ATTACHMENT H

MECHANICAL

FOR

REPAIR-RENOVATE BUILDING 3453
to SUPPORT "SPINSTRA" MOVE
PROJECT No. 1060124

1. GENERAL:

1.1 Publications: 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. Unless otherwise noted, all publications shall be the latest edition in effect on the date of solicitation.

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

ASHRAE Guideline 0-2005	The Commissioning Process
ASHRAE Guideline 1.1-2007	HVAC&R Technical Requirements for the Commissioning Process
ASHRAE 52.2	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (ANSI Approved)
ASHRAE 62.1	Ventilation for Acceptable Indoor Air Quality
ASHRAE 70	Method of Testing the Performance of Air Outlets and Air Inlets
ASHRAE 90.1	Energy Standard for Buildings Except Low-Rise Residential Buildings
ASHRAE EQUIPMENT HANDBOOK	

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

SMACNA 1143	HVAC Air Duct Leakage Test Manual
SMACNA 1966	HVAC Duct Construction Standards – Metal and Flexible

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.3	Process Piping Code

MANUFACTURERS STANDARDIZATION SOCIETY (MSS)

MSS SP-69	Pipe Hangers and Supports – Selection and Application (ANSI-approved American National Standard)

AMERICAN WELDING SOCIETY (AWS)

AWS WHB-2.9	Welding Handbook Volume 2 – Part 1: Welding Processes

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	Motors and Generators
NEMA MG 10	Energy Management Guide for Selection and Use of Fixed Frequency Medium AC Squirrel-Cage Polyphase Induction Motors
NEMA MG 11	Energy Management Guide for Selection and Use of Single-Phase Motors

UL

UL 181	Standard for Factory-Made Air Ducts and Air Connectors
UL 555S	Standard for Smoke Dampers
UL 586	Standard for Safety for High-Efficiency, Particulate, Air Filter Units
UL 900	Standard for Air Filter Units

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	Installation of Air-Conditioning and Ventilating Systems

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 210	Laboratory Methods of Testing Fans for Ratings
AMCA 500-D	Laboratory Methods of Testing Dampers for Rating

DEPARTMENT OF DEFENSE (DoD)

DoD Manual 5200.01	DoD Information Security Program: Protection of Classified Information

ASTM INTERNATIONAL

ASTM C1071	Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE (AHRI)

AHRI 410	Forced-Circulation Air-Heating and Air-Cooling Coils

1.1 Basic Mechanical Materials and Equipment:

Refer to SOW Sequence of Work in Table 1.4.1 for work requirements. This Scope of Work is intended to convey scope and general arrangement only. The drawings do not necessarily indicate every required duct, pipe, offset, fitting, transition, or other equipment items regardless how indicated. The Contractor shall coordinate the piping, ductwork, and equipment locations and routes IAW all manufacturer's recommendations and as required to provide a complete system and service. Also provide alternate piping routes, ductwork routes, additional offsets as required for ductwork and piping. Also, where existing mechanical systems and motor-operated equipment require modifications, provide electrical components in accordance with the Electrical requirements of this SOW and IAW manufacturer directions. Contractor shall provide final plans showing actual tie-ins and ductwork and piping routing.

Furnish ductwork, piping offsets, fittings, and accessories as required to provide a complete installation. Coordinate the work of the different trades to avoid interference between piping, equipment, structural, and electrical work. Provide all necessary offsets in piping, ductwork, all fittings, and other components, complete and in place as required to install the work as indicated and specified.

1.2 Posted Operating Instructions:

Provide for each system and principal item of equipment as specified in the technical sections for use by operation and maintenance personnel. The operating instructions shall include the following:

a. Wiring diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Start up, proper adjustment, operating, lubrication, and shutdown procedures.

c. Safety precautions.

d. The procedure in the event of equipment failure.

e. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal or peeling.

1.3 Energy Star: Where applicable, provide equipment that is an ENERGY STAR Qualified product or a Federal Energy Management Program (FEMP) designated product.

1.4 High Efficiency Motors:

1.4.1 High Efficiency Single-Phase Motors: Unless otherwise specified, single-phase fractional-horsepower alternating-current motors shall be high efficiency types corresponding to the applications listed in NEMA MG 11.

1.4.1.1 High Efficiency Polyphase Motors:

Unless otherwise specified, select polyphase motors based on high efficiency characteristics relative to the applications as listed in NEMA MG 10. Additionally, polyphase squirrel-cage medium induction motors with continuous ratings shall meet or exceed energy efficient ratings in accordance with Table 12-6C of NEMA MG 1.

1.4.1.2 Three-Phase Motor Protection

Provide controllers for motors rated one horsepower and larger with electronic phase-voltage monitors designed to protect motors from phase-loss, undervoltage, and overvoltage. Provide protection for motors from immediate restart by a time adjustable restart relay.

1.4.1.3 Provide motor torque capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Provide motor starters complete with thermal overload protection and other necessary appurtenances. Fit motor bearings with grease supply fittings and grease relief to outside of the enclosure.

Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers are allowed to accomplish the same function. Use solid-state variable-speed controllers for motors rated 10 hp or less and variable frequency drives for larger motors.

1.5 Submittals: Submit the following in accordance with SOW Submittal Procedures paragraph:

1.5.1 Shop Drawings:

1.5.1.1 Equipment and Ductwork: Submit detailed shop drawings showing equipment performance data, equipment layout, catalog data including assembly and installation details and electrical connection diagrams, ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing, rigidity classification, static pressure, and seal classifications. Include any information required to demonstrate that the system has been coordinated and functions properly as a unit on the drawings and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Submit drawings showing bolt-setting information, and foundation bolts prior to concrete foundation construction for all equipment indicated or required to have concrete foundations. Submit function designation of the equipment and any other requirements specified throughout this SOW with the shop drawings.

1.5.1.2 For connections to existing systems, provide sufficient layout information to identify line sizes, duct sizes, electrical connections, controls and other information.

1.5.1.3 Chilled Water Piping (Use Copper Type “L” unless otherwise noted): Submit detailed shop drawings for all piping, valves and specialties showing conformance with the referenced standards contained within this section. Submit the following items: pipe size, shape, dimensions, temperature ratings, vibration, thrust limitations, minimum burst pressures, shut-off and non-shock pressures, and weld characteristics. Include any information required to demonstrate that the system has been coordinated and functions properly as a unit on the drawings and show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Submittal shall include, but not be limited to, Certificates of Compliance for Hydrostatic Testing, Valve Operating Tests, and Operational Testing.

1.5.1.4 Provide cutoff valves for all equipment such as fan coils, air handlers packaged equipment connections and other HVAC hydronics. Provide balancing valves on all zones. Provide bleeder vents for all coils at the highest points in the system. Submit Connection Diagrams for pipes, valves, and specialties indicating the relations and connections of devices and apparatus by showing the general physical layout of all controls, the interconnection of one system (or portion of system) with another, and internal tubing, wiring, and other devices.

1.5.1.5 Condensate Drain Lines: Provide and install condensate drainage for each item of equipment that generates condensate. Condensate shall drain to a suitable system environmentally acceptable for such byproducts.

1.5.1.6 Backflow Preventers: IAW manufacturer directions. Backflow preventers shall be installed at all main water sources.

1.5.1.7 Insulation: IAW ASHRAE Handbook. All chilled water and heating water piping shall be insulated.

1.5.1.8 Testing and Commissioning Procedures: Submit proposed testing and commissioning procedures for all new equipment, ductwork, and piping. Submittal shall include, but not be limited to, ductwork leak test results, piping pressure tests, and performance tests and commissioning of all new systems and existing systems that have been tied into. Note: Testing and commissioning procedures submittals shall be submitted at least 14 calendar days prior to system testing and commissioning.

<u>Note, Testing and Commissioning only applies to new HVAC equipment/systems in this project scope and not the entire building 3453.</u>

1.5.1.9 Operation and Maintenance (O&M) Data, Manuals, and Training: Submit complete Manufacturer Data, Manuals, and Training for all new equipment, ductwork, and piping. Provide training to owner to cover all new equipment and systems installed. This training shall occur on site once the systems have been commissioned.

1.5.1.10 As-Built Drawings: Refer to SOW Submittals paragraph for submittal requirements.

1.5.1.11 Submit installation drawings for air-diffusion devices. Indicate on drawings overall physical features, dimensions, ratings, service requirements, and equipment weights.

1.5.1.12 Testing, Adjusting and Balancing (TAB): Submit plan and final report IAW ASHRAE Guidelines 0-2005 and 1.1-2007. HVAC system shall be commissioned as a perquisite of final acceptance. Provide full documentation to support testing.

1.5.1.13 Direct Digital Control (DDC) Points: Report on calibration, adjustment, and commissioning. Verify sequences of operation perform as specified. Document any changes to the sequences.

1.6 Delivery, Storage, and Handling: Protect stored equipment at the jobsite from the weather, humidity and temperature variations, dirt and dust, or other contaminants. Additionally, cap or plug all pipes until installed.

1.7 Anchor Bolts: Provide anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts to be of the size and number recommended by the equipment manufacturer and located by means of suitable templates. Installation of anchor bolts shall not degrade the surrounding concrete.

1.8 Indoor Air Quality: Provide equipment and components that comply with the requirements of ASHRAE 62.1. Provide any CO_2 monitoring to verify indoor air quality. This shall be provided in densely populated classroom related to the SPINSTRA area in the South Annex.

2.0 PRODUCTS:

2.1 Duct Systems:

2.1.1 Metal Ductwork: Provide metal ductwork construction, including all fittings and components, that complies with SMACNA 1966, as supplemented and modified by this SOW.

2.1.2 Metallic Flexible Duct: Provide duct that conforms to UL 181 and NFPA 90A standards with factory-applied insulation, vapor barrier, and end connections. Provide duct assembly that does not exceed 25 for flame spread and 50 for smoke developed. Flexible duct connections shall be limited to no more than 10 feet in length and in low pressure ductwork only.

2.1.3 All ductwork shall be metal. Insulation material shall not be fiberglass or friable in any manner. Main ductwork shall be rated for medium pressure up to the zones. Downstream from the zones low pressure duct is suitable.

2.1.4 Duct Access Doors: Provide hinged access doors conforming to SMACNA 1966 in ductwork and plenums where indicated and at all air flow measuring primaries, automatic dampers, fire dampers, coils, thermostats, and other apparatus requiring service and inspection in the duct system. Provide access doors upstream and downstream of air flow measuring primaries and heating and cooling coils. Provide doors that are a minimum 15 by 18 inches, unless otherwise shown. Where duct size does not accommodate this size door, make the doors as large as practicable.

2.1.5 Manual Balancing Dampers: Furnish manual balancing dampers with accessible operating mechanisms. Use chromium plated operators (with all exposed edges rounded) in finished portions of the building. Provide manual volume control dampers that are operated by locking-type quadrant operators. Install dampers that are 2 gauges heavier than the duct in which installed. Unless otherwise indicated, provide opposed blade type multileaf dampers with maximum blade width of 12 inches. Provide access doors or panels for all concealed damper operators and locking setscrews.

2.1.6 Automatic Smoke-Fire Dampers: Provide multiple blade type, 180 °F fusible fire

damper link, smoke damper assembly to include pneumatically powered operator. Utilize UL 555 standard as a 1.5 hour rated fire damper; further qualified under UL 555S as a leakage rated damper. Provide a leakage rating under UL 555S that is no higher than Class II at an elevated temperature Category B (250 °F for 30 minutes). Ensure that pressure drop in the damper open position does not exceed 0.1 inch water gauge with average duct velocities of 2500 feet per minute (fpm).

2.1.7 Fire Dampers: Provide fire dampers for any duct penetrations through fire rated walls and corridors.

2.1.8 Air Supply And Exhaust Air Dampers: Where outdoor air supply and exhaust air dampers are required they shall have a maximum leakage rate when tested in accordance with AMCA 500-D as required by ASHRAE 90.1 - IP, including: Maximum Damper Leakage at 1.0 inch w.g. is 10 cubic feet per minute (cfm) per square foot of damper area for motorized dampers and for 20 cfm per square foot of damper area for non-motorized dampers. Dampers smaller than 24 inches in either direction may have leakage of 40 cfm per square foot.

Any exterior penetrations in the SPINTRA area greater than 96 square inches shall be shall be hardened in accordance with Military Handbook 1013/1A and in accordance with DoD Manual 5200.01 Physical Security Standards.

2.1.9 Air Deflectors and Branch Connections: Provide air deflectors at all duct mounted supply outlets, takeoff or extension collars to supply outlets, duct branch takeoff connections, and 90 degree elbows, as well as locations as indicated on the drawings or otherwise specified. Conical branch connections or 45 degree entry connections are allowed in lieu of deflectors for branch connections. Furnish all air deflectors, except those installed in 90 degree elbows, with an approved means of adjustment. Provide easily accessible means for adjustment inside the duct or from an adjustment with sturdy lock on the face of the duct.

2.1.10 Sound Attenuation Equipment: Provide sound absorbing material conforming to ASTM C1071, Type I or II, in any areas where noise levels exceed 50 decibels.

2.2 Diffusers, Registers, and Grilles:

Provide factory-fabricated units of aluminum that distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 50 fpm in occupied zone, or dead spots anywhere in the conditioned area. Provide outlets for diffusion, spread, throw, and noise level as required for specified performance. Certify performance according to ASHRAE 70. Provide sound rated and certified inlets and outlets according to ASHRAE 70. Provide sound power level as indicated. Provide diffusers and registers with volume damper with accessible operator, unless otherwise indicated, or if standard with the manufacturer, an automatically controlled device is acceptable. Provide opposed blade type volume dampers for all diffusers and registers, except linear slot diffusers. Provide linear slot diffusers with round or elliptical balancing dampers. Where the inlet and outlet openings are located less than 7 feet above the floor, protect them by a grille or screen according to NFPA 90A.

2.2.1 Diffusers: Furnish ceiling mounted units with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Provide diffusers with air deflectors of the type indicated. Provide air handling troffers or combination light and ceiling diffusers conforming to the requirements of UL Electrical Construction for the interchangeable use as cooled or heated air supply diffusers or return air units. Install ceiling mounted units with rims tight against ceiling. Provide sponge rubber gaskets between ceiling and surface mounted diffusers for air leakage control. Provide suitable trim for flush mounted diffusers. For connecting the duct to diffuser, provide duct collar that is airtight and does not interfere with volume controller. Provide return or exhaust units that are similar to supply diffusers.

2.2.2 Registers and Grilles: Provide units that are four-way directional-control type, except provide return and exhaust registers that are fixed horizontal or vertical louver type similar in appearance to the supply register face. Furnish registers with sponge-rubber gasket between flanges and wall or ceiling. Install wall supply registers at least 6 inches below the ceiling unless otherwise indicated. Locate return and exhaust registers 6 inches above the floor unless otherwise indicated. Achieve four-way directional control by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Provide grilles as specified for registers, without volume control damper.

2.2.3 Louvers: Provide louvers for installation in exterior walls that are associated with the air supply and distribution system. Style of louvers shall match existing on the building.

2.2.4 Air Vents, Penthouses, and Goosenecks: Fabricate air vents, penthouses, and goosenecks from galvanized steel [or aluminum] sheets with galvanized [or aluminum] structural shapes. Provide sheet metal thickness, reinforcement, and fabrication that conform to SMACNA 1966. Accurately fit and secure louver blades to frames. Fold or bead edges of louver blades for rigidity and baffle these edges to exclude driving rain. Provide air vents, penthouses, and goosenecks with bird screen.

2.3 Equipment:

2.3.1 Fans: Test and rate fans according to AMCA 210.

2.3.2 Centrifugal Fans: Provide fully enclosed, single-width single-inlet, or double-width double-inlet centrifugal fans, with AMCA Pressure Class I, II, or III as required. Provide automatically operated outlet dampers. Unless otherwise indicated, provide motors that do not exceed 1800 rpm and have totally enclosed enclosures. Provide reduced-voltage-start type motor starters with general-purpose enclosure.

2.3.3 Coils: Provide fin-and-tube type coils constructed of seamless copper tubes and aluminum fins mechanically bonded or soldered to the tubes. Provide copper tube wall thickness that is a minimum of 0.020 inches. Provide aluminum fins that are 0.0055 inch minimum thickness. Provide casing and tube support sheets that are not lighter than 16 gauge galvanized steel, formed to provide structural strength. When required, provide multiple tube supports to prevent tube sag. Test each coil at the factory under water at not less than 400 psi air pressure and make suitable for 200 psi working pressure and 300 °F operating temperature unless otherwise stated. Mount coils for counterflow service. Rate and certify coils to meet the requirements of AHRI

410. Provide automatic bleeder vents for all coils. Maximum air velocity across any coil shall be limited to 500 fpm.

2.3.4 Condenser systems:

2.3.4.1 Water Coils: Install water coils with a pitch of not less than 1/8 inch/foot of the tube length toward the drain end. Use headers constructed of cast iron, welded steel, or copper. Furnish each coil with a plugged vent and drain connection extending through the unit casing. Provide removable water coils with drain pans.

2.3.5 Air Filters: List air filters according to requirements of UL 900, except list high efficiency particulate air filters of 99.97 percent efficiency by the DOP Test method under the Label Service to meet the requirements of UL 586. All air handling units and packaged equipment shall have pre-filters and final filters.

2.3.6 Replaceable Media Filters: Provide dry-media type replaceable media filters, of the size required to suit the application. Provide filtering media that is not less than 2 inches thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Enclose pad in a holding frame of not less than 16 gauge galvanized steel, equipped with quick-opening mechanism for changing filter media. Base the air flow capacity of the filter on net filter face velocity not exceeding 300 fpm, with initial resistance of 0.13 inches water gauge. Provide MERV that is not less than 8 when tested according to ASHRAE 52.2

2.3.7 Fan Coil Units (FCU): In the rooms listed in the Mechanical Drawings, provide Fan Coil Units with the required cooling capacities, air flowrates, and static pressures. Provide new supply diffusers, return registers, temperature sensors, and rectangular, round, and z ducting required for conditioning the listed spaces.

2.3.8 Chilled Water Pump: In the listed room, provide a new chilled water pump with a variable frequency drive with the listed water flowrate, hydraulic head, and suction and discharge line size.

2.4 Backflow Preventers: Provide backflow preventers IAW manufacturer directions and with appropriate pressure reducers.

2.5 Insulation: All piping and ductwork shall be insulated, identified, and properly labelled.

2.6 Direct Digital Controls: Refer to the project drawings for summary of control points to be reused and relocated as well as new control points. Provide new direct digital control (DDC) system and connect to and existing base DDC system including associated equipment and accessories. The DDC system shall be a complete system suitable for the heating, ventilating and air conditioning (HVAC) system. This DDC system shall be fully 100% compatible with the existing base wide front-end Energy Monitoring and Control System (EMCS) currently installed on Goodfellow Air Force Base. This existing front-end EMCS system is manufactured by Automated Logic Corporation, Marietta, Georgia. Goodfellow AFB personnel will work with the DDC Controls Contractor on commissioning of the DDC Control System.

DDC shall utilize BACnet open protocol standard communication. Controllers shall be fully

programmable and application specific. Manufacturer supplied controllers with packaged equipment shall be fully BACnet compatible and shall integrate both readable and writable information into an Automated Logic front end application. All software and tools to support programming and controller configurations shall be provided.

Fan coils shall use application specific controllers which communicate BACnet master slave token passing (MSTP) protocol. Fully programmable controllers shall utilize BACnet IP and shall be Automated Logic. Packaged equipment shall utilize BACnet IP or MSTP protocol. Contractor shall provide all the required BACnet routers to fully integrate the system into the Goodfellow Automated Logic head end application.

Control logic shall employ energy savings strategies, optimize operations, and integrate equipment. Provide sufficient sensors and head end information for all air and water flows, air and water pressures, VFD speeds, damper position, compressor loads, condenser head pressure, air and water temperature, valve position, energy consumption, and other data to fully operate, troubleshoot, and manage the equipment and systems.

PART 3 EXECUTION

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

a. Installation: Install materials and equipment in accordance with the requirements of the contract drawings and approved manufacturer's installation instructions. Accomplish installation by workers skilled in this type of work. Perform installation so that there is no degradation of the designed fire ratings of walls, partitions, ceilings, and floors.

b. Condensate Drain Lines: Provide water seals in the condensate drain from all units.

c. Equipment and Installation: Provide frames and supports for tanks, compressors, pumps, valves, air handling units, fans, coils, dampers, and other similar items requiring supports. Floor mount or ceiling hang air handling units as indicated. Anchor and fasten as detailed. Set floor-mounted equipment on not less than 6 inch concrete pads or curbs doweled in place unless otherwise indicated. Make concrete foundations heavy enough to minimize the intensity of the vibrations transmitted to the piping, duct work and the surrounding structure, as recommended in writing by the equipment manufacturer.

d. Access Panels: Install access panels for concealed valves, vents, controls, dampers, and items requiring inspection or maintenance of sufficient size, and locate them so that the concealed items are easily serviced and maintained or completely removed and replaced.

e. Flexible Duct: Install pre-insulated flexible duct in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Provide hangers, when required to suspend the duct, of the type recommended by the duct manufacturer and set at the intervals recommended.

f. Metal Ductwork: Install metal ductwork according to SMACNA 1966 unless otherwise

indicated. Install duct supports for sheet metal ductwork according to SMACNA 1966, unless otherwise specified. Do not use friction beam clamps indicated in SMACNA 1966.Anchor risers on high velocity ducts in the center of the vertical run to allow ends of riser to move due to thermal expansion. Erect supports on the risers that allow free vertical movement of the duct. Attach supports only to structural framing members and concrete slabs. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members, provide suitable intermediate metal framing. Where C-clamps are used, provide retainer clips.

3.2 Equipment Pads: Provide equipment pads to the dimensions shown or, if not shown, to conform to the shape of each piece of equipment served with a minimum 3-inch margin around the equipment and supports. Allow equipment bases and foundations, when constructed of concrete or grout, to cure a minimum of 14 calendar days before being loaded.

3.3 Cleaning: Thoroughly clean surfaces of piping and equipment that have become covered with dirt, plaster, or other material during handling and construction before such surfaces are prepared for final finish painting or are enclosed within the building structure. Before final acceptance, clean mechanical equipment, including piping, ducting, and fixtures, and free from dirt, grease, and finger marks.

3.4 Color Coding Scheme for Locating Hidden Utility Components: Use scheme in buildings having suspended grid ceilings. Provide color coding scheme that identifies points of access for maintenance and operation of components and equipment that are not visible from the finished space and are accessible from the ceiling grid, consisting of a color code board and colored metal disks.

Provide identification tags made of brass, engraved laminated plastic, or engraved anodized aluminum, indicating service and item number on all valves and dampers. Provide tags that are 1-3/8 inch minimum diameter with stamped or engraved markings.

3.5 Ductwork Leak Test: Perform ductwork leak test for the entire air distribution and exhaust system, including fans, coils, filters, and other equipment. Provide test procedures, apparatuses, and reports that conform to SMACNA 1143.

3.6 Testing, Adjusting, and Balancing (TAB): Begin testing, adjusting, and balancing only when the air supply and distribution, including controls, has been completed, with the exception of performance tests. Provide copies of the TAB report for all air and hydronic systems. Any systems that have been used to tie new equipment shall be completely tested and be balanced back to the main sources. Testing and Balancing contractor shall provide the location and differential pressure setting to the controls contractor for all VFD controlled devices.

3.7 Performance Testing: After testing, adjusting, and balancing is complete as specified, test each system as a whole to see that all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Record the testing during the applicable season. Make corrections and adjustments as necessary to produce the conditions indicated or specified. Conduct capacity tests and general operating tests by an

experienced engineer. Provide tests that cover a period of not less than 2 days for each system and demonstrate that the entire system is functioning according to the specifications. Make coincidental chart recordings at points indicated on the drawings for the duration of the time period and record the temperature at space thermostats or space sensors, the humidity at space humidistats or space sensors and the ambient temperature and humidity in a shaded and weather protected area.

Submit test reports for the ductwork leak test, and performance tests in booklet form, upon completion of testing. Document phases of tests performed including initial test summary, repairs and adjustments made, and final test results in the reports.

3.8 Cleaning and Adjusting: Provide a temporary bypass for water coils to prevent flushing water from passing through coils. Inside of room fan-coil units air terminal units, thoroughly clean ducts, plenums, and casing of debris and blow free of small particles of rubbish and dust and then vacuum clean before installing outlet faces. Wipe equipment clean, with no traces of oil, dust, dirt, or paint spots. Provide temporary filters prior to startup of all fans that are operated during construction, and install new filters after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. Maintain system in this clean condition until final acceptance. Properly lubricate bearings with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions. Maintain all equipment installed under the contract until close out documentation is received, the project is completed and the building has been documented as beneficially occupied.

3.9 Flushing: Systems shall be flushed, filled and inhibitors replaced when tapping into for new equipment. Assure that all air has been purged from system upon filling. Provide copies of water treatment reports after the system is restored.

3.10 Pipe Installation: Fabricate and install piping systems in accordance with ASME B31.3, MSS SP-69, and AWS WHB-2.9. Securely support piping systems with due allowance for thrust forces, thermal expansion and contraction, and shall not be subjected to mechanical, chemical, vibrational or other damage as specified in ASME B31.3. Installation shall conform to manufacturer's instructions.

3.11 Valves: Provide valves in piping mains and all branches and at equipment where indicated and as described in the plans. Provide valves to permit isolation of branch piping and each equipment item from the balance of the system. Riser and down-comer drains above piping shutoff valves in piping 2-1/2 inches and larger shall be provided.-All valves shall be ball valves.

Valves unavoidably located in furred or other normally inaccessible places shall be provided with access panels adequately sized for the location and located so that concealed items may be serviced, maintained, or replaced. Provide vibration isolation supports where needed.

3.12 Penetrations: Effective sound stopping and adequate operating clearance shall be

provided to prevent structure contact where piping penetrates walls, floors, or ceilings into occupied spaces adjacent to equipment rooms; where similar penetrations occur between occupied spaces; and where penetrations occur from pipe chases into occupied spaces. Occupied spaces shall include space above ceilings where no special acoustic treatment of ceiling is provided. Penetrations shall be finished to be compatible with surface being penetrated.

3.13 Sleeves: Provide sleeves where piping passes through roofs, masonry, concrete walls and floors.

3.14 Escutcheons: Provide escutcheons at all penetrations of piping into finished areas.

3.15 Fire calk any fire rated wall penetrations.

3.16 Certify air diffusion devices having been tested and rated in accordance with ASHRAE EQUIP IP HDBK, Chapter 17.

3.16.1 Preclude flutter, rattle, or vibration on air-diffusion device construction and mounting. Modify devices and provide accessories necessary for mounting in indicated surface construction. Ensure air-diffusion device volume and pattern adjustments can be made from the face of the device. Provide aluminum construction. Install equipment as indicated and specified and in accordance with manufacturer's recommendations.

3.17 Fan coils: In rooms indicated on Mechanical drawings, fan coils shall be replaced with listed equipment within manufacturer’s specifications or equivalent.

3.18 Variable Frequency Drives (VFDs): All motors 5 HP and larger shall be VFDs and controlled by differential pressure sensors. VFDs shall be utilize BACnet protocol and all points integrated into the head end application.

3.19 Closed loop hydronic systems: Any closed loop hydronic systems opened for new equipment shall be flushed, filled, provided with chemical treatment, air bled and rebalanced upon completion.

Table 1 – Supply Air Diffuser Schedule

Room	Room Type	Number of Diffusers	Diffuser Type	Diffuser Make and Model (Or Equivalent)	Module Size	Neck Size	Estimated Flowrate per Diffuser (CFM)
155A	Hazmat	4	Louvered Ceiling Diffuser	Titus Omni	24"x24"	12" Round Neck	415
155B	Hazmat	4	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
198	Hazmat Lab	2	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
200	Classroom	4	Louvered Ceiling Diffuser	Titus Omni	24"x24"	10" Round Neck	296
211A	Block I Test Lab	2	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
211B	Storage	1	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
220	Instructor Offices	4	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
221	Block I, Math and Physics Classroom	4	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
223	Electronics Principles Classroom	4	Louvered Ceiling Diffuser	Titus Omni	24"x24"	12" Round Neck	415
224A	Special Equipment Maintenance Classroom	2	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
224B		2	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
225	Soldering and Subsurface Maintenance Classrooms	6	Louvered Ceiling Diffuser	Titus Omni	24"x24"	12" Round Neck	395
227	Secured Room - Communications Closet and Classified Course Collaboration Center	4	Louvered Ceiling Diffuser	Titus Omni	24"x24"	10" Round Neck	296

Room	Room Type	Number of Diffusers	Diffuser Type	Diffuser Make and Model (Or Equivalent)	Module Size	Neck Size	Estimated Flowrate per Diffuser (CFM)
228	Remote Sensing, Phenomonology, & ISR Classrooms	2	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
229	Subsurface Analysis Classroom	4	Louvered Ceiling Diffuser	Titus Omni	24"x24"	14" Round Neck	474
237	Testing/EOC Lan/Overlap and Backup Classroom Space	4	Louvered Ceiling Diffuser	Titus Omni	24"x24"	10" Round Neck	296

Table 2 – Return Air Register Schedule

Room	Room Type	Number of Return Registers	Register Type	Register Make and Model (Or Equivalent)	Module Size	Neck Size	Estimated Return Air Flowrate per Register (CFM)
155A	Hazmat	4	Drop-Face Return Panel	Titus PXP-DF	24"x24"	14" Diameter	303
155B	Hazmat	4	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	362
198	Hazmat Lab	2	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	400
200	Classroom	4	Drop-Face Return Panel	Titus PXP-DF	24"x24"	12"x12" Square Neck	252
211A	Block I Test Lab	2	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	415
211B	Storage	1	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	415
220	Instructor Offices	4	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	428

Room	Room Type	Number of Return Registers	Register Type	Register Make and Model (Or Equivalent)	Module Size	Neck Size	Estimated Return Air Flowrate per Register (CFM)
221	Block I, Math and Physics Classroom	4	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	439
223	Electronics Principles Classroom	4	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	380
224A	Special Equipment Maintenance Classroom	2	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	430
224B		2	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	430
225	Soldering and Subsurface Maintenance Classrooms	6	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	335
227	Secured Room - Communications Closet and Classified Course Collaboration Center	4	Drop-Face Return Panel	Titus PXP-DF	24"x24"	12"x12" Square Neck	252
228	Remote Sensing, Phenomonology, & ISR Classrooms	2	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	385
229	Subsurface Analysis Classroom	4	Drop-Face Return Panel	Titus PXP-DF	24"x24"	15"x15" Square Neck	384
237	Testing/EOC Lan/Overlap and Backup Classroom Space	4	Drop-Face Return Panel	Titus PXP-DF	24"x24"	12"x12" Square Neck	252

Table 3 – Return Air Duct Sizes

Room	Room Type	Register Duct Size	Intermediate Duct Size	Second Intermediate Duct Size	Duct Size to Fan Coil Unit
155A	Hazmat	14" Diameter	8"x14" Rectangular Duct	-	10"x20" Rectangular Duct
155B	Hazmat	15"x15" Square Neck	8"x16" Rectangular Duct	-	12"x20" Rectangular Duct
198	Hazmat Lab	15"x15" Square Neck	-	-	10"x14" Rectangular Duct
200	Classroom	12"x12" Square Neck	8"x12" Rectangular Duct	-	12"x14" Rectangular Duct
211A	Block I Test Lab	15"x15" Square Neck	-	-	10"x14" Rectangular Duct
211B	Storage	15"x15" Square Neck	-	-	-
220	Instructor Offices	15"x15" Square Neck	10"x14" Rectangular Duct	-	12"x20" Rectangular Duct
221	Block I, Math and Physics Classroom	15"x15" Square Neck	10"x14" Rectangular Duct	-	12"x20" Rectangular Duct
223	Electronics Principles Classroom	15"x15" Square Neck	8"x16" Rectangular Duct	-	14"x16" Rectangular Duct
224A	Special Equipment Maintenance Classroom	15"x15" Square Neck	-	-	10"x14" Rectangular Duct
224B		15"x15" Square Neck	-	-	10"x14" Rectangular Duct
225	Soldering and Subsurface Maintenance Classrooms	15"x15" Square Neck	10"x12" Rectangular Duct	12"x18" Rectangular Duct	14"x20" Rectangular Duct

Room	Room Type	Register Duct Size	Intermediate Duct Size	Second Intermediate Duct Size	Duct Size to Fan Coil Unit
227	Secured Room - Communications Closet and Classified Course Collaboration Center	12"x12" Square Neck	8"x12" Rectangular Duct	-	12"x14" Rectangular Duct
228	Remote Sensing, Phenomonology, & ISR Classrooms	15"x15" Square Neck	-	-	10"x14" Rectangular Duct
229	Subsurface Analysis Classroom	15"x15" Square Neck	10"x14" Rectangular Duct	-	12"x20" Rectangular Duct
237	Testing/EOC Lan/Overlap and Backup Classroom Space	12"x12" Square Neck	8"x12" Rectangular Duct	-	12"x14" Rectangular Duct

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