, occupant overrides, and night setback as defined in the sequence of operations.

g. Schedule Display and Modification: Show the ability to display any schedule with start and stop times for the calendar year. Show that all calendar entries and schedules are modifiable from any connected workstation by an operator with sufficient privilege.

h. Archival Storage of Data: Show that data archiving is handled by the operator workstation/server, and local trend archiving and display is accomplished with BACnet Trend Log objects.

i. Modification of Trend Log Object Parameters: Show that an operator with sufficient privilege can change the logged data points, sampling rate, and trend duration.

j. Device and Network Management: Show the following capabilities:

(1) Display of Device Status Information

(2) Display of BACnet Object Information

(3) Silencing Devices that are Transmitting Erroneous Data

(4) Time Synchronization

(5) Remote Device Reinitialization

(6) Backup and Restore Device Programming and Master Database(s)

(7) Configuration Management of Half-Routers, Routers and BBMDs

(8) Demonstrate load shed operations if commanded by the EMCS.

3.5.9 Execution of Sequence of Operation

Demonstrate that the HVAC system operates properly through the complete sequence of operation. Use read/write property services to globally read and modify parameters over the internetwork.

3.5.10 Control Loop Stability and Accuracy

For all control loops tested, give the Government trend graphs of the control variable over time, demonstrating that the control loop responds to a 20 percent sudden change of the control variable set point without excessive overshoot and undershoot. If the process does not allow a 20 percent set point change, use the largest change possible. Show that once the new set point is reached, it is stable and maintained. Control loop trend data shall be in real-time with the time between data points 30 seconds or less.

3.5.11 Performance Verification Testing Report

Upon successful completion of the PVT, submit a PVT Report to the Government and prior to the Government taking use and possession of the facility. Do not submit the report until all problems are corrected and successfully re-tested. The report shall include the annotated PVT Plan used during the PVT. Where problems were identified, explain each problem and the corrective action taken. Include a written certification that the installation and testing of the control system is complete and meets all of the contract's requirements.

3.6 TRAINING REQUIREMENTS

Provide a qualified instructor (or instructors) with two years minimum field experience with the installation and programming of similar BACnet DDC systems. Orient training to the specific systems installed. Coordinate training times with the Contracting Officer and BAS Owner after receiving approval of the training course documentation. Training shall take place at the job site and/or a nearby Government-furnished location. A training day shall occur during normal working hours, last no longer than 8 hours and include a one-hour break for lunch and two additional 15-minute breaks. The project's approved Controls System Operators Manual shall be used as the training text. The Contractor shall ensure the manuals are submitted, approved, and available to hand out to the trainees before the start of training.

3.6.1 Training Documentation

Submit training documentation for review 30 days minimum before training. Documentation shall include an agenda for each training day, objectives, a synopses of each lesson, and the instructor's background and qualifications. The training documentation can be submitted at the same time as the project's Controls System Operators Manual.

3.6.2 Phase I Training - Fundamentals

The Phase I training session shall last one day and be conducted in a classroom environment with complete audio-visual aids provided by the contractor. Provide each trainee a printed 8.5 by 11 inch hard-copy of all visual aids used. Upon completion of the Phase I Training, each trainee should fully understand the project's DDC system fundamentals. The training session shall include the following:

a. Review of O&M Manual

   1. Network Drawing

2. Equipment
3. Flow Diagram
4. Sequence of Operation
5. Wiring
6. Valve Schedule
7. Damper Schedule
8. Bill of Material

b. Network

1. Communication Equipment
2. Configuration Setup of Program
3. Backup Procedures

c. Mechanical Equipment

1. Flow Diagram
2. Wiring & Terminations
3. Hardware Interlocks
4. Sequence of Operation
5. Program Decisions and Illustrations of How Program Meets the Sequence of Operation
6. Global Programming Affecting Each Piece of Equipment

d. Building Data Base

1. Alarm Management
2. Trend Management
3. Building Global Interlocks
4. System Load Shedding & Demand Limiting
5. Utility Data (Water, Steam, Solar)

e. System Tools

1. Network Equipment
2. Supervisory Controllers
3. Equipment Controllers
4. Archives

3.6.3 Phase II Training - Operation

Provide Phase II Training shortly after completing Phase I Training. The Phase II training session shall last one day and be conducted at the DDC system workstation, at a notebook computer connected to the DDC system in the field, and at other site locations as necessary. Upon completion of the Phase II Training, each trainee should fully understand the project's DDC system operation. The training session shall include the following:

a. A walk-through tour of the mechanical system and the installed DDC components (controllers, valves, dampers, surge protection, switches, thermostats, sensors, etc.)

b. Adding and removing network devices

-- End of Section --

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SECTION 23 81 28.10 22

VARIABLE REFRIGERANT FLOW (VRF) MULTI-SPLIT AIR CONDITIONING AND HEAT PUMP EQUIPMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ANSI/ASHRAE 15 & 34	(2013; Addenda A 2014; ERTA 2014) ANSI/ASHRAE Standard 15-Safety Standard for Refrigeration Systems and ANSI/ASHRAE Standard 34-Designation and Safety Classification of Refrigerants
ASHRAE 90.1 - IP	(2010; ERTA 2011-2013) Energy Standard for Buildings Except Low-Rise Residential Buildings

ETL TESTING LABORATORIES (ETL)

ETL DLP	(updated continuously) ETL Listed Mark Directory

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 9001	(2008; Corr 1 2009) Quality Management Systems- Requirements
ISO 14001	(2009; Corr 1) Environmental Management Systems - Requirements With Guidance for Use - TECHNICAL CORRIGENDUM 1 - Second Edition

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3 2014) National Electrical Code

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00

SUBMITTAL PROCEDURES 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Refrigerant Piping System Layout; G

Submit Shop Drawings, at least 5 weeks prior to beginning construction, provided in adequate detail to demonstrate compliance with contract requirements.

SD-03 Product Data

Indoor Units; G

Outdoor Units; G

Branch Selector Box; G

Refrigerant Valves; G

SD-06 Test Reports

Performance Tests; G

SD-08 Manufacturer's Instructions

Manufacturers Installation Instructions; G

Operation and Maintenance Training

SD-10 Operation and Maintenance Data

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and 01 78 24.00 20 FACILITY ELECTRONIC OPERATION AND MAINTENANCE SUPPORT INFORMATION (eOMSI).

Operation and Maintenance Manuals; G

Indoor Units; G, Data Package 3

Outdoor Units; G, Data Package 3

1.3 GENERAL REQUIREMENTS

Section 23 00 00 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS applies to work specified in this section.

Section 23 03 00.0020 BASIC MECHANICAL METARIALS, AND METHODS applies to work specified in this section.

[Section 22 05 48.00 22 MECHANICAL SOUND, VIBRATION, AND SEISMIC CONTROL][Section 23 05 48.00 40 VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT, applies to work specified in this section.]

Section 23 23 00 REFRIGERANT PIPING, applies to work specified in this section.

1.4 SYSTEM DESCRIPTION

a. Provide a complete air cooled, multiple evaporator, direct expansion heating and cooling system. The system shall consist of multiple evaporators using PID control The outdoor unit shall be a direct expansion (DX), air-cooled heat recovery air-conditioning system, variable speed driven compressor multi zone split system, using R410A refrigerant. The outdoor unit may connect an indoor evaporator capacity up to 200 percent to that of the outdoor condensing unit capacity. All indoor units shall each be capable of operating separately with individual temperature control.

b. The outdoor units shall be interconnected to the indoor units in accordance with the manufacturer's engineering data detailing each available indoor unit. The indoor units shall be connected to the outdoor utilizing the manufacturer's specified piping joints and headers.

1.5 QUALITY ASSURANCE

a. The units shall be listed by ETL DLP and bear the ETL label.

b. All wiring shall be in accordance with NFPA 70, the National Electric Code.

c. The system will bear the Energy Star label.

d. The system will be produced in an ISO 9001 and ISO 14001 facility. The system shall be factory tested for safety and function.

e. The outdoor unit shall be factory charged with R410A.

1.6 DELIVERY, STORAGE, AND HANDLING

Unit shall be stored and handled according to the manufacturer's recommendations.

1.7 WARRANTY

The units shall have a manufacturer's warranty for a period of one (1) year from date of installation. The units shall have a limited labor warranty for a period of one (1) year from date of installation. The compressors shall have a minimum warranty of 5 years parts and labor.

PART 2 PRODUCTS

2.1 OUTDOOR UNITS

2.1.1 General

The outdoor unit shall be designed specifically for use with all other series components.

a. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of a scroll compressor, motors, fans, condenser coil, electronic expansion valve, solenoid valves, 4 way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service parts, liquid receivers and accumulators.

b. Both liquid and suction lines must be individually insulated between the outdoor and indoor units.

c. The outdoor unit can be wired and piped with outdoor unit access from left, right or rear.

d. The connection ratio of indoor units must be individually insulated between the outdoor and indoor units.

e. The sound pressure dB(A) at rated conditions shall be a value of 58 decibels at 3 feet from the front of the unit. The outdoor unit shall be capable of operating at further reduced noise during the night time.

f. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for re-programming.

g. The outdoor unit shall be modular in design and should allow for a side-by-side installation with minimum spacing.

h. The following safety devices shall be included on the condensing unit: high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, overcurrent protection for the inverter and anti-recycling timers. To ensure the liquid refrigerant does not flash when supplying to the various fan coil units, the circuit shall be provided with a sub-cooling feature. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation.

i. The outdoor unit shall be capable of heating operation at 0 degrees F dry bulb ambient temperature without additional low ambient controls.

2.1.2 Condenser Coil

a. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.

b. The coil shall be of a waffle louver fin and high heat exchanger, rifled bore tube design to ensure highly efficient performance.

c. The coils shall be complete with corrosion treatment of an acrylic resin type. The thickness of the coating must be between 2.0 to 3.0 microns.

d. Coils shall be tested in accordance with ANSI/ASHRAE 15 & 34 at the factory and be suitable for the working pressure of the installed system.

2.1.3 Compressor

a. The scroll compressor shall be variable speed controlled which is capable of changing the speed to follow the variations in total cooling load as determined by the suction gas pressure as measured in the condensing unit.

b. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC, hermetically sealed scroll.

c. The capacity control range shall be 6 to 100 percent, with 29 individual capacity steps. Each non-inverter compressor shall also be of the hermetically sealed scroll type.

d. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.

e. Oil separator shall be standard with equipment together with an oil balancing circuit.

f. The compressor shall be mounted to avoid the transmission of vibration.

g. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with 2-cable wire, thus simplifying the wiring operation.

h. The VRV system must interface with the BACnet DDC system as described in Section [23 09 23.13 20][23 09 23.13 22] BACnet DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC.

i. The control wiring lengths are: outdoor to indoor unit is 6,665 ft, outdoor to central controller is 3,330 ft, outdoor unit to remote controller is 1,665 ft. Wiring type is 16 AWG, 2 wire, non-polarity, non-shielded, stranded.

2.2 BRANCH SELECTOR BOX FOR VRV HEAT RECOVERY SYSTEM

2.2.1 General

The branch selector boxes shall be provided for use with heat recovery system components.

a. These selector boxes shall be factory assembled, wired and piped.

b. The sum of connected capacity of all indoor air handlers shall range up to 200 percent of rated capacity.

c. These branch controllers must be run tested at the factory.

d. These selector boxes must be mounted indoors.

e. When simultaneously heating and cooling, the units in heated mode shall energize their sub cooling solenoid valve.

2.2.2 Unit Cabinet

a. These units shall have a galvanized steel plate casing.

b. Each cabinet shall house multiple refrigeration control valves and a liquid gas separator.

c. The cabinet shall contain a tube in tube heat exchanger.

d. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

2.2.3 Refrigerant Valves

a. The unit shall be furnished with a 3-way refrigerant valve to control the direction of refrigerant flow.

b. Electronic expansion valves shall be used to control the variable refrigerant flow.

c. The refrigerant connections must be of the solder-joint type.

2.2.4 Drainage

a. The unit shall not require drainage.

b. The control voltage between the indoor and outdoor unit shall be non-shielded 2 conductor cable.

2.3 INDOOR UNITS - CEILING CONCEALED DUCTED UNIT

2.3.1 General

The indoor unit shall be a built-in ceiling concealed fan coil unit, operable with R410A refrigerant, equipped with an electronic expansion valve, for installation into the ceiling cavity. The unit shall be constructed of a galvanized steel casing. It shall be available from 7,500 Btu/h to 48,000 Btu/h capacities and compatible with the outdoor unit heat pump and heat recovery model. It shall be a horizontal discharge air with horizontal return air or bottom return air configuration. Unit shall be a low height (11-7/8") construction. Computerized PID control shall be used to maintain room temperature within 1 degrees F. The unit shall be equipped with a programmed drying mechanism that dehumidifies while inhibiting changes in room temperature. Included as standard equipment, MERV B filters, isolation valves at evaporator, a condensate drain pan and drain pump kit. The indoor units sound pressure shall range from 35 dB(A) to 43 dB(A) at low speed 5 feet below the suction grille.

2.3.2 Indoor Unit

a. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, solder-joint connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have an adjustable external static pressure switch.

b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.

c. Both refrigerant lines shall be insulated from the outdoor unit.

d. Return air shall be through a net mold resistant filter.

e. The indoor units shall be equipped with a condensate pan and condensate pump.

f. The indoor units shall be equipped with a return air thermistor.

g. Switch box shall be reached from the side or bottom for ease of service and maintenance.

2.3.3 Unit Cabinet

The cabinet shall be located into the ceiling and ducted to the supply and return openings. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation. Optional high efficiency air filters shall be available for the unit.

2.3.4 Fan

The fan shall be direct-drive Sirocco type fan, statically and dynamically balanced impeller with high and low fan speeds available. The air flow rate shall be available in high and low settings. The fan motor shall be thermally protected and shall be tested in accordance with ASHRAE 90.1 - IP.

2.3.5 Filter

The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

2.3.6 Coil

a. Coils shall be the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.

b. The coil shall be a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.

c. The coil shall be a 3 row cross fin copper evaporator coil with 14 FPI design completely factory tested.

d. The refrigerant connections shall be solder-joint connections and the condensate will be 1 -1/4 inch outside diameter PVC.

e. A condensate pan shall be located under the coil.

f. A condensate pump shall be located below the coil in the condensate pan with a built in safety arm.

g. A thermistor will be located on the liquid and gas line.

2.3.7 Electrical

Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet). Transmission (control) wiring between the indoor and remote controller shall be a maximum distance of 1,640 feet.

2.3.8 Control

The unit shall have controls to perform input functions necessary to operate the system. The unit shall be compatible with interfacing with connection to BACnet networks.

2.3.9 Accessories

Provide a wall mounted, hard wired remote sensor kit for ceiling-embedded type fan coils. The temperature sensor shall be located where indicated in the documents, if not indicated, contractor shall request a location from the engineer in writing.

2.4 INDIVIDUAL ZONE CONTROLLER - WIRED REMOTE CONTROLLER

2.4.1 Physical Characteristics

The control system shall be a neutral color plastic material. Each control may have a Liquid Crystal Display (LCD).

2.4.2 Electrical Characteristics

2.4.2.1 General

From each circuit board to the controls, the electrical voltage shall be 16 volts DC.

2.4.2.2 Wiring

Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit then to the branch selector box and outdoor unit. Control wiring shall run from the indoor unit terminal block to the specific. The wire shall be a non-shielded, 2-core sheathed vinyl cord or cable, size AWG18-2.

2.4.3 Controller Characteristics

The wired remote controller shall be able to control 1 group (maximum of 16 fan coil units) and shall be able to function as follows:

a. The controller shall have a maximum wiring length of 1,640 feet.

b. The controller shall have a self diagnosis function that constantly monitors the system for malfunctions (total of 80 components).

c. The controller shall be able to immediately display fault location and condition.

d. An LCD digital display will allow the temperature to be set in 1 degrees F units.

e. The controller shall monitor room temperature and preset temperature by microcomputer and can select cool/heat operation mode automatically.

f. The controller shall allow the user to select cool / heat / fan operation mode with indoor remote controller of choice without using the cool / heat selector.

The wired remote controller shall have the following features:

Operation	Start/Stop Operation Mode Temperature Settings 60 Degrees F - 90 Degrees F Set Point Range Fan Speed Airflow Direction
Monitoring	Status

	Malfunction Flashing Malfunction Content Filter Sign Operation Mode Temperature Setting Permit/Prohibit Selection Fan Speed Airflow Direction
Control Management	Field Setting Mode Group Setting Auto Re-Start

2.5 INTELLIGENT TOUCH CONTROLLER

2.5.1 Physical Characteristics

The control system shall be a neutral color plastic material. The controller has a 5.7" Liquid Crystal Display (LCD, QVGA 320x240, 4096 colors).

2.5.2 Electrical Characteristics

2.5.2.1 General

From each outdoor unit circuit board to the I-touch controller, the daisy chained wiring electrical voltage shall be 16 volts DC.

2.5.2.2 Wiring

For heat recovery the control wiring shall be installed in a daisy chain configuration from outdoor unit to each branch selector box then from the branch selector box to the indoor unit.

2.5.2.3 Control Wiring Size

The wire shall be a non-shielded, stranded, 2 conductor PVC or vinyl clad cable. 18-gauge copper cabling specified. Application of UV stabilized cable should be standard when exposed to outside elements. Plenum rated where applicable. Maximum wiring length between controller and indoor units: 3,280 ft.

2.5.2.4 Power Supply to Controller

24V AC (transformer to be field supplied).

2.5.3 Controller Characteristics

The intelligent controller shall be able to control, via a full color LCD touch screen, up to 10 outdoor units and 64 indoor unit groups (maximum 128 Fan Coil Units) with the following functions:

a. On/Off selection for each fan coil unit or group

b. Temperature set point adjustment for each fan coil unit or group

c. Fan speed adjustment for each fan coil unit or group

d. Heat/cool/automatic changeover mode selection

e. Forced shutdown terminals

f. Priority settings for restriction of local access for start/stop, heat/cool mode and set point adjustment (at local remote controllers if installed)

g. Temperature limitation in both heating and cooling mode

h. Weekly schedule with start up and shut off times, temperature settings and operation modes, 16 operations/ each day can be set in one schedule, and 8 different schedules are available. In addition a yearly calendar is also available for holidays or periods of non use.

i. Actual time and display setting

j. Reset ability for malfunction codes and filter maintenance warning

k. Maximum 13 months backup power supply to maintain the memory

l. Malfunction reports can be sent via e-mail to a cell phone or a PC

m. Remote monitoring via PC, network and web browser (optional). Available web browser are: Real time status monitoring/Operation/Malfunction history display/User password setting and schedule setting

Manufacturer to provide Web based software for off-site monitoring purposes.

PART 3 EXECUTION

3.1 INSTALLATION

The system shall be installed by factory trained and authorized contractor. The contractor shall install the VRF system in accordance with the recommendations of the VRF manufacturer as outlined in the Manufacturers Installation Instructions. Provide a Refrigerant Piping System Layout for approval along with the VRF System equipment.

3.2 START-UP

Equipment start-up, performance tests, and commissioning shall be provided by a factory trained and authorized contractor. Control start-up and commissioning shall be provided by the factory.

3.3 PRODUCT SUPPORT

Installation, Operation and Maintenance Manuals are to be provided to the owner once commissioning is complete. Eight (8) hours of Operation and Maintenance training will be provided to the owner and owner's personnel once commissioning is complete.

-- End of Section --

The contractor shall install the VRF system in accordance with the recommendations of the VRF manufacturer as outlined in the Manufacturers Installation Instructions.

3.2 START-UP

Equipment start-up, performance tests, and commissioning shall be provided by a factory trained and authorized contractor. Control start-up and commissioning shall be provided by the factory.

3.3 PRODUCT SUPPORT

Installation, Operation and Maintenance Manuals are to be provided to the owner once commissioning is complete. Eight hours of Operation and Maintenance training will be provided to the owner and owner's personnel once commissioning is complete.

-- End of Section --

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SECTION 28 31 76

INTERIOR FIRE ALARM AND MASS NOTIFICATION SYSTEM

08/11

PART 1 GENERAL

1.1 RELATED SECTIONS

Division 26 applies to this section for basic electrical materials and methods, with the additions and modifications specified herein. In addition, refer to the following sections for related work and coordination:

Section 23 03 00 BASIC MECHANICAL MATERIALS AND METHODS

Section 21 13 13.00 10 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S3.2	(2009) Method for Measuring the Intelligibility of Speech Over Communication Systems (ASA 85)

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60268-16	(2003) Sound System Equipment - Part 16: Objective Rating Of Speech Intelligibility By Speech Transmission Index; Ed 3.0

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 7240-16	(2007) Fire Detection And Alarm Systems — Part 16: Sound System Control And Indicating Equipment

ISO 7240-19	(2007) Fire Detection and Alarm Systems — Part 19: Design, Installation, Commissioning and Service of Sound Systems for Emergency Purposes

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2011; TIA 11-1; Errata 2011; TIA 11-2; TIA 11-3; TIA 11-4) National Electrical Code
NFPA 72	(2013) National Fire Alarm and Signaling Code
NFPA 90A	(2012) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-601-02	(2010) Operations and Maintenance: Inspection, Testing, and Maintenance of Fire Protection Systems

UNDERWRITERS LABORATORIES (UL)

UL 1480	(2003; Reprint Jun 2010) Standard for Speakers for Fire Alarm, Emergency, and Commercial and Professional Use
UL 1638	(2001; Reprint Oct 2008) Visual Signaling Appliances - Private Mode Emergency and General Utility Signaling
UL 1971	(2002; Reprint Oct 2008) Signaling Devices for the Hearing Impaired
UL 2017	(2008; Reprint May 2011) General-Purpose Signaling Devices and Systems
UL 268	(2009) Smoke Detectors for Fire Alarm Systems
UL 464	(2009; Reprint Jan 2011) Standard for Audible Signal Appliances
UL 864	(2003; Reprint Jan 20110) Standard for Control Units and Accessories for Fire Alarm Systems
UL Electrical Constructn	(Current) Electrical Construction Equipment Directory
UL Fire Prot Dir	(Current) Fire Protection Equipment Directory

1.3 DEFINITIONS

Wherever mentioned in this specification or on the drawings, the equipment, devices, and functions shall be defined as follows:

a. Interface Device: An addressable device that interconnects hard wired systems or devices to an analog/addressable system.

b. Fire Alarm Control Unit and Mass Notification Autonomous Control Unit (FMCP): A master control panel having the features of a fire alarm and mass notification control unit and fire alarm and mass notification control units are interconnected. The panel has central processing, memory, input and output terminals, and LCD, LED Display units.

c. Terminal Cabinet: A steel cabinet with locking, hinge-mounted door that terminal strips are securely mounted.

d. Local Operating Console (LOC): A unit designed to allow emergency responders and/or building occupants to operate the MNS including delivery or recorded and/or live messages, initiate strobes and textural visible appliance operation, and other relayed functions.

1.4 SYSTEM DESCRIPTION

1.4.1 Scope

a. This work includes completion of design and providing a new, complete, addressable fire alarm and mass notification system as described herein and on the contract drawings for Building FC241. Include in the system wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, alarm, and supervisory signal initiating devices, alarm notification appliances, supervising station fire alarm system transmitter, and other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide system complete and ready for operation.

b. Provide equipment, materials, installation, workmanship, inspection, and testing in strict accordance with the required and advisory provisions of NFPA 72, ISO 7240-16, IEC 60268-16, except as modified herein. The system layout on the drawings show the intent of coverage and are shown in suggested locations. Final quantity, system layout, and coordination are the responsibility of the Contractor.

1.4.2 Technical Data and Computer Software

Technical data and computer software (meaning technical data that relates to computer software) that are specifically identified in this project, and may be defined/required in other specifications, shall be delivered, strictly in accordance with the CONTRACT CLAUSES. Identify data delivered by reference to the particular specification paragraph against which it is furnished. Data to be submitted shall include complete system, equipment, and software descriptions. Descriptions shall show how the equipment will operate as a system to meet the performance requirements of this contract. The data package shall also include the following:

a. Identification of programmable portions of system equipment and capabilities.

b. Description of system revision and expansion capabilities and methods of implementation detailing both equipment and software requirements.

c. Provision of operational software data on all modes of programmable portions of the fire alarm and detection system.

d. Description of Fire Alarm and Mass Notification Control Panel equipment operation.

e. Description of auxiliary and remote equipment operations.

f. Library of application software.

g. Operation, maintenance, and programming manuals.

1.4.3 Keys

Keys and locks for equipment shall be identical. Provide not less than six keys of each type required. Master all keys and locks to a single key as required by the Installation Fire Department.

LOC is not permitted to be locked or lockable.

1.5 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Annotated catalog data, in table format on the drawings, showing manufacturer's name, model, voltage, and catalog numbers for equipment and components. Submitted shop drawings shall not be smaller than 24 inches by 36 inches.

Nameplates
Wiring Diagrams
System Layout
System Operation
Notification Appliances
Amplifiers

SD-03 Product Data

Technical Data And Computer Software
Fire Alarm and Mass Notification Control Unit (FMCP)
Terminal cabinets
Manual stations
Transmitters (including housing)
Batteries
Battery chargers
Smoke sensors
Notification appliances
Addressable interface devices
Amplifiers
Tone generators
Digitalized voice generators
Digital alarm communicator transmitter (DACT)

SD-05 Design Data

Battery power
Battery chargers

SD-06 Test Reports

Field Quality Control
Testing Procedures
Smoke sensor testing procedures

SD-07 Certificates

Installer
Formal Inspection and Tests
Final Testing

SD-09 Manufacturer's Field Reports

System Operation
Fire Alarm/Mass Notification System

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions
Instruction of Government Employees

SD-11 Closeout Submittals

As-Built Drawings

1.6 QUALITY ASSURANCE

Equipment and devices shall be compatible and operable with existing station fire alarm system and shall not impair reliability or operational functions of existing supervising station fire alarm system. The supervising equipment is existing and consists of a Sur-Gard System III Digital Alarm Communicator Receiver which receives signals via contact ID protocol.

a. In NFPA publications referred to herein, consider advisory provisions to be mandatory, as though the word "shall" had been substituted for "should" wherever it appears; interpret reference to "authority having jurisdiction" to mean the Naval Facilities Engineering Command, Fire Protection Engineer.

b. The recommended practices stated in the manufacturer's literature or documentation shall be considered as mandatory requirements.

c. Devices and equipment for fire alarm service shall be listed by UL Fire Prot Dir or approved by FM APP GUIDE.

1.6.1 Qualifications

1.6.1.1 Design Services

Installations requiring completion of installation drawings and specification or modifications of fire detection, fire alarm, and mass notification system or fire suppression systems shall require the services and review of a qualified engineer. For the purposes of meeting this requirement, a qualified engineer is defined as a registered professional engineer (P.E.) in fire protection engineering.

1.6.1.2 Supervisor

NICET Fire Alarm Technicians to perform the installation of the system. A NICET Level 4 Fire Alarm Technician shall supervise the installation of the fire alarm/mass notification system. A Fire Alarm Technician with a minimum of 8 years of experience shall perform/supervise the installation of the fire alarm/mass notification system. The Fire Alarm technicians supervising the installation of equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.6.1.3 Technician

Fire Alarm Technicians with a minimum of four years of experience utilized to install and terminate fire alarm/mass notification devices, cabinets and panels. The Fire Alarm technicians installing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.6.1.4 Installer

NICET Level II technician to assist in the installation of fire alarm/mass notification devices, cabinets and panels. An electrician shall be allowed to install wire, cable, conduit and backboxes for the fire alarm /mass notification system. The Fire Alarm installer shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.6.1.5 Test Personnel

Fire Alarm Technicians with a minimum of eight years of experience (NICET Level IV)utilized to test and certify the installation of the fire alarm/mass notification devices, cabinets and panels. The Fire Alarm technicians testing the equipment shall be factory trained in the installation, adjustment, testing, and operation of the equipment specified herein and on the drawings.

1.6.1.6 Manufacturer's Representative

The fire alarm and mass notification equipment manufacturer's representative shall be present for the connection of wiring to the control panel. The Manufacturer's Representative shall be an employee of the manufacturer with necessary technical training (NICET Level IV)on the system being installed.

1.6.1.7 Manufacturer

Components shall be of current design and shall be in regular and recurrent production at the time of installation. Provide design, materials, and devices for a protected premises fire alarm/mass notification system, complete, conforming to NFPA 72, except as otherwise or additionally specified herein.

1.6.2 Regulatory Requirements

1.6.2.1 Requirements for Fire Protection Service

Equipment and material shall have been tested by UL and listed in UL Fire Prot Dir or approved by FM and listed in FM APP GUIDE. Where the terms "listed" or "approved" appear in this specification, they shall mean listed in UL Fire Prot Dir or FM APP GUIDE. The omission of these terms under the description of any item of equipment described shall not be construed as waiving this requirement. All listings or approval by testing laboratories shall be from an existing ANSI or UL published standard.

1.6.2.2 Fire Alarm/Mass Notification System

Furnish equipment that is compatible and is UL listed, FM approved, or listed by a nationally recognized testing laboratory for the intended use. All listings by testing laboratories shall be from an existing ANSI or UL published standard. Submit a unique identifier for each device, including the control panel and initiating and indicating devices, with an indication of test results, and signature of the factory-trained technician of the control panel manufacturer and equipment installer. With reports on preliminary tests, include printer information. Include the NFPA 72 Record of Completion and NFPA 72 Inspection and Testing Form, with the appropriate test reports.

1.6.2.3 Fire Alarm Testing Services or Laboratories

Install fire alarm and fire detection equipment in accordance with UL Fire Prot Dir, UL Electrical Constructn, or FM APP GUIDE.

1.7 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity, and temperature variation, dirt and dust, and other contaminants.

1.8 OPERATION AND MAINTENANCE (O&M) INSTRUCTIONS

Submit 6 copies of the Operation, Maintenance, and Programming Instructions, indexed and in booklet form. The Operation, Maintenance, and Programming Instructions shall be a single volume or in separate volumes, and may be submitted as a Technical Data Package. Manuals shall be approved prior to training. The Interior Fire Alarm And Mass Notification System Operation and Maintenance Instructions shall include:

a. "Manufacturer Data Package 5" as specified in Section 01 78 23 OPERATION AND MAINTENANCE DATA.

b. Operating manual outlining step-by-step procedures required for system startup, operation, and shutdown. The manual shall include the manufacturer's name, model number, service manual, parts list, and complete description of equipment and their basic operating features in addition to the list of Contact ID Point Description.

c. Maintenance manual listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The manuals shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed.

d. The manuals shall include complete procedures for system revision and expansion, detailing both equipment and software requirements.

e. Software delivered for this project shall be provided, on each type of CD/DVD media utilized.

f. Printouts of configuration settings for all devices.

g. Routine maintenance checklist. The routine maintenance checklist shall be arranged in a columnar format. The first column shall list all installed devices, the second column shall state the maintenance activity or state no maintenance required, the third column shall state the frequency of the maintenance activity, and the fourth column for additional comments or reference. All data (devices, testing frequencies, etc.) shall comply with UFC 3-601-02.

1.9 EXTRA MATERIALS

1.9.1 Repair Service/Replacement Parts

Repair services and replacement parts for the system shall be available for a period of 10 years after the date of final acceptance of this work by the Contracting Officer. During guarantee period, the service technician shall be on-site within 24 hours after notification. All repairs shall be completed within 24 hours of arrival on-site.

1.9.2 Interchangeable Parts

Spare parts furnished shall be directly interchangeable with the corresponding components of the installed system. Spare parts shall be suitably packaged and identified by nameplate, tagging, or stamping. Spare parts shall be delivered to the Contracting Officer at the time of the final acceptance testing.

1.9.3 Spare Parts

Furnish the following spare parts and accessories:

a. Four of each type of notification appliance in the system (e.g. speaker, FA strobe, speaker/strobe, MNS strobe, etc.)

b. Two of each type of initiating device included in the system (e.g. smoke detector, thermal detector, manual station, etc.)

c. Four fuses for each fused circuit for each FMCP. Mount spare fuses in the FMCP.

d. One Solo 823 Smoke Detector Test Kit with Bag, Heat Tester, and Battery Charger for each type of sensor/device installed.

1.9.4 Parts List

Furnish a list, in duplicate, of all other parts and accessories which the manufacturer of the system recommends to be stocked for maintenance.

1.9.5 Special Tools

Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as part of this contract. Software, connecting cables and proprietary equipment, necessary for the maintenance, testing, and reprogramming of the equipment shall be furnished to the Contracting Officer. Software required to maintain the system that is provided as part of this contract shall continue to operate for the entire lifetime of the installed equipment and not require any additional cost or renewal fees to the government.

Provide five (5) field programming devices for maintaining and updating the building fire alarm systems. Each programming device shall include all required software and cable to maintain, test, and reprogram the fire alarm equipment.

Note: Handheld programmer for programming digital alarm communicator transmitter (DACT), devices, and VESDA smoke detection system.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Submit annotated catalog data as required in the paragraph SUBMITTAL, in table format on the drawings, showing manufacturer's name, model, voltage, and catalog numbers for equipment and components. Submitted shop drawings shall not be smaller than 24 inches by 36 inches. Also provide UL or FM listing cards for equipment provided.

2.1.1 Standard Products

Provide materials, equipment, and devices that have been tested by a nationally recognized testing laboratory, such as UL or FM Approvals, LLC (FM), and listed or approved for fire protection service when so required by NFPA 72 or this specification. Select material from one manufacturer, where possible, and not a combination of manufacturers, for any particular classification of materials. Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least two years prior to bid opening.

2.1.2 Nameplates

Major components of equipment shall have the manufacturer's name, address, type or style, model or serial number, catalog number, date of installation, installing Contractor's name and address, and the contract number provided on a new plate permanently affixed to the item or equipment. In addition, provide a nameplate with the manufacturer and model number permanently affixed to the front of the FACP/FMCP that is visible without opening the enclosure. Major components include, but are not limited to, the following:

a. FMCPs

b. Automatic transmitter/transceiver

c. Terminal Cabinet

Furnish nameplate illustrations and data to obtain approval by the Contracting Officer before installation. Obtain approval by the Contracting Officer for installation locations. Nameplates shall be etched metal or plastic, permanently attached by screws to panels or adjacent walls.

2.2 GENERAL PRODUCT REQUIREMENT

All fire alarm and mass notification equipment shall be listed for use under the applicable reference standards. Interfacing of Listed UL 864 or similar approved industry listing with Mass Notification Panels listed to UL 2017 shall be done in a laboratory listed configuration, if the software programming features cannot provide a listed interface control. If a field modification is needed, such as adding equipment like relays, the manufacturer of the panels being the same or a different brand, the manufacturer shall provide detailed modification instructions/diagrams to the installing contractor for review and confirmation by the installing contractor. As part of the submittal documents, provide this information.

2.3 SYSTEM OPERATION

The Addressable Interior Fire Alarm and Mass Notification System shall be a complete, supervised, noncoded, analog/addressable fire alarm and mass notification system conforming to NFPA 72, UL 864, and UL 2017. The system shall be activated into the alarm mode by actuation of any alarm initiating device. The system shall remain in the alarm mode until the initiating device is reset and the control panel is reset and restored to normal. The system may be placed in the alarm mode by local microphones, LOC, or remotely from authorized locations/users.

Submit data on each circuit to indicate that there is at least 25 percent spare capacity for notification appliances, 25 percent spare capacity for initiating devices. Annotate data for each circuit on the drawings. Submit a complete description of the system operation in matrix format on the drawings. Submit a complete list of device addresses and corresponding messages.

2.3.1 Alarm Initiating Devices and Notification Appliances (Visual, Voice, Textural)

a. Connect alarm initiating devices to initiating device circuits (IDC) Class "B" and installed in accordance with NFPA 72. Label all IDC devices with a typed printed label.

b. Connect alarm notification appliances and speakers to notification appliance circuits (NAC) Class "B". Label all NAC and devices with a typed printed label.

c. The system shall operate in the alarm mode upon actuation of any alarm initiating device or a mass notification signal. The system shall remain in the alarm mode until initiating device(s) or mass notification signal is/are reset and the control panel is manually reset and restored to normal. Audible, and visual appliances and systems shall comply with NFPA 72 and as specified herein. Fire alarm system/mass notification system components requiring power, except for the control panel power supply, shall operate on 24 Volts dc.

2.3.2 Functions and Operating Features

The system shall provide the following functions and operating features:

a. The FMCP shall provide power, annunciation, supervision, and control for the system. Addressable systems shall be microcomputer (microprocessor or microcontroller) based with a minimum word size of eight bits with sufficient memory to perform as specified.

b. For Class "A" circuits with conductor lengths of 3m (10 feet) or less, the conductors shall be permitted to be installed in the same raceway in accordance with NFPA 72.

c. Provide notification appliance circuits. The visual alarm notification appliances shall have the flash rates synchronized as required by NFPA 72.

d. Provide electrical supervision of the primary power (AC) supply, presence of the battery, battery voltage, and placement of system modules within the control panel.

e. Provide an audible and visual trouble signal to activate upon a single break or open condition, or ground fault. The trouble signal shall also operate upon loss of primary power (AC) supply, absence of a battery supply, low battery voltage, or removal of alarm or supervisory panel modules. Provide a trouble alarm silence feature that shall silence the audible trouble signal, without affecting the visual indicator. After the system returns to normal operating conditions, the trouble signal shall again sound until the trouble is acknowledged. A smoke sensor in the process of being verified for the actual presence of smoke shall not initiate a trouble condition.

f. Provide program capability via switches in a locked portion of the FMCP to bypass the automatic notification appliance circuits, fire reporting system air handler shutdown features. Operation of this programming shall indicate this action on the FMCP display and printer output.

g. Provide alarm verification capability for smoke sensors. Alarm verification shall initially be set for 20 seconds.

h. Alarm, supervisory, and/or trouble signals shall be automatically transmitted to the supervising station.

i. Alarm functions shall override trouble or supervisory functions. Supervisory functions shall override trouble functions.

j. The system shall be capable of being programmed from the panels keyboard. Programmed information shall be stored in non-volatile memory.

k. The system shall be capable of operating, supervising, and/or monitoring both addressable and non-addressable alarm and supervisory devices.

l. There shall be no limit, other than maximum system capacity, as to the number of addressable devices, that may be in alarm simultaneously.

m. Where the fire alarm/mass notification system is responsible for initiating an action in another emergency control device or system, such as an HVAC system, the addressable fire alarm relay shall be in the vicinity of the emergency control device.

n. An alarm signal shall automatically initiate the following functions:

(1) Transmission of an alarm signal to the supervising station.

(2) Visual indication of the device operated on the control panel (FMCP), and sound the audible alarm at the respective panel.

(3) Continuous actuation of all alarm notification appliances.

(4) Recording of the event via electronically in the history log of the fire control system unit.

(5) Operation of a duct smoke sensor shall shut down the appropriate air handler in accordance with NFPA 90A in addition to other requirements of this paragraph and as allowed by NFPA 72.

(6) Operation of a sprinkler waterflow switch shall activate audible and visual fire alarm devices and the exterior waterflow strobe.

p. A supervisory signal shall automatically initiate the following functions:

(1) Visual indication of the device operated on the FMCP and sound the audible alarm at the respective panel.

(2) Transmission of a supervisory signal to the supervising station .

(3) Recording of the event electronically in the history log of the control unit.

q. A trouble condition shall automatically initiate the following functions:

(1) Visual indication of the system trouble on the FMCP and sound the audible alarm at the respective panel.

(2) Transmission of a trouble signal to the supervising station.

(3) Recording of the event in the history log of the control unit.

r. The maximum permissible elapsed time between the actuation of an initiating device and its indication at the FMCP is 10 seconds.

s. The maximum elapsed time between the occurrence of the trouble condition and its indication at the FMCP is 200 seconds.

t. Activation of a LOC pushbutton shall activate the audible and visual alarms in the facility. The audible message shall be the one associated with the pushbutton activated.

2.4 SYSTEM MONITORING

2.4.1 Valves

Each valve affecting the proper operation of a fire protection system, including automatic sprinkler control valves, standpipe control valves, sprinkler service entrance valve, valves at fire pumps, isolating valves for pressure type waterflow or supervision switches, and valves at backflow preventers, whether supplied under this contract or existing, shall be electrically monitored to ensure its proper position. Provide each tamper switch with a separate address. Label each sprinkler addressable device and circuit with a typed printed label.

2.5 MASS NOTIFICATION SYSTEM FUNCTIONS

2.5.1 Notification Appliance Network

The audible notification appliance network consists of speakers located to provide intelligible instructions at all locations in the building. The Mass Notification System announcements shall take priority over all other audible announcements of the system including the output of the fire alarm system in a normal or alarm state. When a mass notification announcement is activated during a fire alarm, all fire alarm system functions shall continue in an alarm state except for the output signals of the fire alarm audible and visual notification appliances.

2.5.2 Wide Area MNS

The Wide Area MNS system (if available) in the area of the building shall not be activated by the in-building MNS.

2.5.3 Voice Notification

An autonomous voice notification control unit is used to monitor and control the notification appliance network and provide consoles for local operation. Using a console, personnel in the building can initiate delivery of pre-recorded voice messages, provide live voice messages and instructions, and initiate visual strobe and optional textual message notification appliances. The autonomous voice notification control unit will temporarily override audible fire alarm notification while delivering Mass Notification messages to ensure they are intelligible.

2.5.4 Installation-Wide Control

If an installation-wide control system for mass notification exists on the base, the autonomous control unit shall communicate with the central control unit of the installation-wide system. The autonomous control unit shall receive commands/messages from the central control unit and provide status information.

2.6 OVERVOLTAGE AND SURGE PROTECTION

2.6.1 Signaling Line Circuit Surge Protection

For systems having circuits located outdoors, communications equipment shall be protected against surges induced on any signaling line circuit and shall comply with the applicable requirements of IEEE C62.41.1 and IEEE C62.41.2. Cables and conductors, that serve as communications links, shall have surge protection circuits installed at each end that meet the following waveform(s):

a. A 10 microsecond by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 microsecond by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Protection shall be provided at the equipment. Additional triple electrode gas surge protectors, rated for the application, shall be installed on each wireline circuit within 3 feet of the building cable entrance. Fuses shall not be used for surge protection.

2.6.2 Sensor Wiring Surge Protection

Digital and analog inputs and outputs shall be protected against surges induced by sensor wiring installed outdoors and as shown. The inputs and outputs shall be tested with the following waveforms:

a. A 10 by 1000 microsecond waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.

b. An 8 by 20 microsecond waveform with a peak voltage of 1000 volts and a peak current of 500 amperes. Fuses shall not be used for surge protection.

2.7 ADDRESSABLE INTERFACE DEVICES

The initiating device being monitored shall be configured as a Class "B" initiating device circuits. The system shall be capable of defining any module as an alarm module and report alarm trouble, loss of polling, or as a supervisory module, and reporting supervisory short, supervisory open or loss of polling such as waterflow switches, valve supervisory switches, fire pump monitoring, independent smoke detection systems, relays for output function actuation, etc. The module shall be UL or FM listed as compatible with the control panel. The monitor module shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. Monitor module shall contain an integral LED that flashes each time the monitor module is polled and is visible through the device cover plate. Pull stations with a monitor module in a common backbox are not required to have an LED.

2.8 ADDRESSABLE CONTROL MODULE

The control module shall be capable of operating as a relay (dry contact form C) for interfacing the control panel with other systems, and to control door holders or initiate elevator fire service. The module shall be UL or FM listed as compatible with the control panel. The indicating device or the external load being controlled shall be configured as a Class "B" notification appliance circuits. The system shall be capable of supervising, audible, visual and dry contact circuits. The control module shall have both an input and output address. The supervision shall detect a short on the supervised circuit and shall prevent power from being applied to the circuit. The control model shall provide address setting means compatible with the control panel's SLC supervision and store an internal identifying code. The control module shall contain an integral LED that flashes each time the control module is polled and is visible through the device cover plate. Control modules shall be located in environmental areas that reflect the conditions to which they were listed.

2.9 ISOLATION MODULES

Provide isolation modules to subdivide each signaling line circuit into groups of not more than 20 addressable devices between adjacent isolation modules.

2.10 SMOKE SENSORS

2.10.1 Photoelectric Smoke Sensors

Provide addressable photoelectric smoke sensors as follows:

a. Provide analog/addressable photoelectric smoke sensors utilizing the photoelectric light scattering principle for operation in accordance with UL 268. Smoke sensors shall be listed for use with the fire alarm control panel.

b. Provide self-restoring type sensors that do not require any readjustment after actuation at the FMCP to restore them to normal operation. Sensors shall be UL listed as smoke-automatic fire sensors.

c. Components shall be rust and corrosion resistant. Vibration shall have no effect on the sensor's operation. Protect the detection chamber with a fine mesh metallic screen that prevents the entrance of insects or airborne materials. The screen shall not inhibit the movement of smoke particles into the chamber.

d. Provide twist lock bases for the sensors. The sensors shall maintain contact with their bases without the use of springs. Provide companion mounting base with screw terminals for each conductor. Terminate field wiring on the screw terminals. The sensor shall have a visual indicator to show actuation. Label each base with its address utilizing a typed printed label.

e. The sensor address shall identify the particular unit, its location within the system, and its sensitivity setting. Sensors shall be of the low voltage type rated for use on a 24 VDC system.

f. An operator at the control panel, having a proper access level, shall have the capability to manually access the following information for each initiating device.

(1) Primary status

(2) Device type

(3) Present average value

(4) Present sensitivity selected

(5) Sensor range (normal, dirty, etc.)

2.10.2 Duct Smoke Sensors

Duct-mounted photoelectric smoke detectors shall be furnished and installed in accordance with NFPA 90A. Units shall consist of a smoke detector as specified in paragraph Photoelectric Detectors, mounted in a special housing fitted with duct sampling tubes. Detector circuitry shall be mounted in a metallic enclosure exterior to the duct. (It is not permitted to cut the duct insulation to install the duct detector directly on the duct). Detectors shall have a manual reset. Detectors shall be rated for air velocities that include air flows between 500 and 4000 fpm. Detectors shall be powered from the fire alarm panel.

a. Sampling tubes shall run the full width of the duct. The duct detector package shall conform to the requirements of NFPA 90A, UL 268A, and shall be UL listed for use in air-handling systems. The control functions, operation, reset, and bypass shall be controlled from the fire alarm control panel.

b. Lights to indicate the operation and alarm condition; and the test and reset buttons shall be visible and accessible with the unit installed and the cover in place. Remote indicators shall be provided where required by NFPA 72 and these shall be provided with test and reset switches.

c. Remote lamps and switches, as well as the affected fan units, shall be properly identified in etched plastic placards. Detectors shall provide for control of auxiliary contacts that provide control, interlock, and shutdown functions shall be coordinated with mechanical drawings and as specified in 23 03 00 BASIC MECHANICAL MATERIALS AND METHODS. Auxiliary contacts provide for this function shall be located within 3 feet of the controlled circuit or appliance. The detectors shall be supplied by the fire alarm system manufacturer to ensure complete system compatibility.

2.10.3 Smoke Sensor Testing

Smoke sensors shall be tested in accordance with NFPA 72 and manufacturer's recommended calibrated test method. Submit smoke sensor testing procedures for approval. In addition to the NFPA 72 requirements, smoke detector sensitivity shall be tested during the preliminary tests.

2.11 ELECTRIC POWER

2.11.1 Primary Power

Power shall be 120 VAC service for the FMCP from the AC service to the building in accordance with NFPA 72.

2.12 SECONDARY POWER SUPPLY

Provide for system operation in the event of primary power source failure. Transfer from normal to auxiliary (secondary) power or restoration from auxiliary to normal power shall be automatic and shall not cause transmission of a false alarm.

2.12.1 Batteries

Provide sealed (valve-regulated lead acid) batteries as the source for emergency power to the FMCP. Batteries shall contain suspended electrolyte. The battery system shall be maintained in a fully charged condition by means of a solid state battery charger. Provide an automatic transfer switch to transfer the load to the batteries in the event of the failure of primary power.

2.12.1.1 Capacity

Battery size shall be the greater of the following two capacities:

a. Sufficient capacity to operate the system under supervisory conditions, including audible signal devices for 48 hours and audible and visual signal devices under alarm conditions for an additional 15 minutes.

b. Sufficient capacity to operate the mass notification for 60 minutes in alarm after initial loss of AC power.

2.12.1.2 Battery Power Calculations

a. Verify that battery capacity exceeds supervisory and alarm power requirements.

    (1) Substantiate the battery calculations for alarm, alert, and supervisory power requirements. Include ampere-hour requirements for each system component and each panel component, and compliance with UL 864.

    (2) Provide complete battery calculations for both the alarm, alert,

and supervisory power requirements. Submit ampere-hour requirements for each system component with the calculations. The calculations shall include a 20% safety margin on the ampere-hour.

(3) A voltage drop calculation to indicate that sufficient voltage is available for proper operation of the system and all components, at the minimum rated voltage of the system operating on batteries.

b. For battery calculations use the following assumptions: Assume a starting voltage of 24 VDC for starting the calculations to size the batteries. Calculate the required Amp-Hours for the specified standby time, and then calculate the required Amp-Hours for the specified alarm time. Calculate the nominal battery voltage after operation on batteries for the specified time period. Using this voltage perform a voltage drop calculation for circuit containing device and/or appliances remote from the power sources.

2.12.2 Battery Chargers

Provide a solid state, fully automatic, variable charging rate battery charger. The charger shall be capable of providing 120 percent of the connected system load and shall maintain the batteries at full charge. In the event the batteries are fully discharged (20.4 Volts dc), the charger shall recharge the batteries back to 95 percent of full charge within 48 hours after a single discharge cycle as described in paragraph CAPACITY above. Provide pilot light to indicate when batteries are manually placed on a high rate of charge as part of the unit assembly if a high rate switch is provided.

2.13 FIRE ALARM AND MASS NOTIFICATION CONTROL UNIT(FMCP)

Provide a complete control panel fully enclosed in a lockable steel cabinet as specified herein. Operations required for testing or for normal care and maintenance of the systems shall be performed from the front of the enclosure. If more than a single unit is required at a location to form a complete control panel, the unit cabinets shall match exactly.

a. Each control unit shall provide power, supervision, control, and logic for the entire system, utilizing solid state, modular components, internally mounted and arranged for easy access. Each control unit shall be suitable for operation on a 120 volt, 60 hertz, normal building power supply. Provide each panel with supervisory functions for power failure, internal component placement, and operation.

b. Visual indication of alarm, supervisory, or trouble initiation on the fire alarm control panel shall be by liquid crystal display or similar means. At least two lines of information with a minimum of 20 characters per line displayed. The total number of characters shall be 80 minimum. The LCD text display size shall meet the requirements of Chapter 24 of NFPA 72.

c. The mass notification control unit shall have the capability of temporarily deactivate the fire alarm audible notification appliances while delivering voice messages.

d. Provide secure operator console for initiating recorded messages, strobes and displays; and for delivering live voice messages. Provide capacity for at least eight pre-recorded messages. Provide the ability to automatically repeat pre-recorded messages. Provide a secure microphone for delivering live messages. Provide adequate discrete outputs to temporarily deactivate fire alarm audible notification, and initiate/synchronize strobes. Provide a complete set of self-diagnostics for controller and appliance network. Provide local diagnostic information display and local diagnostic information and system event log file.

2.13.1 Cabinet

Install control panel components in cabinets large enough to accommodate all components and also to allow ample gutter space for interconnection of panels as well as field wiring. The enclosure shall be identified by an engraved laminated phenolic resin nameplate. Lettering on the nameplate shall say "Fire Alarm and Mass Notification Control Panel" and shall not be less than 1 inch high. Provide prominent rigid plastic or metal identification plates for lamps, circuits, meters, fuses, and switches. The cabinet shall be provided in a sturdy steel housing, complete with back box, hinged steel door with cylinder lock, and surface mounting provisions.

2.13.2 Control Modules

Provide power and control modules to perform all functions of the FMCP. Provide audible signals to indicate any alarm, supervisory, or trouble condition. The alarm signals shall be different from the trouble signal. Connect circuit conductors entering or leaving the panel to screw-type terminals with each terminal marked for identification. Locate diodes and resistors, if any, on screw terminals in the FMCP. Circuits operating at 24 VDC shall not operate at less than the UL listed voltage at the sensor or appliance connected. Circuits operating at any other voltage shall not have a voltage drop exceeding 10 percent of nominal voltage

2.13.3 Silencing Switches

2.13.3.1 Alarm Silencing Switch

Provide an alarm silencing switch at the FMCP that shall silence the audible and visual. This switch shall be overridden upon activation of a subsequent alarm.

2.13.3.2 Supervisory/Trouble Silencing Switch

Provide supervisory and trouble silencing switch that shall silence the audible trouble and supervisory signal, but not extinguish the visual indicator. This switch shall be overridden upon activation of a subsequent alarm, supervision, or trouble condition. Audible trouble indication must resound automatically every 24 hours after the silencing feature has been operated.

2.13.4 Non-Interfering

Power and supervise each circuit such that a signal from one device does not prevent the receipt of signals from any other device. Circuits shall be manually reset by switch from the FMCP after the initiating device or devices have been restored to normal.

2.13.5 Audible Notification System

The Audible Notification System shall comply with the requirements of

NFPA 72 for Emergency Voice/Alarm Communications System requirements ISO 7240-16, IEC 60268-16, except as specified herein. The system shall be a two-way multi-channel voice notification system incorporating user selectability of a minimum eight distinct sounds for tone signaling, and the incorporation of a voice module for delivery of prerecorded messages. Audible appliances shall produce a temporal code 3 tone for three cycles followed by a voice message that is repeated until the control panel is reset or silenced. Automatic messages shall be broadcast through speakers throughout the building/facility but not in stairs or elevator cabs. A live voice message shall override the automatic audible output through use of a microphone input at the control panel or the LOC.

a. When using the microphone, live messages shall be broadcast throughout the building. The system shall be capable of operating all speakers at the same time. The microprocessor shall actively interrogate circuitry, field wiring, and digital coding necessary for the immediate and accurate rebroadcasting of the stored voice data into the appropriate amplifier input. Loss of operating power, supervisory power, or any other malfunction that could render the digitalized voice module inoperative shall automatically cause the code 3 temporal tone to take over all functions assigned to the failed unit in the event an alarm is activated.

b. The Mass Notification functions shall override the manual or automatic fire alarm notification or Public Address (PA) functions. Other fire alarm functions including transmission of a signal(s) to the fire department shall remain operational. The system shall have the capability of utilizing LOC with redundant controls of the notification system control panel. Notification Appliance Circuits (NAC) shall be provided for the activation of strobe appliances. The activation of the NAC Circuits shall follow the operation of the speaker NAC circuits. Audio output shall be selectable for line level. Amplifier outputs shall be not greater than 100 watts RMS output. The strobe NAC Circuits shall provide at least 2 amps of 24 VDC power to operate strobes and have the ability to synchronize all strobes. A hand held microphone shall be provided and, upon activation, shall take priority over any tone signal, recorded message or PA microphone operation in progress, while maintaining the strobe NAC Circuits activation.

c. Speaker placement/installation shall ensure that a CIS value greater than the required minimum value is provided in each area where building occupants typically are found. The minimum required value is 0.7 CIS.

2.13.5.1 Outputs and Operational Modules

All outputs and operational modules shall be fully supervised with on-board diagnostics and trouble reporting circuits. Provide form "C" contacts for system alarm and trouble conditions. Provide circuits for operation of auxiliary appliance during trouble conditions. During a Mass Notification event the panel shall not generate nor cause any trouble alarms to be generated with the Fire Alarm system.

2.13.5.2 Mass Notification

a. Mass Notification functions shall take precedence over all other functions performed by the Audible Notification System. Messages shall utilize a female voice and shall be similar to the following:

(1) 1000 Hz tones (as required in 18.4.2.1 of NFPA 72)

(2) "May I have your attention please. May I have your attention please. An fire emergency has been reported in the building. Please leave the building by the nearest exit." (Provide a 2 second pause.) "May I have your attention please, (repeat the message)."

b. Include ALL installation specific messages in this section. Pre-recorded messages shall address at least these subjects:

(1) Bomb threat or actual bomb within/around the building.

(2) Intruder/hostile person sighted within/around the building.

(3) Directions to occupants to take cover within the building.

(4) Evacuation of the building using exits other than the normal main entrance/exit (since the front entrance/exit is often a location targeted by terrorists.

(5) Emergency weather conditions appropriate for the local area.

(6) "All Clear" message.

(7) A test message intended for verifying functionality of the system.

c. The Local Operating Console (LOC) shall incorporate a Push-To-Talk (PTT) microphone, redundant controls and system status indicators of/for the system. The unit shall incorporate microphone override of any tone generation or prerecorded messages. The unit shall be fully supervised from the control panel. The housing shall contain a latch (not lock) A push button must be provided within the LOC enclosure to manually shut down all HVAC equipment..

d. Auxiliary Input Module shall be designed to be an outboard expansion module to either expand the number of optional LOC's, or allow a telephone interface.

2.13.6 Memory

Provide each control unit with non-volatile memory and logic for all functions. The use of long life batteries, capacitors, or other age-dependent devices shall not be considered as equal to non-volatile processors, PROMS, or EPROMS.

2.13.7 Field Programmability

Provide control units and control panels that are fully field programmable for control, initiation, notification, supervisory, and trouble functions of both input and output. The system program configuration shall be menu driven. System changes shall be password protected and shall be accomplished using personal computer based equipment. Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as part of this contract.

2.13.8 Input/Output Modifications

The FMCP shall contain features that allow the bypassing of input devices from the system or the modification of system outputs. These control features shall consist of a panel mounted keypad. Any bypass or modification to the system shall indicate a trouble condition on the FMCP.

2.13.9 Resetting

Provide the necessary controls to prevent the resetting of any alarm, supervisory, or trouble signal while the alarm, supervisory or trouble condition on the system still exists.

2.13.10 Instructions

Provide a typeset printed or typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. Install the frame in a conspicuous location observable from the FMCP. The card shall show those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions, normal, alarm, supervisory, and trouble. The instructions shall be approved by the Contracting Officer before being posted.

2.13.11 Walk Test

The FMCP shall have a walk test feature. When using this feature, operation of initiating devices shall result in limited system outputs, so that the notification appliances operate for only a few seconds and the event is indicated in the history of the panel, but no other outputs occur.

2.13.12 History Logging

The control panel shall have the ability to store a minimum of 400 events in a log. These events shall be stored in a battery-protected memory and shall remain in the memory until the memory is downloaded or cleared manually. Resetting of the control panel shall not clear the memory.

2.14 AMPLIFIERS, PREAMPLIFIERS, TONE GENERATORS

Any amplifiers, preamplifiers, tone generators, digitalized voice generators, and other hardware necessary for a complete, operational, textual audible circuit conforming to NFPA 72 shall be housed in a terminal cabinet, or in the FMCP. Submit data to indicate that the amplifiers have sufficient capacity to simultaneously drive all notification speakers at the maximum rating plus 50 percent spare capacity. Annotate data for each circuit on the drawings.

2.14.1 Operation

The system shall automatically operate and control all building speakers.

2.14.2 Construction

Amplifiers shall utilize computer grade solid state components and shall be provided with output protection devices sufficient to protect the amplifier against any transient up to 10 times the highest rated voltage in the system.

2.14.3 Inputs

Equip each system with separate inputs for the tone generator, digitalized voice driver and panel mounted microphone. Microphone inputs shall be of the low impedance, balanced line type. Both microphone and tone generator input shall be operational on any amplifier.

2.14.4 Tone Generator

The tone generator shall be of the modular, plug-in type with securely attached labels to identify the component as a tone generator and to identify the specific tone it produces. The tone generator shall produce a code 3 temporal tone and shall be constantly repeated until interrupted by either the digitalized voice message, the microphone input, or the alarm silence mode as specified. The tone generator shall be single channel with an automatic backup generator per channel such that failure of the primary tone generator causes the backup generator to automatically take over the functions of the failed unit and also causes transfer of the common trouble relay.

2.14.5 Protection Circuits

Each amplifier shall be constantly supervised for any condition that could render the amplifier inoperable at its maximum output. Failure of any component shall cause automatic transfer to a designated backup amplifier, illumination of a visual "amplifier trouble" indicator on the control panel, appropriate logging of the condition on the system printer, and other actions for trouble conditions as specified.

2.15 MANUAL STATIONS

Provide metal or plastic, semi-flush mounted, double action, addressable manual stations, that are not subject to operation by jarring or vibration. Stations shall be equipped with screw terminals for each conductor. Stations that require the replacement of any portion of the device after activation are not permitted. Stations shall be finished in fire-engine red with molded raised lettering operating instructions of contrasting color. The use of a key shall be required to reset the station. The operable portions of the manual stations shall be mounted at 44 inches above the finished floor.

Provide a backup means to manually activate the fire alarm system when the automatic fire detection system or waterflow devices are out of service due to maintenance or testing.

Provide a manual fire alarm box connected to a separate circuit that is not placed "on test" when the detection or sprinkler system is placed "on test".

2.16 NOTIFICATION APPLIANCES

2.16.1 Fire Alarm/Mass Notification Speakers

Audible appliances shall conform to the applicable requirements of UL 464. Appliances shall be connected into notification appliance circuits. Surface mounted audible appliances shall be painted red. Recessed audible appliances shall be installed with a grill that is painted red.

a. Speakers shall conform to the applicable requirements of UL 1480. Speakers shall have six different sound output levels and operate with audio line input levels of 70.7 VRMs and 25 VRMs, by means of selectable tap settings. Tap settings shall include taps of 1/8, 1/4, 1/2, 1, and 2 watt. Speakers shall incorporate a high efficiency speaker for maximum output at minimum power across a frequency range of

150 Hz to 10,000 Hz, and shall have a sealed back construction. Speakers shall be capable of installation on standard 4 inch square electrical boxes. Where speakers and strobes are provided in the same location, they may be combined into a single wall mounted unit. All inputs shall be polarized for compatibility with standard reverse polarity supervision of circuit wiring via the FMCP.

b. Provide speaker mounting plates constructed of cold rolled steel having a minimum thickness of 16 gauge or molded high impact plastic and equipped with mounting holes and other openings as needed for a complete installation. Fabrication marks and holes shall be ground and finished to provide a smooth and neat appearance for each plate. Each plate shall be primed and painted.

c. Speakers shall utilize screw terminals for termination of all field wiring.

d. Exterior supervised horn loud speakers shall be a STH-15S. The horn shall be weather resistant and constructed of heavy gauge, treated aluminum. The horn shall be able to operate within any ambient temperature environment ranging from 150 degrees F. to -30 degrees F. The horn shall be a double reentrant type with a 15 watt RMS audio power rated compression driver producing a UL rated 102 dB measured at 15 watts at 10 feet. The horn shall have an impedance selection via a 7 position switch of 5000, 2500, 1300, 666, 333, 89 & 45. Power taps shall be available at 2.0, 4.0, 7.5, and 15 watts for the 100 volt line, .9, 1.8, 3.8, 7.5, and 15 watts for the 70 volt line and .48, .94, 1.8, 7.5, and 15 watts for the 25 volt line. Each power tap shall have a 3dB incremental rating. The frequency response range shall be 400 - 4000 Hz. The horn shall have a dispersion of 70 degrees. The horn assembly shall be furnished with a mounting bracket that allows adjustment on either a vertical or horizontal plane with a single locking pin and include provisions for mounting, banding or strapping. Wiring terminals shall be fully enclosed and a vandal-resistant adapter cover shall provide connection protection for cable or conduit. The horn shall be 7.875 inches W x 8.75 inches H x 9.313 inches D. The horn shall be finished in gray baked epoxy.

2.16.2 Visual Notification Appliances

Visual notification appliances shall conform to the applicable requirements of UL 1971 and conform to the Architectural Barriers Act (ABA). Colored lens, such as amber, shall comply with UL 1638. The manufacturer shall have the color lens tested to the full UL 1971 polar plotting criteria, voltage drop, and temperature rise as stated in 1971.Fire Alarm/Mass Notification Appliances shall have clear high intensity optic lens, xenon flash tubes, and output white light and be marked "ALERT" in red letters. The light pattern shall be disbursed so that it is visible above and below the strobe and from a 90 degree angle on both sides of the strobe. Strobe flash rate shall be 1 flash per second and a minimum of 15 candela (actual output after derating for tinted lens) based on the UL 1971 test. Strobe shall be semi-flush mounted. Where more than two appliances are located in the same room or corridor or field of view, provide synchronized operation. Devices shall use screw terminals for all field wiring.

2.16.3 Exterior Waterflow Strobe

Provide an exterior weatherproof strobe with a red lens. the housing shall not be marked "Fire" or "Alert" but be void of any lettering. Attach a sign to the exterior wall utilizing no less then four lead anchors and stainless steel screws. Sign shall have a minimum of 3 inch typed red lettering on a reflective white background with an aluminum core. The sign shall have a 0.5 inch wide red border.

2.17 ENVIRONMENTAL ENCLOSURES OR GUARDS

Environmental enclosures shall be provided to permit Fire Alarm or Mass Notification components to be used in areas that exceed the environmental limits of the listing. The enclosure shall be listed for the device or appliance as either a manufactured part number or as a listed compatible accessory for the UL category that the component is currently listed. Guards required to deter mechanical damage shall be either a listed manufactured part or a listed accessory for the category of the initiating device or notification appliance.

2.18 INTERFACE TO THE BASE WIDE MASS NOTIFICATION NETWORK

2.18.1 Secure Radio System

2.18.1.1 Communications Network

The communications network provides two-way signals between central control units and autonomous control units (in individual building systems), and should include redundant (primary and backup) communication links. The system shall incorporate technology to prevent easy interruption of the radio traffic for MNS Alerting.

2.18.1.2 Radio Frequency Communications

Use of radio frequency-type communications systems shall comply with National Telecommunications and Information Administration (NTIA) requirements. The systems shall be designed to minimize the potential for interference, jamming, eavesdropping, and spoofing.

2.19 AUTOMATIC FIRE TRANSMITTERS

2.19.1 Digital Alarm Communicator Transmitter (DACT)

Provide DACT that is compatible with the existing supervising station fire alarm system. Provide a point reporting DACT that is compatible with the existing supervising station fire alarm system and is programmed to report by points to the Sur-Gard System III Digital Alarm Communicator Receiver at the supervising station. Transmitter shall have a means to transmit alarm, supervisory, and trouble conditions via a single transmitter. Transmitter shall have a source of power for operation that conforms to NFPA 72. Transmitter shall be capable of initiating a test signal daily at any selected time. Transmitter shall be arranged to seize telephone circuits in accordance with NFPA 72.

a. Operation: Each transmitter shall operate from 120-volt ac power. In the event of 120-volt AC power loss, the transmitter shall automatically switch to battery operation. Switchover shall be accomplished with no interruption of protective service, and shall automatically transmit a trouble message. Upon restoration of ac power, transfer back to normal ac power supply shall also be automatic.

b. Transmitter housing shall be NEMA Type 1. The housing shall contain a lock that is keyed identical to the fire alarm system for the building.

2.19.2 Signals to Be Transmitted to the Base Receiving Station

The following signals shall be sent to the base receiving station:

a. Sprinkler water flow

b. Manual pull stations

c. Smoke detectors

d. Duct smoke detectors

e. Fire Extinguishing System

f. Sprinkler valve supervision

g. Carbon Monoxide Detector

h. All other signals as required elsewhere in this specification

2.20 WIRING

Provide wiring materials under this section as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM with the additions and modifications specified herein. NFPA 70 accepted fire alarm cables that do not require the use of raceways except as modified herein are permitted. All fire alarm cables are to be installed in metallic conduit.

2.20.1 Alarm Wiring

The SLC wiring shall be solid copper cable in accordance with the manufacturers requirements. Copper signaling line circuits and initiating device circuit field wiring shall be No. 14 AWG size twisted and shielded solid conductors at a minimum. Visual notification appliance circuit conductors, that contain audible alarm appliances, shall be solid copper No. 14 AWG size conductors at a minimum. Speaker circuits shall be copper No. 16 AWG size twisted and shielded conductors at a minimum. Wire size shall be sufficient to prevent voltage drop problems. Circuits operating at 24 VDC shall not operate at less than the UL listed voltages for the sensors and/or appliances. Power wiring, operating at 120 VAC minimum, shall be a minimum No. 12 AWG solid copper having similar insulation. Acceptable power-limited cables are FPL, FPLR or FPLP as appropriate with red colored covering. Nonpower-limited cables shall comply with NFPA 70.

PART 3 EXECUTION

3.1 INSTALLATION OF FIRE ALARM INITIATING DEVICES AND NOTIFICATION APPLIANCES

3.1.1 FMCP

Locate the FMCP where indicated on the drawings. Recess the enclosure with the top of the cabinet 6 feet above the finished floor or center the cabinet at 4 feet, whichever is lower. Conductor terminations shall be labeled. A drawing containing conductors, their labels, their circuits, and their interconnection shall be permanently mounted in a Documentation Cabinet. Documentation Cabinet shall be prominently labeled "System Record

Documents" with a cylinder key locking hinge-mounted door. Items to be stored within cabinet are completed record of inspection and testing, cd/dvd of site specific software stored in a cd jewel case, as-built drawings, and installer business card.

Locate Documentation Cabinet adjacent to FMCP.

3.1.2 Manual Stations

Locate manual stations as required by NFPA 72 and as shown on the drawings. Mount stations so that their operating handles are 44 inches above the finished floor. Mount stations so they are located no farther than 5 feet from the exit door they serve, measured horizontally.

3.1.3 Notification Appliance Devices

Locate notification appliance devices as required by NFPA 72. Mount assemblies on walls as required by NFPA 72 and to meet the intelligibility requirements. Ceiling mounted speakers shall conform to NFPA 72.

3.1.4 Smoke and Heat Sensors

Locate sensors as required by NFPA 72, their listings, and as indicated on a 4 inch mounting box. Locate smoke and heat sensors on the ceiling. Install heat sensors not less than 4 inches from a side wall to the near edge. Heat sensors located on the wall shall have the top of the sensor at least 4 inches below the ceiling, but not more than 12 inches below the ceiling. Smoke sensors are permitted to be on the wall no lower than 12 inches from the ceiling with no minimum distance from the ceiling. Install smoke sensors no closer than 5 feet from air handling supply outlets.

3.1.5 Water Flow Detectors and Tamper Switches

Connect to water flow detectors and tamper switches.

3.1.6 Local Operating Console (LOC)

Locate the LOC as required by NFPA 72, UFC 4-021-01, and as indicated. Mount the console so that the top message button is no higher than 44 inches above finished floor.

3.2 SYSTEM FIELD WIRING

3.2.1 Wiring within Cabinets, Enclosures, and Boxes

Provide wiring installed in a neat and workmanlike manner and installed parallel with or at right angles to the sides and back of any box, enclosure, or cabinet. Label each conductor. Conductors that are terminated, spliced, or otherwise interrupted in any enclosure, cabinet, mounting, or junction box shall be connected to screw-type terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. The use of wire nuts or similar devices is prohibited. Conform wiring to NFPA 70.

Indicate the following in the wiring diagrams.

a. Point-to-point wiring diagrams showing the points of connection and terminals used for electrical field connections in the system, including interconnections between the equipment or systems that are supervised or controlled by the system. Diagrams shall show connections from field devices to the FMCP and remote fire alarm control units, initiating circuits, switches, relays and terminals.

b. Complete riser diagrams indicating the wiring sequence of devices and their connections to the control equipment. Include a color code schedule for the wiring. Include floor plans showing the locations of devices and equipment.

3.2.2 Terminal Cabinets

Provide a terminal cabinet at the base of any circuit riser, on each floor at each riser, and where indicated on the drawings. Terminal size shall be appropriate for the size of the wiring to be connected. Conductor terminations shall be labeled and a drawing containing conductors, their labels, their circuits, and their interconnection shall be permanently mounted in the terminal cabinet. Minimum size is 8 inches by 8 inches. Only screw-type terminals are permitted.

3.2.3 Alarm Wiring

Voltages shall not be mixed in any junction box, housing, or device, except those containing power supplies and control relays. Provide all wiring in electrical metallic conduit or tubing (rigid, IMC, EMT, FMC, etc. as permitted by NFPA 72 and NFPA 70). Conceal conduit in finished areas of new construction and wherever practicable in existing construction. The use of flexible conduit not exceeding a 6 foot length shall be permitted in initiating device or notification appliance circuits. All wiring must be solid copper, except for speaker circuits or circuits requiring shielding.

Use of cables that do not require a raceway as stated hereinbefore are permitted; install them in accordance with NFPA 70. Protect any exposed (as defined in NFPA 70) cables against physical damage by the use of magnetic raceways which shall also be red colored. Utilize shielded wiring where recommended by the manufacturer. For shielded wiring, ground the shield at only one point, that is in or adjacent to the FMCP. Pigtail or T-tap connections to signal line circuits, initiating device circuits, supervisory alarm circuits, and notification appliance circuits are prohibited. Color coding is required for circuits and shall be maintained throughout the circuit. Conductors used for the same functions shall be similarly color coded. Conform wiring to NFPA 70.

3.2.4 Conductor Terminations

Labeling of conductors at terminal blocks in terminal cabinets, FMCP, and remote FMCP and the LOC shall be provided at each conductor connection. Each conductor or cable shall have a shrink-wrap label to provide a unique and specific designation. Each terminal cabinet, FMCP, and remote FMCP shall contain a laminated drawing that indicates each conductor, its label, circuit, and terminal. The laminated drawing shall be neat, using 12 point lettering minimum size, and mounted within each cabinet, panel, or unit so that it does not interfere with the wiring or terminals. Maintain existing color code scheme where connecting to existing equipment.

3.3 DISCONNECTION AND REMOVAL OF EXISTING SYSTEM

Maintain existing fire alarm equipment fully operational until the new equipment has been tested and accepted by the Contracting Officer. As new equipment is installed, label it "NOT IN SERVICE" until the new equipment is accepted. Once the new system is completed, tested, and accepted by the Government, it shall be placed in service and connected to the station fire alarm system. Remove tags from new equipment and tag the existing equipment "NOT IN SERVICE" until removed from the building.

a. After acceptance of the new system by the Contracting Officer, remove existing equipment not connected to the new system, remove unused exposed conduit, and restore damaged surfaces. Remove the material from the site and dispose.

b. Disconnect and remove the existing fire alarm and smoke detection systems where indicated and elsewhere in the specification.

c. Control panels and fire alarm devices and appliances disconnected and removed shall be turned over to the Contracting Officer.

d. Properly dispose of fire alarm outlet and junction boxes, wiring, conduit, supports, and other such items.

3.4 CONNECTION OF NEW SYSTEM

The following new system connections shall be made during the last phase of construction, at the beginning of the preliminary tests. New system connections shall include:

a. Connection of new system transmitter to existing base fire reporting system.

Once this connection is made, system shall be left energized and new audio/visual devices deactivated. Report immediately to the Contracting Officer, coordination and field problems resulting from the connection of the above components.

3.5 PAINTING

Paint exposed electrical, fire alarm conduit, and surface metal raceway to match adjacent finishes in exposed areas. Paint junction boxes red in unfinished areas and conduits and surface metal raceways shall be painted with a 1-inch wide red band every 10 feet in unfinished areas. Painting shall comply with Section 09 90 00 PAINTS AND COATINGS. Paint all fire alarm junction boxes and covers red in unfinished areas (i.e.above ceilings, mechanical rooms, etc). In finished areas, conduit and junction boxes can be painted to match the room finish, the inside cover of the junction box must be identified as “Fire Alarm” and the conduit must have painted red bands 3/4-inch wide at 10 foot centers and at each side of a floor, wall, or ceiling penetration.

3.6 FIELD QUALITY CONTROL

3.6.1 Testing Procedures

Submit detailed test procedures, prepared and signed by a Registered Professional Engineer or a NICET Level 4 Fire Alarm Technician, and signed by representative of the installing company, for the fire detection and alarm system 30 days prior to performing system tests. Detailed test procedures shall list all components of the installed system such as initiating devices and circuits, notification appliances and circuits, signaling line devices and circuits, control devices/equipment, batteries, transmitting and receiving equipment, power sources/supply, annunciators, special hazard equipment, emergency communication equipment, interface equipment, Guard's Tour equipment, and transient (surge) suppressors. Test procedures shall include sequence of testing, time estimate for each test, and sample test data forms. The test data forms shall be in a check-off format (pass/fail with space to add applicable test data; similar to the form in NFPA 72) and shall be used for the preliminary testing and the acceptance testing. The test data forms shall record the test results and shall:

a. Identify the NFPA Class of all Initiating Device Circuits (IDC), Notification Appliance Circuits (NAC), Voice Notification System Circuits (NAC Audio), and Signaling Line Circuits (SLC).

b. Identify each test required by NFPA 72 Test Methods and required test herein to be performed on each component, and describe how this test shall be performed.

c. Identify each component and circuit as to type, location within the facility, and unique identity within the installed system. Provide necessary floor plan sheets showing each component location, test location, and alphanumeric identity.

d. Identify all test equipment and personnel required to perform each test (including equipment necessary for testing smoke detectors using real smoke).

e. Provide space to identify the date and time of each test. Provide space to identify the names and signatures of the individuals conducting and witnessing each test.

3.6.2 Tests Stages

3.6.2.1 Preliminary Testing

Conduct preliminary tests to ensure that devices and circuits are functioning properly. Tests shall meet the requirements of paragraph entitled "Minimum System Tests." After preliminary testing is complete, provide a letter certifying that the installation is complete and fully operable. The letter shall state that each initiating and indicating device was tested in place and functioned properly. The letter shall also state that panel functions were tested and operated properly. The letter shall include the names and titles of the witnesses to the preliminary tests. The Contractor and an authorized representative from each supplier of equipment shall be in attendance at the preliminary testing to make necessary adjustments.

3.6.2.2 Request for Formal Inspection and Tests

When tests have been completed and corrections made, submit a signed, dated certificate with a request for formal inspection and tests to the Naval Facilities Engineering Command, Fire Protection Engineer.

3.6.2.3 Final Testing

Notify the Contracting Officer in writing when the system is ready for final acceptance testing. Submit request for test at least 15 calendar days prior to the test date. The tests shall be performed in accordance with the approved test procedures in the presence of the Contracting

Officer. Furnish instruments and personnel required for the tests. A final acceptance test will not be scheduled until the following are provided at the job site:

a. The systems manufacturer's technical representative

b. Marked-up red line drawings of the system as actually installed

c. Megger test results

d. Loop resistance test results

e. Complete program printout including input/output addresses

The final tests will be witnessed by the Contracting Offices Designated Representative (COR). At this time, any and all required tests shall be repeated at their discretion.

3.6.2.4 System Acceptance

Following acceptance of the system, as-built drawings and O&M manuals shall be delivered to the Contracting Officer for review and acceptance. Submit six sets of detailed as-built drawings. The drawings shall show the system as installed, including deviations from both the project drawings and the approved shop drawings. These drawings shall be submitted within two weeks after the final acceptance test of the system. At least one set of as-built (marked-up) drawings shall be provided at the time of, or prior to the final acceptance test.

a. Furnish one set of CD or DVD discs containing software back-up and CAD based drawings in latest version of AutoCAD and DXF format of as-built drawings and schematics.

b. Include complete wiring diagrams showing connections between devices and equipment, both factory and field wired.

c. Include a riser diagram and drawings showing the as-built location of devices and equipment.

d. Include a list of contact ID point descriptions.

In existing buildings, the transfer of devices from the existing system to the new system and the permission to begin demolition of the old fire alarm system will not be permitted until the as-built drawings and O&M and programming manuals are received.

3.6.3 Minimum System Tests

Test the system in accordance with the procedures outlined in NFPA 72, ISO 7240-16, IEC 60268-16. The required tests are as follows:

a. Megger Tests: After wiring has been installed, and prior to making any connections to panels or devices, wiring shall be megger tested for insulation resistance, grounds, and/or shorts. Conductors with 300 volt rated insulation shall be tested at a minimum of 250 VDC. Conductors with 600 volt rated insulation shall be tested at a minimum of 500 VDC. The tests shall be witnessed by the Contracting Officer and test results recorded for use at the final acceptance test.

b. Loop Resistance Tests: Measure and record the resistance of each circuit with each pair of conductors in the circuit short-circuited at the farthest point from the circuit origin. The tests shall be witnessed by the Contracting Officer and test results recorded for use at the final acceptance test.

c. Verify the absence of unwanted voltages between circuit conductors and ground. The tests shall be accomplished at the preliminary test with results available at the final system test.

d. Verify that the control unit is in the normal condition as detailed in the manufacturer's O&M manual.

e. Test each initiating device and notification appliance and circuit for proper operation and response at the control unit. Smoke sensors shall be tested in accordance with manufacturer's recommended calibrated test method. Use of magnets is prohibited. Testing of duct smoke detectors shall comply with the requirements of NFPA 72 except that, for item 12(e) (Supervision) in Table 14.4.2.2, disconnect at least 20 percent of devices. If there is a failure at these devices, then supervision shall be tested at each device.

f. Test the system for specified functions in accordance with the contract drawings and specifications and the manufacturer's O&M manual.

g. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the time period and in the manner specified.

h. Determine that the system is operable under trouble conditions as specified.

i. Visually inspect wiring.

j. Test the battery charger and batteries.

k. Verify that software control and data files have been entered or programmed into the FMCP. Hard copy records of the software shall be provided to the Contracting Officer.

l. Verify that red-line drawings are accurate.

m. Measure the current in circuits to ensure there is the calculated spare capacity for the circuits.

n. Measure voltage readings for circuits to ensure that voltage drop is not excessive.

o. Disconnect the verification feature for smoke sensors during tests to minimize the amount of smoke needed to activate the sensor. Testing of smoke sensors shall be conducted using real smoke or the use of canned smoke which is permitted.

p. Measure the voltage drop at the most remote appliance (based on wire length) on each notification appliance circuit.

3.6.3.1 Intelligibility Tests

Intelligibility testing of the System shall be accomplished in accordance with NFPA 72 for Voice Evacuation Systems, IEC 60268-16, and ASA S3.2. Following are the specific requirements for intelligibility tests:

a. Intelligibility Requirements: Verify intelligibility by measurement after installation.

b. Ensure that a CIS value greater than the required minimum value is provided in each area where building occupants typically could be found. The minimum required value for CIS is 0.7.

c. Areas of the building provided with hard wall and ceiling surfaces (such as metal or concrete) that are found to cause excessive sound reflections may be permitted to have a CIS score less than the minimum required value if approved by the DOD installation, and if building occupants in these areas can determine that a voice signal is being broadcast and they must walk no more than 33 feet to find a location with at least the minimum required CIS value within the same area.

d. Areas of the building where occupants are not expected to be normally present are permitted to have a CIS score less than the minimum required value if personnel can determine that a voice signal is being broadcast and they must walk no more than 50 feet to a location with at least the minimum required CIS value within the same area.

e. Take measurements near the head level applicable for most personnel in the space under normal conditions (e.g., standing, sitting, sleeping, as appropriate).

f. The distance the occupant must walk to the location meeting the minimum required CIS value shall be measured on the floor or other walking surface as follows:

   (1) Along the centerline of the natural path of travel, starting from any point subject to occupancy with less than the minimum required CIS value.

   (2) Curving around any corners or obstructions, with a 12 inches clearance there from.

   (3) Terminating directly below the location where the minimum required CIS value has been obtained.

Use commercially available test instrumentation to measure intelligibility as specified by ISO 7240-19 and ISO 7240-16 as applicable. Use the mean value of at least three readings to compute the intelligibility score at each test location.

3.7 INSTRUCTION OF GOVERNMENT EMPLOYEES

Equipment manufacturer or experienced training representative shall provide 2 days on-site and 5 days of technical training at the manufacturing facility to the government.

3.7.1 Instructor

Include in the project the services of an instructor, who has received specific training from the manufacturer for the training of other persons regarding the inspection, testing, and maintenance of the system provided. The instructor shall train the Government employees designated by the

Contracting Officer, in the care, adjustment, maintenance, and operation of the fire alarm and fire detection system. Each instructor shall be thoroughly familiar with all parts of this installation. The instructor shall be trained in operating theory as well as in practical O&M work. Submit the instructors information and qualifications including the training history.

3.7.2 Required Instruction Time

Provide 2 days (16 hours) of on-site instruction after final acceptance of the system. The instruction shall be given during regular working hours on such dates and times as are selected by the Contracting Officer. The instruction may be divided into two or more periods at the discretion of the Contracting Officer. The training shall allow for rescheduling for unforeseen maintenance and/or fire department responses.

3.7.2.1 Technical Training

Equipment manufacturer or a factory representative shall provide 5 days of technical training for three government employees at the manufacturing facility. Training shall allow for classroom instruction as well as individual hands on programming, troubleshooting and diagnostics exercises. Transportation, room, and board shall be included for three government personnel. Training shall occur within 6 months of system acceptance.

3.8 Technical Data and Computer Software

Provide, in manual format, lesson plans, operating instructions, maintenance procedures, and training data for the training courses. The operations training shall familiarize designated government personnel with proper operation of the installed system. The maintenance training course shall provide the designated government personnel adequate knowledge required to diagnose, repair, maintain, and expand functions inherent to the system.

Any proprietary equipment and proprietary software needed by qualified technicians to implement future changes to the fire alarm system shall be provided as part of this contract.

Maintenance software required and provided as part of this contract shall not require any type of annual license agreement or annual cost to continue use of the software. The software that is provided will continue to operate during the entire lifetime of the installed equipment without any additional cost to the government.

-- End of Section --

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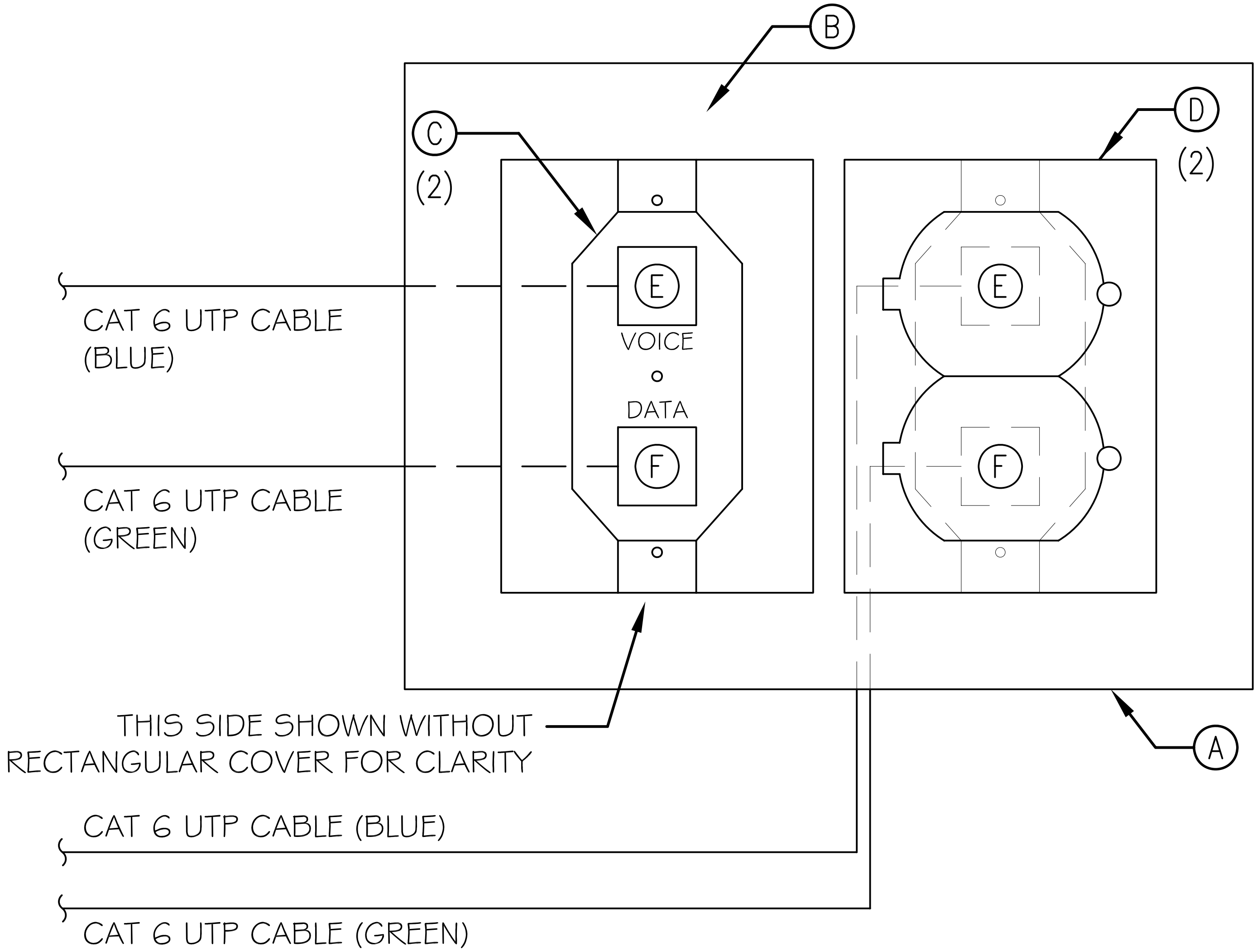

(A) ELECTRICAL BOX, RECTANGULAR STAMPED STEEL, 2-GANG, 2-1/8" MINIMUM DEPTH
HUBBELL PART# B2482 OR EQUAL

(B) RECTANGULAR FLANGE, 2-GANG, ALUMINUM
HUBBELL PART# SA3084W OR EQUAL

(C) OUTLET FRAME, 2-PORT, BLACK
HUBBELL PART# BR106B OR EQUAL

(D) RECTANGULAR COVER, DUPLEX FLAP, ALUMINUM
HUBBELL PART# SA3825 OR EQUAL

(E) VOICE JACK, CAT 6 (BLUE)
HUBBELL PART# HXJ6B OR EQUAL

(F) DATA JACK, CAT 6 (GREEN)
HUBBELL PART# HXJ6GN OR EQUAL

TELECOMUNICATIONS FLOOR OUTLET DETAIL

SCALE: NOT TO SCALE

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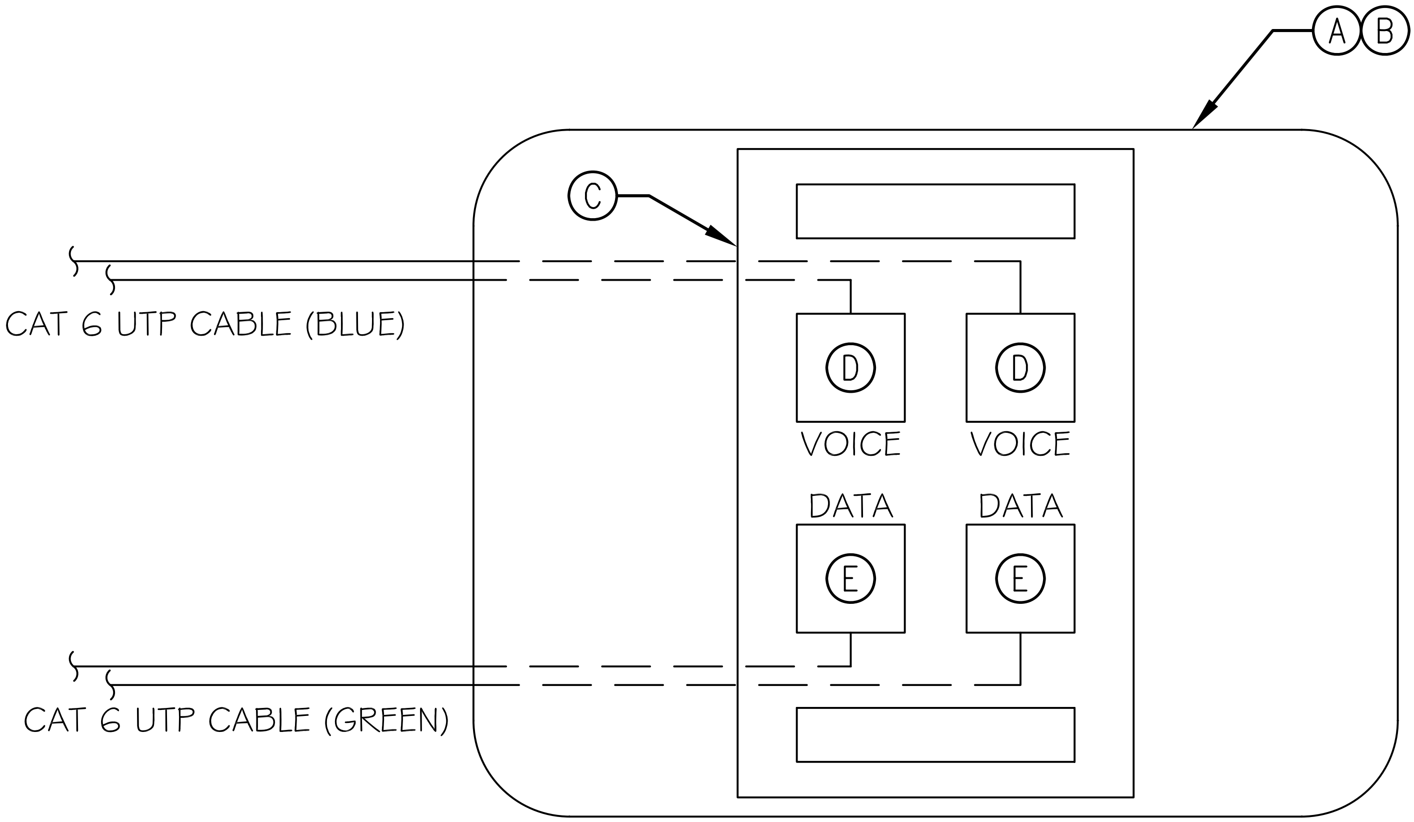

A ELECTRICAL BOX, RECTANGULAR STAMPED STEEL, 2-GANG, 2-1/8" MINIMUM DEPTH
HUBBELL PART# B2482 OR EQUAL

B SINGLE GANG REDUCER RING/ADAPTER

C FACEPLATE, SINGLE-GANG, 4 PORT, REARLOADING
HUBBELL PART# IFP14TI OR EQUAL

D VOICE JACK, CAT 6 (BLUE)
HUBBELL PART# HXJ6B OR EQUAL

E DATA JACK, CAT 6 (GREEN)
HUBBELL PART# HXJ6GN OR EQUAL

TELECOMUNICATIONS WALL OUTLET DETAIL

SCALE: NOT TO SCALE

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USACE / NAVFAC / AFCESA / NASA UFGS-26 51 00.00 22 (September 2013)

Preparing Activity: NAVFAC Edited to provide specific MARINE CORPS North Carolina IPT Requirements

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2015.
****

SECTION 26 51 00.00 22

INTERIOR LIGHTING
07/15

****
NOTE: This guide specification covers requirements for interior lighting installations. Requirements for materials and procedures for special or unusual design should be added as necessary to fit specific projects.

This copy of this specification section has been edited to contain LED lighting requirements.

Adhere to UFC 1-300-02 **Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.**

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be directed to NAVFAC MIDLANT MC-IPT ERNIE JOHNSON (757) 341-0336 robert.e.johnson10@navy.mil.
****

****
NOTE: In compliance with Executive Order 12902 and FAR section 23.704 which directs federal agencies to purchase products in the upper 25 percent of energy efficiency, the following products specified in this section meet or exceed the U.S. Department of Energy, Federal Energy Management Program (DOE/FEMP) Product Energy Efficiency Recommendations (PEER) for the Recommended energy efficiency levels.

This specification contains products recommended by FEMP. The following recommendations are currently on the FEMP site on the internet. Additional

recommendations may be added or existing recommendations updated at any time.

FEMP LT-1	**(1998) How to Buy Energy Efficient Fluorescent Tube Lamps**
FEMP LT-2	**(1998) How to Buy Energy-Efficient Fluorescent Ballasts**
FEMP LT-3	**(1998) How to Buy Energy-Efficient Fluorescent Luminaires**
FEMP LT-4	**(1998) How to Buy Energy-Efficient Exit Signs**
FEMP LT-5	**(1999) How to Buy Energy-Efficient Compact Fluorescent Light Bulbs**
FEMP LT-6	**(1999) How to Buy Energy-Efficient Industrial HID Luminaires**
FEMP LT-7	**(2000) How to Buy Energy-Efficient Commercial Downlight Luminaires**
FEMP LT-8	**(2000; Draft) How to Select Lighting Controls For Offices and Public Buildings**

Be aware that PEER is based on certain cost-effectiveness assumptions. Where energy prices and hours of use differ from those assumed in the PEER, recalculate cost effectiveness using the ratios given in the PEER.

For additional information on PEER, contact FEMP at 800-363-3732. To view the latest information about buying energy efficient products on-line go to the FEMP home page at: http://www.eren.doe.gov/femp/procurements.

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NOTE: TO DOWNLOAD UFGS GRAPHICS

Go to http://www.wbdg.org/ccb/NAVGRAPH/graphtoc.pdf.

****

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NOTE: This section contains the following sketches (Graphics) and are available in metric (SI) and U.S. Customary (IP) system dimensions. Sketch titles and style numbers are unchanged for both types. The metric values indicated are a conversion of the IP system dimensions.

Do not include list of sketches, or sketches themselves, in project specifications. Use lighting fixture sketches as details on drawings whenever possible. If special features are required for a

project, do not modify sketches, but indicate these changes on notes in fixture schedule. The "NL" style numbers and dates should remain on the drawing details.

SKETCH NUMBER	TITLE
NL-1	Surface Mounted Wrap-Around Luminaire for Premium Office/Classroom Type Spaces
NL-2	Surface Mounted Wrap-Around Luminaire for Standard Office Type Spaces and Other Type Spaces
NL-3	Fluorescent Troffer Luminaire Lens Type
NL-4	Wall-Mounted Fluorescent
NL-5	Wall-Mounted Indirect Fluorescent With Wood Shielding
NL-6	Industrial Fluorescent
NL-7	Strip Fluorescent
NL-8	Wet/Damp Location Luminaries
NL-9	Parabolic Troffers 610 mm by 610 mm and 610 mm by 1220 mm 2 by 2 and 2 by 4
NL-10	Parabolic Troffer 305 mm by 1220 mm 1 by 4
NL-11	Surface, Pendant or Bracket-Mounted Parabolic Luminaire
NL-12	Steel Sided Surface Fluorescent
NL-13	Round Surface Fluorescent
NL-14	Surface Mounted 1-Lamp Vandal Resistant Luminaire
NL-15	Arm Mounted Outdoor Sign Luminaire
NL-16	Decorative/Specialty 1-Lamp Luminaire
NL-17	Recessed Round, Lens Type Compact Fluorescent
NL-18	Recessed Round, Open Bottom Multigroove Compact Fluorescent
NL-19	Recessed Round, Open Bottom Compact Fluorescent
NL-20	Round-Surface, Pendant, or Wall Mount Compact Fluorescent - Interior/Exterior
NL-21	Fluorescent Troffer With Plastic Parabolic Cube Louvers
NL-22	High Bay Open/Enclosed Industrial HID
NL-23	Low Bay Industrial HID
NL-24	Pendant/Wall Mount - Indirect HID
NL-25	Exterior Commercial Wall Mount HID
NL-26	Exterior Compact Fluorescent and Low Pressure Sodium-Wall Mount
NL-27	Recessed Round Regressed Lens Type HID
NL-28	Handball and Racquetball Court Luminaire
NL-29	Architectural Style Security/Area Luminaire
NL-30	Warehouse HID Aisle Luminaire
NL-31	Surface Mounted Commercial HID
NL-32	Recessed Commercial HID
NL-33 thru 39	Reserved for Future HID Luminaries
NL-40	Step Light/Night Light
NL-41	Adjustable Incandescent Interior Spotlight
NL-42	Semi-Recessed Baffle Downlight
NL-43	Open Recessed Baffle Downlight
NL-44	Adjustable Semi-Recessed Spotlight
NL-45	Exterior Luminaries
NL-46	Ceiling-Mounted Vandal-Resistant Luminaire
NL-47	Wall-Mounted Vandal-Resistant Luminaire
NL-48	Fluorescent Exit Sign
NL-49	Explosion-Proof Luminaire

SKETCH NUMBER	TITLE
NL-50	Obstruction Light
NL-51	Emergency Lighting Unit
NL-52	Lens Type Emergency Lighting Unit
NL-53	Cylinder Type Emergency Lighting Unit
NL-54	Remote Fixtures for Use With Battery Unit
NL-55	Not Used
NL-56	Recessed Shower Light
NL-57	Recessed Downlight - Incandescent/Fluorescent
NL-58 and 59	Reserved for Future Luminaires
NL-60	Industrial Fluorescent - Hazardous Location
NL-61	Light Emitting Diode Exit Sign
NL-62 thru 98	Reserved for Future Luminaires
NL-99	Sample Lighting Fixture Schedule

NOTE: Do not include this index in project specification.

****

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NOTE: The following information shall be shown on project drawings:

1. Type, style, mounting, and lamp arrangement

2. Location of fixtures

3. Wattage, voltage, and frequency rating required

4. Type of reflector, diffuser required

5. Glass/plastic lens

6. Accessories required, such as photocell, time switches, sensors, and auxiliary lamps

7. Mounting height above floor or grade to bottom of fixture

8. Where wire for humid areas, rods, or straps are used (if more than one type of hanger is used)

9. Reflecting or nonreflecting surface finish

10. Shielding required

11. Referenced sketch

12. NEMA distribution type (when applicable).

13. Occupancy sensor location, mounting, and sensor detection type.

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NOTE: Demolition work that involves disposal of fluorescent and HID lamps and ballasts will require the use of Section 02 84 16 HANDLING OF LIGHTING

BALLASTS AND LAMPS CONTAINING PCBs AND MERCURY.
****

PART 1 GENERAL

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A1008/A1008M	(2013) Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardened
ASTM A580/A580M	(2014) Standard Specification for Stainless Steel Wire
ASTM A641/A641M	(2009a; R 2014) Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A653/A653M	(2013) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B117	(2011) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B164	(2003; R 2014) Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire
ASTM B633	(2013) Standard Specification for Electrodeposited Coatings of Zinc on Iron

	and Steel
ASTM E2129	(2010) Standard Practice for Data Collection for Sustainability Assessment of Building Products

CALIFORNIA ENERGY COMMISSION (CEC)

CEC Title 24	(2008; Effective Jan 2010) California's Energy Efficiency Standards for Residential and Nonresidential Buildings

GREEN SEAL (GS)

GS-12	(1997) Occupancy Sensors

ILLUMINATING ENGINEERING SOCIETY (IES)

IES HB-10	(2011) IES Lighting Handbook
IES LM-79	(2008) Electrical and Photometric Measurements of Solid-State Lighting Products
IES LM-80	(2008) Measuring Lumen Maintenance of LED Light Sources

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 100	(2000; Archived) The Authoritative Dictionary of IEEE Standards Terms
IEEE C2	(2012; Errata 2012; INT 1-4 2012; INT 5-7 2013; INT 8 2014) National Electrical Safety Code
IEEE C62.41.1	(2002; R 2008) Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits
IEEE C62.41.2	(2002) Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

ANSI ANSLG C78.41	(2006) For Electric Lamps--Guidelines for Low-Pressure Sodium Lamps
ANSI ANSLG C78.42	(2009) For Electric Lamps: High-Pressure Sodium Lamps
ANSI C78.1381	(1998) American National Standard for Electric Lamps - 250-Watt, 70 Watt, M85 Metal-Halide Lamps
NEMA ANSLG C78.377	(2011) American National Standard for Electric Lamps— Specifications for the Chromaticity of Solid State Lighting

Products

ANSI C78.901	(2005) American National Standard for Electric Lamps - Single Base Fluorescent Lamps--Dimensional and Electrical Characteristics
ANSI C82.1	(2004) American National Standard for Electric Lamp Ballasts - Line Frequency Fluorescent Lamp Ballasts
ANSI C82.2	(2002) American National Standard for Lamp Ballasts--Methods of Measurement of Fluorescent Lamp Ballasts
ANSI C82.4	(2002) American National Standard for Ballasts for High-Intensity-Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)
ANSI/ANSLG C78.43	(2013) American National Standard for Electric Lamps - Single-Ended Metal-Halide Lamps
NEMA 250	(2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ANSLG C78.81	(2014) American National Standard for Electric Lamps--Double-Capped Fluorescent Lamps--Dimensional and Electrical Characteristics
NEMA ANSLG C82.11	(2011) Lamp Ballasts - High-Frequency Fluorescent Lamp Ballasts
NEMA C136.10	(2010) American National Standard for Roadway and Area Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles--Physical and Electrical Interchangeability and Testing
NEMA C82.77	(2002) Harmonic Emission Limits - Related Power Quality Requirements for Lighting Equipment
NEMA ICS 2	(2000; R 2005; Errata 2008) Standard for Controllers, Contactors, and Overload Relays Rated 600 V
NEMA ICS 6	(1993; R 2011) Enclosures
NEMA IEC 60529	(2004) Degrees of Protection Provided by Enclosures (IP Code)
NEMA LL 1	(1997; R 2002) Procedures for Linear Fluorescent Lamp Sample Preparation and the TCLP Extraction

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 101	(2015) Life Safety Code
NFPA 70	(2014; AMD 1 2013; Errata 1 2013; AMD 2 2013; Errata 2 2013; AMD 3 2014; Errata 3-4 2014; AMD 4-6 2014) National Electrical Code
NFPA 90A	(2015) Standard for the Installation of Air Conditioning and Ventilating Systems

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

Energy Star	(1992; R 2006) Energy Star Energy Efficiency Labeling System (FEMP)

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15	Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 1029	(1994; Reprint Dec 2013) High-Intensity-Discharge Lamp Ballasts
UL 1310	(2011; Reprint Dec 2014) UL Standard for Safety Class 2 Power Units
UL 1598	(2008; Reprint Oct 2012) Luminaires
UL 20	(2010; Reprint Feb 2012) General-Use Snap Switches
UL 595	(1985) Marine-Type Electric Lighting Fixtures
UL 773	(1995; Reprint Mar 2002) Standard for Plug-In, Locking Type Photocontrols for Use with Area Lighting
UL 773A	(2006; Reprint Nov 2013) Standard for Nonindustrial Photoelectric Switches for Lighting Control
UL 844	(2012) Standard for Luminaires for Use in Hazardous (Classified) Locations
UL 8750	(2009; Reprint May 2014) UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products
UL 924	(2006; Reprint Apr 2014) Standard for Emergency Lighting and Power Equipment
UL 935	(2001; Reprint Aug 2014) Standard for Fluorescent-Lamp Ballasts

1.2 RELATED REQUIREMENTS

Materials not considered to be lighting equipment or lighting fixture accessories are specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Lighting fixtures and accessories mounted on exterior surfaces of buildings are specified in this section.

NOTE: Building mounted exterior fixtures are specified in Section 26 56 00 EXTERIOR LIGHTING.

1.3 DEFINITIONS

****

NOTE: Delete definitions that are not applicable for project.

****

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

b. Average life is the time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

[c. For LED luminaire light sources, "Useful Life" is the operating hours before reaching 70 percent of the initial rated lumen output (L70) with no catastrophic failures under normal operating conditions. This is also known as 70 percent "Rated Lumen Maintenance Life" as defined in IES LM-80.]

d. Total harmonic distortion (THD) is the root mean square (RMS) of all the harmonic components divided by the total fundamental current.

1.4 SYSTEM DESCRIPTION

1.4.1 Lighting Control System

****

NOTE: Edit this paragraph to provide additional requirements as required to supplement the information contained on the drawings. Delete components that are not included in the project.

****

Provide lighting control system as indicated. Lighting control equipment shall include, if indicated: control modules, power packs, dimming ballasts, occupancy sensors, and light level sensors.

1.5 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

Use section 01 33 00 SUBMITTAL PROCEDURES on Design-Bid-Build projects and 01 33 00.05 20 on

Design-Build projects.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.
****

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are[for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with 01 33 00 SUBMITTAL PROCEDURES 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

Data, drawings, and reports shall employ the terminology, classifications, and methods prescribed by the IES HB-10, as applicable, for the lighting system specified.

SD-01 Preconstruction Submittals

Photometric Plan; G

LED Luminaire Warranty; G

SD-02 Shop Drawings

LED Luminaire drawings; G, [_____]

SD-03 Product Data

Fluorescent lighting fixtures; G, [_____]

Fluorescent electronic ballasts; G, [_____]

Fluorescent electromagnetic ballasts; G, [_____]

Fluorescent lamps; G, [_____]

High-intensity-discharge (HID) lighting fixtures; G, [_____]

HID ballasts; G, [_____]

High-pressure sodium (HPS) lamps; G, [_____]

Low-pressure sodium lamps; G, [_____]

Metal-halide lamps; G, [_____]

Incandescent lighting fixtures; G, [_____]

Incandescent lamps; G, [_____]

LED Luminaires; G

Dimmer switch; G, [_____]

Lighting contactor; G, [_____]

Time switch; G, [_____]

Photocell; G, [_____]

Power hook fixture hangers; G, [_____]

Exit signs; G, [_____]

Emergency lighting equipment; G, [_____]

Central emergency system; G, [_____]

Occupancy sensors; G, [_____]

Electronic dimming ballast; G, [_____]

Dimming ballast controls; G, [_____]

Light Level Sensor ; G, [_____]

[Local/Regional Materials

Documentation indicating distance between manufacturing facility and the project site. Indicate distance of raw material origin from the project site. Indicate relative dollar value of local/regional materials to total dollar value of products included in project.]

[Environmental Data]

Energy Efficiency

SD-05 Design Data

Design Data for luminaires; G, [_____]

SD-04 Samples

****
NOTE: Samples involve additional shipping cost. Use only for special fixtures on a project. If samples are not essential to the specific application, delete them.
****

Lighting fixtures, complete with lamps and ballasts; G, [_____]

LED Luminaires; G, [_____]

SD-06 Test Reports

LED Luminaire - IES LM-79 Test Report; G

LED Light Source - IES LM-80 Test Report; G

Operating test

Submit test results as stated in paragraph entitled "Field Quality Control."

SD-07 Certificates

Luminaire Useful Life Certificate; G

Submit certification from the manufacturer indicating the expected useful life of the luminaires provided. The useful life shall be directly correlated to the IES LM-80 test data, adjusted for the thermal properties of manufacturer's luminaire, and adjusted for local average ambient operating conditions.

SD-10 Operation and Maintenance Data

****
NOTE: Require O&M manuals for lighting control systems that use low voltage control circuits. Example: Light level sensors used with dimming ballast, or occupancy sensors used with power packs.
****

Lighting Control System, Data Package 5; G, [_____]

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA and as specified herein, showing all light fixtures, control modules, control zones, occupancy sensors, light level sensors, power packs, dimming ballasts, schematic diagrams and all interconnecting control wire, conduit, and associated hardware.

Operational Service

Submit documentation that includes contact information, summary of procedures, and the limitations and conditions applicable to the project. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.

1.6 QUALITY ASSURANCE

1.6.1 Drawing Requirements

1.6.1.1 LED Luminaire Drawings

Include dimensions, accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, and[computerized] candlepower distribution data shall accompany shop drawings.

1.6.2 Design Data for Luminaires

****
NOTE: Depending on the ambient brightness of the site surroundings and each lamp's initial lumens, luminaires shall have IESNA full or semi cutoff designation for exterior applications. Maximum initial horizontal illumination at ground level shall be limited to the most current IESNA Lighting Handbook recommendations for exterior luminaires. Designing lighting to reduce light pollution contributes to the following LEED credit: SS8.
****

a. Provide safety certification and file number for the luminaire family. Include listing, labeling and identification per NFPA 70 (NEC). Applicable testing bodies are determined by the US Occupational Safety Health Administration (OSHA) as Nationally Recognized Testing Laboratories (NRTL) and include: CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

1.6.3 Photometric Plan

For LED luminaires, provide computer-generated photometric analysis of the "designed to" values for the "end of useful life" of the luminaire installation using a light loss factor of 0.7. Submittal shall include the following:

a. Horizontal illuminance measurements at finished grade, taken at maximum of every 3050 mm 10 feet.

b. Vertical illuminance measurements at 1500 mm 5 feet above finished grade.

c. Minimum and maximum lux footcandle level.

d. Average maintained lux footcandle level.

e. Maximum to minimum ratio for horizontal illuminance only.

1.6.4 LED Luminaire - IES LM-79 Test Report

Submit test report on manufacturer's standard production model luminaire. Submittal shall include all photometric and electrical measurements, as well as all other pertinent data outlined under "14.0 Test Report" in IES LM-79.

1.6.5 LED Light Source - IES LM-80 Test Report

Submit report on manufacturer's standard production LED package, array, or module. Submittal shall include:

a. Testing agency, report number, date, type of equipment, and LED light source being tested.

b. All data required by IES LM-80.

1.6.5.1 Test Laboratories

Test laboratories for the IES LM-79 and IES LM-80 test reports shall be one of the following:

a. National Voluntary Laboratory Accreditation Program (NVLAP) accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program.

b. One of the qualified labs listed on the Department of Energy - Energy Efficiency & Renewable Energy, Solid-State Lighting web site.

c. A manufacturer's in-house lab that meets the following criteria:

1. Manufacturer has been regularly engaged in the design and production of high intensity discharge roadway and area luminaires and the manufacturer's lab has been successfully certifying these fixtures for a minimum of 15 years.

2. Annual equipment calibration including photometer calibration in accordance with National Institute of Standards and Technology.

1.6.6 Fluorescent Electronic Ballasts

Submit ballast catalog data as required in the paragraph entitled "Fluorescent Lamp Electronic Ballasts" contained herein. As an option, submit the fluorescent fixture manufacturer's electronic ballast specification information in lieu of the actual ballast manufacturer's catalog data. This information shall include published specifications and sketches, which covers the information required by the paragraph entitled "Fluorescent Lamp Electronic Ballasts" herein. This information may be supplemented by catalog data if required, and shall contain a list of vendors with vendor part numbers.

1.6.7 Lighting Fixtures, Complete With Lamps and Ballasts

****

NOTE: Delete this paragraph if samples are not required.

Delete bracketed options if samples are required for all fixture types. Choose bracketed options only if samples of some fixtures are required. Indicate in the fixture schedule on the drawings which fixture types require samples or specify using the last bracketed sentence.

****

Submit one sample of each fixture type[indicated] for inspection, review, and approval. The sample shall be retained for comparison against the remainder of the fixtures. The sample may be used in the final fixture installation.[Provide samples for the following fixture types indicated on the drawings: [_____________].]

1.6.8 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.9 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.6.9.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.6.9.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

1.6.9.3 Energy Efficiency

****

NOTE: Meet Energy Star requirements for all lighting per EO 13123.

****

****

NOTE: The Energy Policy Act of 2005 requires new buildings to use 30 percent less energy than the ASHRAE 90.1 level. Efficient lighting equipment contributes to the following LEED credits: EA Prerequisite 2; EA1.

****

Comply with National Energy Policy Act and Energy Star requirements for lighting products. [Submit documentation for Energy Star qualifications for equipment provided under this section.]Submit data indicating lumens per watt efficiency and color rendition index of light source.

1.7 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7.1 Electronic Ballast Warranty

****
NOTE: The warranty clause in this section has been approved by a Level 1 Contracting Officer, and may be used without further approval or request for waiver.
****

Furnish the electronic ballast manufacturer's warranty. The warranty period shall not be less than 5 years from the date of manufacture of the electronic ballast. Ballast assembly in the lighting fixture, transportation, and on-site storage shall not exceed 12 months, thereby permitting 4 years of the ballast 5 year warranty to be in service and energized. The warranty shall state that the malfunctioning ballast shall be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement ballast shall be identical to, or an improvement upon, the original design of the malfunctioning ballast.

1.7.2 [LED Luminaire Warranty

****
NOTE: Choose this paragraph for LED applications.
****

Provide Luminaire Useful Life Certificate.

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

a. Provide a written five year on-site replacement warranty for material, fixture finish, and workmanship. On-site replacement includes transportation, removal, and installation of new products.

    1. Finish warranty shall include warranty against failure and against substantial deterioration such as blistering, cracking, peeling, chalking, or fading.

    2. Material warranty shall include:

        (a) All power supply units (drivers).

        (b) Replacement when more than 10 percent of LED sources in any lightbar or subassembly(s) are defective or non-starting.

b. Warranty period must begin on date of beneficial occupancy. Contractor shall provide the Contracting Officer signed warranty certificates prior to final payment.

]1.8 OPERATIONAL SERVICE

****
NOTE: Maintenance agreements are standard practice in the building industry. Take-back programs refer to programs in which the product manufacturer "takes-back" scrap material and/or packaging associated with its product. Under a green lease, when the customer no longer requires the use of the particular product or requires an updated model, the manufacturer is obligated to reclaim it and refurbish it or disassemble it for recycling as appropriate. Using one of these manufacturer's services contributes to the following LEED credit: MR2.
****

Coordinate with manufacturer for [maintenance agreement] [take-back program]. Collect information from the manufacturer about [maintenance agreement] [green lease] options, and submit to Contracting Officer. Services shall reclaim materials for recycling and/or reuse. Services shall not landfill or burn reclaimed materials. Indicate procedures for compliance with regulations governing disposal of mercury. When such a service is not available, local recyclers shall be sought after to reclaim the materials.

1.9 SUSTAINABLE DESIGN REQUIREMENTS

1.9.1 Local/Regional Materials

****
NOTE: Using local materials can help minimize transportation impacts, including fossil fuel consumption, air pollution, and labor.

Note: This is optional for Army projects.
****

[Use materials or products extracted, harvested, or recovered, as well as manufactured, within a [800][_____] kilometer [500][_____] mile radius from the project site, if available from a minimum of three sources.]

1.9.2 Environmental Data

****
NOTE: ASTM E2129 provides for detailed documentation of the sustainability aspects of products used in the project. This level of detail may be useful to the Contractor, Government, building occupants, or the public in assessing the sustainability of these products.

NOTE: This is optional for Army projects.
****

[Submit Table 1 of ASTM E2129 for the following products: [_____].]

PART 2 PRODUCTS

2.1 FLUORESCENT LIGHTING FIXTURES

****
NOTE: For projects within the United States and its possessions, do not specify hard metric recessed lighting fixtures as the only option.
****

UL 1598. Fluorescent fixtures shall have electronic ballasts [unless specifically indicated otherwise].

2.1.1 Fluorescent Lamp Electronic Ballasts

****
NOTE: Electronic ballasts may have system compatibility problems when installed in certain environments. The problems mainly concern the radiated and conducted EMI due to the relatively high switching frequencies inherent in electronic ballasts and possibly due to utilization of the same power source for lighting and other equipment. Shielding technologies today can prevent interference with surroundings, and therefore this is rarely an issue. Environments where electronic ballasts have the potential for EMI are:

1. Libraries or other facilities which utilize magnetic detectors to prevent theft or inventory control. However, it has been reported that electronic ballasts have no impact on the magnetic detectors if the separation distance is greater than 3050 to 4575 mm 10 to 15 feet. This includes distances in all directions through floors, ceilings, and walls.

2. Facilities using high frequency power line carrier (PLC) control systems, such as a central clock system. These PLC systems usually have a 50,000 Hz to 200 kHz carrier frequency which may be affected by the harmonics generated by the electronic ballasts.

3. Areas where sensitive electronic equipment is installed such as hospital critical care units, other areas utilizing sensitive electronic equipment based life support systems, and electronic testing facilities.

With proper design considerations, electronic ballasts should provide satisfactory performance even in these and other sensitive areas. The designer must consider fixture location, fixture performance characteristics, manufacturers' recommendations, environmental constraints, etc. in the lighting design. Edit this specification as required to solve specific design problems.
****

The electronic ballast shall as a minimum meet the following characteristics:

a. Ballast shall comply with UL 935, NEMA ANSLG C82.11, NFPA 70, and CEC Title 24 unless specified otherwise. Ballast shall be 100 percent electronic high frequency type with no magnetic core and coil components. Ballast shall provide transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected.

b. Power factor shall be 0.95 (minimum).

c. Ballast shall operate at a frequency of 20,000 Hertz (minimum). Ballast shall be compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.

d. Ballast shall have light regulation of plus or minus 10 percent lumen output with a plus or minus 10 percent input voltage regulation. Ballast shall have 10 percent flicker (maximum) using any compatible lamp.

e. Ballast factor shall be between 0.85 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum).

f. Ballast shall be UL listed Class P with a sound rating of "A."

g. Ballast shall have circuit diagrams and lamp connections displayed on the ballast.

****

NOTE: Choose the bracketed option and require programmed start ballasts for Army and Air Force projects.

For Navy projects, provide instant start ballasts for areas not subject to frequent switching (i.e., more than once every three hours). Provide programmed start ballasts for areas subject to frequent switching, including all areas controlled by occupancy sensors. Identify fixtures requiring each type on the drawings.

****

h. [Ballasts shall be instant start unless otherwise indicated. Ballasts shall be programmed start where indicated. Instant start ballasts shall operate lamps in a parallel circuit configuration that permits the operation of remaining lamps if one or more lamps fail or are removed.][Ballasts shall be programmed start unless otherwise indicated.]Programmed start ballasts may operate lamps in a series circuit configuration. Provide series/parallel wiring for programmed start ballasts where available.

i. Ballasts for compact fluorescent fixtures shall be programmed start.

j. Ballasts for T-5 and smaller lamps shall have end-of-life protection circuits as required by NEMA ANSLG C78.81 and ANSI C78.901 as applicable.

****
NOTE: A source of light other than fluorescent is recommended for areas subject to temperatures below minus 17 degrees C 0 degrees F.
****

k. Ballast shall be capable of starting and maintaining operation at a minimum of minus 17 degrees C 0 degrees F unless otherwise indicated.

l. Electronic ballast shall have a full replacement warranty of 5 years from date of manufacture as specified in paragraph entitled "Electronic Ballast Warranty" herein.

2.1.1.1 T-8 Lamp Ballast

****
NOTE: Total harmonic distortion of 20 percent is acceptable for most applications.
****

a. Total harmonic distortion (THD): Shall be [20 percent][____ percent] (maximum).

b. Input wattage.

[1. 32 watts (maximum) when operating one F32T8 lamp]

[2. 62 watts (maximum) when operating two F32T8 lamps]

[3. 92 watts (maximum) when operating three F32T8 lamps]

[4. 114 watts (maximum) when operating four F32T8 lamps]

****
NOTE: Multilevel switching for light control is recommended for some locations, such as classrooms and conference rooms where multilevel switching is desired.
****

c. Ballast efficacy factor.

[1. 2.54 (minimum) when operating one F32T8 lamp]

[2. 1.44 (minimum) when operating two F32T8 lamps]

[3. 0.93 (minimum) when operating three F32T8 lamps]

[4. 0.73 (minimum) when operating four F32T8 lamps]

[d. Provide three[and four] lamp fixtures with two ballasts per fixture where multilevel switching is indicated.]

****
NOTE: To avoid potential maintenance problems, use following bracketed option only when requested by

the activity.
****

[e. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.]

2.1.1.2 F17T8 Lamp Ballast

a. Total harmonic distortion (THD): Shall be 25 percent (maximum).

b. Input wattage:

1. 34 watts (maximum) when operating two F17T8 lamps.

2.1.1.3 T-5 Long Twin Tube Lamp Ballast

a. Total harmonic distortion (THD): Shall not be greater than[25 percent when operating one lamp,][15 percent when operating two lamps,][and][20 percent when operating three lamps].

b. Input wattage:

[1. 45 watts (maximum) when operating one F40 T-5 lamps]

[2. 74 watts (maximum) when operating two F40 T-5 lamps]

[3. 105 watts (maximum) when operating three F40 T-5 lamps]

****
NOTE: Multilevel switching for light control is recommended for some locations, such as classrooms and conference rooms where multilevel switching is desired.
****

[c. Provide three[and four] lamp fixtures with two ballasts per fixture where multilevel switching is indicated.]

****
NOTE: To avoid potential maintenance problems, use following bracketed option only when requested by the activity. Also, serving multiple fixtures from a single ballast may alter the minimum starting and operating temperature for the fixture. Design accordingly.
****

[d. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.]

2.1.1.4 F96T8 Lamp Ballast

a. Total harmonic distortion (THD): Shall not be greater than[30 percent when operating one lamp][and][20 percent when operating two lamps].

b. Input wattage:

[1. 56 watts (maximum) when operating one F96T8 lamps]

[2. 102 watts (maximum) when operating two F96T8 lamps]

****
NOTE: To avoid potential maintenance problems, use following bracketed option only when requested by the activity. Also, serving multiple fixtures from a single ballast may alter the minimum starting and operating temperature for the fixture. Design accordingly.
****

[c. A single ballast may be used to serve multiple fixtures if they are continuously mounted and factory manufactured for that installation with an integral wireway.]

2.1.2 Fluorescent Lamp Electronic Dimming Ballast

****
NOTE: Electronic dimming ballast may have the same system compatibility problems as normal light output electronic ballast when installed in certain environments. The problems mainly concern the radiated and conducted EMI due to the relatively high switching frequencies inherent in electronic ballast and possibly due to utilization of the same power source for lighting and other equipment. Environments where electronic ballast have the potential for EMI are listed in the criteria note for electronic ballast.

Electronic dimming ballasts as specified in the following paragraph, are for general workplace dimming and daylight harvesting for energy conservation. For architectural dimming applications with very low light levels, 100 percent to 1 percent, the specifier must review all parameters of this paragraph and ensure competitive sources.

Electronic dimming ballasts can be controlled by a number of devices: manual dimmers, occupancy sensors, light level sensor, photosensors, and timers, or with energy management systems. All control types are not specified here and the specifier must ensure system compatibility between ballast and controls.

If dimming ballast and non-dimming ballast are used in the same area, designer and specifier may need to coordinate the ballast factors at full light output.
****

The electronic ballast shall as a minimum meet the following characteristics:

a. Ballast shall comply with NEMA ANSLG C82.11, UL 935, and NFPA 70, unless specified otherwise. Ballast shall provide transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2. Ballast dimming capability range shall be from 100 to 5 percent (minimum range) of light output, flicker free. Ballast shall start lamp at any preset light output setting without first having to go to full light output. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected.

b. Power factor shall be 0.95 (minimum) at full light output, and 0.90 (minimum) over the entire dimming range.

c. Ballast shall operate at a frequency of 20,000 Hertz (minimum). Ballast shall be compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available.

d. Ballast factor at full light output shall be between 0.85 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum).

e. Ballast shall be UL listed Class P with a sound rating of "A".

f. Ballast shall have circuit diagrams and lamp connections displayed on the ballast.

g. Ballast shall be programmed start. Ballast may operate lamps in a series circuit configuration. Provide series/parallel wiring for programmed start ballasts where available.

h. Ballasts for compact fluorescent fixtures shall be programmed start.

****

NOTE: A source of light other than fluorescent is recommended for areas subject to temperatures below minus 17 degrees C 0 degrees F.

****

i. Ballast shall be capable of starting and maintaining operation at a minimum of minus 17 degrees C 0 degrees F unless otherwise indicated.

j. Total harmonic distortion (THD): Shall be 20 percent (maximum) over the entire dimming range.

k. Ballasts for T-5 and smaller lamps shall have end-of-life protection circuits as required by NEMA ANSLG C78.81 and ANSI C78.901 as applicable.

2.1.2.1 T-8 Lamp Ballast

Input wattage, for indicated lamp quantity shall be:

a. 35 watts (maximum) when operating one F32T8 lamp.

b. 70 watts (maximum) when operating two F32T8 lamps.

c. 104 watts (maximum) when operating three F32T8 lamps.

2.1.3 Dimming Ballast Controls

The dimming ballast controls shall be a slide dimmer with on/off control.

The slide dimmer shall be compatible with the ballast and control the ballast light output over the full dimming range. Dimming ballast controls shall be approved by the ballast manufacturer.

2.1.4 Light Level Sensor

UL listed. Light level sensor shall be capable of detecting changes in ambient lighting levels, shall provide a dimming range of 20 percent to 100 percent, minimum, and shall be designed for use with dimming ballast and voltage system to which they are connected. Sensor shall be capable of controlling 40 electronic dimming ballast, minimum. Sensor light level shall be adjustable and have a set level range from 100 to 1000 lux 10 to 100 footcandles, minimum. Sensor shall have a bypass function to electrically override sensor control.

2.1.5 [Fluorescent Electromagnetic Ballasts

****
NOTE: Generally, electromagnetic ballasts should not be specified. Include this paragraph only for specific project requirements. Include this paragraph if any of the optional subparagraphs are used. Delete last two sentences when only compact fluorescent fixtures paragraph is used.
****

UL 935. Ballasts shall be high power factor type (0.9 minimum),[unless indicated otherwise] and shall be designed to operate on the voltage system to which they are connected. Ballasts shall be Class P and shall have sound rating "A"[unless otherwise noted]. Fixtures and ballasts shall be designed and constructed to limit the ballast case temperature to 90 degrees C when installed in an ambient temperature of [40][_____] degrees C. Electromagnetic ballasts for T-8 and T-12 lamps shall be energy saving. Provide three lamp fixtures with two ballasts per fixture.

2.1.5.1 Electromagnetic Energy-Saving Ballasts

****
NOTE: Energy-saving ballasts are generally not available for low temperature applications (below 10 degrees C 50 degrees F). Additionally, the combination of energy-saving ballasts and energy-saving lamps are not recommended below 15 degrees C 60 degrees F.
****

****
NOTE: Include last bracketed sentence and use 123 input wattage in lieu of 136, when required by the Post or Base or Activity involved.
****

ANSI C82.1. Provide energy-saving fluorescent ballasts of the CBM certified full light output type[except where fixtures are provided with low temperature ballasts]. Ballasts shall have an average input wattage of [40 or less when operating one 32-watt F32T8 lamp][45 or less when operating two 17 watt F17T8 lamps][72 or less when operating two 32 watt F32T8 lamps][109 or less when operating two 59-watt F96T8 lamps][[_____] or less when operating [_____] lamps] tested in accordance with ANSI C82.2

methods.[Provide ballasts which are compatible with energy-saving lamps.]

2.1.5.2   Electromagnetic Ballasts for Compact Fluorescent Lamps

Provide electromagnetic ballasts for compact fluorescent lamps.

2.1.5.3   Electromagnetic Low Temperature Ballasts

****

NOTE: A source of light other than fluorescent is recommended for areas subject to temperatures below minus 17 degrees C 0 degrees F. If fluorescent fixtures are required, low temperature ballasts should be indicated and specified where ambient temperatures may normally drop below 10 degrees C 50 degrees F if required by the design. Low temperature ballasts are not CBM certified and do not conform to ANSI C82.1.

****

Provide fluorescent ballasts having a minimum starting temperature of[minus 17 degrees C][minus 28 degrees C][zero degrees F][minus 20 degrees F] for 800 milliampere, high output (HO) lamps in fixtures mounted[in cold rooms,][outdoors,][in unheated buildings,][and as indicated].

2.1.5.4   [Electromagnetic Ballasts for T-5 Long Twin Tube Lamps

Provide electromagnetic ballasts with an average input wattage of[49 or less when operating one][86 or less when operating two] 40-watt T-5 long twin tube lamps.

]]2.1.6   Fluorescent Lamps

****

NOTE: T-8 lamps with CRI of 75 and color temperature of 3500 K are recommended for most applications.

Low mercury lamps must be specified on projects that use 1220 mm (4 foot) 4-foot lamps and are located in the continental United States. For other locations or lamp types, the specifier must ensure availability of the low mercury lamps.

****

[a. T-8 rapid start[low mercury] lamps shall be rated 32 watts (maximum), 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of [3500 K][_____], and an average rated life of 20,000 hours.[Low mercury lamps shall have passed the EPA Toxicity Characteristic Leachate Procedure (TCLP) for mercury by using the lamp sample preparation procedure described in NEMA LL 1.]]

[b. T-8 rapid start lamp, 17 watt (maximum), nominal length of 610 mm 24 inches, 1300 initial lumens, CRI of 75 (minimum), color temperature of [3500 K][_____], and an average rated life of 20,000 hours.]

[c. T-8 instant start lamp, 59 watts (maximum), nominal length of 2438 mm (96 inches) 96 inches, minimum CRI of 75, 5700 initial lumens, color temperature of [3500 K][_____], and average rated life of 15,000 hours.]

[d. T-12 slim line lamps shall be rated 60 watts (maximum), 5750 initial lumens (minimum), 12,000 hours average rated life.]

[e. T-5, long twin tube fluorescent lamp, 40 watts (maximum), [3500 K][_____], 574 mm 22.6 inches maximum length, 20,000 hours average rated life, 3150 initial lumens, CRI of 80 (minimum), 2G11 Type base, 90 to 100 lumens/watt depending on wattage.]

[f. T-8, U shaped fluorescent lamp, 31 watts maximum, 2600 initial lumens (minimum), [3500 K][_____], 75 CRI (minimum), 20,000 hours average rated life, [41.29 mm][[_____] mm] [1.625][_____] inch leg spacing.]

[g. Compact fluorescent lamps shall be: CRI 80, minimum, [3500 K][_____], 10,000 hours average rated life, and as follows:

1. T-4, twin tube, rated[5 watt, 250 initial lumens (minimum)][7 watts, 400 initial lumens (minimum),][9 watts, 600 initial lumens (minimum),][and][13 watts, 825 initial lumens (minimum),][as indicated].

2. T-4, double twin tube, rated[13 watts, 900 initial lumens (minimum),][18 watts, 1200 initial lumens (minimum),][and][26 watts, 1800 initial lumens (minimum),][as indicated].]

Average rated life is based on 3 hours operating per start.

2.1.7 Compact Fluorescent Fixtures

Compact fluorescent fixtures shall be manufactured specifically for compact fluorescent lamps with ballasts integral to the fixture. Providing assemblies designed to retrofit incandescent fixtures is prohibited except when specifically indicated for renovation of existing fixtures. Fixtures shall use lamps as indicated, with a minimum CRI of 80.

2.1.7.1 Bare Bulb Retrofits

Replace 40-watt incandescent bulbs (495+ lumens) with 11- to 14-watt compact fluorescent bulbs (45+ lumens per watt). Replace 60-watt incandescent bulbs (900+ lumens) with 15- to 19-watt compact fluorescent bulbs (60+ lumens per watt). Replace 75-watt incandescent bulbs (1200+ lumens) with 20- to 25-watt compact fluorescent bulbs (60+ lumens per watt). Replace 100-watt incandescent bulbs (1750+ lumens) with 29-watt or greater compact fluorescent bulbs (60+ lumens per watt).

2.1.7.2 Reflector Type Bulb Retrofits

Replace 50-watt incandescent bulbs (550+ lumens) with 17- to 19-watt compact fluorescent bulbs (33+ lumens per watt). Replace 60-watt incandescent bulbs (675+ lumens) with 20- to 21-watt compact fluorescent bulbs (40+ lumens per watt). Replace 75-watt incandescent bulbs (875+ lumens) with 22-watt or greater compact fluorescent bulbs (40+ lumens per watt).

2.1.8 Open-Tube Fluorescent Fixtures

****

NOTE: Select one of bracketed options where lamp breakage is detrimental, such as above food counters.

****

Provide with self-locking sockets, or lamp retainers (two per lamp).[Provide lamps with shatter resistant coating, non-yellowing, nominal thickness of 0.38 mm 15 mils, and with 97 percent (minimum) light transmission.][Provide a clear polycarbonate protective sleeve with end caps, over lamp, with 95 percent (minimum) light transmission. The sleeve shall be rated to withstand the thermal profile of the lamp and ballast.]

2.1.9 Air Handling Fixtures

Fixtures used as air handling registers shall meet requirements of NFPA 90A.

2.1.10 [Electromagnetic Interference Filters

****
NOTE: Use filters only when specifically required by activity. Filters available for mounting within lighting fixtures provide only basic interference suppression. For shielded enclosures and secure facilities, provide power line filters in the circuits serving the lighting.
****

Provide in each fluorescent fixture mounted[in shielded enclosures][where indicated].[Filters shall be integral to the fixture assembly with one filter per ballast and shall suppress electromagnetic interference in the AM radio band from 500 to 1700 kHz.][Filters shall be in the circuit serving the lighting fixtures mounted where indicated and shall conform to requirements of Section 26 35 46.00 20 RADIO FREQUENCY INTERFERENCE POWER LINE FILTERS.]

]2.2 HIGH-INTENSITY-DISCHARGE (HID) LIGHTING FIXTURES

UL 1598.[Provide HID fixtures with tempered glass lenses when using metal-halide lamps.]

2.2.1 HID Ballasts

UL 1029 and ANSI C82.4 and shall be constant wattage autotransformer (CWA) or regulator, high power factor type (minimum 90 percent). Provide single-lamp ballasts which shall have a minimum starting temperature of minus 30 degrees C. Ballasts shall be:

a. Designed to operate on the voltage system to which they are connected.

b. Designed for installation in a normal ambient temperature of [40][_____] degrees C.

c. Constructed so that open circuit operation will not reduce the average life.

High-pressure sodium (HPS) ballasts shall have a solid-state igniter/starter with an average life in the pulsing mode of 3500 hours at the intended ambient temperature. Igniter case temperature shall not exceed 90 degrees C in any mode.

2.2.2 High-Pressure Sodium (HPS) Lamps

ANSI ANSLG C78.42 wattage as indicated. 150 watt lamps, if required, shall be 55 volt type.

2.2.2.1 [Standby HPS Lamps

****
NOTE: Dual ARC tube HPS Lamps may, under certain conditions be used as auxiliary stand-by lighting when momentary power interruptions are anticipated.
****

Standby HPS lamps shall have two arc tubes and an average rated life of 40,000 hours (minimum) and hot restart instant lumen output shall be 8 percent, minimum, of total light output.

]2.2.2.2 Luminaire Efficiency Rating (LER)

a. Upward efficiency of 0 percent

   [1. 150-399 watts: minimum 58 LER for closed fixture; minimum 68 for open fixture]

   [2. 400-999 watts: minimum 63 LER for closed fixture; minimum 84 for open fixture]

b. Upward efficiency of 1 percent - 10 percent

   [1. 150-399 watts: minimum 64 LER for closed fixture; minimum 63 for open fixture]

   [2. 400-999 watts: minimum 82 LER for closed fixture; minimum 89 for open fixture]

   [3. 1000+ watts: minimum 109 LER for open fixture]

c. Upward efficiency of 11 percent to 20 percent

   [1. 150-399 watts: minimum 78 LER for open fixture]

   [2. 400-999 watts: minimum 94 for open fixture]

d. Upward efficiency greater than 20 percent

   1. 150-399 watts: minimum 75 LER for closed fixture; minimum 77 for open fixture

2.2.3 Low-Pressure Sodium Lamps

****
NOTE: Use low-pressure sodium where color rendition is not a factor, but high lamp efficiency is.
****

ANSI ANSLG C78.41.

2.2.4 Metal-Halide Lamps

****
NOTE: Metal-halide lamp safe operation requires lamps to be turned off at least 15 minutes per week or lamp may rupture near the end of its expected life. Lamp rupture may discharge glass and extremely hot quartz (greater than 900 degrees C) into the surrounding area. Therefore, designs for metal-halide lamps shall include weekly turnoff instructions when continuously operated, 24 hours per day, 7 days per week. These instructions shall be detailed on the drawings for posting at the control locations. For indoor use, color rendition index (CRI) and color temperature (CCT) may need to be specified.
****

[a. Double-ended, 70 watt, conforming to ANSI C78.1381]

[b. Single-ended, wattage as indicated, conforming to ANSI/ANSLG C78.43]

2.2.4.1 Luminaire Efficiency Rating (LER)

a. Upward efficiency of 0 percent

[1. 150-399 watts: minimum 41 LER for closed fixture]

[2. 400-999 watts: minimum 53 LER for closed fixture; minimum 59 for open fixture]

[3. 1000+ watts: minimum 77 LER for closed fixture]

b. Upward efficiency of 1 percent - 10 percent

[1. 150-399 watts: minimum 56 LER for closed fixture]

[2. 400-999 watts: minimum 62 LER for closed fixture; minimum 64 for open fixture]

[3. 1000+ watts: minimum 88 LER for open fixture]

c. Upward efficiency greater than 20 percent

[1. 150-399 watts: minimum 62 LER for closed fixture; minimum 77 for open fixture]

[2. 400-999 watts: minimum 65 LER for closed fixture]

2.3 INCANDESCENT LIGHTING FIXTURES

Use of incandescent lamps and fixtures is prohibited, unless specifically indicated otherwise. UL 1598.

2.3.1 Incandescent Lamps

Provide the number, type, and wattage indicated.

2.4 LED LUMINAIRES

****
NOTE: Luminaire plates and details shown on project plans are provided for a visual perspective of the luminaire desired. Shapes, dimensions and other requirements shown are not intended to restrict selection to luminaires of a specific manufacturer. Luminaires producing comparable or competitive photometric results on a given plan area, and of similar or equal material, finish and craftsmanship will be considered for approval.
****

UL 1598, NEMA C82.77 and UL 8750. Provide luminaires as indicated in luminaire schedule and plates or details on project plans. Provide luminaires complete with light sources of quantity, type, and wattage indicated. All luminaires of the same type shall be provided by the same manufacturer. Details, shapes, and dimensions are indicative of the general type desired, but are not intended to restrict selection to luminaires of a particular manufacturer. Luminaires of similar designs, light distribution and brightness characteristics, and of equal finish and quality will be acceptable as approved.

2.4.1 General Requirements

a. LED luminaire housings shall be die cast or extruded aluminum.

[b. LED luminaires shall be rated for operation within an ambient temperature range of minus 30 degrees C minus 22 degrees F to[40 degrees C 104 degrees F][50 degrees C 122 degrees F].]

[c. Luminaires shall be UL listed for wet locations per UL 1598 where indicated.[Optical compartment for LED luminaires shall be sealed and rated a minimum of IP65 per NEMA IEC 60529.]]

[d. LED luminaires shall produce a minimum efficacy of 60 lumens per watt driven at a maximum 600 mA, tested per IES LM-79. Theoretical models of initial raw LED lumens per watt are not acceptable.]

e. Luminaires shall have IES distribution and NEMA field angle classifications as indicated in luminaire schedule on project plans per IES HB-10.

f. Housing finish shall be baked-on enamel, anodized, or baked-on powder coat paint. Finish shall be capable of surviving ASTM B117 salt fog environment testing for 2500 hours minimum without blistering or peeling.

g. Luminaires shall be fully assembled and electrically tested prior to shipment from factory.

h. The finish color shall be as indicated in the luminaire schedule or detail on the project plans.

i. Luminaire lenses shall be constructed of[clear][frosted] tempered glass or UV-resistant acrylic.

j. Incorporate modular electrical connections, and construct luminaires to allow replacement of all or any part of the optics, heat sinks, power supply units, ballasts, surge suppressors and other electrical components using only a simple tool, such as a manual or cordless electric screwdriver.

k. Luminaires shall have a nameplate bearing the manufacturer's name, address, model number, date of manufacture, and serial number securely affixed in a conspicuous place. The nameplate of the distributing agent will not be acceptable.

l. All factory electrical connections shall be made using crimp, locking, or latching style connectors. Twist-style wire nuts are not acceptable.

2.4.2 [LED Light Sources

****
NOTE: Typically, select a CCT in the range of 3000 to 4000 degrees K.
****

a. Correlated Color Temperature (CCT) shall be in accordance with NEMA ANSLG C78.377:

[Nominal CCT: 3000 degrees K: 3045 plus or minus 175 degrees K]

[Nominal CCT: 3500 degrees K: 3465 plus or minus 245 degrees K]

[Nominal CCT: 4000 degrees K: 3985 plus or minus 275 degrees K]

b. Color Rendering Index (CRI) shall be:

Greater than or equal to [80] [__] for 3000 - 3500 degrees K light sources.

Greater than or equal to [70] [__] for 4000 - 4500 degrees K light sources.

c. Color Consistancy:

Manufacturer shall utilize a maximum 4-step MacAdam ellipse binning tolerance for color consistancy of LEDs used in luminaires.

]2.4.3 [LED Power Supply Units (Drivers)

UL 1310. LED Power Supply Units shall meet the following requirements:

a. Minimum efficiency shall be 85 percent.

b. Drive current per LED shall not exceed 600 mA, plus or minus 10 percent.

c. Shall be rated to operate between ambient temperatures of minus 30 degrees C minus 22 degrees F and 40 degrees C 104 degrees F.

d. Shall be designed to operate on the voltage system to which they are connected, typically ranging from 120 V to 480 V nominal.

e. Operating frequency shall be: 50 or 60 Hz.

f. Power Factor (PF) shall be greater than or equal to 0.90.

g. Total Harmonic Distortion (THD) current shall be less than or equal to 20 percent.

h. Shall meet requirements of FCC Part 15 (47 CFR 15), Class B.

i. Shall be RoHS-compliant.

j. Shall be mounted integral to luminaire. Remote mounting of power supply is not allowed.

k. Power supplies in luminaires shall be UL listed with a sound rating of A.

[l. Shall be dimmable, and compatible with a standard dimming control circuit of 0 - 10V or other approved dimming system.]

m. Shall be equipped with over-temperature protection circuit that turns light source off until normal operating temperature is achieved.

]2.4.4 Surge Protection

Provide surge protection integral to luminaire to meet "C Low" waveforms as defined in IEEE C62.41.2, Scenario 1 Location Category C.

2.5 RECESS- AND FLUSH-MOUNTED FIXTURES

Provide type that can be relamped from the bottom. Access to ballast shall be from the bottom. Trim for the exposed surface of flush-mounted fixtures shall be as indicated.

2.6 SUSPENDED FIXTURES

****

NOTE: Coordinate pendant sway bracing details with the architect. The architect may prefer to provide pendant sway bracing details in locations where appearance is important. Specify shock absorbing hangers for fixtures in certain hazardous locations if indicated. Specify swivel hangers to satisfy antiterrorist/force protection requirements.

****

Provide hangers capable of supporting twice the combined weight of fixtures supported by hangers. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with a swivel-ball tapped for the conduit size indicated.[Hangers shall be shock-absorbing type where indicated.] Hangers shall allow fixtures to swing within an angle of 0.79 rad 45 degrees. Brace pendants 1219 mm 4 feet or longer[provided in shops or hangers] to limit swinging. Single-unit suspended[fluorescent] fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 4.57 mm 0.18 inch diameter.

2.7 FIXTURES FOR HAZARDOUS LOCATIONS

In addition to requirements stated herein, provide[fluorescent][HID][

incandescent] fixtures for hazardous locations which conform to UL 844 or which have Factory Mutual certification for the class and division indicated.[Fixture shall also conform to UL 595 for marine environments as indicated.]

2.8 SWITCHES

2.8.1 Toggle Switches

Provide toggle switches as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.8.2 Incandescent Dimmer Switch

****
NOTE: Do not specify central dimming systems with this specification.
****

UL 20, single-pole, [600][_____] watt, 120 volt ac, full-range rotary on-off type with built-in electromagnetic interference filter.

2.9 [LIGHTING CONTACTOR

NEMA ICS 2. Provide a [mechanically][electrically]-held lighting contactor [housed in a NEMA [1][3R][4][__] enclosure conforming to NEMA ICS 6]. Contactor shall have [2][4][6][__] poles, configured as [normally open (NO)][normally closed (NC)]. Contacts shall be rated [600][___] volts, [30][__] amperes for a resistive load. Coil operating voltage shall be [24][120][277][__] volts. Contactor shall have silver cadmium oxide double-break contacts [and coil clearing contacts for mechanically held contactors] and shall require no arcing contacts. [Provide contactor with hand-off-automatic [on-off] selector switch.] [Provide contactor as specified above along with [disconnect switch][circuit breaker] in integral NEMA [1][3R][__] enclosure with flange-mounted handle to satisfy requirement for a "combination lighting contactor" when specified.]

]2.10 [TIMESWITCH

[Timeswitch shall be electromechanical type with a [24 hour] [7 day] [astronomic] dial [that changes on/off settings according to seasonal variations of sunset and sunrise]. Switch shall be powered by an enclosed synchronous motor with a maximum 3 watt operating rating. Timeswitch contacts shall be rated for [40] [__] amps at 120-277 VAC resistive load in a [SPST][DPST][SPDT][DPST][normally open (NO)][normally closed (NC)] configuration. Switch shall have an automatic spring mechanism to maintain accurate time for up to 16 hours during a power failure.[Provide switch with function that allows automatic control to be skipped on certain selected days of the week.][Provide switch with manual bypass or remote override control.]]

[Timeswitch shall be an electronic type with a[24 hour][7 day] [astronomic] programming function [that changes on/off settings according to seasonal variations of sunset and sunrise], providing a total of [56][__] on/off set points. Digital clock display format shall be[AM/PM 12 hour][24 hour] type. Provide power outage backup for switch utilizing a[capacitor][alkaline batteries][lithium battery] which provides coverage for a minimum of [7 days][3 years][8 years]. Timeswitch shall provide control to [1][2][4][__] channels or loads. Contacts shall be rated for [30][__] amps at 120-277 VAC resistive load in a [SPST][DPST][SPDT][DPST] [normally open (NO)][normally closed (NC)] configuration. [Provide switch with [function that allows automatic control to be skipped on certain selected days of the week][manual bypass or remote override control][daylight savings time automatic adjustment][EEPROM memory module][momentary function for output contacts][ability for photosensor input]].]

Timeswitch shall be housed in a surface-mounted, lockable NEMA [1][3R] enclosure constructed of painted steel or plastic polymer conforming to NEMA ICS 6.

]2.11 [PHOTOCELL

****

NOTE: Cadmium sulfide is the older of the two technologies. Silicon diode sensors are a solid state device and more resistant to higher temperatures and environmental contamination. Silicon diode type are usually specified when mounting directly to luminaires, but both types are proven, reliable technologies.

****

UL 773 or UL 773A. Photocells shall be hermetically sealed,[cadmium sulfide][silicon diode] light sensor type, rated at [_____] watts, [_____] volts, 50/60 Hz with single-pole, [single][double]-throw contacts. Photocell shall be designed to fail to the ON position. Housing shall be constructed of [polycarbonate] [die cast aluminum] [UV stabilized polypropylene], rated to operate within a temperature range of minus 40 to 70 degrees C minus 40 to 158 degrees F.[Photocell shall have a 13 mm 1/2 in threaded base for mounting to a junction box or conduit. Provide[fixed][swivel] base type housing.][Photocell shall be twist-lock receptacle type conforming to NEMA C136.10. Provide with solid brass prongs and voltage markings and color coding on exterior of housing.] Photocell shall turn on at 10-30 lux 1-3 footcandles and turn off at 30 to 150 lux 3 to 15 footcandles. A time delay shall prevent accidental switching from transient light sources.[Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.][Provide photocell with metal oxide varistor (MOV) type surge protection.]

]2.12 POWER HOOK FIXTURE HANGERS

Provide UL listed assembly including through-wired power hook housing, interlocking plug and receptacle, power cord, and fixture support loop. Power hook housing shall be cast aluminum having two 19 mm 3/4 inch threaded hubs. Support hook shall have safety screw. Fixture support loop shall be cast aluminum with provisions for accepting 19 mm 3/4 inch threaded fixture stems. Power cord shall include 410 mm 16 inches of 3 conductor No. 16 Type SO cord. Assembly shall be rated[120 volts or 277 volts, 15 amperes][480 volts, 20 amperes].

2.13 EXIT SIGNS

****

NOTE: For LANTNAVFACENGCOM projects, provide LED type self-powered exit signs (battery backup) unless specifically instructed otherwise. Normal mode of

power to these signs shall be the branch circuit serving normal lighting in the area connected ahead of any local switches; emergency mode of power shall be the unit's self-contained power/battery pack. Luminous exit signs contain radiation emitting sources and are not permitted because of potential radioactive hazards and disposal problems.
****

UL 924, NFPA 70, and NFPA 101. Exit signs shall be[self-powered][remote-powered] type. Exit signs shall use no more than 5 watts.

2.13.1 Self-Powered LED Type Exit Signs (Battery Backup)

Provide with automatic power failure device,[test switch, pilot light,][integral self-testing module] and fully automatic high/low trickle charger in a self-contained power pack. Battery shall be sealed electrolyte type, shall operate unattended, and require no maintenance, including no additional water, for a period of not less than 5 years. LED exit sign shall have emergency run time of 1 1/2 hours (minimum). The light emitting diodes shall have rated lamp life of 70,000 hours (minimum).

2.13.2 Remote-Powered Exit Signs

Provide remote ac/dc exit signs with provisions for wiring to external ac and dc power sources. Provide signs with a minimum of two ac lamps for normal illumination and a minimum of two dc lamps for emergency lighting.

2.14 EMERGENCY LIGHTING EQUIPMENT

****
NOTE: Lamp wattage shall be properly specified to provide the required illumination per NFPA. In lieu of an installation involving many individual emergency lighting units, consider several emergency lighting units with remote heads or central system with zone control. Remote heads shall be shown on the drawings. Circuit shall be hard wired to normal power system. A variety of battery types exists. Each has differing life expectancies and maintenance requirements. Choose the battery type which best suits the application.
****

UL 924, NFPA 70, and NFPA 101. Provide lamps in wattage indicated.[Provide accessories required for remote-mounted lamps where indicated. Remote-mounted lamps shall be as indicated.]

2.14.1 Emergency Lighting Unit

Provide as indicated.[Emergency lighting units shall be rated for 12 volts, except units having no remote-mounted lamps and having no more than two unit-mounted lamps may be rated 6 volts.][Equip units with brown-out sensitive circuit to activate battery when ac input falls to 75 percent of normal voltage[and 15 minute time delay feature for areas with HID lighting].][Provide integral self-testing module.]

2.14.2 Fluorescent Emergency System

****
NOTE: Designer shall decide on number of lamps and minimum lumens required to meet criteria.
****

Each system shall consist of an automatic power failure device, test switch operable from outside of the fixture, pilot light visible from outside the fixture, and fully automatic solid-state charger in a self-contained power pack.[Provide self-testing module[mounted adjacent][integral] to the fixture.] Charger shall be either trickle, float, constant current or constant potential type, or a combination of these. Battery shall be sealed electrolyte type with capacity as required to supply power to[[_____] lamps][the number of lamps shown for each system] for 90 minutes at a minimum of [600][1100][400][_____] lumens per lamp output. Battery shall operate unattended and require no maintenance, including no additional water, for a period of not less than 5 years. Emergency ballasts provided with fixtures containing solid-state ballasts shall be fully compatible with the solid-state ballasts.

2.15 [SELF-TESTING MODULE

****
NOTE: Activity and designer shall decide on appropriate usage of self-testing module. The self-testing module can significantly increase emergency lighting and exit fixture pricing. If self-testing module is not used, coordinate with options in paragraphs entitled "Exit Signs" and "Emergency Lighting Equipment."
****

Self-testing module for exit signs and emergency lighting equipment shall perform the following functions:

a. Continuous monitoring of charger operation and battery voltage with visual indication of normal operation and of malfunction.

b. Monthly discharge cycling of battery with monitoring of transfer circuit function, battery capacity and emergency lamp operation with visual indication of malfunction. The battery capacity test may be conducted by using a synthetic load.

c. Manual test switch to simulate a discharge test cycle.

d. Module shall have low voltage battery disconnect (LVD) and brown-out protection circuit.

]2.16 CENTRAL EMERGENCY SYSTEM

****
NOTE: Clearly show on plans how system is zoned.
****

Each system shall supply [_____] watts of emergency power at[[277][120][_____] volts, 60 Hz sine wave ac][[32][_____] volts dc] for a minimum period of [90][_____] minutes.[Sine wave ac system shall have an inverter output distortion of not more than 10 percent at unity power factor.] The system shall be designed to handle surges during loss and recovery of power.

2.16.1 Operation

With normal power applied, batteries shall be automatically charged. Upon loss of normal power, system shall automatically disengage from the normal input line and switch to a self-contained inverter within[1 second when serving incandescent and fluorescent lamps][2 milliseconds when serving HID lamps]. Inverter shall have built-in protection when output is shorted or overloaded. When normal power resumes, the emergency system shall automatically switch back to normal operation before the power loss. Size transfer switch for this function to handle 125 percent of full load.

2.16.2 Battery Charger

[Provide two-rate charger for lead-calcium batteries.][Provide three-rate charger for nickel-cadmium batteries .]The charger shall be solid-state, completely automatic, maintaining the batteries in a fully charged condition, and recharging the batteries to full capacity as specified in UL 924.

2.16.3 Batteries

Batteries shall be[sealed lead-calcium][nickel-cadmium] type, shall operate unattended, and shall require no maintenance, including no additional water, for a period of not less than[10][5] years.

2.16.4 Accessories

****
NOTE: Electrolyte level detector is not applicable to sealed batteries.
****

Provide visual indicators to indicate normal power, inverter power, and battery charger operation. Provide test switch to simulate power failure by interrupting the input line,[battery voltage meter,][load ammeter,][automatic brown-out circuitry to switch to emergency power when input line voltage drops below 75 percent of normal value,][electrolyte level detector that will activate a visual or audio alarm in the event of a low water condition,][time delay feature for areas with HID lighting,][and][low voltage cutoff (LVD) to disconnect inverter when battery voltage drops to approximately 80 percent of nominal voltage].

2.16.5 Enclosure

Provide a free-standing cabinet with floor stand. Cabinet construction shall be of 14 gage sheet steel with baked-on enamel finish and locking type latch.

2.17 AUXILIARY INSTANT-ON SYSTEM

****
NOTE: Specify auxiliary quartz or compact fluorescent system for luminaries where extinguishing of HID lamps caused by momentary power interruptions is unacceptable for safety or security reasons, and inclusion of a central emergency system

is beyond the project scope.
****

UL listed, automatically switched instant-on [_____][150][250] watt[quartz][compact fluorescent] lamp. [Quartz][Compact fluorescent] lamp shall come on when luminaire is initially energized and following a momentary power outage and shall remain on until HID lamp reaches approximately 60 percent light output. Wiring for[quartz][compact fluorescent] lamp shall be internal to the ballast and shall be independent of the incoming line voltage to the ballast.[Provide instant-on[quartz][compact fluorescent] system for each HID fixture.][Provide instant-on[quartz][compact fluorescent] system as indicated.]

2.18 OCCUPANCY SENSORS

****
NOTE: Occupancy sensors are useful in lighting control applications for private and open offices, restrooms, conference rooms, classrooms, utility areas, warehouses, and corridors. Consult the Interim Technical Guidance (ITG FY96-02) on Occupant Sensors, dated 1 Jul 96. This ITG is available from the Whole Building Design Guide web site at http://www.wbdg.org/ccb/NAVFAC/INTCRIT/fy96_02.pdf.

Also, most occupancy sensor manufacturers offer design services for their products.
****

****
NOTE: Typical sensor applications are:
Ultrasonic - Restrooms, Hallways
Infrared - Warehouses, Open Offices
Combination Sensor - Classrooms, Conference Rooms
****

UL listed. Comply with GS-12. Occupancy sensors and power packs shall be designed to operate on the voltage indicated. Sensors and power packs shall have circuitry that only allows load switching at or near zero current crossing of supply voltage. Occupancy sensor mounting as indicated. Sensor shall have an LED occupant detection indicator. Sensor shall have adjustable sensitivity and adjustable delayed-off time range of 5 minutes to 15 minutes. Wall mounted sensors shall[be ivory][be white][match the color of adjacent wall plates as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM], ceiling mounted sensors shall be white. Ceiling mounted sensors shall have 6.28 rad 360 degree coverage unless otherwise indicated.

[a. Ultrasonic sensor shall be crystal controlled and shall not cause detection interference between adjacent sensors.]

[b. Infrared sensors shall have a daylight filter. Sensor shall have a fresnel lens that is applicable to space to be controlled.]

[c. Ultrasonic/Infrared Combination Sensor

[d. Microwave and audiophonic sensors.]

Occupancy detection to turn lights on requires both ultrasonic and infrared sensor detection. Lights shall remain on if either the ultrasonic or infrared sensor detects movement. Infrared sensor shall have lens selected for indicated usage and daylight filter to prevent short wavelength infrared interference. Ultrasonic sensor frequency shall be crystal controlled.]

2.19 SUPPORT HANGERS FOR LIGHTING FIXTURES IN SUSPENDED CEILINGS

2.19.1 Wires

****

NOTE: Select zinc-coated steel wire for all locations except those listed in the note in the paragraph entitled "Wires, for Humid Spaces," below. When spacing of hanger wires exceeds 1219 mm 4 feet or when heavy lighting fixtures are supported, 8 or 10 gage wire should be specified.

****

ASTM A641/A641M, galvanized regular coating, soft temper, [2.68 mm][[_____] mm] [0.1055][_____] inches in diameter ([12][_____] gage).

2.19.2 [Wires, for Humid Spaces

****

NOTE: Select stainless steel or nickel copper alloy wire for facilities where high humidity can be expected such as large kitchens, dishwashing areas, etc. Select nickel copper alloy when hangers are used in an indoor pool environment. When spacing of hanger wires exceeds 1219 mm 4 feet or when heavy lighting fixtures are supported, 8 or 10 gage wire should be specified.

****

[ASTM A580/A580M, composition 302 or 304, annealed stainless steel [2.68 mm][[_____] mm] [0.1055][_____] inches in diameter ([12][_____] gage).]

[ASTM B164, UNS NO4400, annealed nickel-copper alloy [2.68 mm][[_____] mm] [0.1055][_____] inches in diameter ([12] [_____] gage).]

]2.19.3 [Straps

****

NOTE: Normally wire hangers should be used. If the project is in an area subject to violent storms, steel strap or rod hangers should be specified. Check with area Engineering Office to determine if straps or rods are needed.

****

Galvanized steel, 25 by 4.76 mm one by 3/16 inch, conforming to ASTM A653/A653M, with a light commercial zinc coating or ASTM A1008/A1008M with an electrodeposited zinc coating conforming to ASTM B633, Type RS.

]2.19.4 [Rods

****

NOTE: Normally wire hangers should be used. If the

project is in an area subject to violent storms, steel straps or rod hangers should be specified. Check with area Engineering Office to determine if straps or rods are needed.
****

Threaded steel rods, 4.76 mm 3/16 inch diameter, zinc or cadmium coated.

]2.20 EQUIPMENT IDENTIFICATION

2.20.1 Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.20.2 Labels

****
NOTE: Labeling of lighting components is an inexpensive and effective method for helping facilities personnel properly operate and maintain the lighting systems. The labels shall be easy to read when standing next to the equipment, and durable to match the life of the equipment to which they are attached. Refer to the FEMP guidelines for lighting at http://www.eere.energy.gov/femp/technologies/eep_lighting_guidance.cfm.
****

Provide labeled luminaires in accordance with UL 1598 requirements. All luminaires shall be clearly marked for operation of specific light sources and ballasts according to proper lamp type. The following lamp characteristics shall be noted in the format "Use Only _____":

****
NOTE: Choose requirements as applicable for project.
****

[a. Light source tube diameter code (e.g. T-4, T-5, T-8), tube quantity configuration (e.g. twin, quad, triple), base type (e.g. G24q-2, GX 24 q-4), and nominal wattage for fluorescent and compact fluorescent luminaires.]

[b. Light source type, wattage, bulb type (e.g. ED17, BD56) and coating (clear or coated) for HID luminaires.]

[c. Start type (e.g. programmed-start, rapid-start, instant-start) for fluorescent and compact fluorescent luminaires.]

[d. ANSI ballast type (e.g. M98, M57) for HID luminaires.]

e. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

All markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place.[Ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.]

2.21 FACTORY APPLIED FINISH

****
NOTE: This paragraph covers only the basic painting requirements for most electrical equipment. Include any special finishes for high or low temperatures and corrosive atmospheres.
****

Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Lamps

****
NOTE: Indicate all lamp types and colors on the lighting fixture schedule.
****

Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons and installed just prior to project completion. Lamps installed and used for working light during construction shall be replaced prior to turnover to the Government if more than 15 percent of their rated life has been used. Lamps shall be tested for proper operation prior to turn-over and shall be replaced if necessary with new lamps from the original manufacturer. Provide 10 percent spare lamps of each type from the original manufacturer.

3.1.2 Lighting Fixtures

****
NOTE: The electrical designer shall coordinate these requirements with architectural plans and specifications. Ensure requirements for antiterrorism/force protection for fixtures in suspended ceilings are included in and coordinated with Section 09 51 00 ACOUSTICAL CEILINGS by referencing ASTM E 580 seismic requirements in that section.

Lighting fixtures for facilities located in earthquake zones shall have additional supports and restraining devices as described in Army UFC 1-200-01, "General Building Requirements" and UFC 3-310-04, "Seismic Design for Buildings".
****

Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturers' directions and approved drawings. Installation shall meet requirements of NFPA 70. Mounting heights specified or indicated shall be to the bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before commencing installation and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Recessed and semi-recessed fixtures shall be independently supported from the building structure by a minimum of four wires[or straps][or rods] per fixture and located near each corner of each fixture. Ceiling grid clips are not allowed as an alternative to independently supported light fixtures. Round fixtures or fixtures smaller in size than the ceiling grid shall be independently supported from the building structure by a minimum of four wires[or straps][or rods] per fixture spaced approximately equidistant around the fixture. Do not support fixtures by ceiling acoustical panels. Where fixtures of sizes less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently and provide at least two 19 mm 3/4 inch metal channels spanning, and secured to, the ceiling tees for centering and aligning the fixture. Provide wires[or straps][or rods] for lighting fixture support in this section. Lighting fixtures installed in suspended ceilings shall also comply with the requirements of Section 09 51 00 ACOUSTICAL CEILINGS.

3.1.3 Suspended Fixtures

****

NOTE: Coordinate pendant sway bracing details with the architect. The architect may prefer to provide pendant sway bracing details in locations where appearance is important.

****

Suspended fixtures shall be provided with 0.79 rad 45 degree swivel hangers so that they hang plumb and shall be located with no obstructions within the 0.79 rad 45 degree range in all directions. The stem, canopy and fixture shall be capable of 0.79 rad 45 degree swing. Pendants, rods, or chains 1.2 meters 4 feet or longer excluding fixture shall be braced to prevent swaying using three cables at 2.09 rad 120 degree separation. Suspended fixtures in continuous rows shall have internal wireway systems for end to end wiring and shall be properly aligned to provide a straight and continuous row without bends, gaps, light leaks or filler pieces. Aligning splines shall be used on extruded aluminum fixtures to assure hairline joints. Steel fixtures shall be supported to prevent "oil-canning" effects. Fixture finishes shall be free of scratches, nicks, dents, and warps, and shall match the color and gloss specified. Pendants shall be finished to match fixtures. Aircraft cable shall be stainless steel. Canopies shall be finished to match the ceiling and shall be low profile unless otherwise shown. Maximum distance between suspension points shall be 3.1 meters 10 feet or as recommended by the manufacturer, whichever is less.

3.1.4 [Ballasts

3.1.4.1 [Remote Ballasts

Remote type ballasts or transformers, where indicated, shall be mounted in a well ventilated, easily accessible location, within the maximum operating distance from the lamp, as designated by the manufacturer.

]3.1.4.2 [Electronic Dimming Ballasts

All electronic dimming ballasts controlled by the same controller shall be of the same manufacturer. All fluorescent lamps on electronic dimming ballast control shall be seasoned or burned in at full light output for 100 hours before dimming.

]]3.1.5 Exit Signs and Emergency Lighting Units

****

NOTE: Use this paragraph for most projects.

The bracketed subparagraphs should only be used in special cases such as where energy monitoring systems are used, where facilities use breakers as switches, and where central emergency systems are used. In these cases emergency lighting may have to be on separate circuits rather than connected ahead of the local switching.

****

Wire exit signs and emergency lighting units ahead of the switch to the normal lighting circuit located in the same room or area.

3.1.5.1 [Exit Signs

****

NOTE: Use this subparagraph only in special cases and as indicated in the above note.

****

Wire exit signs on separate circuits and serve from[an emergency panel][a separate breaker][a fused disconnect switch]. Signs shall have only one control, which shall be[the circuit breaker in the emergency panel][the separate breaker][the disconnect switch]. Paint control device red and provide lockout.

]3.1.5.2 [Emergency Lighting from Central Emergency System

****

NOTE: Use this subparagraph only for projects utilizing a central emergency system. Central emergency system details including zone control must be included on the drawings.

****

Wire emergency lighting powered from a central emergency system as indicated on the drawings.

]3.1.6 Photocell Switch Aiming

Aim switch according to manufacturer's recommendations.[Set adjustable window slide for [_____][minimum] lux [_____][minimum] footcandles photocell turn-on.]

3.1.7 Occupancy Sensor

****

NOTE: Before selecting locations for occupancy

sensors, consult the Interim Technical Guidance (ITG FY96-02) on Occupant Sensors, dated 1 Jul 96. This ITG is available from the Whole Building Design Guide web site at http://www.wbdg.org/ccb/NAVFAC/INTCRIT/fy96_02.pdf

Edit last sentence for desired "on" duration.
****

Provide quantity of sensor units indicated as a minimum. Provide additional units to give full coverage over controlled area. Full coverage shall provide hand and arm motion detection for office and administration type areas and walking motion for industrial areas, warehouses, storage rooms and hallways. Locate the sensor(s) as indicated and in accordance with the manufacturer's recommendations to maximize energy savings and to avoid nuisance activation and deactivation due to sudden temperature or airflow changes and usage. Set sensor "on" duration to [10][15][_____] minutes.

3.1.8 Light Level Sensor

Locate light level sensor as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for 50 footcandles 500 lux or for the indicated light level at the typical work plane for that area.

3.2 FIELD APPLIED PAINTING

****
NOTE: Use and coordinate paint and coating requirements with Section 09 90 00 PAINTS AND COATINGS when provided in the job. If Section 09 90 00 is not provided or when requirements are beyond what is specified in Section 09 90 00, specify the requirements in this paragraph.
****

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Painting shall be as specified in Section 09 90 00 PAINTS AND COATINGS.

3.3 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that equipment operates in accordance with requirements of this section.

3.3.1 Electronic Dimming Ballast

Test for full range of dimming capability. Observe for visually detectable flicker over full dimming range.

3.3.2 Occupancy Sensor

Test sensors for proper operation. Observe for light control over entire area being covered.

-- End of Section --

Interior Design Policy: Best Value Determinations Feb 2011

FAR 8.405-1 States the designer shall review at least three schedule contractors through GSA (NAVSUP BPAs). In addition to price, when determining best value, the designer may consider the factors such as special features, trade in considerations, life cycle analysis, warranty, maintenance, past performance, sustainability, comfort, delivery, training needed, technical qualifications, compatibility, and administrative costs as part of the Best Value Determination (BVD) (Enclosures 1 and 2)

If other than price is the deciding factor for selection, the designer must document the decision in a narrative paragraph as part of the BVD.

The designer must sign the BVD forms under Submitting Official

BVD REQUIREMENTS

$3,000 or less: For any procurement in the FF&E package with a value of $3,000 or less, the interior designer may utilize any BPA holder. If the BPA holders cannot supply the item, then any other manufacturer may be utilized.

Greater than $3,000 and $150,000 or less: for any procurement in the FF&E package with a value greater than $3,000 and $150,000 or less, the contractor's interior designer shall always review pricing from at least three BPA holders/manufacturers as well as UNICOR. UNICOR must always be solicited which is done by sending an email with the requirements and evaluation criteria. In addition to the review of published list prices, the contractor's interior designer must confirm the pricing with the vendor. The BVD form (Enclosure 1) must be completed and submitted for all FF&E procurements greater than $3,000 and $150,000 or less. (FAR 2.101)

Greater than $150,000: At a minimum, the contractor's interior designer shall solicit proposals from all BPA holders in the EAST and ALL regions under the applicable group for FF&E procurements greater than $150,000. UNICOR must always be solicited. The NAVFAC interior designer will approve the BPA categories and quantity of BVDs. The contractor's interior designer shall develop performance criteria and project requirements based on a generic design for the BPA holders and UNICOR to develop a price and performance proposal. The BVD form (Enclosure 2) must be completed and submitted for all FF&E procurements greater than $150,000 (FAR 2.101) and manufacturer's quotes and a summary of all proposals must be attached.

Federal Prison Industries (UNICOR) must be considered as part of all BVDs. UNICOR contact information to obtain pricing or send solicitations is enclosed. (Enclosure 3)

This policy is in effect immediately for any projects awarded after 1 Mar 09. Any questions can be directed to Peggy Noland, CID, Supervisory Interior Designer, NAVFAC MIDLANT at 757-341-0136 or margaret.noland@navy.mil.

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Enclosure (1)

BEST VALUE DETERMINATION GUIDELINES
$3,000 - $150,000

(Schedule Purchases are subject to FAR 8.4, DFARS 208.4, and DFARS PGI Supplement 208.405-70) (FAR 2.101)

- FAR 8.4 required that you make a best value determination before placing Multiple Award Schedule (MAS) orders above the micro-purchase limit (currently $3,000).
- The Navy Furniture BPAs shall be the primary source for FF&E. Refer to Specification Section E20.
- For orders between $3,000 and $150,000, review pricing from at least three sources and UNICOR. (FAR 8.405-1(c)) (FAR 2.101)
- Seek additional price discounts from the contractor offering the best value. (FAR 8.405-1(d))

1. Brief Description of Item, System or Component to be Procured:

2. Did you review the required number of sources under the BPA and/or Federal Supply Schedule? YES ☐ NO ☐

3. Identify the Navy Furniture BPA or other Federal Supply Schedule utilized or indicate not applicable.

4. Was UNICOR included in the review? YES ☐ NO ☐

5. List the name(s) and contract number(s) of contractor(s) who were considered:

List three or more contractors' names, contract numbers and business size reviewed.

6. Identify the contractor recommended as the best value.

7. When you sought additional price reductions, were they received? YES ☐ NO ☐

8. Identify price with discounts for the recommended best value contractor.

9. Is installation, site preparation, design or ancillary services included in this project? YES ☐ NO ☐ If yes, be sure that the installation, site preparation, design or ancillary services are included as separate line items in each quote.

10. Are you selecting the lowest priced item? YES ☐ NO ☐ If no, indicate in addition to price, those factors listed below, considered in your decision.

- ☐ Price
- ☐ Special features required in effective program performance:
- ☐ Trade-in considerations
- ☐ Probable life of the item selected as compared with that of a comparable item: .
- ☐ Warranty considerations:
- ☐ Maintenance availability
- ☐ Past performance
- ☐ Environmental and energy efficiency considerations
- ☐ Comfort/suitability of the item:
- ☐ Delivery terms
- ☐ Your administrative costs
- ☐ Training needed or provided
- ☐ Technical qualifications
- ☐ Compatibility with existing furniture / Products / Technology (circle appropriate category)
- ☐ Other (*specify*):

11.
Best Value Determination:
A narrative justification for each box checked above for other than low price selection must be attached. Describe the evaluation factor, how the recommended best value contractor's offer met or exceeded the standard for each factor, and why the offeror represents the best value to the Government compared to the other offerors.

SUBMITTING OFFICIAL (PRIME CONTRACTOR'S INTERIOR DESIGNER)
In accordance with FAR 8.404(b), all agency specific regulations and statutes applicable to this purchase are attached. I have reviewed the findings and documentation attached and I have affirmatively determined them to be complete and accurate.

Name:________________________Title: ________________________________ Date: _____________________

Telephone: _____________________________ Email: ____

Signature:____

Enclosure (2)

BEST VALUE DETERMINATION GUIDELINES
Greater than $150,000

(Schedule Purchases are subject to FAR 8.4, DFARS 208.4, and DFARS PGI Supplement 208.405-70) (FAR 2.101)

- FAR 8.4 required that you make a best value determination before placing Multiple Award Schedule (MAS) orders above the micro-purchase limit (currently $3,000).
- The Navy Furniture BPAs shall be the primary source for FF&E. Refer to Specification Section E20.
- For orders greater than $150,000, all BPA holders for the applicable schedule shall be given an opportunity to compete for the requirement. In addition, UNICOR shall also be solicited. (DFARS PGI 208.405-70) (FAR 2.101)
- Seek additional price discounts from the contractor offering the best value. (FAR 8.405-1(d))

1. Brief Description of Item, System or Component to be Procured:

2. Were all BPA holders and/or Federal Supply Schedule holders given the opportunity to propose on the requirement?
   YES ☐ NO ☐

3. Identify the Navy Furniture BPA or other Federal Supply Schedule utilized or indicate not applicable.

4. Was UNICOR included in the review? YES ☐ NO ☐

5. Provide evidence of affording all BPA holder and/or Federal Supply Schedule holders the opportunity to compete.
   Also, provide evidence that UNICOR was solicited.

6. <u>List the name(s) and contract number(s) of contractor(s) who responded to the request for proposal for this requirement:</u>
   <u>List contractors' names, contract numbers and business size for those who responded.</u>

7. Provide copies of all quotes received and reviewed.

8. Identify the contractor recommended as the best value.

9. When you sought additional price reductions, were they received? YES ☐ NO ☐

10. Identify price with discounts for the recommended best value contractor.

11. Is installation, site preparation, design or ancillary services included in this project? YES ☐ NO ☐
If yes, be sure that the installation, site preparation, design or ancillary services are included as separate line items in each quote.

12. Are you selecting the lowest priced item? YES ☐ NO ☐
If no, indicate in addition to price, those factors listed below, considered in your decision.

☐ Price

☐ Special features required in effective program performance:

☐ Trade-in considerations

☐ Probable life of the item selected as compared with that of a comparable item: .

☐ Warranty considerations:

☐ Maintenance availability

☐ Past performance

☐ Environmental and energy efficiency considerations

☐ Comfort/suitability of the item:

☐ Delivery terms

☐ Your administrative costs

☐ Training needed or provided

☐ Technical qualifications

☐ Compatibility with existing furniture / Products / Technology (circle appropriate category)

☐ Other (*specify*):

13.
Best Value Determination:
A narrative justification for each box checked above for other than low price selection must be attached. Describe the evaluation factor, how the recommended best value contractor's offer met or exceeded the standard for each factor, and why the offeror represents the best value to the Government compared to the other offerors.

SUBMITTING OFFICIAL (PRIME CONTRACTOR'S INTERIOR DESIGNER)
In accordance with FAR 8.404(b), all agency specific regulations and statutes applicable to this purchase are attached. I have reviewed the findings and documentation attached and I have affirmatively determined them to be complete and accurate.

Name:________________________Title: ________________________________ Date: _____________________

Telephone: ______________________________ Email: ______________________________________

Signature:____

FURNITURE PROCUREMENT DATA SHEET

_______________ DIVISION NAVAL FACILITIES ENGINEERING COMMAND			SHEET: DATE:
PROJECT/LOCATION:			PROJECT #:
ITEM:			ITEM CODE:
FSC GRP:	PART: SECTION:	EXP: DATE: MOL:	GSA #/OPEN MARKET : FED. STOCK #:

MANUFACTURER:

ORDERING ADDRESS:

CONTRACTOR:

SHIP TO ADDRESS (if applicable):

LOCAL REP:

PHONE NUMBER:

ANY VARIANCE OR MODIFICATION OF THIS SPECIFICATION WILL BE COORDINATED THROUGH _________ DIVISION, NAVAL FACILITIES ENGINEERING COMMAND.

CONTACT:
____________________, INTERIOR DESIGNER, ________NAVFACENGCOM, ___(Phone)_______________

DESCRIPTION:	QTY:	UNIT COST:	TOTAL COST:
LOCATION OF ITEMS			
NOTES/SPECIAL INSTRUCTIONS			
TOTAL:			

FOB/REMARKS:

file name:

FURNITURE PROCUREMENT DATA SHEET (continued)

_______________ DIVISION

NAVAL FACILITIES ENGINEERING COMMAND

MANUFACTURER:

ITEM NO.:

photo of item here

FINISH:

representative finish here

file name:

REVIEW AND CERTIFICATION
FOR
DOD MINIMUM ANTITERRORISM STANDARDS FOR BUILDINGS
CHECKLIST

Instructions: The information outlined in this document shall be used to provide the ***minimum*** *requirement for development of DOD Minimum Antiterrorism Standards for Buildings submittals for all building projects. Additional and supplemental information may be used to further develop the review. Insert N/A after criteria, which may be "not applicable". Provide this checklist with certification signatures in the project Design Analysis at each submittal.*

Applicable Standards: UFC 4-010-01

Chapter 1-2

Project Name: (Fill In Project Name)

Applicability: The DoD Minimum Antiterrorism Standards for Buildings apply to this project.

A. New Construction **This project consists of new construction.**

- Primary Gathering _______
- Billeting _______
- Inhabited _______
- Low Occupancy _______
- Expeditionary _______
- Temporary _______

B. Existing Building _______

Cost exceeds 50% of Replacement Cost _______
Cost less than 50% of Replacement Cost _______

- Primary Gathering _______
- Billeting _______
- Inhabited _______
- Low Occupancy _______
- Expeditionary _______
- Temporary _______

C. Building Addition _______

50% or more of the Gross Area _______
Less than 50% of the Gross Area _______

D. Leased Building _______

E. Expeditionary & Temporary Structures _______

- Has Appendix D requirements been incorporated? _______

F. National Guard Building _______

G. Tenant Bldgs. on DOD Installations _______

H. Exempt _______

Site Planning:

1. Standard 1 – Standoff Distance
Appendix B-1.1 & Table B-1

- Controlled Perimeter or Parking and Roadways w/o Controlled Perimeter
  - Primary Gathering – 148 Feet _______
  - Billeting – 148 Feet _______
  - Inhabited – 82 Feet _______

- Parking and Roadways within a Controlled Perimeter
  - Primary Gathering – 82 Feet _______
  - Billeting – 82 Feet _______
  - Inhabited – 33 Feet _______

- Trash Containers
  - Primary Gathering – 82 Feet _______
  - Billeting – 82 Feet _______
  - Inhabited – 33 Feet _______

- Parking of Emergency, Command, and Operations Support Vehicles
  - Is parking of vehicles required? _______
  - Have the conditions for parking vehicles been met?

- Parking of Vehicles Undergoing Maintenance
  - Is parking of vehicles required? _______
  - Have the conditions for parking vehicles been met? _______

- New Parking and Roadway projects
  - Does new parking and road location meet minimum standoff distance requirements from existing buildings? _______

2. Standard 2 – Unobstructed Space
Appendix B-1.2

- Are there any obstructions within 33 Feet of the building that is 6 inches or greater in height? _______

- Are packages within the 33 foot distance observable by building occupants? _______

- Is Electrical and Mechanical Equipment 33 Feet or greater from the building? _______

- Equipment Enclosures:
    - Are walls or screening devices more than two sides? _______

    - If "yes" has a four sided enclosure w/ a top been provided? _______

3. <u>Standard 3 – Drive-Up/Drop-Off Areas</u>
   Appendix B-1.3

   - Are drive-up or drop-off areas, or drive-through lanes near building required? _______
       - If "yes" are the areas or lanes clearly defined and marked to to prevent parking in those areas? _______
       - Are drive-up or drop-off areas, or drive-through lanes not located under inhabited portion of bldg? _______

4. <u>Standard 4 – Access Roads</u>
   Appendix B-1.4

   - Have access control measures been provided on access roads required for the operation of the building? _______

5. <u>Standard 5 – Parking Beneath Buildings or on Rooftops</u>
   Appendix B-1.5 & UFC 4-023-03

   - Is parking beneath the building or on roof top required? _______
       - If "yes" has access control Measures been provided? _______
       - Are floors beneath or roofs above inhabited areas designed to prevent progressive collapse? _______

6. <u>Appendix C – Recommended Additional Measures</u>
   Appendix C-1.1 thru C-1.10

   - Has recommendations 1 thru 10 been considered?
       - 1 – Vehicle Access Points? _______
       - 2 – High-speed Vehicle Approaches? _______
       - 3 – Vantage Points? _______
       - 4 – Drive-up / Drop Off? _______

- 5 – Building Location? _______
- 6 – Railroad Location? _______
- 7 – Access Control for Family Housing? _______
- 8 – Standoff for Family Housing? _______
- 9 – Minimize Secondary Debris? _______
- 10 – Building Separation? _______

Structural:

7. <u>Standard 6 – Progressive Collapse Avoidance</u>
   Appendix B-2.1 & UFC 4-023-03

   - Is building 3 or more stories? (NOTE: Basements are considered a story if one or more walls are exposed.) _______

   - If "yes" are walls, columns, and floors in accordance with UFC 4-023-03, Design of Buildings to Resist Progressive Collapse? _______

8. <u>Standard 7 – Structural Isolation</u>
   Appendix B-2.2

   - Is new building addition structural system independent from the adjacent adjacent existing building? _______

   - Is inhabited portion of new building structurally independent from the uninhabited portion of the building? _______

9. <u>Standard 8 – Building Overhangs</u>
   Appendix B-2.3

   - Does building have overhangs with inhabited spaces above them? _______
     - If "yes" insure that there are no roadways or parking areas under the overhangs.
     - If "yes" insure that floors beneath inhabited areas are in accordance with UFC 4-023-03, Design of Buildings to Resist Progressive Collapse.
     - If "yes" insure that superstructure is in accordance with UFC 4-023-03, Design of Buildings to Resist Progressive Collapse.

10. <u>Standard 9 – Exterior Masonry Walls</u>
    Appendix B-2.4

    - Is masonry wall in new building reinforced with required minimum enforcement? _______

- Has mitigating measures been provided for masonry wall in existing building that provides an equivalent level of protection? _______

11. Appendix C – Recommended Additional Measures
Appendix C-2.1

- Has recommendation 11 been considered?
- 11 – Structural Redundanct? _______

12. Other Structural Requirements

- Has structural requirements related to windows been considered? (See Architectural Standard 10)
  - o Yes _______
  - o No _______

Architectural:

13. Standard 10 – Windows and Skylights
Appendix B-3.1 & UFC 4-011-02

- Has required thickness of exterior glazing be determined using Tables B-2 & B-3? _______

- Do window frames, anchorages, and supporting elements meet required minimum level of protection for the following? _______
  - o Frame Member Design
  - o Glazing Frame Bite
  - o Frame Connection to Wall
  - o Supporting Structural Elements

14. Standard 11 – Building Entrance Layout
Appendix B-3.2

- Does building main entrance face away from the installation perimeter or other uncontrolled vantage point? _______
  - o If "no" provide means to screen Lines of site.

15. Standard 12 – Exterior Doors
Appendix B-3.3

- Do all exterior doors from inhabited areas open outwards? _______

- Does glazing in doors meet Provisions of Standard 10 above? _______

16. <u>Standard 13 – Mailrooms</u>
Appendix B-3.4 & B-4.2

- Is mailroom located on the exterior perimeter of the building? _______

- Is mailroom located as far away from heavily populated areas as possible? _______

- Is mailroom sealed between its envelope and other portions of the building in which it is located? _______
    - Does mailroom have a hard ceiling or does mailroom walls extend full height and are sealed to underside of structure above? _______
    - Does mailroom door have weather stripping on all four edges? _______

17. <u>Standard 14 – Roof Access</u>
Appendix B-3.5

- Are external roof access points controlled? _______

18. <u>Standard 15 – Overhead Mounted Architectural Features</u>
Appendix B-3.6

- Are overhead mounted features weighing 31 lbs. or more mounted to minimize falling and injuring building occupants? _______

- Are these items mounted to resist forces of 0.5 times the component weight in any direction and 1.5 times the component weight in the downward direction? _______

19. <u>Appendix C – Recommended Additional Measures</u>
Appendix C-2.2 thru C-2.7

- Has recommendations 12 thru 17 been considered?
    - 12 – Internal Circulation? _______
    - 13 – Visitor Control? _______
    - 14 – Asset Location? _______
    - 15 – Room Layout? _______
    - 16 – External Hallways? _______
    - 17 – Windows? _______

Mechanical and Electrical:

20. Standard 16 – Air Intakes
    Appendix B-4.1

    - Are all air intakes a minimum of 10 feet above the ground? _____

21. Standard 17 – Mailroom Ventilation
    Appendix B-4.2 & DOD Security Engineering Design Manual

    - Does mailroom have separate dedicated air ventilation system? _______
    - Is dedicated exhaust system to maintain slight negative air pressure provided? _______
    - Has outside air intakes and exhausts With low leakage isolation dampers been provided? _______
    - Has separate switches or methods of control to isolate mailroom been provided? _______

22. Standard 18 – Emergency Air Distribution Shutoff
    Appendix B-4.3

    - Has Emergency shutoff switch in HVAC control system been provided? _______
    - Is switch(es) easily accessible to building occupants? _______

23. Standard 19 – Utility Distribution and Installation
    Appendix B-4.4

    - Are critical or fragile utilities routed so they are not located on exterior walls or on walls shared with mailrooms? _______
    - If redundant utilities are required are they routed so they are not collocated or are not run in same chases? _______
    - If emergency backup systems are required are they located away from the system components for which they provide backup? _______

24. Standard 20 – Equipment Bracing
    Appendix B-4.5

    - Are overhead mounted features weighing 31 lbs. or more located to minimize falling and injuring building occupants? _______

- Are these items mounted to resist forces of 0.5 times the component weight in any direction and 1.5 times the component weight in the downward direction? _______

25. <u>Standard 21 – Under Building Access</u>
    Appendix B-4.6

    - Are accesses to crawl spaces, utility tunnels, and other means of under building access controlled? _______

26. <u>Standard 22 – Mass Notification</u>
    Appendix B-4.7 & UFC 4-021-01

    - Has a mass notification system been provided in the new building? _______

      If required the design must comply with Standard 22. The MNS must integrate with existing Base MNS. Point of Contact: Provost Marshal Office, Physical Security Section, Mr. Zack parks at (910) 451-5810.

    - Has a mass notification system been provided in existing primary gathering, billeting, and high occupancy family housing buildings? ______

      If required the design must comply with Standard 22. The MNS must integrate with existing Base MNS. Point of Contact: Provost Marshal Office, Physical Security Section, Mr. Zack parks at (910) 451-5810.

Certification of Force Protection Requirements
Preparers of this document certify the accuracy and completeness of the Antiterrorism Force Protection features for this project in accordance with the attached completed form(s).

This Review and Certification for DoD Minimum Antiterrorism Standards for Buildings Checklist was completed on the following date:

INTERIM or PRELIMINARY DESIGN

(Fill In Project Name)

Architect-Engineer
Certification of Antiterrorism Standards
(Note: Edit the team members if necessary)

Preparers of this document certify the accuracy and completeness of the Antiterrorism Force Protection features of this project.

Civil Engineer of Record:

____
Signature Date

Architect of Record:

____
Signature Date

Structural Engineer of Record:

____
Signature Date

Mechanical Engineer of Record:

____
Signature Date

Electrical Engineer of Record:

____
Signature Date

CAMP LEJEUNE, NORTH CAROLINA

ANTITERRORISM STANDARDS REVIEW

for

(Fill in Project Name)

INTERIM or PRELIMINARY DESIGN

Review and Certification for Minimum Antiterrorism Standards for Buildings Checklist has been completed and is attached. The Antiterrorism Force Protection review, and related design analysis documentation have been checked and approved by the in-house design team.

Project Design Team Leader Signature Date

________________________________ ____________

Antiterrorism Force Protection Team:

Civil Team Member Signature Date

________________________________ ____________

Architectural Team Member Signature Date

________________________________ ____________

Structural Team Member Signature Date

________________________________ ____________

Mechanical Team Member Signature Date

________________________________ ____________

Electrical Team Member Signature Date

________________________________ ____________

CAMP LEJEUNE, NORTH CAROLINA

ANTITERRORISM STANDARDS REVIEW

for

(Fill in Project Name)

FINAL DESIGN

The project specific **Review and Certification for Minimum Antiterrorism Standards for Buildings Checklist** has been completed and is attached. The construction contract plans, specifications, and related design analysis documentation have been checked and approved for accuracy and coordination.

Project Design Team Leader Signature   Date

________________________________   ____________

Camp Lejeune Antiterrorism Officer Signature: Date

__________________________________   ____________

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
**Use referenced notes where additional space required.			
Air Quality	**PERMIT: Construction**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Air Quality	**PERMIT: Operating**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Air Quality	**PERMIT: Asbestos Demolition & Removal**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Air Quality	**PERMIT: Other**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Water Pollution	**PERMIT: Wastewater Collection System**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
☐	Issuing Agency:		
	Special Provisions and Requirements:**		
Water Pollution	**PERMIT: Wastewater Pump Station**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
☐	Issuing Agency		
	Special Provisions and Requirements:		
Water Pollution	**PERMIT: Wastewater Treatment Plant**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
☐	Issuing Agency:		
	Special Provisions and Requirements:**		
Water Pollution	**PERMIT: Pretreatment, i.e. Oil/Water Separator**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
☐	Issuing Agency:		
	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Water Pollution	**PERMIT: Septic System**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Water Pollution	**PERMIT: Erosion & Sediment Control**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Water Pollution	**PERMIT: Stormwater Management**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Water Pollution	**PERMIT: Other**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Discharge Permit	**PERMIT: New or Increased Capacity NPDES**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Discharge Permit	**PERMIT: General NPDES (≥1 Acre Land Disturbance)**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Discharge Permit	**PERMIT: Other**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Drinking Water	**PERMIT: Water Distribution System**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Drinking Water	**PERMIT: Water Treatment Plant**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Drinking Water	**PERMIT: Well Construction**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Drinking Water	**PERMIT: Underground Injection**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Drinking Water	**PERMIT: Other**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Fuel Tanks	**PERMIT: Underground Storage Tank Construction**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Fuel Tanks	**PERMIT: Underground Storage Tank Operating**		
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Fuel Tanks	**PERMIT: Other**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions, and Requirements:		
Solid and Hazardous Waste	**PERMIT: Hazardous Waste Treatment, Storage, Disposal, Handling**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Solid and Hazardous Waste	**PERMIT: Landfill**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Solid and Hazardous Waste	**PERMIT: Used Oil Collection Center, Aggregation Point, Transporter & Transfer Facility**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Solid and Hazardous Waste	**PERMIT: Other**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Coastal Management Permit	**PERMIT: Coastal Consistency Determination Authorization**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)	**PROJECT TITLE:**		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Coastal Management Permit	**PERMIT: Coastal Barrier**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Coastal Management Permit	**PERMIT: Floodplain Management**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Coastal Management Permit	**PERMIT: Other**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Work in Navigable Waters**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Other Permits	**PERMIT: Dredging**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Clearing**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Essential Fish Habitat Assessment Consultation**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Marine Mammal Protection Act**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Other Permits	**PERMIT: Take Permits**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Work in Wetlands**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Digging Permit**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Traffic**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Other Permits	**PERMIT: Airport Hazard/Airfield Safety Clearances**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Railroad Crossing**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Historic Preservation**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Noise Abatement**	Date Obtained:	Date Closed:
☐	Basis of Decision (Yes/No):**		
	Issuing Agency:		
	Special Provisions and Requirements:**		

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PERMITS RECORD OF DECISION (PROD)

PERMIT REQUIRED (Check Box)			
	PROJECT TITLE:		**WORK ORDER NUMBER:**
	LOCATION:		
	GOVERNMENT PROJECT MANAGER:		
Other Permits	**PERMIT: Endangered/Species/Critical Habitat**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		
Other Permits	**PERMIT: Other**	Date Obtained:	Date Closed:
	Basis of Decision (Yes/No):**		
	Issuing Agency:		
☐	Special Provisions and Requirements:**		

Prepared by: ______________________ *Date* ______________________

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SECTION 01 91 13.00 22

GENERAL COMMISSIONING REQUIREMENTS FOR CONSTRUCTION
11/14

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this section to the extent referenced. The publications are referred to within the text by the basic designation only.

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB PROCEDURAL STANDARDS	(2005) Procedural Standards for TAB (Testing, Adjusting and Balancing) Environmental Systems

U.S. GREEN BUILDING COUNCIL (USGBC)

LEED GBDC	(2009) LEED Reference Guide for Green Building Design and Construction
LEED NC	(2009) Leadership in Energy and Environmental Design(tm) New Construction Rating System

1.2 COMMISSIONING - GENERAL

Commissioning is a quality-oriented, systematic process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meet defined objectives and criteria. The commissioning process shall include specific tasks to be conducted during each phase in order to verify that design, construction, documentation, and training provided for this facility meets the Government's project requirements.

Commissioning shall:

a. Verify that applicable equipment and systems are installed according to the contract documents, manufacturer's recommendations, industry accepted minimum standards, and equipment and systems have received adequate operational checkout by the Contractor.

b. Verify and document proper performance of equipment and systems.

c. Verify that O&M documentation prepared for this project is accurate and complete.

d. Verify that all components requiring servicing can be accessed, serviced and removed without disturbing nearby components including ducts, piping, cabling or wiring.

e. Verify that the Government's operating personnel are adequately trained.

It is the intent of the Government that the commissioning process shall comply with the requirements of LEED NC prerequisite EAp1 - Fundamental Commissioning [and credit EAc3 - Enhanced Commissioning]. Refer to LEED GBDC for reference.

The Commissioning Authority (CxA) shall be provided by the Government or its representative and shall direct and coordinate the project commissioning activities.

Commissioning Team: A team comprised of the Commissioning Authority (CxA), Government Project Manager, Designer of Record (DOR), Contractor, subcontractors, and O&M personnel. Commissioning Team members shall have the authority to act on behalf of the entity he or she represents relative to the commissioning process. The Commissioning Team is explicitly organized to implement the commissioning process through collaborative and coordinated action. All team members shall work together to fulfill their contracted responsibilities and meet the objectives of the contract documents.

The commissioning process shall not take away from nor reduce the responsibility of the system designers or Contractor to provide a finished and fully functioning product.

Contractor shall include the cost of his commissioning activities in the total contract price.

Contractor is responsible for providing commissioning support for the equipment he supplies. Include cost of all special tools and instruments required for testing, operating, and maintaining equipment according to these contract documents in the total contract price.

1.3 RELATED UFGS SECTIONS

Refer to the following Sections for system specific commissioning requirements:

a. [Section 01 33 29 LEED DOCUMENTATION][Section 01 33 29.00 20 SUSTAINABLE REQUIREMENTS].

b. Section 22 08 00.00 22 COMMISSIONING OF PLUMBING SYSTEMS for commissioning process activities for plumbing systems.

c. Sections 23 08 00.00 22 COMMISSIONING OF HVAC SYSTEMS and 23 05 93 TESTING, ADJUSTING AND BALANCING FOR HVAC for commissioning process activities for HVAC systems and equipment.

d. Section 26 08 10.00 22 COMMISSIONING OF ELECTRICAL SYSTEMS for commissioning process requirements for the facility electrical power and lighting control systems.

e. The responsible Fire Protection Engineer will function as the commissioning agent for fire suppression [and fire alarm] systems. Refer to Division 21 technical section requirements and Section 21 08 00.00 22 COMMISSIONING OF FIRE SUPPRESSION SYSTEMS for commissioning process activities for these activities.

1.4 SUBMITTAL REQUIREMENTS

The CxA will provide Contractor with a specific request for the type of submittal documentation the CxA will require to facilitate the commissioning work. These requests will be integrated into the normal submittal process and protocol of the construction team. At minimum, the request will include the manufacturer and model number, the manufacturer's printed installation and detailed startup procedures, full sequences of operation, O&M data, and performance data, any performance test procedures, control drawings and details of manufacturer's tests and calibration procedures. In addition, the installation and checkout materials that are actually shipped with/inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the CxA. All documentation requested by the CxA will be included by the Contractor in the O&M manual.

The CxA will review and approve submittals related to the commissioned equipment for conformance to the contract documents as it relates to the commissioning process, to the performance of the equipment and adequacy of information for developing test procedures. This review is intended primarily to aid in the development of performance procedures and only secondarily to verify compliance with equipment specifications. The CxA will notify the Government of items missing or areas that are not in conformance with contract documents and which require resubmission.

These submittals to the CxA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the contractor, though the CxA will review and approve them for adequacy with respect to the commissioning review.

1.5 DEFINITIONS

Acceptance: Acceptance is a formal action, to declare that some aspect of the project meets defined requirements, thus permitting subsequent activities to proceed.

Acceptance Phase Commissioning: Commissioning tasks executed after the construction has been completed, all Site Observations and Static Tests have been completed and all Pre-Functional Testing has been completed and accepted. The main commissioning activities performed during this phase are verification that the installed systems are functional as verified by conducting Functional Performance tests and Government Training.

Basis of Design (BOD): The Engineer's Basis of Design is comprised of two components: the Design Criteria and the Design Narrative, these documents record the concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements (OPR) and to satisfy applicable regulatory requirements, standards, and guidelines. See also: Design Narrative.

Benchmarks: Benchmarks are the comparison of a building's water and energy usage to other similar buildings and to the building itself.

Building Commissioning: Commissioning of building systems such as Building Envelope, HVAC, Electrical, Special Electrical Fire Alarm, Security & Communications, Plumbing and Fire Protection.

Calibrate: The act of comparing an instrument of unknown accuracy with a standard of known accuracy to detect, correlate, report, or eliminate by adjustment any variation in the accuracy of the tested instrument.

Checklists: Lists of data or inspections that should be verified to ensure proper system or component installation, operation and function. Verification checklists are developed and used during all phases of the commissioning process to verify that the Owner's Project Requirements (OPR) are being achieved.

Commissioning Authority (CxA): The entity, who plans, schedules and coordinates the commissioning team to implement the Commissioning Process. Where CxA is used it means the Commissioning Authority, members of his staff or appointed members of the commissioning team. The qualifications for the CxA shall comply with the requirements of LEED NC prerequisite EAp1 - Fundamental Commissioning.

Commissioning Issue: Any condition that adversely affects the commissionability, operability, maintainability or functionality of a system, equipment or component. Any condition that is in conflict with the Contract Documents and/or performance requirements of the installed systems and components. Can also be referred to as "Deficiency".

Commissioning Observation: An issue that does not conform to the project OPR, contract documents or standard industry best practices.

Commissioning Plan: A document that outlines the scope and defines responsibilities, processes, schedules, and the documentation requirements of the Commissioning Process.

Commissioning Process: A quality focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that the facility and all of its systems, components, and assemblies are planned, designed, installed, tested, can be operated, and maintained to meet the Owner's Project Requirements.

Commissioning Report (Cx): The final document which presents the commissioning process results for the project. Cx reports include an executive summary, the commissioning plan, issue log, correspondence, and all appropriate check sheets and test forms.

Commissioning Design Review: A commissioning design review is a collaborative review of the design professionals design documents for items pertaining to the following: owner's project requirements; basis of design; operability and maintainability (O&M) including documentation; functionality; training; energy efficiency, control systems' sequence of operations including building automation system features; commissioning specifications and the ability to functionally test the systems.

Commissioning Team: A team comprised of the Commissioning Authority (CxA), Government Project Manager, DOR, Contractor, and O&M personnel. Commissioning Team members shall have the authority to act on behalf of the entity he or she represents relative to the commissioning process. The Commissioning Team is explicitly organized to implement the commissioning process through collaborative and coordinated action.

Contractor: "Contractor" includes all subcontractors, vendors, etc. that are responsible to the Contractor.

Construction Phase Commissioning: All commissioning efforts executed during the construction process after the design phase and prior to the Acceptance Phase Commissioning.

Contract Documents: The documents binding on parties involved in the construction of this project (drawings, specifications, change orders, amendments, contracts, commissioning plan, etc.

Corrective Action: The implementation of actions that correct a tested or observed commissioning issue.

Data Logging: The monitoring and recording of temperature, flow, current, status, pressure, etc. of equipment using stand-alone data recorders.

Deferred System Functional Test: Tests that cannot be completed at the end of the acceptance phase due to ambient conditions, schedule issues or other conditions preventing testing during the normal acceptance testing period.

Design Criteria: A listing of the projects design requirements, including its source. These are used during the design process to show the design element meets the OPR.

Design Intent: The overall term that includes the OPR and the BOD. It is a detailed explanation of the ideas, concepts, and criteria that are defined by the Government to be important. The design intent documents are utilized to provide a written record of these ideas, concepts and criteria.

Design Phase Commissioning: All commissioning tasks executed during the design phase of the project.

Functional Performance Test (FPT): Functional performance tests are tests that are intended to prove functionality of the component or system using direct observation and monitoring methods. Functional Performance Tests include static testing, dynamic testing, failure modes, and integrated systems testing. FPT tests are done after all Pre-Functional Checklists are complete. Also called Systems Functional Performance Test, Functional Test, or Integrated Systems Test.

Functional Test Procedure: A written protocol that defines methods, steps, personnel, and acceptance criteria for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.

Industry Accepted Best Practice: A design component or construction process that has achieved industry consensus for quality performance and functionality.

Installation Verification: Observations or inspections that confirm the system or component has been installed in accordance with the contract documents and to industry accepted best practices.

Issues Log: A formal and ongoing record of issues, observations, problems or concerns - and their resolution - that have been raised by members of the commissioning team during the course of the commissioning process.

Manual Test: Testing using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the 'observation').

Operations and Maintenance (O&M) Manual: O&M manuals describe key components of each system or piece of equipment and explain how they should be operated and maintained for optimum performance.

Owner's Project Requirements (OPR): A written document that details the project requirements and the expectations of how the building and its systems will be used and operated. These include project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

Precision: The ability of an instrument to produce repeatable readings of the same quantity under the same conditions. The precision of an instrument refers to its ability to produce a tightly grouped set of values around the mean value of the measured quantity.

Pre-Design Phase Commissioning: Commissioning tasks performed prior to the commencement of design activities that includes project programming and the development of the commissioning process for the project.

Pre-Functional Checklist: A form used by the contractor to verify that appropriate components are onsite, correctly installed, set up, calibrated, functional and ready for functional testing.

Sampling: Performing observation, review, testing or other verification on only a fraction of the total number of identical or near identical pieces of equipment, drawings, events, etc. Sampling techniques include random statistical sampling and less formal professional judgment methods.

Site Observation Visit: On-site inspections and observations made by the Commissioning Authority for the purpose of verifying component, equipment, and system installation, to observe contractor testing, equipment start-up procedures, or other purposes.

Site Observation Reports: Reports of site inspections and observations made by the Commissioning Authority. Observation reports are intended to provide early indication of an installation issue which will need correction or analysis.

Start Up Tests: Tests that validate the component or system is ready for automatic operation in accordance with the manufacturers' requirements.

Static Tests: Tests or inspections that validate a specified static condition such as pressure testing. Static tests may be specification or code initiated.

Systems Manual: A system-focused composite manual organized by system which contains the information needed to optimally operate the building systems. Much of the Systems Manual is not found in traditional vendor O&M Manuals. For reference, ASHRAE includes all maintenance and design documentation in their definition of Systems Manual.

Test Procedure: A written protocol that defines methods, personnel, and expectations for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.

Testing: The use of specialized and calibrated instruments to measure parameters such as: temperature, pressure, vapor flow, air flow, fluid flow, rotational speed, electrical characteristics, velocity, and other data in order to determine performance, operation, or function.

Testing, Adjusting, and Balancing (TAB): A systematic process or service applied to heating, ventilating and air-conditioning (HVAC) systems and other environmental systems to achieve and document air and hydronic flow rates. The standards and procedures for providing these services are referred to as "Testing, Adjusting, and Balancing" and are described in NEBB PROCEDURAL STANDARDS.

Thermal Scans: Thermographic pictures taken with an Infrared Thermographic

Camera. Thermographic pictures show the relative temperatures of objects and surfaces and are used to identify leaks, thermal bridging, thermal intrusion, electrical overload conditions, moisture containment, and insulation failure.

Training Plan: A written document that details, in outline form, the expectations of the operator training. Training agendas should include instruction on how to obtain service, operate, startup, shutdown and maintain all systems and components of the project.

Unresolved Commissioning Issue: Any Commissioning Issue that, at the time that the Final Report or the Amended Final Report is issued that has not been either resolved by the Contractor or accepted by the Government.

Validation: The process by which work is verified as complete and operating correctly:

a. First party validation occurs when a firm or individual verifying the task is the same firm or individual performing the task.

b. Second party validation occurs when the firm or individual verifying the task is under the control of the firm performing the task or has other possibilities of financial conflicts of interest in the resolution (Architects, Designers, General Contractors and Third Tier Subcontractors or Vendors).

c. Third party validation occurs when the firm verifying the task is not associated with or under control of the firm performing or designing the task.

Verification: The process by which specific documents, components, equipment, assemblies, systems, and interfaces among systems are confirmed to comply with the criteria described in the Contract Documents and Owner's Project Requirements.

Warranty Period: Period of time in which the contractor is responsible for equipment repairs following turnover to the Government. The warranty period is defined in the construction contract.

Warranty Phase Commissioning: Commissioning efforts executed after a project has been completed and accepted by the Government. Warranty Phase Commissioning includes follow-up on verification of system performance, measurement and verification tasks and assistance in identifying warranty issues and enforcing warranty provisions of the construction contract.

Warranty Visit: A commissioning meeting and site review where all outstanding warranty issues and deferred testing is reviewed and discussed.

1.6 SYSTEMS TO BE COMMISSIONED

Commissioning of a system or systems specified for this project is part of the construction process. Documentation and testing of these systems, as well as training of the Government's personnel, is required in cooperation with the Government and the Commissioning Authority.

1.6.1 Building Envelope (Division 07 and Division 08)

The following systems shall be commissioned as part of this project:

a. Roofs: Asphalt shingles, slate shingles, wood shingles, clay roof tiles, built-up bituminous, modified bituminous, EPDM, PVC, fluid-applied, sprayed polyurethane, flashing & sheet metal, metal roofing, roof specialties, and roof accessories.

b. Exterior Insulation and Finish Systems (EIFS).

c. Curtain Wall Systems: Mullions, glazing, and sealing

d. Exterior Doors: Revolving, glass leaf, emergency exit, and service

e. Exterior Windows: Aluminum, steel, glazing, storm

f. Louvers and Vents

g. Sealants: Caulking, mechanical seals, and wind and vapor barriers

h. Air Barrier Systems

i. Vapor Barrier Systems

1.6.2 Fire Suppression (Division 21)

The following systems shall be commissioned as part of this project:

a. Fire Protection Systems: Fire pump, jockey pump, fire pump automatic transfer switch/controller, Wet-pipe fire suppression, dry-pipe fire suppression, pre-action fire suppression, dry system air compressors and motors, clean agent fire suppression, and foam fire suppression.

b. Smoke Control Systems: Smoke evacuation, smoke control, and stair pressurization.

1.6.3 Plumbing (Division 22)

Provide Plumbing commissioning as required in Section 22 08 00.00 22 COMMISSIONING OF PLUMBING SYSTEMS.

1.6.4 HVAC (Division 23)

Provide HVAC commissioning as required in Section 23 08 00.00 22 COMMISSIONING OF HVAC SYSTEMS.

1.6.5 Electrical (Divisions 26 and 33)

Provide electrical commissioning as required in Section 26 08 10.00 22 COMMISSIONING OF ELECTRICAL SYSTEMS.

1.6.6 Communications (Divisions 27 and 33)

Provide Communications commissioning as required in Section 26 08 10.00 22 COMMISSIONING OF ELECTRICAL SYSTEMS.

1.6.7 Electronic Safety and Security (Division 28)

The following systems shall be commissioned as part of this project:

a. Fire Detection [and Alarm]Systems: Master panel and software, addressable units - i.e. pull stations, flow detectors, heat detectors, etc., controls[and alarm functions], horns/bells/door releases and other output devices, and fire command center functions - stairwell communications, stairwell pressurization fan start, mechanical systems shutdowns.

b. Intrusion Detection Systems

c. Access Control Systems

d. Video Surveillance Systems / Closed Circuit Control Systems

e. Radio Communications Systems

f. Chemical, Biological, Radiological, Nuclear (CRRNE) Detection Systems

1.6.8 Site Utility Systems

The following systems shall be commissioned as part of this project:

a. Sanitary Sewage Lift Stations: Lift station sump or tank level controls, pump alternator, alarms and alarm panel, pumps and motors.

b. Steam Condensate Pump Stations: Condensate receivers and transfer pumps, motors, controls, pump alternator, alarms and instrumentation, and safeties.

c. Storm Drainage Pump Systems: Sump level controls, pump alternator, alarms and alarm panel, pumps and motors.

1.6.9 Other Systems

The following systems shall be commissioned as part of this project:

a. Solar Systems: Solar water heaters, transpired solar collectors, and Photovoltaic.

b. Renewable Energy Systems: Wind turbines, waste-to-energy, and geo-thermal.

1.7 COMMISSIONING PLAN

The CxA will develop the Commissioning Plan which shall be coordinated with and incorporated into the Contractor's project schedule, approved by the Government. The Commissioning Plan outlines the scope and defines responsibilities, processes, schedules, and the documentation requirements of the commissioning process. The Commissioning Plan shall be initially developed during the design phase of the project and shall be refined, with the assistance and input of the Contractor, throughout construction. The Contractor, as an integral member of the Commissioning Team, shall support the CxA and the Commissioning Team throughout the contract. The components of the Commissioning Plan are outlined in this section and other technical sections in the contract documents.

The Commissioning Plan shall naturally evolve over the course of construction. The CxA shall add, modify and refine the commissioning procedures, as approved by the Government, to suit field conditions and actual manufacturer's equipment, incorporate test data and procedure results, and provide detailed scheduling for all commissioning tasks. Contractor should reasonably expect modifications to the Commissioning Plan throughout construction.

1.8 RESPONSIBILITIES

The general responsibilities of various parties in the commissioning process are provided in this Article. The specific responsibilities are in the technical specification sections.

The Contractor shall provide all equipment, materials, and labor to inspect, check-out, start-up and test equipment and systems, except for specified testing with portable data-loggers, which shall be supplied and installed by the CxA, as required.

1.8.1 Commissioning Authority (CxA)

Coordinates and directs the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.

References herein to the "CxA" shall be inferred to mean "CxA or his designated representative".

1.8.1.1 Construction Phase

a. Coordinate the commissioning work and with Commissioning Team members, help integrate commissioning activities into the master schedule.

b. Revise the Construction Phase Commissioning Plan as necessary.

c. Plan and conduct commissioning scoping meetings and other commissioning meetings.

d. Request and review additional information required to perform commissioning tasks, including O&M materials, manufacturer's supplemental instructions, and contractor startup and checkout procedures.

e. Write and distribute construction checklists and functional test procedures. Prepare and maintain completed construction checklist log. Obtain the completed construction checklists from the Contractor and verify and approve by selected site observation and spot checking of a random number of typical installations.

f. Before startup, gather and review the current control sequences and interlocks and work with Contractor and DOR until sufficient clarity has been obtained, in writing, to be able to write the detailed, functional testing procedures.

g. Review and approve normal Contractor submittals applicable to systems being commissioned for compliance with commissioning needs, concurrent with the DOR reviews.

h. Develop an enhanced startup and initial systems checkout plan with Contractor.

i. Perform site visits as necessary to observe component and system installations. Attend selected planning and job-site meetings to ensure that commissioning activities are included in job progress meetings and to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.

j. Verify the execution of commissioning process activities using random sampling. Verification will include, but is not limited to, equipment submittals, construction checklists, pre-functional checklists, start-up reports, training, operating and maintenance data, functional performance tests, and test reports to verify compliance with the OPR. When a random sample does not meet the requirement, report the failure in the "Issues Log."

k. Review TAB execution plan for HVAC.

l. Oversee sufficient testing of the control system and approve it to be used for TAB, before TAB is executed.

m. Recommend approval of air and water systems balancing by spot testing, by reviewing completed reports and by selected site observation.

n. Coordinate the development of a systems manual.

1.8.1.2 Acceptance Phase

a. Witness HVAC piping flushing and test procedures, to ensure that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify PM/CM of any deficiencies in results or procedures.

b. Witness ductwork cleaning and testing procedures, to ensure that proper procedures were followed. Document this testing and include the documentation in O&M manuals. Notify PM/CM of any deficiencies in results or procedures.

c. Recommend approval of systems startup by reviewing startup reports and by selected site observation.

d. With assistance as needed from installing contractors, witness the functional performance verification testing (PVT) of equipment and systems, performed by the Contractor and sub-contractors, including energy management control system trending, stand-alone data logger monitoring or manual performance testing, as required. Coordinate, witness, verify and document retesting as necessary until satisfactory performance is achieved. Coordinate and supervise required 2nd season testing and corrections to deficiencies.

e. Analyze any PVT trend logs and monitoring data to verify performance.

f. Maintain a master Issues Log and a separate testing record. Provide the PM/CM with written progress reports and test results with recommended actions.

g. Review and approve the training materials prepared by the Contractor for the Government's operating and maintenance personnel.

h. Review and evaluate the Operation and Maintenance (O&M) manuals submitted by the Contractor for completeness.

i. Provide a final commissioning report.

j. When necessary to solve a specific issue, prepare a standard trend logging package of primary parameters that will allow troubleshooting of improper system operations and solution recommendation.

1.8.1.3 Warranty Phase

a. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.

b. Return to the site at 10 months into the 12 month warranty period and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff in developing reports, documents and requests for services to remedy outstanding problems.

c. Attend lessons learned sessions as required.

1.8.2 Government Project Manager (PM/CM)

1.8.2.1 Construction Phase

a. Attend the commissioning scoping meetings and selected commissioning team meetings.

b. Perform normal review of contract submittals, construction observation, as-built drawing preparation, O&M manual preparation, etc., as required.

c. Provide any design narrative documentation requested by the CxA.

d. Coordinate resolution of system design and construction deficiencies identified during commissioning, according to the contract documents.

e. Facilitate the coordination of the commissioning work by the CxA and the DOR, and with the assistance of the Contractor, ensure that commissioning activities are being scheduled into the master schedule.

f. Review and approve the final commissioning plan.

g. Furnish a copy of all construction documents, addenda, change orders, and shop drawing submittals related to commissioned equipment to the CxA.

h. Review and approve the functional performance test procedures submitted by the CxA, prior to testing.

1.8.2.2 Acceptance Phase

a. Prepare and submit final as-built design intent documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.

b. When necessary, observe and witness startup and performance verification testing (PVT) of selected equipment.

c. Review commissioning progress and deficiency reports.

d. Coordinate the resolution of non-compliance and design deficiencies identified in all phases of commissioning.

e. Provide the Government's OPR documentation to the CxA for information and use.

f. Provide the BoD documents, prepared by DOR and approved by Government, to the CxA for use in developing the commissioning plan and systems manual.

g. Review and approve the Contractor's Training Plan for operations and maintenance personnel.

h. Coordinate and arrange for facility operation and maintenance personnel to attend various field commissioning activities, including field and classroom training sessions.

i. Provide final approval for the completion of the commissioning work.

1.8.2.3 Warranty Phase

a. Assist the CxA as necessary in the seasonal or deferred testing and deficiency corrections required by the specifications.

b. Attend lessons learned session.

1.8.3 Designer of Record (DOR)

1.8.3.1 Construction Phase

a. Perform normal submittal review, construction observation, as-built drawing preparation, etc., as required. Onsite observation should be completed just prior to system startup.

b. Provide design narratives and automatic controls sequences of operations documentation requested by the CxA. Assist (along with the Contractor) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

c. Attend commissioning scoping meetings and other selected commissioning team meetings.

d. Participate in the resolution of system deficiencies identified during commissioning, according to the contract documents.

e. Prepare and submit the final as-built design intent and operating parameters documentation for inclusion in the O&M manuals. Review and approve the O&M manuals.

f. From the Contractor's red-line drawings, edit and update one-line diagrams developed as part of the design narrative documentation and those provided by the vendor as shop drawings for the domestic water; HVAC systems; supply, return and exhaust air systems and emergency power system.

g. Review and approve the CxA's construction checklist templates for major pieces of equipment for sufficiency prior to their use.

h. Review and approve the CxA's functional performance test procedure forms for major pieces of equipment for sufficiency prior to their use.

1.8.3.2 Acceptance Phase

a. Provide a presentation at one of the training sessions for the Government's personnel.

b. Witness testing of selected pieces of equipment and systems.

1.8.3.3 Warranty Phase

a. During the warranty period, participate in the resolution of non-compliance, non-conformance and design deficiencies identified during commissioning.

b. Attend lessons learned sessions, as required.

1.8.4 Contractor

Contractor shall assign representatives with expertise and authority to act on their behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:

The CxA will provide sufficient notice to the Contractor in order to schedule commissioning activities. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

1.8.4.1 Construction Phase

a. Facilitate the coordination of the commissioning and incorporate commissioning activities (the Commissioning Plan) into the Overall Project Schedule.

b. Submit detailed startup procedures for equipment and systems for approval.

c. Ensure that all commissioning responsibilities are executed according to the contract documents and the commissioning plan.

d. Provide copies of all submittals as required in[Section 01 33 29.00 20 SUSTAINABLE REQUIREMENTS][Section 01 33 29 LEED(TM) DOCUMENTATION], including all changes thereto.

e. Attend and participate in commissioning team meetings.

f. No later than 60 days prior to startup of the first piece of major equipment, meet with the commissioning team to finalize the detailed commissioning procedures and schedule.

g. Review and accept the construction checklists, pre-functional checklists, and functional performance test procedures provided by the CxA.

h. Complete paper copies of construction checklists and pre-functional checklists as work is completed. Provide these completed checklists to the CxA, with copies to the Government and the DOR, on a weekly basis or as otherwise required.

i. Provide all requested submittal data, including detailed startup procedures and specific responsibilities of the Government to keep warranties in force.

j. Analyze specified products and verify that the Government and DOR have specified the newest, most current equipment reasonable for this project's scope and budget.

k. Provide requested information to the CxA regarding equipment sequence of operations and testing procedures.

l. Review construction checklists and test procedures for equipment installed by factory representatives.

1.8.4.2 Acceptance Phase

a. Provide the training of Government personnel.

b. Accomplish the commissioning functional performance test procedures. Provide for retesting as required until the equipment and system have been adjusted for provide satisfactory test results.

c. Evaluate performance deficiencies identified in test reports and, in collaboration with entity responsible for system and equipment installation, recommend corrective action.

d. Cooperate with the CxA for resolution of issues recorded in the "Commissioning Issues Log".

e. Prepare O&M manuals, according to the contract documents, including clarifying and updating the original sequences of operation to as-built/as-tested conditions.

1.8.4.3 Warranty Phase

a. Provide assistance for seasonal or deferred performance testing, observed and documented by the CxA, according to the specifications.

b. Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

c. Perform all guarantee work for materials furnished under the contract for the time specified in the contract, including all warranties and curing all latent defects within the time period provided in the contract.

PART 2 PRODUCTS

2.1 TEST EQUIPMENT

All standard testing equipment required to perform startup and initial checkout and required performance testing shall be provided by the

Contractor for the equipment being tested. This includes, but is not limited to, two-way radios, meters, and data recorders. Data recorders may be provided by the CxA at the option of the Government.

Special equipment, tools, and instruments required for testing equipment according to these contract documents shall be included in the contractor's base bid price and shall be turned over to the Government at Project close-out.

All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance within the tolerances specified in the specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration to NIST traceable standards within the past year to an accuracy of 0.5 degree F and a resolution of + or - 0.1 degree F. Pressure sensors shall have an accuracy of + or - 2.0 percent of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 EXECUTION

3.1 START-UP, PRE-FUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

The following procedures apply to all equipment/systems to be commissioned.

General: Pre-functional checklists are intended to verify that the equipment and systems are fully connected and operational and to ensure that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. The pre-functional checklists for a given system must be successfully completed and approved prior to startup and formal performance testing of equipment or subsystems of the given system.

Startup and Checkout Plan: The CxA will assist the project commissioning team members responsible for startup of any equipment. The primary role of the CxA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures has been completed. The CxA shall provide pre-functional checklists and startup shall be identified in the commissioning scoping meeting and on the checklist forms.

a. The pre-functional checklists shall be provided at the initial commissioning meetings. These checklists indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.

b. Contractor shall determine the trade or trades responsible for executing and documenting each of the line item tasks and shall transmit the checklists to the responsible party.

c. Contractor shall develop the full startup plan by combining the manufacturer's detailed startup and checkout procedures and the pre-functional checklists.

d. Contractor shall submit the full startup plan to the CxA and the Government for review and approval.

e. The CxA will review and approve the procedures and the documentation format for reporting, and will return the procedures and the documentation format to the Contractor.

f. Contractor will implement the full startup plan.

3.1.1 Sensor and Actuator Calibration

All field-installed temperature, relative humidity, CO, CO2, refrigerant, O2, pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated. Verify that the installed locations of these devices are appropriate and away from any external causes, which might contribute to erratic operation. Submit to the CxA the calibration methods and results. All test instruments shall have had a certified calibration within the last six months to NIST traceable standards, and comply with all local, state and federal requirements and certifications, as required. Sensors installed in the equipment/unit at the factory with calibration certification provided need not be field calibrated. Provide bench testing as required at the direction of the CxA.

a. Sensor Calibration Methods:

1. All Sensors: Verify that all sensor locations are appropriate and away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2 percent of the reading, of each other, for pressure. Tolerances for critical applications may be tighter.

2. Sensors without Transmitters: Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.

3. Sensors with Transmitters: Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the BAS. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

4. Critical Applications-- For critical applications (process, manufacturing, etc.) more rigorous calibration techniques may be required for selected sensors. Describe any such methods used on an attached sheet.

b. Tolerances, Standard Applications:

1.	Cooling coil, chilled and condenser water temps	+/- 0.4 F
2.	AHU wet bulb or dew point	+/- 2.0 F
3.	Hot water coil and boiler water temp	+/- 1.5 F
4.	Outside air, space air, duct air temps	+/- 0.4 F
5.	Watt-hour, voltage & amperage	+/- 1% of design
6.	Pressures, air, water & gas	+/- 3% of design
7.	Flow rates, air	+/- 10% of design
8.	Flow rates, water	+/- 4% of design
9.	Relative humidity	+/- 4% of design
10.	Combustion flue temps	+/- 5.0 F
11.	Oxygen or CO2 monitor	+/- 0.1% pts
12.	CO monitor	+/- 0.01% pts
13.	Natural gas and oil flow rate	+/- 1% of design
14.	Steam flow rate	+/- 3% of design
15.	Barometric pressure	+/- 0.1 inch Hg

c. Valve and Damper Stroke Setup and Check EMS Readout: For all valve and damper actuator positions checked, verify the actual position against the BAS readout.

1. Set pumps or fans to normal operating mode. Command valve or damper closed, visually verify that valve or damper is closed and adjust output zero signal as required. Command valve or damper open, verify position is full open and adjust output signal as required. Command valve or damper to a few intermediate positions. If actual valve or damper position doesn't reasonably correspond, replace actuator.

2. Closure for heating coil valves (NO): Set heating setpoint 20°F above room temperature. Observe valve open. Remove control power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set heating setpoint to 20°F below room temperature. Observe the valve close.

3. Closure for cooling coil valves (NC): Set cooling setpoint 20°F above room temperature. Observe the valve close. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set cooling setpoint to 20°F below room temperature. Observe valve open. For pneumatics, by override in the EMS, increase pressure to valve by 3 psi (do not exceed actuator pressure rating) and verify valve stem and actuator position does not change. Restore to normal.

3.1.2 Execution of Pre-Functional Checklists and Startup

a. Four weeks prior to the scheduled startup, Contractor shall coordinate startup and checkout with the Commissioning Team. The execution of the pre-functional checklists, startup, and checkout shall be directed and performed by the Contractor. Signatures are required for verification of completion of the work. Submit for approval by the Government and CxA.

b. Government and DOR, as necessary, shall at minimum observe the procedures for each piece of primary equipment. CxA will observe the functional performance testing of sufficient numbers of equipment or systems based on the project's sampling strategy for commissioning.

c. For lower-level components of equipment, (e.g., sensors, controllers) the CxA shall observe a sampling of the startup procedures.

d. Only individuals of the Contractor (technicians, engineers, tradesmen, vendors, etc.) who have direct knowledge and witnessed that a line item task on the construction checklist was actually performed shall check off that item. It is not acceptable for witnessing supervisors to fill out these forms.

3.1.3 Deficiencies, Non-Conformance, and Approval in Checklists and Startup

a. Contractor shall clearly list on an attached sheet any outstanding items of the initial startup and construction checklist procedures that were not completed successfully. The form and any outstanding deficiencies shall be provided to the CxA within two days of test completion.

b. The CxA will review the report and issue either a non-compliance report or an approval form to the Contractor. The Contractor shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, shall notify members of the Commissioning Team as soon as outstanding items have been corrected, and resubmit an updated startup report with a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CxA will recommend approval of the execution of the checklists and startup of each system.

c. Items left incomplete, which later cause deficiencies or delays during performance may result in back charges to the Contractor.

3.2 PHASED COMMISSIONING

The project requires startup, TAB and performance testing to be executed in phases. Phasing shall be coordinated with the Commissioning Team and be reflected in the overall project schedule and commissioning schedule by the contractor. Final performance testing of all systems will be as required by the phasing plan. The performance testing of the "systems as a whole" will be performed before final turnover of the entire project.

3.3 FUNCTIONAL PERFORMANCE TESTING

Requirements: The functional performance testing shall demonstrate that each system is operating according to the documented design intent and contract documents. Functional performance testing facilitates bringing the systems from a state of individual substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance shall be identified and corrected, improving the operation and functioning of the systems.

Test Equipment: Refer to Part 2 of this Section.

Problem Solving: The burden of responsibility to solve, correct, and retest malfunctions/failures is with the Contractor, with approval of the CxA and the Government as required.

3.3.1 Coordination and Scheduling

Contractor shall provide sufficient notice regarding the completion schedule for the installation of equipment "ready for inspection" dates, to allow for the completion of the pre-functional checklists and startup of all equipment and systems, and to allow the functional performance testing to be scheduled. The Commissioning Team shall oversee, witness, and document the performance of all equipment and systems. The CxA, in association with the Contractor and facility staff as needed shall execute the tests. Functional performance testing shall be conducted after the pre-functional checklists and startup has been satisfactorily completed. The control system shall be sufficiently tested and approved by the CxA before it is used to verify performance of other components or systems. The air balancing and water balancing shall be completed before performance testing of air or water-related equipment or systems. Testing proceeds from components to sub-systems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems shall be checked.

3.3.2 Development of Functional Test Procedures

Before the functional test procedures are finalized, the Contractor shall provide to the CxA all requested documentation and a current list of changes affecting equipment or systems, including an updated points list, program code, control sequences, and testing parameters. Using the testing parameters and requirements in the technical specifications, the CxA and the DOR shall update/develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Contractor shall provide assistance to the CxA in developing the final functional test procedures. Prior to finalization, the CxA and the Government shall review and concur with the functional test procedures.

Test Methods:

a. Performance testing and verification may be achieved by manual testing or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data loggers. The CxA may substitute specified methods or require an additional method to be executed other than what was specified, with the approval of the DOR and the Government. The CxA will determine which method is most appropriate for tests that do not have a specified method.

b. Simulated Conditions: Shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.

c. Overridden Values: Overriding sensor values to simulate a condition, such as overriding the outside air temperature reading in a control system to be something other than it really is, is acceptable.

d. Simulated Signals: Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overridden values.

e. Altering Setpoints: Rather than overriding sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable.

f. Indirect Indicators: Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the test parameters, that the indirect readings through the control system represent actual conditions and responses.

g. Setup: Each performance test shall be performed under conditions that simulate actual conditions as closely as is practically possible. The Contractor shall assist the CxA in executing the test by providing all necessary materials, system modifications, etc., to produce the necessary flows, pressures and temperatures necessary to execute the test according to the specified conditions. At completion of the test, the Contractor shall return all affected equipment and systems to their approved operating settings.

3.4 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

3.4.1 Documentation

The CxA shall witness and verify/pre-approve the documentation of the results of all performance tests. The CxA shall complete all documentation for performance testing.

3.4.2 Non-Conformance

Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the procedure form or on an attached sheet.

As tests progress and a deficiency is identified, the CxA shall discuss the issue with the Contractor, DOR and the Government.

a. When there is no dispute on the deficiency and the Contractor accepts responsibility to correct it:

    1. The CxA will document the deficiency and the Contractor's response and intentions. After the day's work, the CxA will submit the non-compliance reports to the Government and the Contractor. The Contractor shall correct the deficiency, sign the statement of correction certifying that the equipment is ready to be retested, and submit it to the CxA.

    2. Contractor shall reschedule and repeat the test.

b. If there is a dispute about a deficiency:

    1. The dispute shall be documented on the non-compliance form with the Contractor's response.

2. Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the Government. Final acceptance authority is with the Government's Contracting Officer (CO).

3. The CxA shall document the resolution process.

4. Once the interpretation and resolution have been decided, the Contractor shall correct the deficiency, sign the statement of correction on the non-compliance form and submit it to the CxA. The Contractor shall reschedule and repeat the test until satisfactory performance is achieved.

All costs associated with retesting a performance test is the Contractor's responsibility.

The Contractor shall submit in writing to the CxA and the Government, at least as often as commissioning meetings are being scheduled, the status of each outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreement and proposals for their resolutions.

a. The CxA shall retain the original non-conformance forms until the end of the project.

b. Retesting shall not be considered a justified reason for a claim of delay or for a time extension by the Contractor.

3.4.3 Failure Due to Manufacturer Defect

If 10% (or three, whichever is greater) of identical pieces of equipment fail to perform to the contract documents (mechanically or substantively) due to a manufacturing defect, not allowing it to meet its submitted performance specification, all identical units may be considered unacceptable by the Government. In such case, the Contractor shall provide the Government with the following:

a. Within one week of notification from the Government, the Contractor and the manufacturer's representative shall examine all other identical units making a record of the findings.

b. Within two weeks of the original notification, the Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc., and all proposed solutions to the Government and the CxA. The proposed solutions shall not significantly exceed the specification requirements of the original installation.

c. The Government shall determine whether repair or replacement of all identical units is acceptable.

d. Up to two examples of the proposed solution shall be installed by the Contractor and the Government shall test the installations for up to one week, upon which the Government shall decide whether to accept the solution.

e. Upon acceptance, the Contractor and/or the manufacturer shall replace or repair all identical items, at no expense to the Government. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

3.4.4 Approval

The CxA shall note each satisfactorily demonstrated function on the test form. Final approval of the functional performance test by the Government shall be made after review by the CxA and the Government.

3.5 DEFERRED TESTING

3.5.1 Unforeseen Deferred Tests

If any check or test cannot be completed due to the project completion level, required occupancy condition or other deficiency, execution of pre-functional checklists and functional performance testing may be delayed upon approval of the CxA and the Government. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.

3.5.2 Seasonal Testing

During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CxA shall coordinate this activity through the Government. Tests will be executed and documented by the CxA, and deficiencies shall be corrected by the Contractor with the CxA witnessing the testing. Any final adjustments to the O&M manuals and as-built documents due to the testing shall be made by the Contractor.

3.6 TRAINING OF GOVERNMENT PERSONNEL

Contractor shall provide training coordination and shall ensure that training is completed. All training shall be coordinated through the CxA.

a. The Contractor shall provide the CxA with a training plan sixty days before the planned training date covering the following elements:

   1. Equipment

   2. Intended audience

   3. Location of training

   4. Objectives

   5. Subjects covered (description, duration of discussion, special methods, etc.)

   6. Duration of training on each subject

   7. Instructor for each subject

   8. Methods (classroom lecture, manufacturer's quality video, site walk-through, actual operational demonstrations, written handouts, etc.).

b. Provide designated Government personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of equipment that makes up the system.

c. Training shall normally start with classroom sessions followed by hands-on demonstration/training on each piece of equipment.

d. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system shall be repaired or adjusted as necessary and the demonstration repeated at another scheduled time, if necessary.

e. The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.

f. The controls contractor shall attend sessions other than the controls training, as specified, to discuss the interaction of the controls system as it relates to the equipment being discussed.

g. The training sessions shall follow the outline in the table of contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

h. Training shall include:

    1. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.

    2. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include startup, operation in all modes possible, shutdown, seasonal changeover and any emergency procedures.

    3. Discussion of relevant health and safety issues and concerns.

    4. Discussion of warranties and guarantees.

    5. Common troubleshooting problems and solutions.

    6. Explanatory information included in the O&M manuals.

    7. Discussion of any peculiarities of equipment installation or operation.

    8. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.

    9. Hands-on training shall include startup, operation in all modes possible, including manual, shut-down, alarms, power failure and any emergency procedures, and preventative maintenance for all pieces of equipment.

i. Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls not controlled by the central control system.

Contractor shall support all training efforts.

At the discretion of the CxA, training may occur before performance testing is complete if required by the facility operators, to assist the CxA in the performance testing.

Videotaping of the training sessions will be provided by the Contractor and added to the O&M manuals. In addition, factory training videos identifying key troubleshooting, repair, service and/or replacement techniques shall be provided and reviewed with the Government.

3.7 SYSTEMS (COMMISSIONING) MANUALS

Develop a systems manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems in this facility. Similar to an 'owner's manual', the systems manual shall be compiled for the purpose of informing the building staff, including 'future' staff and current or future service contractors, as well as occupants and users as to the basis for operating and maintaining the building's mechanical-electrical-plumbing systems. The systems manual is intended to be useful in the day-to-day operations of a facility, and also shall form the basis of transferring important building information from one party to the next.

In addition to the Design Intent/Owner's Project Requirements (OPR), the Basis of Design (BOD), the project drawings and specifications, the commissioning process requires detailed Operations & Maintenance (O&M) documentation as identified in Section 01 78 23 OPERATION AND MAINTENANCE DATA, Section 01 78 24.00 20 FACILITY ELECTRONIC OPERATION AND MAINTENANCE SUPPORT INFORMATION (eOMSI), and in the technical specifications. The CxA shall review the O&M documentation provided by the Contractor for the equipment and systems for this project. From this documentation the CxA shall develop and compile a Systems (Commissioning) Manual. The Systems Manual should focus on operating, rather than maintaining the equipment, and on the interactions between equipment. The Systems Manual should include the following information for each commissioned system:

a. Executive Summary: Provide an introduction to the Systems Manual, including a history and a general description of the facility, as well as current facility operational requirements.

    1. Facility Description: Location, directions & history.

    2. Site Plan, Buildings & Floors included in the scope.

    3. Current Facility Requirements & Objectives.

    4. Functional Uses/Operational Capabilities.

    5. Space requirements.

    6. Special Requirements.

b. Provide Site Contact Information:

    1. Facilities personnel.

    2. Occupants/Users.

    3. Contractors / Outside Resources.

    4. Architects, Engineers & Consultants.

5. Previous Retrofit Projects information.

c. Design Intent:

1. Owner's Project Requirements (OPR).

2. Architect/Engineer's Basis of Design (BOD).

d. Basic O&M Instructions, Requirements & Procedures:

1. Expectations.

2. General Operating Instructions/Procedures.

3. System single line diagrams.

4. As-built sequences of operations, control drawings and original set points.

5. Operating instructions for integrated building systems.

6. Recommended schedule of maintenance requirements and frequency: Provide a schedule for preventive maintenance (PM) in both printed and electronic format. Provide frequency for each PM task including:

a) Cleaning: Provide instructions and schedules for all routine cleaning and inspection of equipment.

b) Inspection: If periodic inspection of equipment is required for operation, indicate the items to be inspected and provide the inspection criteria for motors, controls, filters and other items.

c) Repairs: Provide instructions for minor repairs or adjustments required for PM routines.

d) Corrective Maintenance: Provide corrective maintenance instructions based on a logical effect-to-cause trouble-shooting philosophy.

e) Troubleshooting: Provide a troubleshooting guide for each major item of equipment. Guide should include columns for 'malfunction', 'probable cause', and 'recommended action'.

f) Repair & Replacement: Indicate repair and replacement procedures most likely to be required in the maintenance of equipment.

7. Project O&M manuals.

8. Recommended schedule for retesting of commissioned systems with blank test forms from the original Commissioning Plan.

9. Recommend schedule for re-calibrating sensors and actuators

10. Operator Training: CxA shall review project training requirements for Government's operations personnel and the Contractor's training plan; and shall verify that the training meets the

Owner's requirements, as stated in the contract documents.

11. Safety Precautions: Provide a listing of safety precautions and instructions to be followed before, during and after making repairs, adjustments or routine maintenance.

12. Manufacturer's Data: Manufacturer's brochures and other descriptive literature covering devices and equipment used in the system. Provide illustrations with exploded views and renewal parts lists.

    a) Indicate any special tools required to service or maintain the equipment.

    b) Performance data, ratings and curves.

    c) Warrantees and Guarantees: Review the conditions to be maintained to keep warranty in effect.

    d) Any service contracts issued or required.

13. Supplemental Data: Provide written narrative or text and any special drawings required to provide necessary information, where manufacturer's standard printed data is not available and information is necessary for a proper understanding, operation and maintenance of the equipment or systems.

e. Major Systems Commissioned: Provide an equipment list, description, and summary of the following major systems. Discuss maintenance requirements, control sequences of operations, trend log points, as-built drawings, etc. Provide model number, serial number and nameplate data for each piece of equipment, and sub-components. Provide installation & start-up instructions for each piece of equipment. Provide all normal and emergency starting and shutdown procedures and data.

1. Chilled Water System.

2. Hot Water System.

3. Outdoor Condensing Units.

4. Building Air Distribution Systems.

5. Plumbing Systems.

6. Electrical Systems: Lighting Controls.

7. Building DDC Controls.

8. Occupancy Requirements; AHU & A/C Unit Operating Schedules.

9. Indoor Environmental Requirements: Temperature & Humidity, Lighting, IAQ.

10. Energy/Utility Costs: Savings goals, Level of Control Desired.

11. Documentation & Training Needs.

12. Performance Acceptance Criteria.

13. DDC Controls for Basic Troubleshooting; Trending & Logging.

14. Recommended 'Best Practice' Maintenance Requirements for Critical Equipment & Systems.

f. Executed Commissioning Test Procedures:

1. Provide a copy of the final, executed commissioning testing & acceptance procedures used for this project.

2. Provide a copy of the final, executed pre-functional (construction) checklists used for this project.

g. Re-Commissioning Test Procedures:

1. Step-by-step procedure for system startup, including a pre-start checklist.

2. Sequence of operations with detailed instruction in proper sequence for each mode of operations, i.e. 'occupied', 'unoccupied', or 'custodial'.

3. Emergency Operation: Provide instructions for manual operation of equipment while some functions are disabled. Provide instructions for operating under these conditions.

4. Shutdown Procedure: Include instructions for stopping and securing the equipment after operation.

h. Operations & Maintenance Submittals: Provide a record copy of all appropriate shop drawing submittals for major items of mechanical, electrical or plumbing equipment, including the equipment manufacturer's O&M manuals.

1. The CxA shall be responsible for compiling, organizing and indexing the following commissioning record data by equipment into labeled, indexed and tabbed binders and deliver to the Contractor to be included in the O&M manuals.

2. Commissioning Plan.

3. System reports including design narratives and criteria including sequences of operations, start-up plan and report, approvals, corrections, construction checklists, completed performance tests, and recommended re-commissioning schedule.

4. Final Commissioning Report: Executive summary, list of participants with roles and responsibilities, overview of commissioning and testing scope, description of testing and verification methods. For each piece of equipment, the report should contain the disposition of the CxA regarding the adequacy of the equipment, as well as the documentation and training meeting the contract requirements.

5. Non-Compliance Items: All outstanding and non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process

changes, etc. shall also be listed. Each non-compliance issue shall be referenced to the specific performance test, inspection, trend log, etc. where the deficiency is documented. The performance and efficiency section for each piece of equipment shall include a brief description of the verification method used (manual testing, BAS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

-- End of Section --

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SECTION 22 08 00.00 22

COMMISSIONING OF PLUMBING SYSTEMS
11/14

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATED AIR BALANCE COUNCIL (AABC)

ACG Commissioning Guideline	(2005) Commissioning Guideline

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB Commissioning Standard	(2009) Procedural Standards for Whole Building Systems Commissioning of New Construction; 3rd Edition

1.2 SUMMARY

The requirements of this section apply to all sections of Division 22. Refer to Division 1 Section 01 91 13.00 22 GENERAL COMMISSIONING REQUIREMENTS FOR CONSTRUCTION for general commissioning requirements applicable to the entire project.

This Section includes Commissioning process requirements for plumbing systems, assemblies, components and equipment to ensure that the work has been completed as specified and that systems are functioning in the manner as described herein, and as specified in the system operating criteria for this project.

a. Commissioning will commence according to the approved construction schedule, after plumbing system rough-in, and after the preliminary inspection punchlist items and commissioning deficiencies are completed by the Contractor and his subcontractors.

b. Construction phase commissioning process shall include the following:

1. Step One: Installation Verification

2. Step Two: System Startup

3. Step Three: Functional Performance Testing

The plumbing commissioning process includes the following tasks:

a. Testing and startup of plumbing equipment and systems.

b. Plumbing equipment and system verification checks.

c. Assistance in functional performance testing to verify equipment and system performance.

d. Provide qualified personnel to assist in commissioning tests, including seasonal testing.

e. Complete and endorse construction phase checklists provided by Commissioning Authority (CxA) to assure equipment and systems are fully operational and ready for functional performance testing.

f. Provide equipment, materials, and labor necessary to correct deficiencies found during commissioning process and to fulfill contract and warranty requirements.

g. Provide operation and maintenance information and record drawings to Commissioning Authority for review verification and organization, prior to distribution.

h. Provide assistance to CxA to develop, edit, and document system operation descriptions.

i. Provide training for systems specified in this Section, coordinated with the CxA.

The commissioning process will also be used to develop test protocol and record the associated test data in an effort to advance the building plumbing systems from a state of substantial completion to a full dynamic operation.

The commissioning process is also intended to assist the Government's operating and maintenance staff in the training and familiarization with new plumbing systems and equipment. The Commissioning Plan and final Commissioning Report should also serve as tools to reduce post-occupancy critical systems operational difficulty or failure. Operational staff training is essential to the commission process and will run concurrently with Steps One through Three referenced above.

The commissioning required by this section is intended to supplement the inspection, testing, and training requirements contained in the technical sections and to consolidate the reports required by those sections. Duplication of the inspection, testing and training required by the technical sections is not required. This section does include additional commissioning requirements.

1.3 DEFINITIONS

Refer to Division 1 Section 01 91 13.00 22 GENERAL COMMISSIONING REQUIREMENTS FOR CONSTRUCTION, Article "Definitions" for definintions applicable to this section.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Commissioning Plan; G
Prefunctional Checklists; G
Functional Performance Test (FPT) procedures; G

Narrative descriptions of the design intent for each of the systems identified; G

SD-06 Test Reports

Commissioning Report; G

1.5 COMMISSIONING SUBMITTAL REQUIREMENTS

Commissioning Authority (CxA) shall prepare Commissioning Plan, Prefunctional Checklists, Functional Performance Test (FPT) procedures, narrative descriptions of the design intent for each of the systems identified, and the Commissioning Report, and execute and document results. All Prefunctional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Government for review and approval.

a. Contractor shall provide CxA with documentation required for Commissioning Work. At minimum, documentation shall include: detailed start-up procedures, full sequences of operation, Operating and Maintenance data and performance data, control drawings, and details of Government-contracted tests.

b. Contractor shall submit to CxA the manufacturers' installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.

c. Contractor shall review and approve other relative documentation for impact on FPT's of the systems:

1. Verify manufacturer's installation instructions are followed by completing the Prefunctional checklists for all plumbing equipment.

2. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPT's.

3. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's. Government may require that system one-line diagrams and applicable Specification Section(s) be attached to the FPT documentation.

4. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

1.6 SYSTEMS TO BE COMMISSIONED

The following systems shall be commissioned as part of this project:

a. Domestic Hot Water Systems: Domestic water heaters, steam-to-hot water converters, hot water circulating pumps and motors, controls, combustion burners/fans/motors.

b. Medical Gas Systems: Medical/dental compressed air system, medical/dental vacuum system, laboratory vacuum system, oxygen, nitrogen, nitrous oxide and oxygen, medical gas alarm system, waste anesthesia gas system, oral evacuation system.

c. Domestic Water Booster Pumps: Controls, piping, compression tanks, pumps, motors, and variable speed drives.

d. Sewage Ejection Pumps: Sump level controls, pump alternator, alarms and alarm panel, pumps and motors.

e. Storm Sump Pumps: Sump level controls, pump alternator, alarms and alarm panel, pumps and motors.

f. Domestic Water Filtration and Softener Systems: Tanks and casings, gages and instruments, controls, pumps and motors, packaged piping, alarms.

g. Chemical Waste Systems & Equipment: Waste storage tanks or sumps, controls and alarms, pumps and motors -for acid waste neutralizers, grease extractors, laboratory waste.

h. Process Water Systems: Controls, piping, tanks and casings, gages and instruments, pumps, motors, and variable speed drives - for reverse osmosis (RO), deionized water (DI) systems.

i. Emergency Plumbing Fixtures: Showers, eye wash stations, water tempering valves, instruments and gages.

j. Compressed Air Systems: General-purpose air compressors, refrigerated air dryers, desiccant air dryers, filters, and storage tanks.

1.7 COMMISSIONING RESPONSIBILITIES

1.7.1 Plumbing Installer Commissioning Responsibilities

a. Attend commissioning meetings.

b. Provide instructions and demonstrations for Government personnel.

c. Ensure subcontractors perform assigned commissioning responsibilities as specified herein.

d. Ensure participation of equipment manufacturers in appropriate startup, testing, and training activities when required by individual equipment specifications and/or the commissioning plan.

e. Develop startup and initial checkout plan using manufacturer's startup procedures and prefunctional (construction) checklists for equipment and systems to be commissioned.

f. During verification check and startup process, execute Plumbing related portions of checklists for equipment and systems to be commissioned.

g. Perform and document completed installation checklists, startup checklists and reports, and system operational checkout procedures, providing copy to CxA.

h. Where specified in the technical sections, provide manufacturer's representatives to execute starting of equipment. Ensure representatives are available and present during agreed upon schedules and are in attendance for duration to complete tests, adjustments and problem-solving.

i. Coordinate with equipment manufacturers to determine specific requirements to maintain validity of warranties.

j. Provide personnel to assist CxA during equipment or system verification checks and functional performance tests.

k. Prior to functional performance tests, review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during tests.

l. Prior to startup, inspect, check, and verify correct and complete installation of equipment and system components for verification checks included in commissioning plan. When deficient or incomplete work is discovered, ensure corrective action is taken and re-check until equipment or system is ready for startup.

m. Provide factory supervised startup services for equipment and systems where specified. Coordinate work with manufacturer and CxA.

n. Perform verification checks and startup on equipment and systems as specified.

o. Assist CxA in performing functional performance tests on equipment and systems as specified.

p. Perform operation and maintenance training sessions scheduled by contractor in accordance with the Commissioning Plan.

q. Conduct Plumbing system orientation and inspection.

1.8 SEQUENCING AND SCHEDULING

Begin the work described in this Section only after all work required in related Sections has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved. Pre-Functional (Construction) Checklists shall be performed for the installation of plumbing equipment, at appropriate times during the construction phase of the Contract.

PART 2 PRODUCTS

2.1 GENERAL

All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 TEST EQUIPMENT

A. Provide all specialized tools, test equipment and instruments required to execute Start-up, checkout, and testing of equipment.

B. All specialized tools, test equipment, and instruments required to execute Start-up, checkout, and testing of equipment shall be of sufficient quality and accuracy to test and/or measure system performance within specified tolerances. A testing laboratory must have calibrated test equipment within the previous twelve (12) months. Calibration shall be NIST traceable, and shall be in accordance with the requirements of the NEBB Commissioning Standard or the ACG Commissioning Guideline. Contractor must calibrate test equipment and instruments according to manufacturer's recommended intervals and whenever the test equipment is dropped or damaged. Calibration tags must be affixed to the test equipment or certificates readily available.

PART 3 EXECUTION

3.1 GENERAL

The Contractor and his Subcontractors shall be responsible for performing procedures presented in the specifications, and as indicated on the contract drawings and as detailed in the Functional Performance Tests (FPT) procedures. Members of the designated Commissioning Team shall witness various portions of the commissioning process. Responsibilities for these activities are listed in the following paragraphs. Commissioning Team members shall sign-off on appropriate sections after verifying installation, operation, or documentation. Final sign-off shall be by the Government and the Commissioning Authority (CxA).

Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by the Contractor and his Subcontractors.

The Contractor shall provide to the Commissioning Team documentation of calibration of controls. Documentation shall include dates, setpoints, calibration coefficients, control loop verification, and other data required to verify system check-out. Documentation shall be dated and initialed by field engineer or technician performing the work.

3.2 COMMISSIONING PLAN

The commissioning plan shall be developed by the CxA and submitted to the Government for approval. The approved commissioning plan shall outline the organization, scheduling, team members, and documentation pertaining to the overall commissioning process.

3.3 CONSTRUCTION CHECKLIST

A. A checklist shall be developed by the CxA for each component of commissioned equipment and systems to ensure that the specified equipment has been provided, is properly installed, and has been initially started and checked out adequately in preparation for full operation and functional testing (e.g., belt tension, fluids topped, labels affixed, gages in place, sensors calibrated, voltage balanced, rotation correct, etc.).

B. The CxA for this project shall develop 'Prefunctional (Construction) Checklists' for this project, which shall be reviewed and approved by the Government; and then provided to, and completed by the Contractor and his sub-contractors to ensure that all equipment and systems are installed properly; have been started up preliminarily, and are reading for commissioning and performance verification testing.

3.4 FUNCTIONAL PERFORMANCE TEST (FPT) PROCEDURES

The FPT procedures at a minimum shall consist of the following sections:

a. Narrative Description: Provide a narrative description of the design intent of each of the plumbing systems to be tested, their intended modes and sequences of operation.

b. Testing Prerequisites: Provide verification and documentation that primary mechanical, electrical, and controls systems that support or interact with the system that the FPT has been prepared for are completed, tested and operational.

c. Installation Verification: Provide verification that the system installation is completed and is ready for commissioning.

d. Commencement of Functional Performance Testing: Record the date and time of the start of system commissioning.

e. System Condition Prior to Starting Performance Testing: Record the current set points and parameters of the system at the start of commissioning.

f. Functional Performance Test: This section shall provide the following:

    1. Sequential steps required to set parameters and conditions required to test components and functions throughout intended ranges of operation.

    2. Full range of checks and tests carried out to determine if electric and pneumatic connections, components, subsystems, systems and interfaces between systems function in accordance with the contract documents and design intents.

    3. All modes and sequences of control operations, interlocks and conditional control responses and specified responses to abnormal emergency conditions.

g. End of Functional Performance Test: Record the date and time of the completion of system commissioning. Include the items in the final commissioning report.

h. Field Notes: Provide a copy of the notes and remarks made and documented during system commissioning.

i. List systems modifications, not required by the Contract Documents, but provided by the Subcontractor. List other questions regarding such system modifications.

j. List problems discovered during Commissioning that were corrected.

k. List problems discovered during Commissioning that were not corrected.

l. List recommended party that should take action on these 'uncorrected' problems.

The CxA for this project shall develop 'Functional Performance Test' (FPT) procedures for this project, which shall be reviewed and approved by the

Government; and then provided to, and completed by the Contractor and his sub-contractors, under the supervision of the CxA, to ensure that all equipment and systems are installed properly; have been started up preliminarily, and are reading for commissioning and performance verification testing.

3.5 OPERATIONAL AND MAINTENANCE STAFF TRAINING

System narrative descriptions will be prepared by the CxA and supported by flow diagrams, one line diagrams, and appropriate specification sections for major systems to be commissioned. The CxA will coordinate "system description" meetings with members of facility management and maintenance department groups to review system description documentation. The meetings will provide an overview of major system features, components, and arrangements.

The Contractor, his sub-contractors and associated manufacturer's representatives shall provide the required training to the Government's operational staff after the system description meetings have occurred. These Contractor training sessions for Government personnel shall provide a more detailed analogy of systems operation and maintenance.

3.6 DOCUMENTATION

The Contractor and his installing subcontractors shall be responsible for collection of pertinent data during system installation, inspection and checkout; during system start-up; and during functional performance testing. The Contractor and his subcontractors shall submit to the CxA documentation of all construction inspections, startup procedures and results, as well as any tests performed prior to and after system start-up. Documentation shall also include the equipment manufacturer's start-up procedures as reviewed and approved by Commissioning Team, including startup reports for equipment and systems conducted by a factory-certified technician or engineer, as specified in the Division 22 Sections for this project.

Provide a title sheet for each section and list the following:

a. Section Title and Specification Section Name and Number requiring this submittal.

b. Project name, project number, and address.

c. Contractor and subcontractor names, addresses, and phone numbers.

d. Name, title, signature, and date of person making the submittal.

e. Table of Contents for each Section.

f. Name of Command, a blank line for signature, and the name and title of person accepting the submittal, and the date accepted by signature.

g. Name, address, and phone number of CxA. Include a blank line for signature; and date of person accepting the submittal.

Provide a Table of Contents for multiple submittals. List each submittal and page number. Number each page, centered on the bottom in sequential numerical order.

3.6.1 STEP ONE - INSTALLATION VERIFICATION

General Commissioning Responsibilities:

a. Before system start-up begins, the Commissioning Team shall conduct a final installation verification audit. The Contractor and his subcontractors shall be responsible for completion of work including change orders and punch list items to the Government's satisfaction. The audit shall include, but not be limited to, checking of:

 1. Piping specialties including balance, control, and isolation valves.

 2. Control sensor types and location.

 3. Identification of piping, valves, equipment, controls, etc.

 4. Major equipment, pumps, valves, starters, gauges, thermometers, etc.

 5. Documentation of prestart-up tests performed, including manufacturer's factory tests.

b. If work is found to be incomplete, incorrect, or non-functional, the Contractor and his subcontractors shall correct the deficiencies before system start-up work proceeds.

3.6.2 STEP TWO - SYSTEM START-UP

General Commissioning Responsibilities: A start-up plan shall be developed and submitted to the Government by the Contractor and his installing subcontractors, for approval. Start-up plan shall include the following:

a. Flushing and cleaning of pipe.

b. Check and replace filters, strainers, and screens, as required.

c. Review control valve min-max, and operating positions.

d. Electrical startup procedures and tests for equipment.

e. Completion of required piping pressure tests.

f. Verification of completion of equipment operating controls, including safeties and interlocks.

g. Verify that chemical treatment systems are as specified, and are operational.

h. Verify that copies of manufacturer's factory tests are available. Verify that manufacturer's startup tests and reports are complete and that all recommendations by the startup engineer have been addressed and completed.

The start-up plan will be reviewed and approved by the Government. After approval is complete, a prestart-up inspection shall be performed by the CxA, and by designated members of the Commissioning Team. The Contractor and his installing subcontractors shall commence with system start-up after approval has been given to start-up plan and the prestart-up inspection is completed.

a. Designated members of the Commissioning Team shall witness system start-ups and list system and equipment deficiencies noted during start-up. The Contractor and his subcontractors shall take corrective action on system deficiencies noted and shall demonstrate satisfactory and suitable system operation to the CxA and to the Commissioning Team.

b. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity shall be noted and corrected.

3.6.3 STEP THREE - FUNCTIONAL PERFORMANCE TESTING

General Commissioning Responsibilities:

a. Functional Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Contractor and his subcontractors. Ideally, the Commissioning training for Government operators and maintenance personnel, including the description of the systems, as well as the hands-on training sessions will also have been completed.

b. The objective of the Functional Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.

c. To attain this objective the CxA will develop individual systems testing protocols which, when implemented by the Contractor/subcontractors will allow the Commissioning Team to observe, evaluate, identify deficiencies, recommend modifications, tune, and document the systems and systems equipment performance over a range of load and functional levels.

d. Functional Performance tests for the systems to be commissioned will be defined in the Commissioning Plan. These tests are intended to be conclusive but may require minor modifications as system operation dictates.

-- End of Section --

SECTION 23 08 00.00 22

COMMISSIONING OF HVAC SYSTEMS
11/14

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATED AIR BALANCE COUNCIL (AABC)

ACG Commissioning Guideline	(2005) Commissioning Guideline

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB Commissioning Standard	(2009) Procedural Standards for Whole Building Systems Commissioning of New Construction; 3rd Edition

1.2 SUMMARY

The requirements of this section apply to all sections of Division 23. Refer to Division 1 Section 01 91 13.00 22 GENERAL COMMISSIONING REQUIREMENTS FOR CONSTRUCTION for general commissioning requirements applicable to the entire project.

This Section includes Commissioning process requirements for HVAC&R systems, assemblies, components and equipment to ensure that the work has been completed as specified and that systems are functioning in the manner as described herein, and as specified in the system operating criteria for this project.

a. Commissioning will commence according to the approved construction schedule, after the completion of the HVAC test, balance and adjust (TAB) report, and after the preliminary inspection punchlist items and commissioning deficiencies are completed by the Contractor and his subcontractors.

b. Construction phase commissioning process shall include the following:

   1. Step One: Installation Verification

   2. Step Two: System Startup

   3. Step Three: Functional Performance Testing

The HVAC commissioning process includes the following tasks:

a. Testing and startup of HVAC equipment and systems.

b. HVAC equipment and system verification checks.

c. Assistance in functional performance testing to verify testing and balancing, and equipment and system performance.

d. Provide qualified personnel to assist in commissioning tests, including seasonal testing.

e. Complete and endorse construction phase checklists provided by Commissioning Authority (CxA) to assure equipment and systems are fully operational and ready for functional performance testing.

f. Provide equipment, materials, and labor necessary to correct deficiencies found during commissioning process and to fulfill contract and warranty requirements.

g. Provide operation and maintenance information and record drawings to Commissioning Authority for review verification and organization, prior to distribution.

h. Provide assistance to CxA to develop, edit, and document system operation descriptions.

i. Provide training for systems specified in this Section, coordinated with the CxA.

The commissioning process will also be used to develop test protocol and record the associated test data in an effort to advance the building HVAC systems from a state of substantial completion to a full dynamic operation.

The commissioning process is also intended to assist the Government's operating and maintenance staff in the training and familiarization with new HVAC systems and equipment. The Commissioning Plan and final Commissioning Report should also serve as tools to reduce post-occupancy critical systems operational difficulty or failure. Operational staff training is essential to the commission process and will run concurrently with Steps One through Three referenced above.

The commissioning required by this section is intended to supplement the inspection, testing, and training requirements contained in the technical sections and to consolidate the reports required by those sections. Duplication of the inspection, testing and training required by the technical sections is not required. This section does include additional commissioning requirements.

1.3 DEFINITIONS

Refer to Division 1 Section 01 91 13.00 22 GENERAL COMMISSIONING REQUIREMENTS FOR CONSTRUCTION, Article "Definitions" for definintions applicable to this section.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Commissioning Plan; G
Prefunctional Checklists; G
Functional Performance Test (FPT) procedures; G

Narrative descriptions of the design intent for each of the systems identified; G

SD-06 Test Reports

Commissioning Report; G

Commissioning Authority (CxA) shall prepare Commissioning Plan, Prefunctional Checklists, Functional Performance Test (FPT) procedures, narrative descriptions of the design intent for each of the systems identified, and the Commissioning Report, and execute and document results. All Prefunctional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Government for review and approval.

a. Contractor shall provide CxA with documentation required for Commissioning Work. At minimum, documentation shall include: detailed start-up procedures, full sequences of operation, Operating and Maintenance data and performance data, control drawings, and details of Government-contracted tests.

b. Contractor shall submit to CxA the manufacturers' installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.

c. Contractor shall review and approve other relative documentation for impact on FPT's of the systems:

1. Verify manufacturer's installation instructions are followed by completing the prefunctional checklists for all HVAC equipment.

2. Draft Test, Adjust and Balance (TAB) Reports: Review and provide comments to Government.

3. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPT's.

4. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's. Government may require that system one-line diagrams and applicable Specification Section(s) be attached to the FPT documentation.

5. Final TAB Reports: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's.

6. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

1.5 COMMISSIONING SUBMITTAL REQUIREMENTS

Commissioning Authority (CxA) shall prepare Commissioning Plan, Prefunctional Checklists, Functional Performance Test (FPT) procedures, narrative descriptions of the design intent for each of the systems identified, and the Commissioning Report, and execute and document results. All Prefunctional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Government for review and approval.

a. Contractor shall provide CxA with documentation required for Commissioning Work. At minimum, documentation shall include: detailed start-up procedures, full sequences of operation, Operating and Maintenance data and performance data, control drawings, and details of Government-contracted tests.

b. Contractor shall submit to CxA the manufacturers' installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.

c. Contractor shall review and approve other relative documentation for impact on FPT's of the systems:

    1. Verify manufacturer's installation instructions are followed by completing the prefunctional checklists for all HVAC equipment.

    2. Draft Test, Adjust and Balance (TAB) Reports: Review and provide comments to Government.

    3. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPT's.

    4. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's. Government may require that system one-line diagrams and applicable Specification Section(s) be attached to the FPT documentation.

    5. Final TAB Reports: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's.

    6. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

1.6 SYSTEMS TO BE COMMISSIONED

The following systems shall be commissioned as part of this project:

a. Air Handling Systems: Fans, motors, variable speed drives, cooling coils and control valves, heating coils and control valves, filters, dampers, safeties such as smoke detectors or freezestats and damper end switches, controls, gages, and vibration isolation.

b. Dehumidification Systems, piping systems, pumps, ductwork systems, packaged DX roof top equipment, split-system DX air conditioning equipment and heat pumps, self-contained air conditioning units, fan-coil units, heat exchangers, computer room air conditioning (CRAC) units, constant and variable volume air terminals, fire dampers and smoke dampers, indoor air quality, equipment sound control (if noted), equipment vibration control (if noted), DDC controls, and test, adjust and balance (TAB) work.

c. Energy Recovery Devices: Enthalpy wheels, fans, motors, variable speed drives, cooling coils and control valves, heating coils and control valves, filters, dampers, safeties, controls, gages, and vibration isolation.

d. Heating Hot Water Generation and Distribution Systems: Boilers, controls, instrumentation and gages, flues, heating water pumps and motors, variable speed drives, mixing valves.

e. Steam Generation and Distribution Systems: Steam boilers, boiler feed-water treatment, boiler feed-water pumps, combustion burners/fans/motors, fuel delivery storage tanks/filters/pumps/motors, flues steam reducing stations, steam condensate receivers steam condensate transfer pumps, de-aerators, safety relief valves, motors, controls, pump alternator, alarms, and instrumentation, motors, and safeties.

f. Chilled Water Generation and Distribution Systems: Chilled water pumps and motors, variable speed drives, chiller motor/compressor, controls, instrumentation and safeties, isolation valves, blending valves, side stream water cleaners/scrubbers/filters.

g. Condenser Water Systems: Condenser water pumps and motors, Variable Speed Drives, cooling tower fans, cooling tower sump level controls, open-circuit water treatment system, water treatment injection pumps and motors, water treatment controls, cooling tower basin heaters and controls, side stream water cleaners/scrubbers/filters, tower bypass valves.

h. Ground Loop Water Systems: Ground loop water pumps, motors, variable speed drives; closed-circuit fluid coolers, fans and motors; open-circuit cooling towers; heat exchangers and control valves; closed-circuit [open-circuit] water treatment systems, pumps, motors & controls.

i. Exhaust Fans: Fan, motor, variable speed drives, controls and safeties.

j. Direct Digital Control Systems (DDC), Building Automation Systems (BAS), Energy Control and Management Systems (EMCS), Utility Management and Control Systems (UMCS): BACnet or similar Local Area Network (LAN), Operator Work Station hardware/software, building controller hardware/software, terminal unit controller hardware/software, all sequences of operation, system accuracy and response time, point-to-point verification.

k. Laboratory Exhaust Systems: Fume hoods, pressure controls, system alarms, fans, motors, and variable speed drives.

l. Laboratory Ventilation Systems: Supply air terminal units and controls, pressure controls and alarms, fans, motors, and variable speed drives.

m. Computer Room HVAC Systems: In-rack cooling systems or CRAC units including fans, motors, variable speed drives, cooling coils and control valves, heating coils and control valves, humidifiers, compressors and liquid-cooled condensers, filters, safeties, controls, gages, vibration isolation, condensate pumps, water/leak detection system and alarms, and shunt trip shut down.

n. Room/Building Pressurization Systems: Pressure sensors, terminal units/dampers, and controls and alarms.

o. HVAC Water Treatment Systems: Closed Circuits - including shot feeders and final water analysis; Open Circuits - including water analysis, chemical/biocide tanks, injection piping, chemical/biocide pumps and motors, controls, water meter, and automatic blowdown.

p. Commercial Kitchen Hoods & Associated Fire Suppression Systems: Fans, motors, variable speed drives, automatic shut down on fire suppression discharge, and gas valve operation.

q. Fuel Delivery and Storage Systems for Boilers and Standby Generators: Fuel level monitoring/controls/alarms, transfer pumps and motors, leak detection monitoring/alarms, and fill systems; fuel filtration and polishing systems, pumps, motors and equipment.

1.7 COMMISSIONING RESPONSIBILITIES

1.7.1 HVAC Equipment/System Installer Commissioning Responsibilities

a. Attend commissioning meetings.

b. Ensure temperature controls installer performs assigned commissioning responsibilities as specified herein.

c. Ensure testing, adjusting, and balancing agency performs assigned commissioning responsibilities as specified herein.

d. Provide instructions and demonstrations for Government personnel.

e. Ensure subcontractors perform assigned commissioning responsibilities.

f. Ensure participation of equipment manufacturers in appropriate startup, testing, and training activities when required by individual equipment specifications and/or the commissioning plan.

g. Develop startup and initial checkout plan using manufacturer's startup procedures and prefunctional (construction) checklists for equipment and systems to be commissioned.

h. During verification check and startup process, execute HVAC related portions of checklists for equipment and systems to be commissioned.

i. Perform and document completed installation checklists, startup checklists and reports. and system operational checkout procedures, providing copy to CxA.

j. Where specified in the technical sections, provide manufacturer's representatives to execute starting of equipment. Ensure representatives are available and present during agreed upon schedules and are in attendance for duration to complete tests, adjustments and problem-solving.

k. Coordinate with equipment manufacturers to determine specific requirements to maintain validity of warranties.

l. Provide personnel to assist CxA during equipment or system verification checks and functional performance tests.

m. Prior to functional performance tests, review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during tests.

n. Prior to startup, inspect, check, and verify correct and complete installation of equipment and system components for verification checks included in commissioning plan. When deficient or incomplete work is discovered, ensure corrective action is taken and re-check until equipment or system is ready for startup.

o. Provide factory supervised startup services for equipment and systems where specified. Coordinate work with manufacturer and CxA.

p. Perform verification checks and startup on equipment and systems as specified.

q. Assist CxA in performing functional performance tests on equipment and systems as specified.

r. Perform operation and maintenance training sessions scheduled by Contractor in accordance with the commissioning plan.

s. Conduct HVAC system orientation and inspection.

1.7.2 HVAC Temperature Controls Installer Commissioning Responsibilities:

a. Attend commissioning meetings.

b. Review design for ability of systems to be controlled including the following:

1. Confirm proper hardware requirements exists to perform functional performance testing.

2. Confirm proper safeties and interlocks are included in design.

3. Confirm proper sizing of system control valves and actuators and control valve operation will result capacity control identified in Contract Documents.

4. Confirm proper sizing of system control dampers and actuators and damper operation will result in proper damper positioning.

5. Confirm sensors selected are within device ranges.

6. Review sequences of operation and obtain clarification from Architect/Engineer.

7. Indicate delineation of control between packaged controls and building automation system (BAS), listing BAS monitor points and BAS adjustable control points.

8. Provide written sequences of operation for packaged controlled equipment. Equipment manufacturers' stock sequences may be included, when accompanied by additional narrative to reflect Project conditions.

c. Inspect, check, and confirm proper operation and performance of control hardware and software provided in other HVAC sections.

d. Submit proposed procedures for performing automatic temperature control system point-to-point checks to CxA and Architect/Engineer.

e. Inspect check and confirm correct installation and operation of automatic temperature control system input and output device operation through point-to-point checks.

f. Perform training sessions to instruct Government's operations and maintenance personnel in hardware operation, software operation, programming, and application in accordance with commissioning plan.

g. Demonstrate system performance and operation to CxA during functional performance tests including each mode of operation.

h. Provide control system technician to assist during CxA verification check and functional performance testing.

i. Provide control system technician to assist testing, adjusting, and balancing agency during performance of testing, adjusting, and balancing work.

j. Assist in performing operation and maintenance training sessions scheduled by the Contractor.

1.7.3 Testing, Adjusting, and Balancing (TAB) Agency Commissioning Responsibilities:

a. Attend commissioning meetings.

b. Participate in verification of testing, adjusting, and balancing report for verification or diagnostic purposes. Repeat sample (percent) of measurements contained in testing, adjusting, and balancing report as indicated in commissioning plan.

c. Assist in performing operation and maintenance training sessions scheduled by the Contractor.

1.8 SEQUENCING AND SCHEDULING

Begin the work described in this Section only after all work required in related Sections has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved. Pre-Functional (Construction) Checklists shall be performed for the installation of mechanical equipment, at appropriate times during the construction phase of the Contract.

PART 2 PRODUCTS

2.1 GENERAL

All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 TEST EQUIPMENT

A. Provide all specialized tools, test equipment and instruments required to execute Start-up, checkout, and testing of equipment.

B. All specialized tools, test equipment, and instruments required to execute Start-up, checkout, and testing of equipment shall be of sufficient quality and accuracy to test and/or measure system performance within specified tolerances. A testing laboratory must have calibrated test equipment within the previous twelve (12) months. Calibration shall be NIST traceable, and shall be in accordance with the requirements of the NEBB Commissioning Standard or the ACG Commissioning Guideline. Contractor must calibrate test equipment and instruments according to manufacturer's recommended intervals and whenever the test equipment is dropped or damaged. Calibration tags must be affixed to the test equipment or certificates readily available.

PART 3 EXECUTION

3.1 GENERAL

The Contractor and his Subcontractors shall be responsible for performing procedures presented in the specifications, and as indicated on the contract drawings and as detailed in the Functional Performance Tests (FPT) procedures. Members of the designated Commissioning Team shall witness various portions of the commissioning process. Responsibilities for these activities are listed in the following paragraphs. Commissioning Team members shall sign-off on appropriate sections after verifying installation, operation, or documentation. Final sign-off shall be by the Government and the Commissioning Authority (CxA).

Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by the Contractor and his Subcontractors.

The Contractor shall provide to the Commissioning Team documentation of calibration of controls. Documentation shall include dates, setpoints, calibration coefficients, control loop verification, and other data required to verify system check-out. Documentation shall be dated and initialed by field engineer or technician performing the work.

3.2 COMMISSIONING PLAN

The commissioning plan shall be developed by the CxA and submitted to the Government for approval. The approved commissioning plan shall outline the organization, scheduling, team members, and documentation pertaining to the overall commissioning process.

3.3 CONSTRUCTION CHECKLIST

A. A checklist shall be developed by the CxA for each component of commissioned equipment and systems to ensure that the specified equipment has been provided, is properly installed, and has been initially started and checked out adequately in preparation for full operation and functional testing (e.g., belt tension, fluids topped, labels affixed, gages in place, sensors calibrated, voltage balanced, rotation correct, etc.).

B. The CxA for this project shall develop 'Prefunctional (Construction) Checklists' for this project, which shall be reviewed and approved by the Government; and then provided to, and completed by the Contractor and his sub-contractors (HVAC, Controls, TAB, etc.) to ensure that all equipment and systems are installed properly; have been started up preliminarily, and are reading for commissioning and performance verification testing.

3.4 FUNCTIONAL PERFORMANCE TEST (FPT) PROCEDURES

The FPT procedures at a minimum shall consist of the following sections:

a. Narrative Description: Provide a narrative description of the design intent of each of the HVAC systems to be tested, their intended modes and sequences of operation.

b. Testing Prerequisites: Provide verification and documentation that primary mechanical, electrical, and controls systems that support or interact with the system that the FPT has been prepared for are completed, tested and operational.

c. Installation Verification: Provide verification that the system installation is completed and is ready for commissioning.

d. Commencement of Functional Performance Testing: Record the date and time of the start of system commissioning.

e. System Condition Prior to Starting Performance Testing: Record the current set points and parameters of the system at the start of commissioning.

f. Functional Performance Test: This section shall provide the following:

    1. Sequential steps required to set parameters and conditions required to test components and functions throughout intended ranges of operation.

    2. Full range of checks and tests carried out to determine if electric and pneumatic connections, components, subsystems, systems and interfaces between systems function in accordance with the contract documents and design intents.

    3. All modes and sequences of control operations, interlocks and conditional control responses and specified responses to abnormal emergency conditions.

g. End of Functional Performance Test: Record the date and time of the completion of system commissioning.

h. Field Notes: Provide a copy of the notes and remarks made and documented during system commissioning. Include these items in the final commissioning report.

i. List systems modifications, not required by the Contract Documents, but provided by the Subcontractor. List other questions regarding such system modifications.

j. List problems discovered during Commissioning that were corrected.

k. List problems discovered during Commissioning that were not corrected.

l. List recommended party that should take action on these 'uncorrected' problems.

The CxA for this project shall develop 'Functional Performance Test' (FPT) procedures for this project, which shall be reviewed and approved by the Government; and then provided to, and completed by the Contractor and his sub-contractors (HVAC, Controls, TAB, etc.), under the supervision of the CxA, to ensure that all equipment and systems are installed properly; have been started up preliminarily, and are reading for commissioning and performance verification testing.

3.5 OPERATIONAL AND MAINTENANCE STAFF TRAINING

System narrative descriptions will be prepared by the CxA and supported by flow diagrams, one line diagrams, and appropriate specification sections for major systems to be commissioned. The CxA will coordinate "system description" meetings with members of facility management and maintenance department groups to review system description documentation. The meetings will provide an overview of major system features, components, and arrangements.

The Contractor, his sub-contractors and associated manufacturer's representatives shall provide the required training to the Government's operational staff after the system description meetings have occurred. These Contractor training sessions for Government personnel shall provide a more detailed analogy of systems operation and maintenance.

3.6 DOCUMENTATION

The Contractor and his installing subcontractors shall be responsible for collection of pertinent data during system installation, inspection and checkout; during system start-up; and during functional performance testing. The Contractor and his subcontractors shall submit to the CxA documentation of all construction inspections, startup procedures and results, as well as any tests performed prior to and after system start-up. Documentation shall also include the equipment manufacturer's start-up procedures as reviewed and approved by Commissioning Team, including startup reports for equipment and systems conducted by a factory-certified technician or engineer, as specified in the Division 23 Sections for this project.

Provide a title sheet for each section and list the following:

a. Section Title and Specification Section Name and Number requiring this submittal.

b. Project name, project number, and address.

c. Contractor and subcontractor names, addresses, and phone numbers.

d. Name, title, signature, and date of person making the submittal.

e. Table of Contents for each Section.

f. Name of Command, a blank line for signature, and the name and title of person accepting the submittal, and the date accepted by signature.

g. Name, address, and phone number of CxA. Include a blank line for signature; and date of person accepting the submittal.

Provide a Table of Contents for multiple submittals. List each submittal and page number. Number each page, centered on the bottom in sequential numerical order.

3.6.1 STEP ONE - INSTALLATION VERIFICATION

General Commissioning Responsibilities:

a. Before system start-up begins, the Commissioning Team shall conduct a final installation verification audit. The Contractor and his subcontractors shall be responsible for completion of work including change orders and punch list items to the Government's satisfaction. The audit shall include, but not be limited to, checking of:

    1. Piping specialties including balance, control, and isolation valves.

    2. Ductwork specialty items including turning devices, balance, fire, smoke, control dampers, and access doors.

    3. Control sensor types and location.

    4. Identification of piping, valves, equipment, controls, etc.

    5. Major equipment, pumps, valves, starters, gauges, thermometers, etc.

    6. Documentation of prestart-up tests performed, including manufacturer's factory tests.

b. If work is found to be incomplete, incorrect, or non-functional, the Contractor and his subcontractors shall correct the deficiencies before system start-up work proceeds.

3.6.2 STEP TWO - SYSTEM START-UP

General Commissioning Responsibilities: A start-up plan shall be developed and submitted to the Government by the Contractor and his installing subcontractors, for approval. Start-up plan shall include the following:

a. Flushing and cleaning of pipe. Cleaning of interior of ductwork and air handling units.

b. Check and replace filters, strainers, and screens, as required.

c. Review control valve/damper min-max, and operating positions.

d. Electrical startup procedures and tests for equipment.

e. Completion of required pressure tests for piping and ductwork.

f. Verification of completion of equipment operating controls, including safeties and interlocks.

g. Verify that chemical treatment systems are as specified, and are operational.

h. Verify that copies of manufacturer's factory tests are available. Verify that manufacturer's startup tests and reports are complete and that all recommendations by the startup engineer have been addressed and completed.

The start-up plan will be reviewed and approved by the Government. After approval is complete, a prestart-up inspection shall be performed by the CxA, and by designated members of the Commissioning Team. The Contractor and his installing subcontractors shall commence with system start-up after approval has been given to start-up plan and the prestart-up inspection is completed.

a. Designated members of the Commissioning Team shall witness system start-ups and list system and equipment deficiencies noted during start-up. The Contractor and his subcontractors shall take corrective action on system deficiencies noted and shall demonstrate satisfactory and suitable system operation to the CxA and to the Commissioning Team.

b. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity shall be noted and corrected.

3.6.3 STEP THREE - FUNCTIONAL PERFORMANCE TESTING

General Commissioning Responsibilities:

a. Functional Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Contractor and his subcontractors. Ideally, the Commissioning training for Government operators and maintenance personnel, including the description of the systems, as well as the hands-on training sessions will also have been completed.

b. The objective of the Functional Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.

c. To attain this objective the CxA will develop individual systems testing protocols which, when implemented by the Contractor/subcontractors will allow the Commissioning Team to observe, evaluate, identify deficiencies, recommend modifications, tune, and document the systems and systems equipment performance over a range of load and functional levels.

d. Functional Performance tests for the systems to be commissioned will be defined in the Commissioning Plan. These tests are intended to be conclusive but may require minor modifications as system operation dictates.

-- End of Section --

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SECTION 26 08 10.00 22

COMMISSIONING OF ELECTRICAL SYSTEMS
11/14

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASSOCIATED AIR BALANCE COUNCIL (AABC)

ACG Commissioning Guideline	(2005) Commissioning Guideline

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB Commissioning Standard	(2009) Procedural Standards for Whole Building Systems Commissioning of New Construction; 3rd Edition

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

NATIONAL ELECTRICAL CONTRACTORS ASSOCIATION (NECA)

NECA/NEIS 90	(2009) Standard for Commissioning Building Electrical Systems

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 110	(2013) Standard for Emergency and Standby Power Systems
NFPA 111	(2013) Standard on Stored Electrical Energy Emergency and Standby Power Systems

1.2 SUMMARY

1.2.1 General

The requirements of this section apply to all sections of Division 26. Refer to Section 01 91 13.00 22 GENERAL COMMISSIONING REQUIREMENTS FOR CONSTRUCTION for general commissioning requirements applicable to the entire project.

The purpose of this Section is to define Contractor responsibilities in the commissioning process, which are being directed by the Government. Additional electrical system testing is required under some Division 27, and 33 Specification Sections. NECA/NEIS 90 provides additional guidance for the commissioning of electrical systems.

This Section includes Commissioning process requirements for electrical systems, assemblies, components and equipment, and requires the participation of the Contractor, to ensure that the work has been completed as specified and that systems are functioning in the manner consistent with the Contract Documents as described herein, and as specified in the system operating criteria for this project.

a. Commissioning will commence according to the approved construction schedule, after electrical system rough-in, and after the preliminary inspection punchlist items and commissioning deficiencies are completed by the Contractor.

b. Construction phase commissioning process shall include the following:

   1. Step One: Installation Verification.

   2. Step Two: System Startup.

   3. Step Three: Functional Performance Testing.

The electrical commissioning process includes the following tasks:

a. Testing and startup of electrical equipment and systems.

b. Electrical equipment and system verification checks.

c. Assistance in functional performance testing to verify equipment and system performance.

d. Provide qualified personnel to assist in commissioning tests, including seasonal testing.

e. Complete and endorse construction phase checklists provided by Commissioning Authority (CxA) to assure equipment and systems are fully operational and ready for functional performance testing.

f. Provide equipment, materials, and labor necessary to correct deficiencies found during commissioning process and to fulfill contract and warranty requirements.

g. Provide operation and maintenance information and record drawings to Commissioning Authority for review verification and organization, prior to distribution.

h. Provide assistance to CxA to develop, edit, and document system operation descriptions.

i. Provide training for systems specified in this Section, coordinated with the CxA.

The commissioning process will also be used to develop test protocol and record the associated test data in an effort to advance the building electrical systems from a state of substantial completion to a full dynamic operation.

The commissioning process is also intended to assist the Government's operating and maintenance staff in the training and familiarization with new electrical systems and equipment. The Commissioning Plan and final Commissioning Report should also serve as tools to reduce post-occupancy critical systems operational difficulty or failure. Operational staff training is essential to the commissioning process and will run concurrently with Steps One through Three referenced above.

The commissioning required by this section is intended to supplement the inspection, testing, and training requirements contained in the technical sections and to consolidate the reports required by those sections. Duplication of the inspection, testing and training required by the technical sections is not required. This section does include additional commissioning requirements.

1.3 DEFINITIONS

Refer to Section 01 91 13.00 22 GENERAL COMMISSIONING REQUIREMENTS FOR CONSTRUCTION, Article "Definitions" for definintions applicable to this section.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for Contractor Quality Control approval. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES 01 33 00.05 20 CONSTRUCTION SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Commissioning Plan; G
Prefunctional Checklists; G
Functional Performance Test (FPT) procedures; G
Narrative descriptions of the design intent for each of the systems identified; G

SD-06 Test Reports

Commissioning Report; G

1.5 COMMISSIONING SUBMITTAL REQUIREMENTS

Commissioning Authority (CxA) shall prepare Commissioning Plan, Prefunctional Checklists, Functional Performance Test (FPT) procedures, narrative descriptions of the design intent for each of the systems identified, and the Commissioning Report, and execute and document results. All Prefunctional Checklists and tests must be documented using specific, procedural forms in Microsoft Word or Excel software developed for that purpose. Prior to testing, Contractor shall submit those forms to the Government for review and approval.

a. Contractor shall provide CxA with documentation required for Commissioning Work. At minimum, documentation shall include: detailed start-up procedures, full sequences of operation, Operating and Maintenance data and performance data, control drawings, and details of Government-contracted tests.

b. Contractor shall submit to CxA the manufacturers' installation and checkout materials actually shipped inside equipment and actual field checkout sheet forms used by factory or field technicians.

c. Contractor shall review and approve other relative documentation for impact on FPT's of the systems:

1. Verify manufacturer's installation instructions are followed by completing the prefunctional checklists for all electrical equipment.

2. Factory Performance Test Reports: Review and compile all factory performance data to assure that the data is complete prior to executing the FPT's.

3. Completed equipment Start-up certification forms along with the manufacturer's field or factory performance and Start-up test documentation: Subcontractor performing the test will review the documentation prior to commencing with the scheduled FPT's. Government may require that system one-line diagrams and applicable Specification Section(s) be attached to the FPT documentation.

4. Operating and Maintenance (O&M) information per requirements of the Technical Specifications and Division 01 requirements: To validate adequacy and completeness of the FPT, the Contractor shall ensure that the O&M manual content, marked-up record Drawings and Specifications, component submittal drawings, and other pertinent documents are available at the Project Site for review.

1.6 SYSTEMS TO BE COMMISSIONED

1.6.1 Electrical (Divisions 26 and 33)

The following systems shall be commissioned as part of this project. Comply with the requirements of Section 26 08 00 APPARATUS INSPECTION AND TESTING as applicable.

[Section 26 11 13.00 20 PRIMARY UNIT SUBSTATION.

][b. Section 26 11 16 SECONDARY UNIT SUBSTATIONS.

][c. Section 26 12 19.10 THREE-PHASE PAD-MOUNTED TRANSFORMERS.

][d. Section 26 12 19.20 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS.

][e. Section 26 13 00.00 20 SF6/HIGH-FIREPOINT FLUID INSULATED PAD-MOUNTED SWITCHGEAR.

] f. Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

[1. Motor Control Centers.]

2. Distribution and Branch Circuit Panelboards.

3. Normal Power Distribution Systems: Building grounding system tests, coordination study review, major circuit breaker settings, meters and gages, receptacles, switches, and controls, etc.

[4. Elevator Systems.]

[5. Security System. For empty conduit system, confirm raceways and device boxes are provided as required for the system that will be provided by others.]

[g. Section 26 23 00 SWITCHBOARDS AND SWITCHGEAR.

][h. Section 26 32 13.00 20 SINGLE OPERATION GENERATOR SETS.

][i. Section 26 33 53.00 20 UNINTERRUPTIBLE POWER SUPPLY (UPS).

1. Battery chargers, static and dynamic power generators - i.e. inverters, MG sets, metering and controls, system power displays, and distribution panel circuit breakers.

][j. Section 26 36 23.00 20 AUTOMATIC TRANSFER SWITCHES.

[1. Hospital Life Safety Power Distribution Systems: Automatic transfer on loss of normal power, grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls.]

[2. Hospital Critical Power Distribution Systems: Automatic transfer on loss of normal power, grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls.]

[3. Hospital Essential Equipment Power Distribution Systems: Automatic transfer on loss of normal power, grounding tests, coordination study review, major circuit breaker settings, meters and gages, and controls.]

][k. Section 26 41 00.00 20 LIGHTNING PROTECTION SYSTEM.

] l. Section 26 51 00 INTERIOR LIGHTING.

1. Lighting Fixtures and Controls: Occupancy sensors, [daylight dimming controls,]and architectural dimming control system hardware/software/scene settings/zone settings/occupancy sensor interface/unoccupied cycle control.

m. Section 26 56 00 EXTERIOR LIGHTING.

1. Lighting Fixtures and Controls: Photocells, time switches, controls, contactors, fixture aiming, etc.

[n. Section 33 71 01 OVERHEAD TRANSMISSION AND DISTRIBUTION.

][o. Section 33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION.

]1.6.2 Communications (Divisions 27 and 33)

The following systems shall be commissioned as part of this project:

a. Section 27 10 00 BUILDING TELECOMMUNICATIONS CABLING SYSTEM.

[b. Section 27 21 00.00 20 INTERCOMMUNICATION SYSTEM.

1. Public Address: Amplifiers and head-end hardware, speaker volume, and background noise - i.e. hiss or similar interference.

][c. Section 27 52 23.00 20 NURSE CALL SYSTEM.

1. Local stations, system hardware and software, reset functions,

response time per activation, and notification signals.

][d. Audio-Visual Systems.

][e. Healthcare Intercommunications and Program Systems: Local stations, system hardware and software, and notification signals.

] f. Section 33 82 00 TELECOMMUNICATIONS OUTSIDE PLANT (OSP).

1.7 COMMISSIONING RESPONSIBILITIES

1.7.1 Electrical Installer Commissioning Responsibilities

a. Attend commissioning meetings, preinstallation meetings and other project meetings scheduled to facilitate the commissioning process.

b. Provide manufacturer's data sheets and shop drawings for equipment to be commissioned. Provide instructions and demonstrations for Government personnel. Provide additional requested documentation to the CxA for the development of Prefunctional Checklists and Functional Performance Test procedures.

c. Ensure subcontractors perform assigned commissioning responsibilities as specified herein.

d. Ensure participation of equipment manufacturers in appropriate startup, testing, and training activities when required by individual equipment specifications and/or the Commissioning Plan.

e. Develop startup and initial checkout plan using manufacturer's startup procedures and prefunctional (construction) checklists for equipment and systems to be commissioned.

[f. With input from the BAS Provider, clarify the operation and control of commissioned equipment in areas where the Specifications, BAS control drawings, or equipment documentation are not sufficient for writing detailed test procedures.]

g. During verification check and startup process, execute electrical related portions of checklists for equipment and systems to be commissioned.

h. Perform and document completed installation checklists, startup checklists and reports, and system operational checkout procedures, providing copy to CxA.

i. Where specified in the technical sections, provide manufacturer's representatives to execute starting of equipment. Ensure representatives are available and present during agreed upon schedules and are in attendance for duration to complete tests, adjustments and problem-solving.

j. Coordinate with equipment manufacturers to determine specific requirements to maintain validity of warranties.

k. Provide personnel to assist CxA during equipment or system verification checks and functional performance tests.

l. Prior to functional performance tests, review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during tests.

m. Prior to startup, inspect, check, and verify correct and complete installation of equipment and system components for verification checks included in commissioning plan. When deficient or incomplete work is discovered, ensure corrective action is taken and re-check until equipment or system is ready for startup.

n. Provide factory supervised startup services for equipment and systems where specified. Coordinate work with manufacturer and CxA.

o. Perform verification checks and startup on equipment and systems as specified.

p. Assist CxA in performing functional performance tests on equipment and systems as specified.

q. Assist in performing operation and maintenance training sessions scheduled by the Contractor.

r. Conduct electrical system orientation and inspection.

1.7.2 Electrical Testing Agency (ETA) Commissioning Responsibilities:

When requested by Government, Contractor shall retain an independent Electrical Testing Agency (ETA) for the purpose of checking and testing of the electrical power distribution equipment per National Electrical Testing Association (NETA). Commissioning responsibiliteis shall include:

a. Attend commissioning meetings.

b. Obtain all required manufacturer's data to facilitate tests.

c. Provide assistance to the CxA in the completion of the specific prefunctional checklists and functional performance test procedures. Generally, ETA shall provide their standard forms to document the NETA tests to be incorporated into the Prefunctional Checklist and Functional Performance Tests record.

d. During related tests, execute and document the tests in the approved forms and/or test record.

e. Perform and clearly document all completed Start-up and system operational checkout procedures, providing a copy to the Contractor.

f. Clearly indicate any deficiencies identified during testing and add to an action list for resolution and tracking. The field technicians shall keep a running log of events and issues. Submit reports of discrepancies, deficient or uncompleted work by others, Contract interpretation requests and lists of completed tests to the Contractor at least twice a week and provide technical assistance in the resolution of deficiencies.

g. Provide skilled technicians to execute testing. Ensure that they are available and present during the agreed-upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.

[h. Perform thermographic imaging of loaded panel at time designated by Contractor.]

1.8 SEQUENCING AND SCHEDULING

Begin the work described in this Section only after all work required in related Sections has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved. Pre-functional (construction) checklists shall be performed for the installation of electrical equipment at appropriate times during the construction phase of the Contract.

PART 2 PRODUCTS

2.1 GENERAL

All materials shall meet or exceed all applicable referenced standards, federal, state and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 TEST EQUIPMENT

Provide all specialized tools, test equipment and instruments required to execute Start-up, checkout, and testing of equipment.

All specialized tools, test equipment, and instruments required to execute Start-up, checkout, and testing of equipment shall be of sufficient quality and accuracy to test and/or measure system performance within specified tolerances. A testing laboratory must have calibrated test equipment within the previous twelve (12) months. Calibration shall be NIST traceable, and shall be in accordance with the requirements of the NEBB Commissioning Standard or the ACG Commissioning Guideline. Contractor must calibrate test equipment and instruments according to manufacturer's recommended intervals and whenever the test equipment is dropped or damaged. Calibration tags must be affixed to the test equipment or certificates readily available.

[Infrared Thermographic Scanner: Infrared scanning equipment shall be an AGA (or approved equal) thermovision set capable of viewing an entire bus or equipment assembly at one time and have a sensitivity of 0.2 degrees C with a liquid nitrogen reference.]

PART 3 EXECUTION

3.1 GENERAL

The Contractor shall be responsible for performing procedures presented in the specifications, and as indicated on the contract drawings and as detailed in the Functional Performance Tests (FPT) procedures. Members of the designated Commissioning Team shall witness various portions of the commissioning process. Responsibilities for these activities are listed in the following paragraphs. Commissioning Team members shall sign-off on appropriate sections after verifying installation, operation, or documentation. Final sign-off shall be by the Government and the Commissioning Authority (CxA).

Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by the Contractor.

The Contractor shall provide to the Commissioning Team documentation of calibration of controls. Documentation shall include dates, setpoints, calibration coefficients, control loop verification, and other data required to verify system check-out. Documentation shall be dated and initialed by field engineer or technician performing the work.

3.2 COMMISSIONING PLAN

The commissioning plan shall be developed by the CxA and submitted to the Government for approval. The approved commissioning plan shall outline the organization, scheduling, team members, and documentation pertaining to the overall commissioning process.

3.3 CONSTRUCTION CHECKLIST

A checklist shall be developed by the CxA for each component of commissioned equipment and systems to ensure that the specified equipment has been provided, is properly installed, and has been initially started and checked out adequately in preparation for full operation and functional testing (e.g., belt tension, fluids topped, labels affixed, gages in place, sensors calibrated, voltage balanced, rotation correct, etc.).

The CxA for this project shall develop 'Construction Checklists' for this project, which shall be reviewed and approved by the Government; and then provided to, and completed by the Contractor to ensure that all equipment and systems are installed properly; have been started up preliminarily, and are ready for commissioning and performance verification testing.

3.4 FUNCTIONAL PERFORMANCE TEST (FPT) PROCEDURES

The FPT procedures at a minimum shall consist of the following sections:

a. Narrative Description: Provide a narrative description of the design intent of each of the electrical systems to be tested, their intended modes and sequences of operation.

b. Testing Prerequisites: Provide verification and documentation that primary systems that support or interact with the system that the FPT has been prepared for are completed, tested and operational.

c. Installation Verification: Provide verification that the system installation is completed and is ready for commissioning.

d. Commencement of Functional Performance Testing: Record the date and time of the start of system commissioning.

e. System Condition Prior to Staring Performance Testing: Record the current set points and parameters of the system at the start of commissioning.

f. Functional Performance Test: This section shall provide the following:

    1. Sequential steps required to set parameters and conditions required to test components and functions throughout intended ranges of operation.

    2. Full range of checks and tests carried out to determine if connections, components, subsystems, systems and interfaces between systems function in accordance with the contract documents

and design intents.

3. All modes and sequences of control operations, interlocks and conditional control responses and specified responses to abnormal emergency conditions.

g. End of Functional Performance Test: Record the date and time of the completion of system commissioning.

h. Field Notes: Provide a copy of the notes and remarks made and documented during system commissioning.

i. List systems modifications, not required by the Contract Documents, but provided by the Contractor. List other questions regarding such system modifications.

j. List problems discovered during Commissioning that were corrected.

k. List problems discovered during Commissioning that were not corrected.

l. List recommended party that should take action on these 'uncorrected' problems.

The CxA for this project shall develop 'Functional Performance Test' (FPT) procedures for this project, which shall be reviewed and approved by the Government; and then provided to, and completed by the Contractor under the supervision of the CxA, to ensure that all equipment and systems are installed properly; have been started up preliminarily, and are ready for commissioning and performance verification testing.

3.5 OPERATIONAL AND MAINTENANCE STAFF TRAINING

System narrative descriptions will be prepared by the CxA and supported by flow diagrams, one line diagrams, and appropriate specification sections for major systems to be commissioned. The CxA will coordinate "system description" meetings with members of facility management and maintenance department groups to review system description documentation. The meetings will provide an overview of major system features, components, and arrangements.

The Contractor and associated manufacturer's representatives shall provide the required training to the Government's operational staff after the system description meetings have occurred. These Contractor training sessions for Government personnel shall provide a more detailed analogy of systems operation and maintenance. Coordinate this training with that required in the technical specification sections.

3.6 DOCUMENTATION

The Contractor shall be responsible for collection of pertinent data during system installation, inspection and checkout; during system start-up; and during functional performance testing. The Contractor shall submit to the CxA documentation of all construction inspections, startup procedures and results, as well as any tests performed prior to and after system start-up. Documentation shall also include the equipment manufacturer's start-up procedures as reviewed and approved by Commissioning Team, including startup reports for equipment and systems conducted by a factory-certified technician or engineer, as specified in the Division 26, 27, and 33 Sections for this project.

Provide a title sheet for each section and list the following:

a. Section Title and Specification Section Name and Number requiring this submittal.

b. Project name, project number, and address.

c. Contractor and subcontractor names, addresses, and phone numbers.

d. Name, title, signature, and date of person making the submittal.

e. Table of Contents for each Section.

f. Name of Command, a blank line for signature, and the name and title of person accepting the submittal, and the date accepted by signature.

g. Name, address, and phone number of CxA. Include a blank line for signature; and date of person accepting the submittal.

Provide a Table of Contents for multiple submittals. List each submittal and page number. Number each page, centered on the bottom in sequential numerical order.

3.6.1 STEP ONE - INSTALLATION VERIFICATION

General Commissioning Responsibilities:

a. Before system start-up begins, the Commissioning Team shall conduct a final installation verification audit. The Contractor shall be responsible for completion of work including change orders and punch list items to the Government's satisfaction. The audit shall include, but not be limited to, checking of:

    1. Provide documentation of all prestart-up tests performed, including manufacturer's factory tests.

    2. Verify integrated performance of all components, including control system components and all interlocks and interactions with other equipment and systems.

    3. Verify all alarm and high and low limit functions and messages generated on all points with alarm settings.

    4. All safety trips shall require a manual reset to allow a system restart.

    5. Verify shut down and restart capabilities both for scheduled and unscheduled events (e.g. power failure recovery and normal scheduled start/stop).

    6. Verify time of day schedules and setpoints.

    7. Verify all energy saving control strategies.

    8. Verify that monitoring system graphics are representative of the systems and that all points and control elements are in the same location on the graphic as they are in the field.

9. Verify operator control of all commandable control system points including proper security level access.

b. If work is found to be incomplete, incorrect, or non-functional, the Contractor shall correct the deficiencies before system start-up work proceeds.

3.6.2 STEP TWO - SYSTEM START-UP

General Commissioning Responsibilities: With the assistance of the CxA, a start-up plan shall be developed by the Contractor. The start-up plan shall include all electrical equipment. The Contractor shall submit the equipment start-up plan to the Government for approval. Start-up plan shall include the following:

a. The CxA shall review the respective prefunctional checklists to provide guidance and comments for the startup plans.

b. The CxA shall obtain from the Contractor the equipment manufacturer's installation, startup and checkout data, including actual field checkout/startup sheets used by the equipment manufacturer's startup technicians.

c. The CxA shall copy all pages of the equipment manufacturer's installation instructions and startup manuals with important instructional data and procedures from the startup and checkout manuals not covered elsewhere in the manufacturer's equipment installation and checkout sheets.

d. The pages referenced above, along with the respective startup data from the prefunctional checklist provided by the CxA, and the manufacturer's equipment installation checkout sheets become the basis for the equipment "Startup and Checkout Plan" for each individual piece of equipment, developed by the Contractor.

e. For systems that may not have adequate manufacturer startup and checkout procedures, particularly for components being integrated with other equipment, the Contractor shall provide the added necessary detail and documentation to the CxA for information and review, prior to execution.

f. The CxA shall review the individual equipment "Startup and Checkout Plans", compile this information into a "full Startup and Checkout Plan", and then transmit same to the Contractor. The Contractor will designate which trade or subcontractor is responsible to fill out each line item on the prefunctional (construction) checklists from the CxA, and support the startup and checkout of each piece of equipment. The Contractor shall then transmit the full start-up plan to the Subcontractors for their review and use.

3.6.2.1 [Thermographic Scanning

a. Contractor shall provide thermographic scanning on all[switchgear,][switchboards,] and distribution panels. In general, the thermographic scanning shall be made when the equipment is energized and is operating at its normal capacity. It is intended that the scan be made after the equipment has been in full operation; however, the Contractor, near the completion of the Project, will determine the exact time of conducting the scan. Some scanning for occupant-created load shall be performed during the Warranty Period as a Deferred Test.

b. Test equipment, miscellaneous tools, and materials shall be transported properly, moved, and set up by trained personnel. Equipment used in testing shall be capable of performing all recommended procedures required by the apparatus and related equipment. All test equipment shall have certification of calibration and be in working order.

c. All hot spots shall be marked, identified, and an infrared thermographic scanning report prepared and furnished to the Owner.

d. The report shall contain infrared photos of trouble spots with temperature readings.

e. The Contractor shall promptly report all sources of heating problems to the Owner for corrective action.

]3.6.2.2 Grounding Systems

a. Provide grounding system tests as required in the technical specification sections.

3.6.2.3 AC Motors - General Across Systems

a. Verify proper alignment, installation, and rotation.

b. Measure the insulation resistance, phase balance, and resistance to ground.

c. Verify that properly sized overloads are in place.

d. Measure voltage available to all phases at time of initial connection and again after motor has been placed in operation. Measure current and speed (RPM) under load conditions.

e. Record all motor nameplate data.

3.6.2.4 [Primary Service Feeders - 15 kV Class

a. Start-up checklists: Perform the following final checks before Start-up:

 1. Inspect underground duct banks.

 2. Inspect cable.

 3. Inspect splicing and terminations.

b. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:

 1. Visually and mechanically inspect to include the following: Exposed cable, compression type terminations, splices where approved by the Engineer and the Owner, and fireproofing in manholes, cable vaults, and similar items.

 2. Correct color code identification and phasing arrangements.

 3. Provide inspection and testing as required in Section

33 71 02.00 20 UNDERGROUND ELECTRICAL DISTRIBUTION and Section 26 08 00 APPARATUS INSPECTION AND TESTING.

]3.6.2.5 [[Unit Substations][and][Pad-Mounted Switchgear]

a. Start-up checklists: Perform the following final checks before Start-up:

1. Inspect power cable terminations.

2. Inspect connections.

3. Inspect grounding.

4. Inspect electrical interlock wiring.

b. Provide inspection, testing and training as required in[Section 26 11 13.00 20 PRIMARY UNIT SUBSTATION,][Section 26 11 16 SECONDARY UNIT SUBSTATIONS,][Section 26 13 00.00 20 SF6/HIGH-FIREPOINT FLUIDS INSULATED PAD-MOUNTED SWITCHGEAR,] and Section 26 08 00 APPARATUS INSPECTION AND TESTING.

]3.6.2.6 [Pad-Mounted Transformers

a. Start-up checklists: Perform the following final checks before Start-up:

1. Inspect primary and secondary power connections.

2. Inspect control interconnections.

3. Inspect grounding.

b. Provide inspection, testing and training as required in[Section 26 12 19.10 THREE-PHASE PAD-MOUNTED TRANSFORMERS,][Section 26 12 19.20 SINGLE-PHASE PAD-MOUNTED TRANSFORMERS,] and Section 26 08 00 APPARATUS INSPECTION AND TESTING.

]3.6.2.7 Secondary Distribution

a. Start-up checklists: Perform the following final checks before Start-up:

1. Inspect transformer connections.

2. Inspect disconnect connections.

3. Inspect grounding.

4. Validate surge protector installation.

5. Verify control interconnections.

6. Check calibration/setting of protective devices from system coordination study.

7. Verify calibration/setting of digital metering.

8. Check installation of equipment nameplates and warning labels.

b. Provide inspection, testing and training as required in[Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM,][Section 26 27 14.00 20 ELECTRICITY METERING,][Section 26 23 00 SWITCHBOARDS AND SWITCHGEAR, and Section 26 08 00 APPARATUS INSPECTION AND TESTING].

c. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:

1. Visually and mechanically inspect to include the following: large junction and pull boxes, supports of raceways, and compression type terminations.

2. Correct identification and phasing arrangements.

3. Perform random continuity test of any branch circuit.

4. Receptacle Polarity Test: Test every receptacle installed or reconnected under this Contract with a receptacle circuit tester. Tester shall test for open ground, reverse polarity, open hot, open neutral, hot and ground reversed, hot or neutral and hot open. Rewire receptacles with faults and retest.

5. Ground-Fault Receptacle Circuit Interrupter Tests:

(a) Test each receptacle or branch circuit breaker having ground-fault circuit protection to assure that the ground-fault circuit interrupter will not operate when subjected to a ground-fault current of less than 4 milliamperes and will operate when subjected to a ground-fault current exceeding 6 milliamperes.

(b) Perform testing using an instrument specifically designed and manufactured for testing ground-fault circuit interrupters. "TEST" button operation will not be acceptable as a substitute for this test.

(c) Replace receptacles that do not shut off power with 6/1000 of an ampere within 1/40th of a second and retest. Submit test report signed by Test Engineer who performed this test.

3.6.2.8 Lighting Fixtures and Lighting Controls

a. Start-up checklists: Perform the following final checks before Start-up:

1. Ensure all labeling is affixed and accurate.

2. Verify quantity, type and location of fixtures.

3. Verify type and location of switches.

4. Ensure all terminations are tight.

5. Check sensor placement is adequate for required duty.

6. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it.

7. Ensure all circuits for the loads are energized and ready for

testing.

b. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:

1. Test, calibrate, and set all digital and analog sensing, and actuating devices.

(a) Calibrate each instrumentation device by making a comparison between the graphic display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5 percent accurate, test equipment shall be +/-0.25 percent accurate over same range).

(b) Record the measured value and displayed value for each device in the Prefunctional Checklist.

(c) Check each digital control point by making a comparison between the control command at the control panel and the status of the controlled device.

(d) Check each digital input point by making a comparison of the state of the sensing device and the display.

(e) Record the results for each device in the Building Automation System Start-up checklist.

2. Verify operation of lighting controls (dimming, photo-control, regular switching).

3. Check loads on all breakers to ensure that the breaker is properly sized.

4. Enter all schedules per occupant's direction.

5. For operator interfaces, verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.

6. Output all specified reports for review and approval.

7. Verify the alarm printing and logging is functional and per requirements.

8. Validate all interfaces with other systems on a point by point basis.

c. Provide inspection, testing and training as required in[Section 26 51 00 INTERIOR LIGHTING][and][Section 26 56 00 EXTERIOR LIGHTING].

3.6.2.9 Lightning Protection

a. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:

1. Visually and mechanically inspect to include the following: air terminal mountings, bonding connections of roof mounted HVAC equipment, down leads routing/roof penetrations, and grounding.

2. Review UL test certification.

3. Check for receipt of UL master label.

b. Provide inspection and testing as required in Section 26 41 00.00 20 LIGHTNING PROTECTION SYSTEM.

3.6.2.10 [Uninterruptible Power Systems (UPS)

a. Provide the services of a manufacturer certified specialist to supervise the installation, make adjustments, and perform tests on the UPS and to train Owner's personnel.

b. Provide inspection, testing and training as required in Section 26 33 53.00 20 UNINTERRUPTIBLE POWER SUPPLY (UPS).

]3.6.2.11 [Automatic Transfer Switches

a. Provide the services of a factory trained manufacturer's representative to assist the Contractor in the installation and startup service of the equipment and to train Owner's personnel as specified.

b. Start-up checklists: Perform the following final checks before Start-up:

1. Visually inspect the systems.

2. Ensure the terminations are tight and all ancillary equipment completely installed.

3. Ensure all overloads are in place.

4. Measure contact resistance.

c. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:

1. Energize Switch.

2. Check positive interlock between systems.

3. Set/Calibrate Voltage sensing relay, transfer time delays (in both directions), and synchronization relays.

4. Measure insulation resistance and resistance to ground.

5. Check manual bypass operation.

d. Provide inspection, testing and training as required in Section 26 36 23.00 20 AUTOMATIC TRANSFER SWITCHES.

]3.6.2.12 [Single Operation Generator Sets

a. Provide the services of a manufacturer certified specialist to supervise the installation, make adjustments, and perform tests on the engine generators.

b. Start-up checklists: Perform the following final checks before

Start-up:

1. Visually inspect the systems.

2. Ensure wiring terminations are tight.

3. Verify all ancillary equipment completely installed.

4. Ensure all overloads are in place.

5. Verify that generator is set in place.

6. Verify fuel connections.

7. Verify radiator connections.

8. Verify battery connection.

9. Verify exhaust connections and insulation installation.

10. Verify block or oil heater connection.

11. Check and record engine oil level, radiator water level, and battery electrolyte level.

12. Inspect the installation and access/clearance for service and maintenance to ensure it meets the Project and manufacturer's requirements.

13. Check lubricating oil for lubricated type equipment.

14. Check for proper seismic restraints.

15. Check that all operating controls are set for initial safe operation.

c. Starting Procedures: Follow the manufacturer's written procedures and the following as a minimum:

1. Test generator at 50, 75, 100, 125 percent load capacity using load banks at 100 percent power factor.

2. Run load test at all loads except 125 percent for 30 minutes recording engine and alternator readings at the start, at 15 minutes and at 30 minutes. 125 percent load to be run for 15 minutes recording readings at the start and end of test.

3. Simulate operation of all generator safeties such as high oil pressure, low oil pressure, high temperature, over speed, etc. Observe function of safeties under actual malfunction situation.

4. Check for excessive vibration and noise.

d. Provide inspection, testing and training as required in Section 26 32 13.00 20 SINGLE OPERATION GENERATOR SETS.

]3.6.3 STEP THREE - FUNCTIONAL PERFORMANCE TESTING

General Commissioning Responsibilities: Functional Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Contractor. Ideally, the Commissioning training for Government operators and maintenance personnel, including the description of the systems, as well as the hands-on training sessions will also have been completed.

a. When testing procedures for commissioned equipment are listed in NETA ATS the NETA test procedures shall be part of the testing requirements of this specification. Additional testing procedures may be listed in this specification.

b. For the conditions, sequences and modes tested, the equipment, integral components and related equipment shall respond to varying loads and changing conditions and parameters appropriately as expected, according to the sequences of operation, as specified, according to acceptable operating practice and the manufacturer's performance specifications. Verify equipment operates within tolerances specified in: governing codes, acceptance criteria contained in the construction documents, manufacturer's literature and according to good operating practice.

c. Electrical Controls Sequences: Verify functionality and compliance with the design intent for each individual sequence module in the sequences of operation. Verify proper operation of all control strategies, energy efficiency and self-diagnostics features by stepping through each sequence and documenting equipment and system performance. Test every step in every written sequence and other significant modes, sequences and operational features not mentioned in written sequences; including startup, normal operation, shutdown, scheduled on and off, unoccupied and manual modes, safeties, alarms, over-rides, lockouts and power failure.

d. Systems shall accomplish their intended function and performance.

e. Resetting a manual safety shall result in a stable, safe, and predictable return to normal operation by the system.

f. Safety circuits and permissive control circuits shall function in all possible combinations of selector switch positions (hand, auto, inverter, bypass, etc.).

g. Scheduled Lighting Controls:

    1. Apply the applicable common testing requirements and acceptance criteria.

    2. Test Methods. Utilize active testing, and trending when available. If able to trend, trend all zones over a week period and follow the trending guidelines in Section 01 91 13.00 22 GENERAL COMMISSIONING REQUIREMENTS FOR CONSTRUCTION.

    3. Sampling Strategy. Manually test 20 percent of the zones or at least four. If more than 10 percent or two zones fail, test another 10 percent sample. If the second sample fails the Contractor shall document retesting on all zones on their own using a Commissioning Authority approved form.

h. Occupancy Sensor Lighting Controls:

    1. Apply applicable common testing requirements and acceptance

criteria.

2. Test all units functions, including sensor sensitivity and time-to-OFF functions and ensure that sensor location is proper and won't be tripped inadvertently by other occupants and movements outdoors, etc.

3. Test Methods: Utilize active test methods.

4. Sampling Strategy. Test 10 percent of the sensors or six, whichever is greater. If more than 10 percent or two sensors fail, test another 10 percent sample. If the second sample fails the Contractor shall document retesting on all units on their own using a Commissioning Authority approved form.

5. Additional Acceptance Criteria. Reasonable sensitivity, no inadvertent trips, lights go off within 15 seconds of design.

[i. Emergency Generator System:

1. Apply applicable common testing requirements and acceptance criteria.

2. Test according to NETA ATS section 7.22.1 and NFPA 110 section 5.13.

3. Record all data and results.

4. Include the following tests:

(a) When in enclosed spaces, verify combustion and ventilation air damper functions and pressure drop of exhaust.

(b) Verify fuel oil system, diesel fuel storage tank, and level and low fuel indication alarms.

(c) Verify all alarms, meters, and auxiliaries and interlocks to the BAS.

5. Building Test. Under a cold generator condition, provide full utility power interruption under load and cause emergency power service operation.[Include all UPS in this test. Load bank the UPS if necessary during test.]

6. Verify all generator functions.

7. Test auto-transfer switch operation under actual voltage drop.

8. Using a power line disturbance monitor, measure the following times: power failure to engine start command, engine start command to engine start (cranking time), engine start to point where generator is at proper volts and frequency and total time from power failure until ATS switches.

9. Verify system reporting & control monitoring point-to-point.

10. Verify that each circuit and equipment served by emergency power, does power up.

11. Step Load Tests:

(a) Test at 0 percent, 25 percent, 50 percent and 100 percent of full load. Measure voltage and frequency and record all gaged engine conditions. The test shall consist of running the engine-generator while connected to the resistive load bank for one hour, and then shutting down for 30 minutes.

(b) Test for multiple generator starts.

(c) Verify all operational data and start-up minimum time interval.

(d) Verify 2-hour full load run utilizing a load bank (building load can serve as part of the load).

(e) Verify all generator-running characteristics.

(f) Verify battery-charging system.

][j. Uninterruptible Power Supply:

1. Apply applicable common testing requirements and acceptance criteria.

2. Test according to NETA ATS section 7.22.2 and NFPA 111 section 5.6.

3. Test the UPS during the Integrated Building Test in the Emergency Generator System test requirements article in this Section.

] -- End of Section --

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