CHAPTER 7

MECHANICAL

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7.1 GENERAL

This chapter provides design criteria and guidance for preparation and development for each of the different required submittal stages for mechanical design. Refer to Unified Facilities Criteria (UFC) for additional document requirements. Guidance for mechanical systems not included herein is provided in the AE contract.

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7.2 LESSONS LEARNED CHECKLISTS

At each design or design-build Request for Proposal (RFP) submittal, submit the appropriate Lesson Learned checklist from Attachment A. Include the project name, P2 number, and the designer/RFP preparer and checker names and identify the design submittal/milestone. Complete the checklist at each milestone to the extent each item has been considered and incorporated. Where inapplicable to the project, mark the item as N/A. Include with design analyses.

For design-build projects, the RFP must incorporate the appropriate checklist for the design-build contractor's designer to submit during design phase with instructions for completion and incorporation into design analyses.

Many of the checklist items reflect errors that have occurred in the past that incurred major costs, contract time growth, operational problems, mission impacts, and administrative burden. Many of these issues are systemic or occur every few years. While the entirety of the design is important and must be correct, place additional attention on these items.

7.3 REQUEST FOR PROPOSAL

Design-Build Requests for Proposal (RFP) shall require that the design conform to this design guide and all applicable Federal, Department of Defense, and agency specific criteria. The following shall also be provided in the RFP:

7.3.1 OCCUPANCY

Include expected occupancy patterns for the facility for cooling load, diversity, and energy modeling purposes.

Example:
Weekday - Building is 50% occupied 0700-0800, 100% occupied 0800-1700, and unoccupied otherwise.
Weekend – Building is unoccupied.
Conference rooms on the 2nd floor are for use by building occupants only; no or limited usage by outside personnel expected.

7.3.2 INTERIOR HEAT GAINS

Provide space matrices indicating the expected number of occupants, occupant activity level, equipment type, and any other information necessary to determine interior heat gains for load calculations for bidding purposes. The contractor shall be required by the RFP to determine the actual usage, equipment, etc. during design.

7.3.3 BUILDING AUTOMATION/DIRECT DIGITAL CONTROL SYSTEM

If the facility will have the building automation system or direct digital control systems integrated with an existing energy or utility monitoring and control system, sufficient information about the existing system must be provided to allow appropriate bids. All points required for override, alarm, monitoring, and trending must be identified in the RFP, either generically or specifically. The trending capabilities required in terms of the points, frequency, duration, etc. must be specifically required in the RFP.

7.3.4 FIRE FLOW DATA

Current fire flow test data must be provided for bidding purposes. The RFP must clearly state that the contractor is required to perform a fire flow test as the basis of their design.

7.4 DESIGN DEVELOPMENT

7.4.1 CONCEPT/PROJECT DEFINITION DESIGN (30-35%) SUBMITTAL REQUIREMENTS

7.4.1.1 Concept Design Analysis

The narrative forms the basis of the future Interim and Final Design Analysis. Refer to Chapter 10 Energy & Sustainability for energy/water optimization and LCCA requirements. Design narrative will be separate from supporting calculations. Include the following:

7.4.1.1.1 Concept Design Narratives

7.4.1.1.1.1 Concept Heating, Ventilation, and Air Conditioning Narrative

a. Criteria listings – include regulations, UFCs, handbooks, manuals, codes, standards, etc. applicable to the project. Indicate the version used for each criteria document listed.
b. Design conditions used in calculations -inside and outside temperatures/humidity, personnel load, equipment heat release, energy sources, exhaust and ventilation requirements, U-factors, and other special conditions. List data and information; relying only on reference to criteria is insufficient.
c. Narrative describing the systems considered, justification for selection, description of air distribution, zoning and control description, and description for any connections to existing systems.
d. Brief description of items of equipment. Indicate operating temperatures and capacities. Example: "Two (2) condensing boilers size for 300 MBTUH each will provide heating…Heating hot water from boilers will be 140 F."
e. Description of piping systems including type of pipe, insulation requirements, and whether concealed or exposed.
f. Energy, Utility, or Facility Monitoring and Control System (UMCS) connection or installation requirements narrative identifying existing UMCS conditions and requirements for providing new or future UMCS on this project.
g. A list of items for which any additional criteria, clarification, or guidance is required.
h. Where heating or cooling is planned to be provided from an existing plant, describe adequacy of the capacity, availability, and reliability of the plant to support project loads.

7.4.1.1.1.2 Concept Plumbing Narrative

a. Criteria listing – include regulations, UFCs, handbooks, manuals, codes, standards, etc. applicable to the project. Indicate the version used for each criteria document listed.
b. Description of plumbing fixtures, type, flow/flush rates, quantities. Include male/female ratio.
c. Decription of domestic water, sanitary, and vent systems.
d. Description of domestic water heating and storage equipment, including capacity and type (gas, electric, boiler, water). Narrative describing the systems considered, justification for selection, and control description.
e. Piping types and location (concealed or exposed), together with material proposed and insulation requirements.
f. Brief description of miscellaneous systems such as compressed air (capacity, pressure, piping, location of air outlets, etc.), roof drainage, natural gas (pressure, quantity, and equipment to be served), POL, and other special systems.
g. Include a description of radon system requirements, including area radon levels, and planned system.
h. A list of items for which additional criteria, clarification, or guidance is required.

7.4.1.1.1.3 Concept Utilities Narrative

a. Criteria listings – include regulations, UFCs, handbooks, manuals, codes, standards, etc. applicable to the project. Indicate the version used for each criteria document listed.
b. Discuss utility system owners, points of contact, and any special considerations related to obtaining services. Description of responsibility of project/contractor vs. utility provider. Indicate who provides service lines, meters, tanks, etc. Indicate metering requirements and backflow prevention requirements.
c. Where project utilities are extensions of existing systems, describe adequacy for the additional load requirements.
d. Description of the utility systems chosen and describe LCCA for utility selection, as applicable. Example: Justification of propane versus natural gas or justification for water tanks versus extending water mains. When building energy optimization is required, refer to Chapter 10 Energy & Sustainability.
e. Metering requirements shall be identified.
f. A list of items for which additional criteria, clarification, or guidance is required.

7.4.1.1.1.4 Concept Fire Suppression Narrative

a. Criteria listings – include regulations, UFCs, handbooks, manuals, codes, standards, etc. applicable to the project. Indicate the version used for each criteria document listed.
b. Listing of the hazard classifications for each space and discussion of protection requirements for specific hazards. Describe any special hazards.
c. Discussion of fire protection features to reflect the types of system considered with a description of the systems selected. Include such systems as fire pumps, storage tanks, standpipes, deluge systems, clean agents, in-rack system, and smoke evacuation.
d. Description of fire detection and alarm system controls which are used to actuate suppression systems.
e. Describe results of flow test data and preliminary hydraulic calculations.
f. List any special requirements requested by the local fire department.

7.4.1.1.2 Concept Calculations

Calculations submitted in PDF format must have each separate calculation separately bookmarked with easy to understand labels to allow quick navigation of the calculation files. Provide the following:

7.4.1.1.2.1 Concept Heating, Ventilation, and Air Conditioning Calculations

a. Block loads for heating and cooling. Load calculation software may include Trane Trace and Carrier HAP. Other load calculation software must be approved in advance by the District. For all computer generated calculations (cooling load, heating load), the design analysis shall contain layout sketches that show how the building or system was zoned for computer input. Include input and output reports, ONLY FOR THE AS DESIGNED SYSTEM, for the calculation. Input reports include library members, schedules, room inputs, system inputs, and plant inputs. (Reports supporting energy analyses, optimization, and LCCA for building energy optimization reside in separate section of the design analysis.)
b. Load analysis input and output shall be organized such that each space, zone, system, item of equipment, building component, etc. is correlated with identifiers on design plans and easily identifiable. Examples: Conference Room #244 is identified as Conf Rm #244 on input/output documents; AHU-2-4 is identified as AHU-2-4 on input/output documents; Zone 3-4 on the input/output files is associated w/ VAV 3-4.
c. Load analysis input and output provided via PDF format must have separate reports bookmarked with easy to understand labels to allow quick navigation of the reports.

d. Provide preliminary sizing calculations for all major HVAC equipment. Examples include boilers, chillers, cooling towers, well-fields, air handling units, fans, package air-conditioning units, condensing units, heat pumps, fan-coil units, and heat exhangers.
e. Where heating or cooling is planned to be provided from an existing plant, provide calculations demonstrating that capacity, availability, and reliability of the plant are adequate to support project loads.

7.4.1.1.2.2 Concept Plumbing Calculations

a. Fixture determination listing quantity and type of fixtures.
b. Cold and hot water and sanitary building service size calculations.
c. Natural gas or propane equipment and building entry sizing calculations.
d. Domestic hot water heating and storage equipment sizing calculations.
e. Calculations for all other equipment/system sizing including major equipment items. Examples are compressed air or lubrication/oil systems.

7.4.1.1.2.3 Concept Utilities Calculations

a. Water exterior distribution and service line pipe size calculations.
b. Natural gas distribution and service line pipe size calculations.
c. Lift station and force main sizing calculations.
d. Inteceptor or separator equipment sizing calculations (oil/water, sand, etc.).
e. Calculations for equipment and pipe sizing for all other mechanical utility systems (generally pressure systems or with mechanical operation).
f. Where buildings are remote from available utilities, provide life-cycle cost analysis to justify utility system selection. (example: water well or propane vs natural gas). When building energy optimization is required, refer to Chapter 10 Energy & Sustainability.
g. Where project utilities are extensions of existing systems provide calculations that these are adequate for the additional load requirements.

7.4.1.1.2.4 Concept Fire Suppression Calculations

a. Preliminary hydraulic calculations for most hydraulically demanding area for each hazard classification to ensure flow and pressure requirements can be met with current water supply.
b. Fire flow test report.
c. Fire pump and storage tank calculations.
d. Calculations for all other fire suppression equipment/systems or mechanical fire protection equipment.

7.4.1.2 Concept Drawings

7.4.1.2.1 Concept HVAC Drawings

Heating, ventilating, and air conditioning equipment layout: chillers or refrigeration compressors, boilers, pumps, condensers or cooling tower, air handling units, fans, terminal units, air distribution duct layout (may be single line), hoods, ductless minisplit units, and other items of major equipment required for the facility. Show unique equipment tags/identifiers for each item of equipment.

7.4.1.2.2 Concept Plumbing Drawings

Plumbing fixture layout, floor and area drains, and plumbing equipment layout (hot water generator, storage tank, air compressors, etc.).

7.4.1.2.3 Concept Utilities Drawings

Indicate locations and sizes of outside utilities, high temperature water, steam, chilled water, and natural gas lines. Show same scale as other site work drawings. Show locations of fire department connections, hydrants, post indicator valves, exterior backflow preventers and meters, etc. Show locations of flow and test hydrants used for water flow tests. Show location and routing of lift stations and force mains. Show gas delivery pressure and capacity (cubic feet per hour) at the gas regulator.

7.4.1.2.4 Concept Fire Suppression Drawings

Prepare a plan for each floor of each building. Provide the following types of information:

a. The location and coverage of any fire suppression systems (fire pumps, storage tanks, sprinkler risers, standpipes, inspector test and drain, fire department connection, etc.).
b. The location of any other major fire suppression equipment.
   Examples: In-rack sprinkler systems, deluge systems, hose racks, etc.
c. Indicate all areas and their hazard classification.

7.4.1.2.5 Concept Enlarged Mechanical Room Plans

A large scale plan (1/2" = 1'-0" (1:20)) of the mechanical room(s) showing all equipment to be located therein including but not limited to HVAC, plumbing, and fire suppression system equipment. Examples: air handling units, pumps, boilers, expansion tanks, water heaters, sprinkler risers, etc. Ensure proper clearance between and around all equipment in mechanical room per appropriate codes/standards and manufacturers' recommendations keeping in mind filter, belt, valve, coil, damper and sensor maintenance/removal.

7.4.1.2.6 Legend

Provide a legend describing all symbology used in the drawings.

7.4.1.3 Concept Specifications

Provide a list of specifications to be used for the project.

7.4.2 PRELIMINARY/INTERIM (60-65%) DESIGN SUBMITTAL REQUIREMENTS

7.4.2.1 Interim Design Analysis

7.4.2.1.1 General

The Interim (60-65%) Design Submittal shall contain the information required for the Concept (30%) Design Analysis.

7.4.2.1.2 Interim Design Narratives

a. Increase detail in narratives from concept and update to reflect any design changes.
b. Identify all references to standard texts, handbooks, guidelines, etc., for all major design decisions or assumptions not otherwise covered by criteria references. Example: ASHRAE Handbooks.
c. Show manufacturer's make and model number of equipment used for layout purposes, and show weights of major items of equipment.
d. Include HVAC controls information. Include sequences of control narratives sufficient to describe generally how systems will operate. Detailed sequences not required for 60-65% Design. Example: Controls such as safties, economizer, setpoint resets, occupancy modes, unoccupied bypass, etc. shall be listed, but detailed written sequence not necessary.

e. Provide a detailed description of the Fire Suppression system and its controls such as activation of the system, interlocks with the HVAC system, and connection to detection and alarm systems. Provide detailed description of volumes and quantities of agents used for clean agent systems.
f. Provide a description of the high performance and sustainable features of the systems. Include description of features that provide positive benefit to energy/water conservation, indoor environmental quality, and materials and resource conservation to demonstrate compliance with UFC 1-200-02 and agency policies. Describe features used to satisfy LEED credit requirements, unless addressed elsewhere in the design analysis.

7.4.2.1.3 Calculations

Provide vendor information (cut sheets) for equipment selected for all systems and mark specific items on the vendor's literature indicating the intended features. Provide the following:

7.4.2.1.3.1 Interim Heating, Ventilation, and Air Conditioning Calculations

a. Update heaing and cooling load calculations and zone layout sketch to reflect any design changes or new information. Provide psychrometric analyses demonstrating the ability of the system to maintain required humidity/temperature conditions in spaces at both full and part-loads.
b. Submit a psychrometric plot of each air-conditioning, humidification, and dehumidification system clearly identifying all points in the process. List the sensible, latent, and total capacity requirements for the equipment accomplishing each process. Example: cooling coil, air washer, steam humidifier, etc.
c. Provide calculations for ventilation and exhaust quantities including a room-by-room inventory that includes the design number of occupants, room area, ventilation required per person and per floor area, ventilation/system effectiveness/efficiency, and adjustments for intermittent or variable occupancy, multiple spaces, etc.
d. Update and refine equipment/system calculations. Add calculations for equipment such as expansion tanks, louvers, VAV units, reheat coils, humidifiers, and other equipment. Any equipment with capacity determined and specificed for the project must have an associated calculation.
e. Provide expansion loop/joint calculations.
f. Provide air balance calculations addressing space/building pressurization.
g. Provide duct sizing calculations including flow quantities, air velocities, duct sizes, pressure drops, fitting losses, and total pressure loss. Provide fan flow rate and static pressure for fans and air handling units. Include consideration for system effect or dirty filters, as applicable, in calculations.
h. Provide air flow diagrams showing supply, return, relief, exhaust, ventilation, transfer, etc. air flows throughout the system. Include flow direction arrows and label equipment.
i. Provide hydronic system pipe and pump sizing calculations including flow quantities, velocity, pipe sizes, friction factors, pressure drops, lengths, and total pressure drop. Include flow diagrams in the analysis unless already shown on interim drawings. Include pump capacity and head calculations.

7.4.1.1.2.2 Interim Plumbing Calculations

a. Cold and hot water, sanitary, and vent pipe sizing calculations for branches out to isolated fixtures or to groups of fixtures.
b. Natural gas or propane equipment branch pipe sizing calculations.
c. Interior roof drainage pipe sizing calculations.
d. Update domestic hot water heating and storage equipment sizing calculations based on any design changes or new information.
e. Booster pump, sump pump, water softening, and all other water/sanitary system equipment sizing calculations.
f. Calculations for all other equipment/system main pipe sizing. Examples are compressed air or lubrication/oil systems.

g. Include flow quantities, pipe sizes, pressure drops, total pressure drop, and initial and final pressures.

7.4.1.1.2.3 Interim Utilities Calculations

a. Update exterior water, natural gas, lift station/force main, separator or interceptor, and any other equipment/system calculations based on any design changes or new information.
b. Provide any exterior chilled water, high or medium temperature hot water, or steam distribution system equipment and pipe sizing calculations.
c. Include flow quantities, pipe sizes, pressure drops, total pressure drop, and initial and final pressures.

7.4.1.1.2.4 Interim Fire Suppression Calculations

a. Update hydraulic calculations or other suppression system calculations based on any design changes or new information.

7.4.2.2 Interim Drawings

Show all information required for the Concept (30%) drawings but in greater detail. In addition, show the following:

7.4.2.2.1 Layout

Floor plan layouts showing the location of all items of mechanical equipment, piping, ductwork, and fixtures. Ductwork and piping may be shown as single line. Indicate pipe and duct sizes. Detailed piping schematic diagrams, details, sections, and elevations are not required for 60-65% design unless required to show intent of design.

7.4.2.2.2 Piping Plans

Floor plan layouts showing chilled water, heating hot water, steam, condensate drainage, domestic water, drainage and vent, gas, and liquid fuel distribution plan showing:

a. Location and size of distribution lines
b. If lines are in pits, show locations of pits and pit equipment. Pits should accommodate maintenance personnel and operations.
c. Except for enlarged mechanical room plan, HVAC systems will be on seprate plans from plumbing plans.
d. HVAC piping plans shall be separate from ductwork plans.
e. Condensate drainage piping may be shown on either plumbing or HVAC piping plans. Show or indicate location for termination of piping at drains or sinks.
f. Plumbing drainage and vent piping plans shall be separate from domestic water plans.

7.4.2.2.3 Interim Enlarged Mechanical Room Plans

Add piping and duct layouts to the enlarged mechanical room. Indicate space required for maintenance of equipment on the plans.

7.4.2.2.4 Interim Equipment Schedules

Provide equipment schedules filled out with what is known; schedules not required to be complete for 60-65% design. Comply with the following:

a. Show electrical characteristics in schedules. Coordinate electrical requirements with the electrical engineer.
b. Minimum efficiency shall be included in the equipment schedules (Examples: efficiency %, EER, COP, etc.). Include part-load efficiency for equipment operating a significant portion of run-time at less than design load. (Examples: IPLV and NPLV) Where the appropriate standards defining rating test conditions are not referenced by specifications or do not exist, indicate conditions at which the equipment meets the indicated efficiency.
c. For standard mechanical equipment, the salient features should be generic for at least three manufacturers to meet the requirements and specifications.

7.4.2.2.5 Plumbing Schedules

Plumbing fixture schedule listing individual fixtures and pipe size connections (cold water, hot water, and waste).

7.4.2.2.6 Fire Suppression

Prepare a schedule describing the system with the following information: fire hazard and occupancy classifications for each room or area of the building, building construction type, gpm/sf sprinkler density, area of operation, demand area, area of coverage/head, sprinkler spacing, and flow test results.

7.4.2.2.7 Other

Any information other than the requirements listed above which the engineer considers necessary to show the intent of design.

7.4.2.3 Interim Specifications

The outline specifications previously submitted with the 30-35% phase shall be revised, updated, further developed and resubmitted. Prepare outline specifications for mechanical work included in the project:

a. Where District or UFGS are to be used without change, a listing of the appropriate Guide specification numbers will suffice.
b. Where a departure or addition to a Guide specification is required, include in listing a brief description of the equipment or procedure constituting the departure or addition.
c. Where no Guide specification is available, prepare an outline specification from available criteria and instructions, giving all pertinent equipment and material characteristics.

7.4.3 FINAL (90%) DESIGN SUBMITTAL REQUIREMENTS

7.4.3.1 Final Design Analysis

7.4.3.1.1 General

The Final Design Analysis is a refinement of the 30-35% and/or 60-65% Design Analysis and contains all the information required for those sections of this chapter, even when Concept (30-35%) or Interim (60-65%) submittal is not required, as well as any analysis of significant design changes. Refer to additional requirements for design submittals in applicable Unified Facilities Criteria.

7.4.3.1.2 References

Show applicable references for design assumptions not found in common reference manuals which were not listed during the earlier design stage(s).

7.4.3.1.4 Final Calculations

Finalize the design of all systems, including calculations, and fully describe in narratives.

7.4.3.1.4 Hydronic Sizing Calculations

Update hydronic piping and pump sizing calculations. Include control valve Cv calculations.

7.4.3.1.5 Plumbing Analysis

Include plumbing piping diagrams. The water and sanitary plumbing piping analysis shall clearly show the main and branch loads in terms of "fixture units" as well as flow quantities.

7.4.3.1.7 Fire Suppression

Include the following:
a. Any applicable zoning information.
b. Size of all riser pipes, including for wet and dry pipes, sprinkler valves, mains, and principle branchs based on hydraulic calculations and available water supply. Verify no conflicts exist with other systems.

7.4.3.1.8 Checking

All computations must be checked. A registered professional engineer must perform or check the computations.

7.4.3.1.9 Engineering Considerations

Provide "Engineering Considerations for Field Personnel" as necessary for mechanical aspects of the construction. Considerations should address critical submittals, list submittals of particular importance for AE review, special inspections or tests for systems, unusual features of the systems, utility coordination issues, permitting, or other information that could mitigate risk during construction. Include the name of the designated Govenrment Commissioning Specialist with contact information.

7.4.3.2 Final Drawings

Final plans are refinements of the 30-35% and 60-65% drawings and add additional detail. Unified Facilities Criteria (UFC) shall not be referenced from the drawings or specifications except as approved by USACE; all requirements for the project shall be fully designed and reflected in the drawings. Refer to additional requirements for design submittals in applicable Unified Facilities Criteria. In addition, show the following:

7.4.3.2.1 Avoid Listing Basis of Design or Sole-Source

Drawing requirements for equipment must not be restrictive or proprietary. At least three manufacturers must be able to meet the specified requirements. Avoid reliance on naming specific equipment make/models to require features, performance, or quality. Do not list manufacturer products. Where deviation is necessary, coordinate with PE/A for exception.

7.4.3.2.1 Sections and Elevations

Show sufficient sections and elevations to clearly indicate the exact location of the particular item in relation to other building components or equipment. Sections shall demonstrate that mechanical items and other building features have no critical interferences. Provide at least one section through the mechanical room and two sections for complex, congested mechanical rooms. The number of sections and elevations must be sufficient to allow construction and installation of work without additional design work by the AE or construction contractor. Examples: mechanical rooms, duct/piping crossovers, wall-mounted ducts in hangars, etc.

7.4.3.2.2 Risers and Isometric Views

Show isometric riser diagrams for domestic water, drainage and vent, gas, compressed air and other piping systems. Show all piping sizes, valves, water hammer arrestors, etc.

When using BIM, provide an isometric view of the mechanical equipment rooms. Label all equipment in the mechanical equipment room isometric; sizes and other notes not required. Indicate that the isometric is for information only.

7.4.3.2.3 Details

The number of details must be sufficient to allow construction and installation of the work without additional design work by the AE or construction contractor. In addition, show the following:

a. Show structural supports for all ceiling or roof-mounted equipment.
b. Show roof mounted equipment installation details sufficient to avoid water leakage and limit air leakage.
c. Show condensate drain details for cooling equipment including depth of trap and slope from drain pan.
d. Air vent indicating drainage location. Indicate requirements for locating at system and at all local high points.
e. Show make-up water to hydronic systems including all accessories such as pressure reducing/regulating valves, relief valves, backflow preventers and check valves, and isolation valves. Show settings for pressure reducing or regulating valve and relief valve. Coordinate settings with expansion tank pressure.
f. Detail any catwalks, ladders, platforms, and access panels required for maintenance access.

7.4.3.2.4 Accessories

Where equipment connection details are shown, indicate all required valves, gages, and fittings required. Coordinate with specification requirements and ensure that valves, fittings, etc., that are specified to be furnished with each piece of equipment are included in the detail.

7.4.3.2.4 Hydronic System Schematic

Provide a schematic representing the hydronic system showing all main equipment such as pumps, heat exchangers, boilers, chillers, cooling towers, wellfields, air separators, expansion tanks, buffer tanks, make-up water system, chemical feeder, and glycol tank/systems. Show all isolation valves, balancing valves, check valves, relief valves, pressure reducing valves, strainers, flexible pipe connections, temperature and pressure gauges, air vents, drains, and all other valves and devices. Indicate flow direction.

7.4.3.2.5 Plans

Final plans must show all equipment, pipe, and ducts. Show all pipe and duct sizes.

a. Draw ductwork to scale on plans and indicate duct pressure class.
b. Add anticipated grading of lines (direction and rate of slope) to hydronic, steam, compressed air, sanitary, condensate or any other piping system that will require ability to drain.

c. Add locations and sizes of expansion loops or joints and anchors to hydronic systems.
d. Show locations for sensors; Examples: Differential pressure, thermostats, humidistats, CO2 sensors, etc.
e. Show locations for HVAC emergency shutdown switch and boiler emergency shutdown switch.
f. Show locations of control panels, variable frequency drives, etc.
g. Label thermostats to clearly indicated associated equipment.
h. The air suction and discharge directions of such items as louvers, wall-mounted grilles/diffusers, fans, air-cooled condensers, and cooling towers shall be indicated on the drawings.
i. Show catwalks, ladders, platforms, access panels, and doors required for operation and maintenance of equipment, valves, and accessories.
j. Show all locations of isolation valves, turning vanes, and all volume, fire, and smoke dampers.
k. Show locations of access panels and doors in walls, floors, and ceilings (except lay-in ceilings). Show sizes.
l. On mechanical equipment room plans, clearly indicate by dotted lines, the space required for equipment maintenance. Example: filter replacement, coil replacement, and "tube pulling" on such items as boilers, chillers, condensers, etc. Allow sufficient room for maintenance, coil removal, filter removal, etc., on each piece of equipment.
m. Provide additional enlarged plans for congested areas.

7.4.3.2.6 Final Equipment Schedules

Finalize and update equipment schedules:
a. Place performance characteristics for all items of mechanical equipment in carefully prepared equipment schedules.
b. Equipment characteristics selected shall not be restrictive to anyone manufacturer but must be competitive among at least three major manufacturers. Performance characteristics shall be minimums or maximums for proper system operation and shall not be based solely on a single vendor’s equipment.
c. Ensure required performance characteristics and features of equipment are fully described.

7.4.3.2.7 Ventilation Schedule

Provide a ventilation schedule showing, for each breathing zone, the total supply air flow rate, ventilation air flow rate, and the number of anticipated occupants. Indicate that the schedule is for information purposes only.

7.4.3.2.8 Duct Construction Classifications and Testing Schedule

In accordance with UFC 3-410-01, provide a completed Ductwork Construction and Leakage Testing Table and indicate duct static pressure, seal and leakage classifications, test type and test pressures.

7.4.3.2.8 HVAC and Plumbing Controls

HVAC control drawings shall include every mode of operation, sequence of operation, interlock, safety, etc. to fully describe system operation for all equipment. Include plumbing or other systems that will be included in the control systems. Packaged equipment internal controls are not required to be described in detail; however, all elements of operation related to the equipment and interaction w/ other parts of the systems must be described. Example: describe when dampers are open or closed, unit start/stop, unit status, conditions maintained by the unit, etc. for an energy recovery unit. Controls sequences must be also be detailed enough for the reviewer to fully understand design intent. Final controls plans shall included:

a. Legend/Symbols defining all symbology.
b. Schematic for each unique item of equipment/system including all sensors, dampers, valves, and other control devices. Show failure positions of dampers and valves (normally open, normally closed, etc.).

c. Written sequences of operation for each item of equipment/system. Include point name within the sequence coordinated with the Point Schedule.
d. Points Schedule indicating point name, setpoints, control/operating ranges, overrides, alarms, UMCS monitor/control points, etc.
e. Description of system architecture including a diagram of the building level and EMCS controls, alarm handling and system scheduling information, and system integration requirements.
f. For critical control sequences or when necessary to clarify complicated control sequences, logic and ladder diagrams with point names coordinated with the Points Schedule.
g. Control valve schedule showing identifier, location, function, type (2-way/3-way, modulating/2-position, etc.), current range, minimum Cv, and close-off rating (or minimum torque).
h. Control damper schedule showing identifier, location, function, type (modulating/2-position, etc.), current range, size, and opposed or parallel blade.
i. Room sensor schedules showing locations, unit served, and features such as unoccupied override, occupancy sensors, etc.
j. Occupancy schedule showing initial times for occupied and unoccupied mode.
k. All labeling for devices and equipment must be consistent across all drawings including equipment schedules, details, plans, schematic diagrams, sequences of operation, point schedules, etc.
l. Provide sequences of operation for plumbing equipment such as water heaters, recirculating systems, solar hot water heating systems, pressure booster systems, etc. Include control and monitoring points on building automation system control point schedules. Coordinate with HVAC Controls.
m. Include any additional information in the drawings in accordance with UFC 3-410-02.

7.4.3.2.9 Fire Suppression

Label fire protection drawings "PRELIMINARY", and provide flow test and results, densities, demand area, areas protected, hazard classification of all areas, sprinkler head coverage, zoning requirements, building entrances, exact control system locations (must include all locations if shown), and device locations. Anything shown must be correct as to numbers and approximate as to locations and sizes for "non-critical projects". Unified Facilities Criteria (UFC) shall not be referenced; all requirements for the project shall be explicitly shown or described in the plans.

7.4.3.3 Final Specifications

7.4.3.3.1 General

Provide original final project specifications.
a. Read and comply with the hidden specifier notes included in the UFGS or LRL .sec files with respect to editing the specification sections.
b. Apply tailoring options using SpecsIntact as appropriate for the project and using service.
c. Unified Facilities Criteria (UFC) shall not be referenced; all requirements for the project shall be explicitly described in the specifications.
d. Request for exceptions may be routed to the LDMDG Mechanical Chapter proponent through the USACE PE/A. Only special circumstances warrant deviation.

7.4.3.3.2 Equipment Designations

The nature of the UFGS system level specifications makes it difficult to associate items of equipment with the applicable specification sections or paragraphs. In the Products part of specification section, add equipment identifiers to paragraph titles or elsewhere to clearly associate equipment to its specification requirements.

7.4.3.3.3 Avoid Listing Basis of Design or Sole-Source

Specifications must not be restrictive or proprietary. The description will be such that at least three manufacturers can meet the specified requirements. Specifications shall be adequate to maintain quality of product and installation without reliance on naming specific equipment make/models. Do not list manufacture products. Where deviation is necessary, coordinate with PE/A for exception.

7.4.3.3.4 Components

Give particular care to the compatibility of components. For example, the burner requirements should suit the boiler; the combustion controls should suit the type of burner selected.

7.4.3.3.5 Coordination with Drawings

Ensure that equipment and systems are fully specified through combination of drawings and specifications. Avoid duplicating requirements and conflicts. Where a specification references drawings, the drawings should reflect the items indicated. Example: Specification states, “Access doors where shown.” Drawings should show access door locations.

7.4.3.3. Submittal Register

Ensure that all appropriate submittals are correctly marked for Government Approval and approving office in the submittal register. Tthe designer of record should review the following; mark “AE” for approving office:

a. Major items of equipment which include fans, coils, air handling units, pumps, heat generation (ex: boilers), cooling plant (ex: chillers), etc.
b. Extensions of design. Examples: fire suppression design, DDC controls contractor design, in-floor radiant systems, etc.
c. Testing, Adjusting, and Balancing (TAB) procedures and reports.
d. Commissioning Plans and Reports.

7.4.4 CORRECTED FINAL DESIGN SUBMITTAL REQUIREMENTS

Update design submittals based on resolutions to Final design review comments or to address customer changes.

7.5 DESIGN/TECHNICAL REQUIREMENTS

7.5.1 BASIS OF DESIGN

Avoid designing based on a single manufacturer’s product. Multiple manufacturers must be able to compete to provide specified equipment. During design, verify that at least three manufacturer’s provide equipment meeting specified requirements within the space available. Develop a justification and obtain approval through the PE/A for any equipment or system that must come from a single source.

7.5.2 INSTALLATION

Ensure that systems will be installed in accordance with manufacturer’s installation requirements and recommendations and accommodate manufacturer required or recommended service or maintenance clearances. Sufficient space shall be provided to allow for changing filters, cleaning or removing coils, and other operations as required to maintain the systems. Mechanical or equipment room layouts shall facilitate ease of maintenance. Bottom of suspended ductwork, piping, and equipment located in mechanical or equipment rooms shall not be lower than 6 feet above finished floor where possible.

Means shall be provided for access to equipment for maintenance without damage to other building components including ladders, catwalks, or platforms as necessary. Maintenance access shall be fixed and shall not require the use of cranes or lifts. For example: Heating and Ventilating Units suspended from the roof structure in a maintenance bay shall have grated catwalks and platforms to facilitate maintenance without the use of a lift. With the approval of the using agency, in writing, indicating that use of cranes or lifts for maintenance access is acceptable, this requirement may be excepted.

Components on suspended equipment that require maintenance shall be easily maintained, repaired, or replaced from the access point. For example: Variable Air Volume terminal units and Air Handling Units suspended above ceilings should have all components within reach of a service technician from the point of access. Access doors shall be provided for access to all components requiring inspection, cleaning, or removal. Means shall be provided to allow maintenance staff to easily and quickly find above-ceiling or otherwise hidden equipment or other system components requiring maintenance or replacement.

System installation and building construction shall be coordinated to allow replacement of equipment without damage to systems or building components.

Conceal all piping and ductwork in occupied areas of all buildings, except storage or service facilities. Minimize roof penetrations where possible.

7.5.3 NOISE/VIBRATION

Design to control noise and vibration in accordance with applicable UFC and ASHRAE Handbooks.

7.5.4 SEISMIC PROTECTION

Earthquake resistant ("seismic") design of nonstructural systems and components shall be in accordance with the applicable UFC, references within the UFC, and facility specific requirements.

7.5.5 SYSTEM SELECTION

Refer to Chapter 10 Sustainable Design & Energy Conservation for building energy optimization requirements. Identify several appropriate HVAC system alternatives for the project. HVAC alternatives must be technically feasible, meet design criteria, be appropriate to the climate and application, and be based on building heating and cooling loads. In the event limited reasonable alternatives are available for comparison or other reasons exist that preclude several alternative systems, develop a justification and pursue an exception through the project PE/A. Do not analyze inappropriate alternatives for analysis.

Along with compliance with energy conservation criteria, HVAC system shall be selected to function to meet project requirements and minimum design criteria while considering maintainability. HVAC system selection shall occur prior to submission of Concept Design Submittal or Charrette Document. Coordinate approval for selected HVAC systems with the PE/A. Concept Energy Modeling and Life Cycle Cost Analyses shall be performed and provided to evaluate the HVAC system alternatives a part of the basis for system selection.

7.5.6 HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

7.5.6.1 Design Conditions

Design Conditions shall be in accordance with applicable UFC and specific customer requirements. In case of conflict, UFC govern. In addition to design temperatures and humidity consider acceptable air velocities, radiant temperatures, and temperature and humidity drifts or ramps. Comply with the latest version of ASHRAE Standard 55. The maximum allowed space relative humidity drift within a 15 minute period is 3% and within a 30 minute period is 4%. Perform a psychrometric analysis showing that design conditions,

including humidity, are maintained during part-load cooling conditions. Designer shall design and select appropriate systems for climate zone of project. This includes proper treatment of ventilation air in humid climates.
At part-load conditions, systems including constant-volume air flow or DX may have difficulty maintaining space humidity conditions while delivering the required ventilation air flow. DX systems need sufficient capacity control to be able to unload to match part-load conditions sufficiently to prevent increase of space humidity beyond the acceptable range. Rather than use constant-volume air flow systems for single zones, consider the use of variable-volume systems instead.

7.5.6.2 Year-Round Cooling Requirements

If an air conditioning system serves areas having high internal heat gains, consider year-round cooling requirements and design the system accordingly. Include provisions for low ambient operation of air-cooled equipment, use of glycol, cycling of water pumps, the use of an outside air economizer cycle, or other strategies as appropriate.

7.5.6.3 Redundancy

Hydronic heating systems and ground and water source heat pump systems shall include at least two pumps for the building circuit. If the ground source heat pump system includes ground well circuit in addition to the building circuit, two pumps shall be provided for the ground well circuit. With a single pump off-line, the remaining pump(s) shall be capable of providing not less than 65% of the design maximum system flow rate. Hydronic heating systems that include heating only from boiler shall include at least two boilers. With a single boiler off-line, the remaining boiler(s) shall be capable of providing not less than 65% of the maximum winter design load.

7.5.6.4 Coil Freeze Protection

Design to avoid potential water or glycol coil freeze or burst conditions and nuisance temperature low-limit alarm operations. Ensure outdoor air and return air streams are well-mixed upstream of coils, provide preheat or energy recovery, etc. as appropriate.

7.5.6.5 Boiler System Design

Consider part-load heating conditions in the design of boiler systems and optimize energy conservation and life of equipment. Consider using multiple boilers. Example: Use a smaller boiler during normal part-load operation and use a larger boiler when higher loads are required.

7.5.6.6 Variable Refrigerant Flow (VRF) Systems

VRF systems shall conform to Buy American Act and other applicable trade agreement requirements. For design-bid-build projects, the AE must show, prior to solicitation, that there are at least two vendors capable of meeting the design requirements and meet the Buy American Act. This may require a component listing w/ country of manufacture. Coordinate with USACE PE/A.

Ensure compliance with UFC 3-410-01 and ASHRAE Standard 15.

7.5.6.7 HVAC Controls

HVAC Controls shall be designed in accordance with applicable UFC and customer requirements. Direct Digital Control system shall be used unless renovating an existing building w/ mechanical controls. Example: Existing building using pneumatic controls.

The DDC control system shall be a single complete non-proprietary system. The system shall be open in that it is designed and installed such that the Government or its agents are able to repair, replace, upgrade, or expand the system without further dependence on the original contractor. DDC controls systems shall use open-protocols (BACNet or LONWorks) in accordance with operator (DPW, RSC, BCE, etc.) requirements.

7.5.6.8 Utility Monitoring and Control Systems (EMCS)

Determine the requirements for UMCS integration from applicable UFC, the using service, and project PE/A as appropriate.

7.5.7 PLUMBING/UTILITIES

7.5.7.1 Chemical Treatment

When a potable water supply is connected with a system such as heating system, chilled water system or cooling tower which is equipped with chemical treatment, provide a positive break such as an air gap or reduced pressure type backflow-prevention device. The positive break should occur between the potable water supply and the system. If the water in such systems is not to be chemically treated, then specify reduced pressure backflow prevention.

7.5.7.2 Expansive Soils

Design piping systems in expansive soils as appropriate.

7.5.7.3 Cathodic Protection

Cathodic protection is required on all underground waterlines and gas lines in areas defined in UFC 3-570-02A, Cathodic Protection. Cathodic protection is also required for all tanks and piping containing environmentally hazardous materials (i.e., fuel, oil, POL, etc.). Provide cathodic protection to protect tanks and piping in all other areas for which life cycle cost studies justify such an installation

7.5.8 FIRE SUPPRESSION

Plans developed for sprinkler systems are of the preliminary layout type. Sprinkler plans are to be a guide for subsequent preparation by the construction contractor of detailed working drawings which will be coordinated with requirements required by the preliminary plans. Show details for risers, fire department connections, flow test results, design conditions, and coverage in the contract documents. However, do not show sprinkler head locations, branch and pipe lateral sizes.

ATTACHMENT A

LESSONS LEARNED CHECKLISTS

USACE-LRL MECHANICAL LESSONS LEARNED CHECKLIST
DESIGN-BID-BUILD

P2 Number:

Project Name:

Design Submittal: [Concept][Interim][Final][Corrected Final]

Designer:

Checker:

Verify that the following lessons learned have been considered and addressed within the project design. Items that have been considered and/or incorporated will be identified with the designer's initials in the blank. Submit the checklist with EACH design submittal. Where inapplicable, identify N/A.

Energy Conservation:

____ **Energy Optimization Alternatives Approval:** Verify that all building features and systems included in energy optimization/LCCA are approved by USACE and stakeholders prior to beginning the analyses to avoid lost effort, ensure sufficient variation in proposed alternatives, and to address stakeholder preferences (to extent possible).

____ **Energy Conservation Analysis:** Verify that energy conservation analyses are prepared and provided in compliance with UFC 1-200-02, ER 1110-1-8173, and the Louisville District Military Design Guide.

General:

____ **(Design-Bid-Build Only) Sole-Source:** Ensure that systems are not designed based on only a single manufacturer's products. Designs must accommodate multiple manufacturers' products to avoid sole-source violations. Further, some design elements may be impacted by construction contractor selected products. Where absolutely necessary**,** an extension of design may be necessary where elements of the design are impacted by final product selection.

____ **System Complexity:** Verify that the system design complexity is limited to the absolute minimum necessary to comply with all regulations, codes, standards, and design criteria. In accordance with Louisville District Military Design Guide and/or AE task order scope of work, alternatives for energy optimization analysis have been approved by USACE.

____ **Noise/Vibration:** Verify compliance with UFC 3-450-01 Noise and Vibration Control and ASHRAE Applications Handbook Chapter – Noise and Vibration Control. Ensure any space whose function could be impaired by excessive noise is addressed in space location and HVAC design. Use appropriate vibration isolation, duct configuration, sound attenuating devices or equipment, etc. as necessary to limit risk of excessive noise. Include sound testing in TAB specification section for rooms at risk.

____ **Environmental Severity/Humid Locations:** Verify compliance with UFC 3-410-01 requirements related to environmental severity and humid locations. Specific environmental classification or climate zones require corrosion resistance measures and equipment locations. Examples: high-humidity or marine climates and areas prone to hurricanes and typhoons.

____ **Occupancy Schedules:** Verify that controls design drawings provide an initial occupancy schedule for set-up during construction. Occupancy schedules are not always modified immediately by operating staff and should not be permitted to run in 24/7 operation unless required by building function.

____ **Buy American Act/ Free Trade Agreements:** Verify that the design does not require equipment or items that would violate the Buy American Act or any applicable Free Trade Agreements. Confirm with USACE PE/A the applicable rules for the project. The specific rules/regulation, agreements, acceptable countries, exceptions, etc. depend on construction cost and other factors. The design must accommodate equipment from multiple manufacturers that comply with the BAA/FTAs.

____ **Brand Name**: Avoid using brand names in projects where possible. If absolutely required to indicate brand name, coordinate with USACE PE/A for required justification and approval to apply to ALL such items/equipment in the project. Regardless of the use of brand name, all required features and performance must be specified in the project design drawings and specifications.

Humidity/Moisture:

____ **Ventilation Dehumidification:** Verify compliance with UFC 3-410-01 relative to ventilation humidity control. Particularly for systems using zone level conditioning equipment, use of a DOAS for ventilation treatment is required. Generally, good practice is to ensure that dewpoint temperature of supply from any equipment handling ventilation air is MAINTAINED at conditions necessary to maintain indoor design humidity conditions. Dewpoint temperature of supply air from equipment handling ventilation air must never be above 55 F in any case.

____ **Equipment Selection**: When using DOAS or Air Handling Units using DX or Heat Pump technology for cooling and dehumidification of ventilation air, verify that appropriate equipment and control is selected. Zone level fan coil units, heat pumps, mini-split units, etc. are not appropriate for conditioning ventilation air. Equipment that will cycle cooling on and off may not be sufficient for ventilation humidity control. Variable speed compressors, refrigerant bypass, hot-gas reheat, energy/dessicant recovery, and other means may be necessary to ensure ventilation air supply is maintained at appropriate conditions. Refer to UFC 3-410-01 for agency specific requirements.

____ **Pychrometric Analysis:** Verify that psychrometric analysis is performed for full-load condition and worst-case part-load conditions to ensure that the systems designed/constructed will maintain required space humidity levels.

____ **Moisture Control Plan:** Verify that the moisture control plan required by UFC 1-200-02 has been provided.

____ **Pipe/Duct Locations & DALT:** Avoid running cold ducts and pipes through unconditioned space to the extent possible. All ductwork is required to undergo duct air leakage testing IAW UFC 3-410-01; this is particularly important when ductwork runs through spaces prone to elevated humidity. Avoid using exterior ductwork except where absolutely necessary.

____ **Insulation:** Verify that appropriate insulation type and thickness has been specified for any equipment or duct/piping that is located in space where the dewpoint temperature of the air is above the temperature of the equipment or duct/pipe at any time in normal operation or unoccupied modes. Use additional insulation beyond the criteria/standard minimum standards, if necessary to preclude condensation.

____ **Occupancy**: Verify with the stakeholders the intended occupancy pattern for the facility. Consider potential low-occupancy periods in addition to normal operation occupancy. Example: For Army Reserve Centers, there are often a few full-time occupants during the week and a very high number of occupants on drill weekends. At times, occupancy can range in between these extremes; this must be considered.

____ **Humidity Sensors:** Include humidity sensors in representative or critical spaces for monitoring purposes and integrate with the building automation system.

Variable Air Volume Systems:

____ **Warm Air Stratification:** For spaces served by reheat VAV units, verify that the combination of discharge air temperature, heating air flows, and controls will prevent stratification in the space or other measures are

implemented to address (destratification fans or other). High ceiling spaces are at higher risk for this issue. Comply with ASHRAE 90.1 simultaneous heating and cooling and discharge temperature limit restrictions.

____ **Low Water Flow at VAV Reheat Coils:** For reheat VAV units, verify that the reheat coil capacity is sufficient to handle both space heating loads and the load required to raise primary/supply air temperature to room neutral space temperature. Verify coil selection is appropriate for the water flow rates specified in design.

Renovation/Rehabilitation - Existing System Investigation: For projects involving reuse of existing systems, perform the following actions. Determine and address impacts to design and whether additional work must be performed:

____ **Validate As-Builts:** Verify accuracy of as-built documents and modify as necessary.

____ **Review Facility Maintenance Records:** Review for trends or indicators associated with system deficiencies or failures.

____ **Interview O&M Staff:** Determine system deficiencies/failures and condition of systems/equipment.

____ **Existing Systems Inspection/Testing:** Perform inspection and testing of existing systems to validate or baseline current performance and condition. As a last resort, when unable to perform this within the schedule, require the construction contractor to perform inspection/testing with Government witness. Deferring this step requires written concurrence from the USACE Project Manager with all risks correctly identified in the associated correspondence.

____ **Existing Capacity:** When reusing existing equipment, verify existing capacity against new demand. Include tables in design analyses to demonstrate.

____ **Hydronic System Flushing:** When reusing existing hydronic systems, require flushing of the entire connected system and provide new water treatment for the system.

USACE-LRL MECHANICAL LESSONS LEARNED CHECKLIST
DESIGN-BUILD REQUEST FOR PROPOSAL

P2 Number:

Project Name:

Design Submittal: [Charrette Document][Draft][Final][Corrected Final]

RFP Preparer:

Checker:

Verify that the following lessons learned have been considered and addressed within the project design-build RFP. Submit the checklist with EACH milestone submittal. Where inapplicable, identify N/A.

In addition to addressing the below requirements as a part of preparing the design-build RFP, ensure the USACE-LRL Mechanical Lessons Learned Checklist for Design-Build Post-Award Design Submittals (follows this form) is included, in the RFP, as a required part of design submissions with instructions for completion.

Energy Conservation:

____ **Energy Optimization Alternatives Approval:** Verify that all building features and systems included in energy optimization/LCCA are approved by USACE and stakeholders prior to beginning the analyses to avoid lost effort, ensure sufficient variation in proposed alternatives, and to address stakeholder preferences (to extent possible).

____ **Energy Conservation Analysis:** Verify that energy conservation analyses are prepared and provided in compliance with UFC 1-200-02, ER 1110-1-8173, and the Louisville District Military Design Guide.

General:

____ **Sole-Source:** Ensure that project RFP language does not restrict systems to only a single manufacturer's products. Solicitation/contract requirements must accommodate multiple manufacturers' products to avoid sole-source violations.

____ **System Complexity:** For prescribed systems, verify that system complexity is limited to the absolute minimum necessary to comply with all regulations, codes, standards, and design criteria. In accordance with Louisville District Military Design Guide and/or AE task order scope of work, verify alternatives for energy optimization analysis have been approved by USACE.

____ **Noise/Vibration:** Verify solicitation/contract requires compliance with UFC 3-450-01 Noise and Vibration Control and ASHRAE Applications Handbook Chapter – Noise and Vibration Control. Ensure any space whose function could be impaired by excessive noise has specified noise criteria. Include sound testing in TAB specification section or paragraphs for rooms at risk.

____ **Environmental Severity/Humid Locations:** Verify compliance with UFC 3-410-01 requirements related to environmental severity and humid locations. Specific environmental classification or climate zones require corrosion resistance measures and equipment locations. Where applicable, indicate the zone in the solicitation package. Examples: high-humidity or marine climates and areas prone to hurricanes and typhoons.

____ **Occupancy Schedules:** Ensure that solicitation package requires that controls design drawings are required to provide an initial occupancy schedule for set-up during construction. Occupancy schedules are not always

modified immediately by operating staff and should not be permitted to run in 24/7 operation unless required by building function.

____ **Buy American Act/ Free Trade Agreements:** Verify that the solicitation/contract requirements do not require equipment or items that would violate the Buy American Act or any applicable Free Trade Agreements. Confirm with USACE PE/A the applicable rules for the project. The specific rules/regulation, agreements, acceptable countries, exceptions, etc. depend on construction cost and other factors. The design must accommodate equipment from multiple manufacturers that comply with the BAA/FTAs.

____ **Brand Name**: Avoid using brand names in the solicitation package where possible. If absolutely required to indicate brand name, coordinate with USACE PE/A for required justification and approval to apply to ALL such items/equipment in the project. Regardless of the use of brand name, all required features and performance must be specified in the project design drawings and specifications.

Humidity/Moisture (All the following must be fully covered by the solicitation/contract requirements; direct and clear language regarding these issues is recommended):

____ **Ventilation Dehumidification:** Ensure solicitation/contract language requires compliance with UFC 3-410-01 relative to ventilation humidity control. Particularly for systems using zone level conditioning equipment, use of a DOAS for ventilation treatment is required. Generally, good practice is to ensure that dewpoint temperature of supply from any equipment handling ventilation air is MAINTAINED at a conditions necessary to maintain indoor design humidity conditions. Dewpoint temperature of supply air from equipment handling ventilation air must never be above 55 F. Verify language in the solicitation package addresses this.

____ **Equipment Selection**: When using DOAS or Air Handling Units using DX or Heat Pump technology for cooling and dehumidification of ventilation air, verify that appropriate equipment and control is selected. Zone level fan coil units, heat pumps, mini-split units, etc. are not appropriate for conditioning ventilation air. Equipment that will cycle cooling on and off may not be sufficient for ventilation humidity control. Variable speed compressors, refrigerant bypass, hot-gas reheat, energy/dessicant recovery, and other means may be necessary to ensure ventilation air supply is maintained at appropriate conditions. Verify language in the solicitation package addresses this.

____ **Pychrometric Analysis:** Verify that psychrometric analysis is performed for full-load condition and worst-case part-load conditions to ensure that the systems designed/constructed will maintain required space humidity levels. Verify language in the solicitation package addresses this.

____ **Moisture Control Plan:** Verify that the moisture control plan required by UFC 1-200-02 has been provided. Verify language in the solicitation package addresses this.

____ **Pipe/Duct Locations & DALT:** Avoid running cold ducts and pipes through unconditioned space to the extent possible. All ductwork is required to undergo duct air leakage testing IAW UFC 3-410-01; this is particularly important when ductwork runs through spaces prone to elevated humidity. Do not allow exterior ductwork unless absoluty necessary. Verify language in the solicitation package addresses this.

____ **Insulation:** Verify that appropriate insulation type and thickness has been specified for any equipment or duct/piping that is located in space where the dewpoint temperature of the air is above the temperature of the equipment or duct/pipe at any time in normal operation or unoccupied modes. Use additional insulation beyond the criteria/standard minimum standards, if necessary to preclude condensation. Verify language in the solicitation package addresses this.

____ **Occupancy**: Verify with the stakeholders the intended occupancy pattern for the facility. Consider potential low-occupancy periods in addition to normal operation occupancy. Example: For Army Reserve Centers, there are often a few full-time occupants during the week and a very high number of occupants on drill weekends. At times, occupancy can range in between these extremes; this must be considered. Verify language in the solicitation package addresses this.

____ **Humidity Sensors:** Include humidity sensors in representative or critical spaces for monitoring purposes and integrate with the building automation system. Verify language in the solicitation package addresses this.

Renovation/Rehabilitation - Existing System Investigation: For projects involving reuse of existing systems, perform the following actions. Determine and address impacts to design and whether additional work must be performed:

____ **Validate As-Builts:** Verify accuracy of as-built documents and modify as necessary.

____ **Review Facility Maintenance Records:** Review for trends or indicators associated with system deficiencies or failures.

____ **Interview O&M Staff:** Determine system deficiencies/failures and condition of systems/equipment.

____ **Existing Systems Inspection/Testing:** Perform inspection and testing of existing systems to validate or baseline current performance and condition. As a last resort, when unable to perform this within the schedule, require the construction contractor to perform inspection/testing with Government witness. Deferring this step requires written concurrence from the USACE Project Manager with all risks correctly identified in the associated correspondence.

____ **Existing Capacity:** When reusing existing equipment, verify existing capacity against new demand. Include tables in design analyses to demonstrate.

____ **Hydronic System Flushing:** When reusing existing hydronic systems, require flushing of the entire connected system and provide new water treatment for system.

USACE-LRL MECHANICAL LESSONS LEARNED CHECKLIST
DESIGN-BUILD POST-AWARD DESIGN SUBMITTALS

P2 Number:

Project Name:

Design Submittal: [Concept][Interim][Final][Corrected Final]

Designer:

Checker:

Verify that the following lessons learned have been considered and addressed within the project design. Items that have been considered and/or incorporated will be identified with the designer's initials in the blank. Submit the checklist with EACH design submittal. Where inapplicable, identify N/A. Include with the design analyses for each submittal.

General:

____ **System Complexity:** Verify that the system design complexity is limited to the absolute minimum necessary to comply with all regulations, codes, standards, and design criteria.

____ **Noise/Vibration:** Verify compliance with UFC 3-450-01 Noise and Vibration Control and ASHRAE Applications Handbook Chapter – Noise and Vibration Control. Ensure any space whose function could be impaired by excessive noise is addressed in space location and HVAC design. Use appropriate vibration isolation, duct configuration, sound attenuating devices or equipment, etc. as necessary to limit risk of excessive noise. Include sound testing in TAB specification section for rooms at risk.

____ **Environmental Severity/Humid Locations:** Verify compliance with UFC 3-410-01 requirements related to environmental severity and humid locations. Specific environmental classification or climate zones require corrosion resistance measures and equipment locations. Examples: high-humidity or marine climates and areas prone to hurricanes and typhoons.

____ **Occupancy Schedules:** Verify that controls design drawings provide an initial occupancy schedule for set-up during construction. Occupancy schedules are not always modified immediately by operating staff and should not be permitted to run in 24/7 operation unless required by building function.

____ **Buy American Act/ Free Trade Agreements:** Verify that the design does not require equipment or items that would violate the Buy American Act or any applicable Free Trade Agreements. Confirm with USACE the applicable rules for the project. The specific rules/regulation, agreements, acceptable countries, exceptions, etc. depend on construction cost and other factors.

Humidity/Moisture:

____ **Ventilation Dehumidification:** Verify compliance with UFC 3-410-01 relative to ventilation humidity control. Particularly for systems using zone level conditioning equipment, use of a DOAS for ventilation treatment is required. Generally, good practice is to ensure that dewpoint temperature of supply from any equipment handling ventilation air is MAINTAINED at a conditions necessary to maintain indoor design humidity conditions. Dewpoint temperature of supply air from equipment handling ventilation air must never be above 55 F.

____ **Equipment Selection**: When using DOAS or Air Handling Units using DX or Heat Pump technology for cooling and dehumidification of ventilation air, verify that appropriate equipment and control is selected. Zone level fan coil units, heat pumps, mini-split units, etc. are not appropriate for conditioning ventilation air. Equipment that will cycle cooling on and off may not be sufficient for ventilation humidity control. Variable speed compressors,

refrigerant bypass, hot-gas reheat, energy/dessicant recovery, and other means may be necessary to ensure ventilation air supply is maintained at appropriate conditions.

____ **Pychrometric Analysis:** Verify that psychrometric analysis is performed for full-load condition and worst-case part-load conditions to ensure that the systems designed/constructed will maintain required space humidity levels.

____ **Moisture Control Plan:** Verify that the moisture control plan required by UFC 1-200-02 has been provided.

____ **Pipe/Duct Locations & DALT:** Avoid running cold ducts and pipes through unconditioned space to the extent possible. All ductwork is required to undergo duct air leakage testing IAW UFC 3-410-01; this is particularly important when ductwork runs through spaces prone to elevated humidity. Avoid exterior ductwork.

____ **Insulation:** Verify that appropriate insulation type and thickness has been specified for any equipment or duct/piping that is located in space where the dewpoint temperature of the air is above the temperature of the equipment or duct/pipe at any time in normal operation or unoccupied modes. Use additional insulation beyond the criteria/standard minimum standards, if necessary to preclude condensation.

____ **Occupancy**: Verify with the stakeholders the intended occupancy pattern for the facility. Consider potential low-occupancy periods in addition to normal operation occupancy. Example: For Army Reserve Centers, there are often a few full-time occupants during the week and a very high number of occupants on drill weekends. At times, occupancy can range in between these extremes; this must be considered.

____ **Humidity Sensors:** Include humidity sensors in representative or critical spaces for monitoring purposes and integrate with the building automation system.

Variable Air Volume Systems:

____ **Warm Air Stratification:** For spaces served by reheat VAV units, verify that the combination of discharge air temperature, heating air flows, and controls will prevent stratification in the space or other measures are implemented to address (destratification fans or other). High ceiling spaces are at higher risk for this issue. Comply with ASHRAE 90.1 simultaneous heating and cooling and discharge air temperature limit restrictions.

____ **Low Water Flow at VAV Reheat Coils:** For reheat VAV units, verify that the reheat coil capacity is sufficient to handle both space heating loads and the load required to raise primary/supply air temperature to room neutral space temperature. Verify coil selection is appropriate for the water flow rates specified in design.

----END OF SECTION----