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D30 HVAC, Heating, Cooling, HVAC Distribution, and TAB

New in this revision (older revisions addressed in Record of Revisions at end of document)

Added Smart Labs guidance, packaged equipment controls integration, use of condensing boilers. Updated NATS table including DOE-STD-1269 and DOE-HDBK-1169, plus AG-1 applicability to non-credited ventilation systems per Variance 10298. Other changes. Added Requirements ID Log references and moved most bases footnotes to log posted with chapter.

Usage Notes

1. Requirements ID Log references — e.g., (Requirement 6-00XX) — refer to log posted with chapter for LANL internal-use
2. For interpretation, variance, and suggestions please contact the Mechanical Standards POC (suggestions link (LANL-only))
3. This document is online at https://engstandards.lanl.gov/

D30GEN ADDITIONAL GENERAL HVAC REQUIREMENTS

Note: Refer to the Mechanical Chapter Section D10-30GEN for general mechanical (thus some HVAC) requirements. General and HVAC piping requirements are in Section D20, Plumbing/Piping/Vessels (e.g., cross connection and expansion control, freeze protection, etc.).

1.0 CODES AND STANDARDS

A. Comply with the following codes and standards as well as others listed in D10-30GEN and other applicable ESM sections. ***Required editions for building codes are per ESM Ch. 16 while most others are governed by ESM Ch. 1 Section Z10 rules.***

B. **NOTE: Many national codes and standards are available for LANL users here.**

1.1 ACGIH (American Conference of Governmental Industrial Hygienists)

A. Industrial Ventilation – A Manual of Recommended Practice for Design. (Requirement 6-0001)

1.2 AHRI (Air-Conditioning, Heating and Refrigeration Institute)

A. http://ahrinet.org/ (Requirement 6-0002)

1.3 ANSI (American National Standards Institute)

A. ANSI/AHIA/ASSE Z9.5, Laboratory Ventilation (Requirement 6-0003)

1.4 ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers)

(Requirement 6-0004)

A. Standard 15, Safety Code for Mechanical Refrigeration.

B. Standard 55, Thermal Environmental Conditions for Human Occupancy.

C. Standard 62.1, Ventilation for Acceptable Indoor Quality

D. Standard 90.1, Energy Standards for Buildings Except for Low Rise Residential Buildings

E. *As a reference only: HVAC Handbooks.*

1.5 LANL

A. ESM Chapter 14, Sustainable Design of Facilities **(includes required edition of ASHRAE 90.1)**

1.6 NFPA (National Fire Protection Association)

A. National Fire Codes and Standards (all except NFPA 5000). (Requirement 6-0005)

B. *Listing of current NFPA codes and standards*

1.7 SMACNA (Sheet Metal and Air Conditioning Contractors National Association)

(Requirement 6-0006)

A. HVAC Duct Construction Standards, Metal and Flexible.

B. HVAC Systems, Duct Design.

C. Seismic Restraint Manual, Guideline for Mechanical Systems

D. Rectangular Industrial Duct Construction Standards.

E. Round Industrial Duct Construction Standards.

F. *Guidance: Guide for Steel Stack Construction*.

G. *Guidance: Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems*.

2.0 ELEVATION/CLIMATIC CRITERIA AND HEAT GAIN EQUATIONS

A. See ESM Chapter 1 Section Z10 for elevation, latitude, barometric pressure, air density, and air density ratio values.

B. Heating Degree-Days (annual mean): 6219 at 65 degrees F base; 2680 at 50 degrees F base. (Requirement 6-0007)

C. Cooling Degree-Days (annual mean): 2187 at 50 degrees F base, 272 at 65 degrees F base.

D. Correct Q for elevation. *Values for 7500 feet (suitable for many locations/situations) are:*

Q (sensible heat)(Btu/hr) = 0.82 (@W = 0) X cfm X Dt (at sea level 0.82 would be 1.08)[1]

Q (latent heat)(Btu/hr) = 0.52 X cfm X DW (gr.) (at sea level 0.52 would be 0.68) [1]

Q (total heat)(Btu/hr) = 3.42 X cfm X Dh (at sea level 3.42 would be 4.50). [1]

where:

cfm = Air flow Rate, cubic feet/min.

D W (gr) = Humidity Ratio Difference, gr. water/lb. dry air.

D h = Enthalpy Difference, Btu/lb. dry air.

W = Humidity Ratio, lb. water/lb. dry air.

D t = Temperature Difference, degrees F.

E. Use Table D30GEN-1 local climate information for HVAC system sizing/design. *Guidance: It is presented in the format of the 1993 ASHRAE Fundamentals Handbook, Load and Energy Calculations Division, Weather Data Chapter 24. Refer to ASHRAE Handbook for explanation of columns and acronyms. [1994-2003 data (both I-P and S-I unit) for energy usage predictions (not sizing) is available from the Mechanical POC or directly from LANL Calculation 00-0000-CALC-M-0006.].*

1. If Los Alamos, NM weather data is included in a commercially available HVAC calculation software program, such may be used in lieu of Table D30GEN-1.

[1] Sea level constants 1.08, 0.68, and 4.50, and equations are from 2005 ASHRAE Fundamentals Handbook, pages 29.16 and 2013 ASHRAE Fundamentals Handbook. Constants have been corrected for 7500 foot conditions.

TABLE D30GEN-1

Climatic Conditions for the United States (from ASHRAE Fundamentals 1993 Weather Data Table 1)

				Winter, deg F		Summer, deg F						Prevailing Wind		Temp, deg F	
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5		Col. 6			Col. 7	Col. 8			Col. 9		Col. 10	
State/Station	Lat.	Long.	Elev.	Design Dry-Bulb		Design Dry Bulb and Mean	Coincident	Wet-Bulb	Mean Daily	Design Wet-Bulb			Winter	Summer	Median of Annual Extr.	
	deg N	deg W	Feet	99%	97.5%	1%	2.5%	5%	Range	1%	2.5%	5%	Knots		Max.	Min.
New Mexico Los Alamos	See note[2]		7,500	5	9	89/60	87/60	85/60	32	62	61	60			89.8	-2.3

[2] Use ESM Chapter 1 Section Z10 Constants

3.0 ELEVATION CORRECTION

A. *Guidance: At LANL's elevation, the air pressure and density are lower than at sea level, the condition for which HVAC equipment is designed/rated. Therefore, HVAC equipment operating at LANL produces less than its catalog rating. Correcting for this during design is required so that procurement of appropriately larger equipment occurs. Thus, in the procurement spec that's developed after the sizing calculations, this larger equipment should be specified, knowing it will be adequately sized when operating at LANL elevation. The spec should be clear that output ratings are already adjusted for elevation and should not be further adjusted by the vendor. If the correction has been made and captured in the specification's data, then the procurement spec shouldn't also say something like "equipment provided be sized for LANL elevation," since this could result in a doubly corrected outcome.*

B. **Only** the calculated actual operating parameters (capacity, static pressure, cooling/heating loads) required at 7,500 ft elevation should be shown on the design drawings and in the technical specifications. Only a statement such as "ALL CAPACITIES SHOWN OR INDICATED ARE AT 7,500 FT ELEVATION" should be included in the drawings or specifications. It is the responsibility of the Engineer to select equipment to meet the requirements at the 7,500 ft. elevation. The equipment manufacturer should be asked to provide submittal (fan curves, performance data) to back up their selection. (Requirement 6-0008)

3.1 Fans

A. Correct catalog data before applying it at LANL's 7,500-foot elevation. (Requirement 6-0009) *Guidance: Failure to correct for elevation will result in undersized equipment. An increase in elevation means a decrease in air density and barometric pressure. Air moving equipment is rated and cataloged at sea level (standard air density 0.075 pcf at 70 degrees and 29.92 inches Hg barometric pressure).*

B. *Guidance: Fans are constant volume devices and therefore air density has no effect on the volume delivered; however, it does affect the motor horsepower, static pressure, and mass flow rate.*

3.2 Fan Selection Procedure at 7,500 Foot Elevation (Guidance)

A. *Determine the actual volumetric flow rate (acfm) at 7,500 feet.*

B. *Using this actual flow rate (acfm) and standard air (sea level) friction data to design the ductwork, calculate the system static pressure at sea level.*

C. *Select the fan by referring to sea level fan capacity tables and using the actual cfm required at elevation and the system static pressure calculated at sea level. The rpm shown in the tables is the rpm at which the fan must operate and need not be corrected.*

D. *Correct the static pressure and brake horsepower (bhp) shown in the fan tables to elevation conditions by dividing these values by the air density ratio at 7,500 feet (nominal 1.32 at 70 degrees F). This yields the static pressure that the fan will produce at elevation and the BHP required at elevation. Refer to Table D30GEN-2 when installation environment involves non-standard temperatures at 7,500 feet elevation.*

TABLE D30GEN-2 ***Error! Bookmark not defined.***

Air Density Correction Factor at 7,500 Feet Elevation		
Temperature (F)	*Density (PCF)*	*Air Density Ratio*
0	*0.065*	*1.15*
40	*0.060*	*1.25*
55	*0.058*	*1.29*
60	*0.058*	*1.30*
65	*0.057*	*1.31*
70	*0.057*	*1.32 (Nominal)*
80	*0.055*	*1.35*
85	*0.055*	*1.36*
90	*0.054*	*1.37*
95	*0.054*	*1.39*
100	*0.054*	*1.40*
120	*0.052*	*1.45*
140	*0.050*	*1.50*

E. *High Temperature: Exercise caution in selecting the motor sizes for operating fans handling high temperature air. If a fan system designed to operate with high temperature air is started when the system is cold, the fan will require more horsepower during start up; therefore, the motor size should be selected for cold starting.*

3.3 Derating Equipment

A. Derate air-cooled equipment (e.g., chillers, coils, condensers, cooling towers, VAVs, VFDs) for elevation. (Requirement 6-0010) *Guidance: Consult with manufacturer and the following publications for derating data:*

1. *Carrier: Engineering Guide for Altitude Effects*.
2. *Trane: Effects of Altitude on Air Conditioning Equipment*.

3.4 Gas-Fired Equipment

A. Determine natural gas consumption (cfh) by dividing the Btu/h input rating at sea level by the gas heating value of 1000 Btu/ft^3. (Requirement 6-0014)

B. Derate gas-fired heating units and atmospheric boilers catalog output rating by 30 percent. (Requirement 6-0015)

C. Specify gas fired units that will be operating at 7500 feet elevation (see Chapter 1, Section Z10 subsection on constants, for elevation exceptions) so the manufacturer can factory install the correct gas orifices. (Requirement 6-0016)

D. For forced-draft boilers, including condensing boilers, consult with manufacturer for derating criteria. (Requirement 6-0017)

3.5 Motors

A. Refer to the Motors subsection below for deration and selection criteria.

4.0 CHEMICAL WATER TREATMENT

A. Clean, flush, and chemically-treat process water in HVAC systems, e.g., steam, hot water, heating, cooling systems, etc. to address LANL's higher-than-neutral pH and silica scaling problems. (Requirement 6-0018)

1. Consult the ESM Mechanical POC for specific requirements, such as type of treatment system, chemicals, etc. *Guidance: For existing facilities the LANL System Engineer should be consulted to determine preferred chemicals.*
2. Provide piping taps to accommodate the circulation of cleaning/flushing chemicals. (Requirement 6-0019)

B. Provide biocide products that are registered with the EPA, with the registration number clearly shown on the drum. (Requirement 6-0020)

C. Chemical supplier personnel using biocide products shall have a New Mexico Department of Agriculture (NMDA) pesticide applicator license. (Requirement 6-0021)

D. Chemical formulations used in water treatment require LANL Water Quality Group (EPC-CP) approval. (Requirement 6-0022)

E. Provide an emergency eyewash per OSHA 10CFR 1910.151 and 1450 if required after an evaluation/analysis by LANL OSH. Consult OSH Industrial Hygiene and Safety for additional emergency equipment requirements. (Requirement 6-0023)

1. *Guidance Note: Portable eyewash station may be acceptable in lieu of permanent*.

F. Refer to the following LANL Engineering Standards for additional guidance:[3]

1. Mechanical Drawing(s) ST-D3030-1, Cooling Tower and Chiller Piping Component Diagram
2. Mechanical Drawing(s) ST-D30GEN-1, Open Cooling Tower Water Treatment.
3. Master Specification Section 23 2500, *HVAC Water Treatment*.

5.0 COILS - HEATING/COOLING

5.1 General

A. Provide Air Conditioning, Heating, and Refrigeration Institute (AHRI)-certified heating and cooling coils for central-station HVAC units and field-built-up systems (Requirement 6-0024).

[3] The drawings and specification provide piping details, additional design guidance, and specifications for equipment and chemicals.

B. For coil selection, use a manufacturer's computerized selection program to facilitate selection for the most energy efficient system, and to obtain the coil rated performance data in accordance with AHRI Standard 410, Forced-Circulation Air-Cooling and Air-Heating Coils, Table 1, Range of Standard Rating Conditions. https://ahrinet.org (Requirement 6-0025)

1. *Guidance: Limit dry (sensible) cooling coils to 575 fpm air face velocity.*
2. *Guidance: Limit heating coils to 750 fpm air face velocity.*

C. For nuclear HVAC applications, use a minimum tube water velocity of 2 fps. (Requirement 6-0026)

D. Limit air face velocities of wet coils (these both cool and dehumidify) to values that prevent water carryover into the ductwork. (Requirement 6-0027)

1. *Guidance: For comfort applications, wet coils are frequently selected in the range of 400-500 fpm air face velocity*.

E. Provide coils with copper tubing and aluminum fins where coil selection and design pressures permit. (Requirement 6-0028)

F. Size heating hot water coils for a maximum leaving water temperature of 130°F. (Requirement 6-0029).

G. Provide sloped stainless steel drip pans when installing cooling coils in built-up systems with intermediate condensate pans at each tier and interconnecting drain piping. (Requirement 6-0030). Provide an approved P-trap at drip pan and pipe drip pans to floor drains. (Requirement 6-0031)

1. For outdoor packaged equipment, drain to daylight. Use splash block if necessary. (Requirement 6-0032)
2. *Guidance: For best indoor air quality choice, slope drip pans in two directions.*

H. Condensate traps: Size and configure per the UMC and the manufacturer's recommendations. (Requirement 6-0033)

I. *Guidance: Use hot water for final heating coils.* [4]

J. Refer to the following LANL standard details for additional guidance:[5]

1. Mechanical Drawing(s) ST-D30GEN-2, Water Coil Piping.
2. Mechanical Drawing(s) ST-D30GEN-3, Steam Coil Piping.

5.2 Preheat Coils

A. General

1. Building air handling units shall include a preheat coil upstream of chilled water or hot water reheat coils. (Requirement 6-0034) The preheat coil shall be sized to heat building from initial 55 degrees to 70 degrees within one hour while

[4] Electric coils have a high operating cost that offsets any low initial cost. Steam coils are hard-to-control and require more maintenance than hot-water coils.
[5] The coil piping details provide piping details for different applications and additional design requirements.

maintaining minimum outside airflow requirements (for buildings with automation systems, the additional capacity to provide for minimum outside air requirements is not necessary if outside air dampers will be closed during warm-up and optimum start controls are used). (Requirement 6-0035)

2. Operate face and bypass coils with 100% steam or water flow prior to reaching freezing intake conditions. Do not modulate flow unless the face dampers are closed. (Requirement 6-0036)

3. Provide a sensor in the discharge air stream to maintain a constant discharge air temperature, regardless of variations in inlet air temperature. (Requirement 6-0037)

B. Design

1. Design preheat coils for 100% outside air systems for an entering air temperature of minus 10 degrees F. (Requirement 6-0038). For steam coils, oversize condensate return piping to handle large condensate flow at startup. (Requirement 6-0039)

2. Provide supply air preheat coils, using hot water or low-pressure steam, with the necessary controls, etc., to protect them from freezing. The following are acceptable systems (Requirement 6-0040):

   a. Preferred Option: Hot water coil with circulating pump to maintain a minimum coil water velocity of 4 fps. Refer to Mechanical Standard Drawing ST-D30GEN-2, *Hot Water Coil – Constant Flow, Fail to Full Heat*.

   b. Vertical tube integral face and bypass steam or water coils with clamshell type dampers to control airflow. [6]

   c. Steam coil with properly designed control valve, steam trap with check valve, and vacuum breaker. Follow ASHRAE *HVAC Systems and Equipment Handbook*, Steam Systems.

6.0 DESIGN TEMPERATURES

6.1 Outdoor (Requirement 6-0041)

A. Winter: 5 degrees F dry bulb

B. Summer: 89 degrees F dry bulb, 60 degrees F wet bulb

6.2 Indoor (Dry-Bulb) (Requirement 6-0042)

A. Cooling:

1. General Comfort: 75 degrees F.

2. Mechanical Rooms: Refer to ESM Mechanical Section D30, Ventilation.

[6] Integral face and bypass coils are used as a freeze protection measure. The temperature of the discharge air is controlled by proportioning entering air through the multiple heating and bypass channels of the face and bypass coils. The air is proportioned by clamshell-shaped dampers, which maintain a constant pressure drop, thus allowing a constant volume of air to pass through the unit.

3. Electrical Rooms: Refer to ESM Chapter 7, Section D5010, *Electrical Service and Distribution.*

B. Heating:

1. Office/Laboratories: 72 degrees F (general comfort)
2. Mechanical Rooms: 50 degrees F
3. Storage Space (unoccupied): 55 degrees F
4. Warehouses: 50 degrees F. Do not provide comfort cooling for warehouses.
5. Kitchens: 60 degrees F
6. Change Rooms: 75 degrees F

Note: Program requirements may require different indoor design temperatures.

7.0 HUMIDITY CONTROL

A. Provide humidity control only when programmatic requirements specify humidity levels in a zone or zones (e.g., in computer or explosive areas to prevent the buildup of static electricity). (Requirement 6-0043)

1. Meet ASHRAE Standard 55, *Thermal Environmental Conditions for Human Occupancy*. (Requirement 6-0044)
2. Provide humidity control system to automatically adjust building conditions as appropriate. If the building has a building automation system, provide control using the BAS. (Requirement 6-0045).
3. *Guidance: Humidity Control is typically not practical for general comfort because of the dry climate in Los Alamos*.

B. Provide vapor barriers in spaces requiring humidity control to prevent moisture migration and condensation in the thermal insulation. (Requirement 6-0046)

1. Humidification: Provide barrier on inside wall surfaces.
2. Dehumidification: Provide barrier on outside wall surfaces.

C. When humidity is added to a space, provide an analysis (to prevent condensation) on where dew point temperatures will occur for exterior walls, roofs, and windows, as well as ductwork passing through the space. Also account for adjacent spaces where humidity can seep into the space and cause condensation issues. (Requirement 6-0047)

1. Limit humidity levels in delivery ductwork to avoid condensation in the ductwork.

D. Provide humidification units with deionized water; Mechanical POC and FOD approval required for other sources. Consult with humidifier representative for water quality requirements (conductivity in micro-ohms). (Requirement 6-0048)

E. When using boiler steam for humidification, provide a steam-to-steam converter.[7] Do not inject plant steam directly into the airstream. (Requirement 6-0049)

[7] ASHRAE 62.1-2019, 5.14.1 requires that water purity shall meet or exceed potable water standards.

F. When using a mechanical cooling system for dehumidification, install the heating coil downstream of the cooling coil to provide reheat. (Requirement 6-0050)

1. *Guidance: A preheat coil may be required to prevent freezing the chilled water coil in the winter. See Coils subsection above.*

8.0 MOTORS

8.1 Derating

A. Pumps: Do not overload elevation-derated motors at any point on the pump curve. (Requirement 6-0051)

B. Fans: Do not overload elevation-derated motors beyond the design operating conditions of the fan curve. (Requirement 6-0052)

C. General: Follow ESM Electrical Chapter 7, Section D5020.

8.2 Enclosures

A. Provide open drip-proof (ODP) motors for clean, dry indoor locations. (Requirement 6-0053)

B. Motors that are part of factory-assembled equipment and are in the air stream may be either totally enclosed non-ventilated (TENV) or totally enclosed fan-cooled (TEFC). (Requirement 6-0054)

C. Provide TEFC motors for outdoor applications and for indoor applications in damp or dusty locations. (Requirement 6-0055)

D. Provide severe duty TEFC motors in wash-down locations or corrosive locations such as draw through cooling towers. (Requirement 6-0056)

E. In hazardous locations use explosion-proof motors that are UL labeled for the location hazard classification. (Requirement 6-0057)

8.3 Selection

A. Use NEMA Premium-labeled energy efficient motors for new installations and for replacements of motors that have failed. Use motors with minimum efficiencies that comply with ASHRAE 90.1 (e.g., Tables 10.8-1 to 10.8-5, and 10.8-6 in 2019). (Requirement 6-0058)

9.0 PUMPS

A. Design and calculate the net positive suction head (NPSH) available in piping systems and ensure that the NPSH required (found on pump curve) is less than the NPSH available. (Requirement 6-0059)

B. Pumps shall be accessible for maintenance. (Requirement 6-0060)

C. Provide redundant pumps for all chilled water and heating hot water systems. Operate pumps in a lead/standby configuration. (Requirement 6-0061)[8]

D. Secondary pump containment (metal pan, angle iron barrier, etc.) may be required for systems handling caustic, contaminated, etc., fluids. Consult with the area ENV or IHS representative or customer for requirements. (Requirement 6-0062)

E. Provide a steam-powered pump when condensate must be moved to a higher elevation or great distances. (Requirement 6-0063)[9]

1. If an electrical-powered condensate pump must be specified, provide an isolation valve between the pump and receiver to prevent draining the receiver during pump maintenance.

F. Provide flexible couplings in the water circulating piping to prevent the transmission of sound and vibration throughout the building. *Guidance: On systems with mechanical couplings, flexible couplings may be used when designed according to the manufacturer's instructions.* (Requirement 6-0064)

G. Heating and cooling pumps with motors drawing 10 hp or more and serving variable flow systems shall be equipped with variable speed drives controlled by system differential pressure. *Guidance: Staged flow is not considered variable flow, VFDs not required.*[10] *Consider VFDs for smaller systems, if life cycle cost effective.* (Requirement 6-0065)

H. Refer to Mechanical Drawing(s) ST-D30GEN-4, Pump Piping Details, for additional guidance.

10.0 SYSTEM DESIGN

A. **Unoccupied Operation:** Primary HVAC systems for office areas shall be designed to allow unoccupied shutdown and temperature setback and shall not provide primary cooling for rooms that require 24-hour consistent temperature control. Server rooms, telecommunications rooms, and other rooms that require 24-hour consistent temperature control shall be served by dedicated air conditioning systems as their primary cooling source. The Mechanical POC can grant variance from this requirement.[11] See also ESM Chapter 19 Communications Section D6010 Data Communications for additional HVAC requirements on such rooms. (Requirement 6-0066)

1. Guidance: only use primary system for ventilation and for backup cooling of rooms requiring 24/7 consistency, if required.

[8] Redundant pumps help ensure continuity of operations for the system, and well as allowing repairs or maintenance to be performed without shutting down system.
[9] Steam-operated pumps provide energy savings over electric ones and are used when electricity is not available or prohibited.
[10] Pumping costs are reduced on larger systems by the addition of variable speed drives.
[11] One of the most effective energy efficiency methods is to turn systems off. Variance appropriate example: Separate units may not be appropriate for labs requiring 24/7 ventilation.

B. **Exhaust Air Energy Recovery:** Exhaust Air Energy recovery systems for heating are required for all 100% outside air HVAC systems for systems with capacity greater than 5,000 cfm except for systems carrying vapors or dust that could deposit nuclear, explosive, or other hazardous residue on the heat recovery surfaces or which can be shown to have a simple payback of greater than 10 years. This applies to all systems that operate 8000 hours per year or more. (Requirement 6-0067)

C. **Alarm Monitoring:** Facilities that require critical alarm monitoring shall be provided with a connection to the Building Automation System (BAS) for alarm notifications. If a BAS is not present, work with the ES-IPD BAS Team to monitor critical points. Supply air temperature, heating water temperature, space temperature or other indication of possible facility damage due to freezing shall be alarmed. Server rooms and other areas where equipment can be damaged by high temperatures shall be provided with high temperature alarms. (Requirement 6-0068)

D. **Table D30GEN-3 (below):** Follow applicable sections of the standards for HVAC and nuclear air treatment systems (NATS). They represent the minimum acceptable methods. ML-1/2 requirements apply to new facilities and "Major Modifications" (see ESM Chapter 1 Section Z10 definition) – and shall be considered for other modifications. (Requirement 6-0069)

TABLE D30GEN-3 **Required Standards for HVAC and Nuclear Air Treatment Systems (NATS) – Titles follow table**				
Function/ Component	**ML-4 (General Service)**	**Radiological, Beryllium, or Other Hazard Confinement (may be ML-3)**	**Safety Significant (SS/ML-2)**	**Safety Class (SC/ML-1)**
General	N/A	*Reference only: DOE-STD-1269, DOE-HDBK-1169; DOE-HDBK-1132*	DOE G 420.1-1A; DOE-STD-1269 *Ref only: DOE-HDBK-1132, DOE-HDBK-1169*	DOE G 420.1-1A; DOE-STD-1269 *Ref only: DOE-HDBK-1132, DOE-HDBK-1169*
Air Handling Units (HVAC only)	AHRI Standards	AHRI Standards	ASME AG-1, DOE-STD-1269	ASME AG-1, DOE-STD-1269
Adsorbers (NATS only)	N/A	*Reference Only:* *ASME AG-1*[12] [13]	ASME AG-1, DOE-STD-1269	ASME AG-1, DOE-STD-1269
Breathing Air	See ESM Ch. 6 Section D20 and Chapter 11 - Radiation Protection			
Coils	AHRI 410	ARHI 410	ASME AG-1	ASME AG-1
Controls	See ESM Chapter 8 I&C			
Dampers	SMACNA; NFPA 90A; UL 555/555S; NFPA 801	AMCA 511; Reference Only: AG-1 (partial)	ASME AG-1 DOE-STD-1269	ASME AG-1 DOE-STD-1269

[12] For Radiological (Less than HC-3), Beryllium, or Other Hazard Confinement Facilities, ASME AG-1 and DOE-HDBK-1169 shall be considered as design guidance. The Facility Design Authority Representative (FDAR) shall approve the minimum applicable requirements of the Nuclear Air Treatment System (NATS).

[13] For HC 1, 2, or 3 Facilities where the ventilation is not credited as SC or SS and only serves up to a Defense-In-Depth function, the minimum design requirements are the same minimum requirements for a Radiological (Less than HC-3) Facility.

The following criterion from DOE G 420.1-1A are considered as additional design guidance for non-credited ventilation system being used as an NATS. The Facility Design Authority Representative (FDAR) shall approve the minimum applicable requirements of the Nuclear Air Treatment System (NATS).

- Materials of construction should be appropriate for normal, abnormal and accident conditions.
- Ventilation system will have appropriate filtration to minimize release.
- Provide system status instrumentation and/or alarms.
- Interlock supply and exhaust fans to prevent positive pressure differential.
- Ventilation system should safely withstand earthquakes (only if credited in the Safety Basis).
- Design supports the periodic inspection & testing of filters and housings, and tests and inspections are conducted periodically.

TABLE D30GEN-3, CONTINUED **Required Standards for HVAC and Nuclear Air Treatment Systems (NATS) – Titles follow table**				
Function/ Component	**ML-4 (General Service)**	**Radiological, Beryllium, or Other Hazard Confinement (may be ML-3)**	**Safety Significant (SS/ML-2)**	**Safety Class (SC/ML-1)**
Ducts	SMACNA 1966 SMACNA 1922 ASHRAE 90.1 *Reference only: ASHRAE Applications Handbook; Systems and Equipment Handbook* NFPA 45	SMACNA 1520, 1966 per AG-1 (partial) SMACNA 1922 ASHRAE 90.1 *Reference only: ASHRAE Applications Handbook; Systems and Equipment Handbook* NFPA 45	ASME AG-1 DOE-STD-1269 ASHRAE 90.1 *Reference only: ASHRAE Applications Handbook; Systems and Equipment Handbook* NFPA 45	ASME AG-1 DOE-STD-1269 ASHRAE 90.1 *Reference only: ASHRAE Applications Handbook; Systems and Equipment Handbook* NFPA 45
Fans	*Reference only: ASHRAE Handbooks*	*Reference only: ASHRAE Handbooks*	ASME AG-1; DOE-STD-1269 *Reference only: ASHRAE Handbooks*	ASME AG-1; DOE-STD-1269 *Reference only: ASHRAE Handbooks*
Filtration	ASHRAE 52.2	ASHRAE 52.2	ASME AG-1 DOE-STD-1269	ASME AG-1 DOE-STD-1269
HEPA Filtration	N/A	*Reference Only: ASME AG-1; DOE STD-3020*	ASME AG-1; DOE STD-3020; DOE-STD-1269	ASME AG-1; DOE STD-3020 ; DOE-STD-1269
Lab Ventilation (e.g., fume hoods)	AIHA Z9.5, NFPA 45 and 91. *Ref only: ASHRAE Applications Handbook, 'Laboratories'*	AIHA Z9.5, NFPA 45 and 91. *Reference only: ASHRAE Applications Handbook, 'Laboratories'*	ASME AG-1 DOE-STD-1269	ASME AG-1 DOE-STD-1269
Local Exhaust	AIHA Z9.2. *Ref only: ASHRAE Applications Handbook, 'Industrial Local Exhaust System.'*	AIHA Z9.2. *Reference only: ASHRAE Applications Handbook, 'Industrial Local Exhaust Systems'*	ASME AG-1 DOE-STD-1269	ASME AG-1 DOE-STD-1269
Off-gas treatment	*Reference only: ASHRAE Handbooks*	DOE-HDBK-1132. *Ref only: ASHRAE Handbooks*	ASME AG-1; DOE-STD-1269	ASME AG-1; DOE-STD-1269
Refrigeration Units	AHRI Standards	AHRI Standards	ASME AG-1; DOE-STD-1269	ASME AG-1; DOE-STD-1269

TITLES FOR TABLE D30GEN-3

AIHA-American Industrial Hygiene Assoc

Z9.2, Fundamentals Governing the Design and Operation of Local Exhaust Systems

Z9.5, Laboratory Ventilation

AMCA-Air Movement and Control Assoc

99, Standards Handbook

261, Directory of Products Licensed to Bear the AMCA Certified Ratings Seal

ANS-American Nuclear Society

59.2, Safety Criteria for HVAC Systems Located Outside Primary Containment

AHRI-Air-Conditioning, Heating, and Refrigeration Institute

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

430, Central-Station Air-Handling Units

450, Water-Cooled Refrigerant Condensers, Remote Type

ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

DG-1, "Heating, Ventilating, and Air-Conditioning Design Guide for Department of Energy Nuclear Facilities."

Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

ASME-American Society of Mechanical Engineers

AG-1, Code on Nuclear Air and Gas Treatment

DOE Directives http://www.directives.doe.gov/

Guide 420.1-1A, Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide for use with DOE O 420.1C Facility Safety

DOE Standards

https://www.standards.doe.gov/

DOE-HDBK-1169, Nuclear Air Cleaning Handbook

DOE-STD-1132, Design Considerations

DOE-STD-1269, Air Cleaning Systems in DOE Nuclear Facilities

DOE-STD-3020, Specification for HEPA Filters used by DOE Contractors

NFPA – National Fire Protection Assoc.

45, Fire Protection for Laboratories Using Chemicals

90A, Installation of Air Conditioning and Ventilation Systems [use vice UMC for smoke detection and fire dampers]

91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids (National Fire Codes, vol. 4)

801, Standard for Fire Protection for Facilities Handling Radioactive Materials (National Fire Codes, vol. 11)

SMACNA-Sheet Metal and Air-Conditioning Contractors' National Association

1520, Round Industrial Duct Construction Standards

1922, Rectangular Industrial Duct Construction Standards

1966, HVAC Duct Construction Standards, Metal and Flexible

UL – Underwriters Laboratories

555, Safety -- Fire Dampers

555S, Safety -- Smoke Dampers

Additional Guidance for Table D30GEN-3

1. *DOE O 420.1C: ASME AG-1 is identified as a requirement only for Safety-Significant (SS) and Safety-Class (SC) Systems in a new HC 1, 2, or 3 Facility OR when associated with a Major Modification in a HC 1, 2, or 3 Facility. The Order has no specific requirements for ventilation systems not supporting a credited safety function (e.g., Other Hazard Controls (OHC), Defense-In-Depth (DID)).*

   Note: DOE O 420.1C Att 3 3.b(4) invokes Appendix A of DOE Guide (G) 420.1-1A for ventilation as follows: "Appendix A of DOE Guide (G) 420.1-1A, Nonreactor Nuclear Safety Design Criteria for use with DOE O 420.1C, Facility Safety, and DOE Handbook-1169-2022, Nuclear Air Cleaning Handbook, provide guidance for confinement ventilation systems design and performance criteria. Alternate methods must be approved by DOE field elements."

   Invoking Appendix A of 420.1-1A and DOE Handbook-1169-2022 through the Order elevates them as requirements documents for SS and SC systems. However, 420.1-1A and DOE Handbook-1169-2022 are considered as guidance only documents for non-credited ventilation systems.

2. *DOE G 420.1-1A: The Guide only applies to new HC 1, 2, or 3 Nuclear Facilities OR when associated with a Major Modification in a HC 1, 2, or 3 Nuclear Facility. For "Defense-In-Depth/Other" confinement ventilation systems, Appendix A of the Guide specifies the following criteria:*
   - *Materials of construction should be appropriate for normal, abnormal and accident conditions.*
   - *Ventilation system will have appropriate filtration to minimize release.*
   - *Provide system status instrumentation and/or alarms.*
   - *Interlock supply and exhaust fans to prevent positive pressure differential.*
   - *Ventilation system should safely withstand earthquakes (only if credited in the Safety Basis).*
   - *Design supports the periodic inspection & testing of filters and housings, and tests and inspections are conducted periodically.*

   Per DOE O 420.1C, Attachment 3, Design Criteria for Safety Structures, Systems and Components, any alternate methods to the above must be approved by the DOE field elements when associated with a SS or SC system. For Defense-in-depth (or less) ventilation systems, the requirements listed above are considered as design guidance only. Any deviation from this guidance should be technically justified and approved by the Facility Design Authority Representative (FDAR).

3. *DOE-HDBK-1169-2022: While the Handbook does reference ASME AG-1 throughout, DOE Standards and DOE Directives are the only two document types that may be invoked requirements. According to introductory statements within them, DOE Handbooks may not be invoked and may not include requirements language (such as "shall," "must," and "will" statements). The Handbook and referenced ASME AG-1 only serves as guidance for good engineering practice. Any deviation from the Handbook, ASME AG-1, or DOE-STD-1269 (where applicable) should be technically justified and approved by the Facility Design Authority Representative (FDAR).*

4. *Storage levels: When a facility (e.g., warehouse) includes storage of level A, B, C, and/or D items, meet the applicable design portions of the checklists in P330-12, Establishing Controlled Storage Areas (e.g., checklists' requirements being design inputs). Ex: "Monitoring or alarm system to signal personnel when temperature goes outside of specified limits."*

D3020 HEATING SYSTEMS

1.0 GENERAL

A. LANL projects shall report to the Air Quality Group the planned installation, modification, or replacement of all fuel-burning equipment for determination of whether the activity or project requires regulatory permitting, emission monitoring or reporting, etc. Provide OSH-DO with a description of the equipment or modification; listing size, rating, manufacturer, model number, fuel, etc. (Requirement 6-0070)

B. For heating design loads, do not take credit for internal heat gains from equipment that is often de-energized, especially during off hours, e.g., lights, personal computers. (Requirement 6-0071)

C. Design new low temperature heating hot water systems for a maximum of 130 degrees F return temperature. (Requirement 6-0072)

D. Two-way valves: All heating water systems shall be designed to maximize the number of 2-way valves (versus 3-way valves) to reduce overall pumping power requirements. Determine minimum flow requirements from pump curve (prevent dead-heading) and provide with either 2-way minimum flow valves or 3-way valves. If a minimum flow valve is used, it shall be placed at the end of the piping run. (Requirement 6-0073)

E. For 100% outside air systems, use hydronic heating. Steam, electric resistance, gas-fired furnace, and other methods are allowed only with ESM Mechanical POC permission. (Requirement 6-0074)

F. Electric resistance heating systems shall not be used for space heating, except where proven to be life cycle cost effective. (Requirement 6-0075)

Exceptions:

1. Where the total capacity of all electric resistance heating systems serving the entire building is less than 10 percent of the total design output capacity of all heating systems serving the entire building.

2. Where the total capacity of all electric resistance heating systems serving the building is no more than 5 kW.

3. Where an electric resistance heating system serves an entire building that:

   a. Has a conditioned floor area no greater than 5,000 square feet; and

   b. Has no mechanical cooling, and

   c. Is in an area where natural gas is not available, and an extension of a natural gas system is impractical, as determined by LANL Utilities and Infrastructure.

4. Where an electric resistance heating system supplements a heating system in which at least 60 percent of the annual energy requirements is supplied by site solar or recovered energy.

5. Where the electric-resistance heating system supplements a heat pump heating system, and the heating capacity of the heat pump is more than 75 percent of the calculated design heating load.

6. *Guidance: If electric heat is used in packaged equipment, first stage of heating should be heat pump.*

G. *Guidance: Natural gas is not allowed in some facilities due to safety reasons. In these instances, consider natural gas fired boilers located in a separate building in lieu of electric heating.*

H. *Guidance: When designing for facilities over 25,000 square feet, consider how the heating system will obtain net-zero emissions by 2030. This could preclude the use of natural gas as the main source for heating energy. (ref. ESM Ch. 14, EO 14057).*

I. *Guidance: When steam is available from a central plant, consider using a steam-to-hot water heat exchanger for the heating system. However, in some instances it may be cost-effective to provide a gas-fired hot water boiler rather than tying into an existing steam and condensate system*.

1. Provide low pressure steam supply (15 psig maximum) to the heat exchanger and preheat coil.

J. For new buildings in TA-3: When using the site steam distribution system, design for incoming temperature of 500 deg F and 125 psig; for the condensate return system design for 250 degrees F and 125 psig (if otherwise is required or a more recent ESM Ch. 3 section is different, contact Civil POC). (Requirement 6-0076)

K. Locate the equipment room at the point of entry of the high-pressure steam distribution supply to the building. Provide a steam PRV within the equipment room per LANL Mechanical Standard Drawing(s) ST-D3020-2, Steam PRV Station. (Requirement 6-0077)

L. Direct-fired furnaces/heaters are only allowed with ESM Mechanical POC permission. The POC can require air quality testing, continuous CO monitoring, or other measures. (Requirement 6-0078)

M. Provide redundant heating for Mechanical rooms, to prevent freeze-up in case of a boiler malfunction (e.g., gas heat, electric heat, or multiple boilers). (Requirement 6-0079)

1. When gas is available, it is preferred to use gas fired radiant heaters with millivolt gas controls. Millivolt gas controls allow the unit to operate when there is an electrical power outage. (Requirement 6-0080)

N. Entry vestibules: Provide a source of heat to prevent freezing of water on floor and reduce cold drafts in lobbies during peak use times. Do not provide cooling for vestibules. (Requirement 6-0081)

O. Locate shell and tube heat exchanges so that the location of joints (unions, flanges, etc.) and adjacent piping, etc. are clear of the tube pulling space. (Requirement 6-0082)

P. Stairwells: Provide a thermostatically controlled source of heat to prevent freezing of water on floor or in standpipes. (Requirement 6-0083)[14]

Q. Refer to the following LANL standards for additional guidance: [15]

1. Mechanical Drawing(s) ST-D30GEN-2, Water Coil Piping
2. Mechanical Drawing(s) ST-D30GEN-3, Steam Coil Piping
3. Mechanical Drawing(s) ST-D3020-1, Steam Unit Heater Piping
4. Mechanical Drawing(s) ST-D3020-2, Steam PRV Station
5. Mechanical Drawing(s) ST-D3020-3, Steam Drip Leg
6. Mechanical Drawing(s) ST-D3020-4, Steam Drip Pan Elbow
7. Master Specification Section 23 2113, *Hydronic Piping*
8. Master Specification Section 23 2215, *Steam and Condensate Heating Piping & Specialties* [for up to 150 psig and 0-366°F, otherwise use 33 6300]
9. Master Specification Section 23 7413, *Packaged, Outdoor, Central Station*
10. Master Specification Section 23 8239, *Unit Heaters*
11. ESM Civil Chapter for site steam/condensate distribution system

2.0 BOILERS

2.1 General

A. Information on boiler procurement, installation and maintenance is contained in ESM Chapter 17.

B. Correct boiler selection for elevation. Refer to Elevation Correction article above. (Requirement 6-0084)

C. Provide boilers manufactured and labeled in accordance with the ASME Boiler and Pressure Vessel Code and registered with the National Board of Boilers and Pressure Vessel Inspectors (ANSI/NB-23). (Requirement 6-0085)

D. A factory-authorized representative of the boiler manufacturer shall provide startup service, stack analysis, and training to the LANL operator. Test reports shall be furnished to LANL. (Requirement 6-0086)

E. Provide boiler water treatment. Refer to Chemical Water Treatment article above. (Requirement 6-0087)

F. Provide condensing boilers for all new heating hot water installations and replacements. (Requirement 6-0088)

1. Cast-iron boilers are not allowed. (Requirement 6-0089)

[14] POC permission to vary is possible for glassed-in, southern exposures where calculated solar gain is sufficient.
[15] The drawings and/or specifications provide piping installation details, material specifications, and additional design requirements and guidance.

2. Direct replacement of non-condensing boilers is allowed if it is not life cycle cost effective to update to condensing boilers (e.g., extensive building modifications are required to fit new boilers in existing mechanical spaces). (Requirement 6-0090)

G. Provide a low NOx burner system, with a maximum NOx emission of 30 ppm, on all gas-fired boilers except where specifically waived by ESM Mechanical POC. (Requirement 6-0091)

1. Refer to the above Subsection D3020, Heating Systems - General, for EPC-ES (Environmental Protection and Compliance Environmental Stewardship Group) reporting requirements.

H. Provide boilers with minimum refractory. (Requirement 6-0092)

I. Group all atmospheric vent lines and pipe one vent to atmosphere above roof to minimize roof penetrations when in the same mechanical room. (Requirement 6-0093).[16]

1. Size vent piping through roof to have a cross-sectional area of not less than the area of the largest vent plus 50% of the areas of the additional vents. (Requirement 6-0094)

2. Do not connect atmospheric vent lines to any common or manifolded gas vent, bleed, or relief lines. Do not manifold with other boiler units. (Requirement 6-0095)

3. Provide fine mesh screen at end of vent piping, and a downward turn to prevent entry of rain and snow. (Requirement 6-0096)

J. Boiler Flues: Design per the boiler manufacturer's requirements; e.g., do not exceed maximum flue weight on boiler, required draft at flue outlet, etc. (Requirement 6-0097)

1. Provide vent caps on boiler flues to keep rain, birds, and debris out of the flue. (Requirement 6-0098)

2.2 Controls

A. Provide automatically fired boilers with controls and safety devices per ASME CSD-1. For boilers 12,500,000 Btu/hr and over, follow NFPA 85. (Requirement 6-0099)

B. Provide controls for gas-fired boilers that comply with UL 353 (Requirement 6-0100).

C. Provide controls for electric boilers that comply with UL 834. (Requirement 6-0101)

D. When boilers are provided with built-in controllers, ensure the compatibility to integrate these controllers with the Building Automation System. See ESM Chapter 8 for further detail. (Requirement 6-0102)

E. Water and steam boiler trim shall include, but is not limited to, the following components (Requirement 6-0103):

1. Enclosed control cabinet including flame safeguard controls with a manual reset.

2. Operating temperature or pressure controls.

3. Water Boiler: High limit temperature control with lockout requiring manual reset.

4. Water Boiler: Float-operated low water cutoff with test and check valves, with lockout requiring manual reset.

5. Steam Boiler: High limit pressure control with lockout requiring manual reset (pipe blowdown to floor drain). Set range not to exceed 15 psig.

[16] When in same mechanical room. Sizing requirements from ASME CSD-1

6. Steam Boiler: Two float operated low water cutoffs (primary and secondary) with lockout requiring manual reset on the secondary. (pipe blowdown to floor drain)
7. Pressure gauge. Range for hot water boilers to be 1.5 – 3.5 times the PRV setting. Range for steam boilers to be not less than 0-30 psi and not more than 0-60 psi.
8. Temperature gauge. Provide range for hot water boilers not less than 70°F to 320°F, but not more than 400°F.
9. Safety relief or safety valve. See ESM Chapter 17 for requirements.
10. Remote boiler shutdown, per CSD-1.

F. Provide two or more boilers and the determination of the proportion of load each handles based on energy, redundancy, and maintenance requirements. *Guidance: Consider minimum turndown capacity when selecting boilers. Examples:* (Requirement 6-0104)

1. *Two modular boilers: 40 percent and 60 percent or 50 percent and 50 percent of system load*.
2. *Three modular boilers: 40 percent and 60 percent with standby at 60 percent of system load or 50, 50, 50 percent configuration.*

G. Provide a dedicated primary pump for each boiler. (Requirement 6-0105)

H. Provide controls that automatically reset hot water for building heating by representative building loads. Do not reset based on outside temperature. Refer to ASHRAE Standard 90.1 (*e.g., Section 6.5.4.4*), for requirements. (Requirement 6-0106)

I. Heating water temperature reset: Heating water temperature reset shall be accomplished by controlling the boiler water supply temperature utilizing the burner controls rather than controlling a three-way heating water mixing valve. When using a non-condensing boiler, the lowest reset temperature shall be 160 degrees F. (Requirement 6-0107).

J. Provide an Industrial Risk Insurers (IRI) gas fuel train on gas-fired boilers greater than 400,000 Btu/hr (input rating at sea level) with pressure gauges factory installed on both sides of the main gas burner regulator. (Requirement 6-0108)

K. On boilers with power burners, provide a temperature indicator on the boiler exit breaching. (Requirement 6-0109)

2.3 Safety Relief/Safety Valves

See ESM Chapter 17.

D3030 COOLING

1.0 GENERAL

A. Design cooling systems using mechanical vapor compression equipment (direct expansion coils or chillers) when close (better than plus or minus 5 degrees F) temperature control in the space is required. (Requirement 6-0110)

B. *Guidance: Consider evaporative/adiabatic cooling for areas that do not require year-round cooling and close temperature control, i.e., warehouses, shops, makeup air ventilation units, and mechanical equipment spaces.* Provide controls that automatically reset building chilled water cooling by representative building loads. Do not reset based on outside temperature. Refer to ASHRAE Standard 90.1 (*e.g., Section 6.5.4.4*), for requirements. (Requirement 6-0111)

C. Refer to LANL Master Specification Sections 23 6200, *Packaged Compressor and Condenser Units*; 23 7413, *Packaged, Outdoor, Central Station*; and 23 8123, *Computer-Room Air-Conditioners* for additional guidance.

D. *Guidance: for packaged rooftop equipment, consider variable speed compressors to match building loads. Increases cooling efficiency and extends equipment life.*

2.0 COOLING TOWERS

2.1 Design Conditions

A. Select cooling tower based on the following: (Requirement 6-0112)

1. Ambient wet bulb temperature (AWB), 65 degrees F.
2. Tower operation at elevation per ESM Chapter 1 Section Z10 (**Note**: elevation correction required)

B. Select the following, based on project requirements: (Requirement 6-0113)

1. Supply cold water temperature leaving cooling tower (LWT).
2. Return hot water temperature entering cooling tower (EWT).
3. Approach temperature (LWT-AWB).
4. Range temperature (EWT-LWT).

2.2 General

A. Provide cooling towers certified by the Cooling Tower Institute (CTI) under Standard 201. (Requirement 6-0114)

B. Wooden towers are not acceptable for new construction. When modifying existing towers, do not use chemically treated lumber. Steel, fiberglass, and clear untreated redwood are acceptable materials for modifications. (Requirement 6-0115)

C. Provide freeze protection for towers that operate during the winter by a suitable method such as variable speed fans, 2-speed motors, reverse fan flow during freeze-up, water return bypass in piping using a 3-way valve, immersion sump heater, etc. Refer to the drawings and specification sections referenced below for additional requirements. (Requirement 6-0116)

D. Refer to Mechanical Chapter, Section D10-30GEN (Meters subsection) and ESM Chapter 14 *Sustainable Design* for water meter requirements in the water make-up and blow-down lines.

E. Slope tower water horizontal return piping away from tower to prevent line from draining into tower sump when pump is not operating. (Requirement 6-0117)

F. Chemically treat water both in open cooling towers and the sumps of closed-circuit cooling towers (Requirement 6-0118). Chemicals used must be approved by EPC-ES (Requirement 6-0119)

G. Provide overflow drain piping and sump drain piping to an approved drain. (Requirement 6-0120)

H. Refer to latest ASHRAE HVAC Systems and Engineering Handbook for additional tower piping design for equalizing lines, isolation valves, balancing valves, etc.

I. Comply with EPA and NPDES permit requirements for blowdown water discharging to outfalls. Reference most current NPDES for limitations on chlorine content, pH, temperature, and other regulated water properties. (Requirement 6-0121)

J. Refer to the following LANL Standards for additional guidance and requirements:[17]

1. Mechanical Drawing(s) ST-D3030-1, Cooling Tower and Chiller Piping Component Diagram Mechanical Drawing(s) ST-D30GEN-1, Open Cooling Tower Water Treatment.

2.3 Location

A. Cooling tower noise, drift, plume (fogging), and prevailing winds shall be considered when selecting a tower site, e.g., do not locate a tower near buildings sensitive to staining or scale deposits from the tower drift or plume. Consider plume effects on adjacent roads, parking lots, etc. Locate such that the cooling tower plume cannot enter occupied spaces; plume discharge shall be at least 20 feet away from any ventilation inlet to a building. (Requirement 6-0122)

B. Provide sufficient free and unobstructed space around the unit, as recommended by the manufacturer, to ensure adequate air supply to the fans and to allow proper servicing. (Requirement 6-0123)

3.0 REFRIGERATION SYSTEMS

3.1 General

A. Systems that fall within the scope of ASME B31 series shall meet the requirements of ESM Chapter 17. (Requirement 6-0124)

B. Comply with UMC and ASHRAE Standard 15, Safety Code for Mechanical Refrigeration, including the special requirements for modern refrigerants. (Requirement 6-0125)

C. When packaged controls are provided, confirm their compatibility to integrate with the Building Automation System. See ESM Chapter 8 for further detail. (Requirement 6-0126)

D. Select refrigerant types considered environmentally safe as outlined in the Clean Air Act (as amended), and the Environmental Protection Agency (EPA). The use of CFCs and HCFCs in new equipment is prohibited. (Requirement 6-0127)

1. For a list of EPA acceptable substitutes for ozone depleting substances refer to: https://www.epa.gov/snap#refac
2. Provide systems that do not contain CFCs or HCFCs.
3. Approval to purchase refrigeration equipment requires a Special Review (Form 410 Approval) by the Meteorology and Air Quality Team (EPC-CP-MAQ). Coordinate with the Meteorology and Air Quality Team during design to ensure the equipment can be approved for purchase during construction.

E. Provide packaged factory-assembled units where practical. Where split systems are required, provide all components (evaporator, condenser, controls, etc.) from the same manufacturer to ensure proper match and single point of contact. (Requirement 6-0128)

[17] The drawings and specifications provide piping details, tower and water treatment specifications, and additional design guidance and requirements.

1. Design refrigerant lines (size, routing, traps, etc.) per ASHRAE Handbooks and manufacturer's written instructions for built-up systems to ensure proper movement of the refrigerant and the oil. (Requirement 6-0129)
2. Do not bury refrigerant lines. (Requirement 6-0130)

F. Review noise criteria when selecting compressor types. Request noise data for all eight octave band center frequencies from 63 to 8000 Hz, measured in accordance with AHRI Standard 575. (Requirement 6-0131). *For additional requirements refer to Mechanical Chapter, Section D10-30GEN, Sound and Vibration Control Subsections.*

G. Route refrigerant pressure relief valve venting to the outside of the building. Size and locate line in accordance with UMC. (Requirement 6-0132). For low pressure refrigeration systems (15 psig and below), provide a rupture disk/PRV combination. (Requirement 6-0133)

H. Provide a factory installed and tested chiller control panel with necessary refrigeration and electrical controls for automatic safety shutdown, manual reset, pump interlocks, chiller sequencing for single and parallel chiller installations, etc. (Requirement 6-0134)

I. Refer to ASHRAE Standard 147 for practices and procedures that will reduce the inadvertent release of halogenated refrigerants. Refer to LANL Master Specification Section 23 2300, *Refrigerant Piping* for additional guidance.

3.2 Air-Cooled

A. Select air-cooled systems for operation at 95 °F outside air temperature entering the condenser. (Requirement 6-0135)

B. Provide low ambient options for refrigeration units with air-cooled condensers operating year-round and select equipment for 0 °F minimum operating temperature. (Requirement 6-0136)

C. Derate air-cooled equipment for elevation. Refer to Elevation Correction article above. (Requirement 6-0137)

D. Provide factory installed hail guards on air cooled equipment (including chillers) installed outdoors to protect the coil fins. (Requirement 6-0138)

3.3 Water-Cooled

A. Select the following water-cooled systems based on project requirements. (Requirement 6-0139)

1. Evaporator chilled water supply temperature leaving the evaporator.
2. Condenser tower water supply temperature entering the condenser.

B. Refer to Mechanical Standard Drawing(s) ST-D3030-1, Cooling Tower and Chiller Piping Component Diagram, for additional guidance.[18]

[18] The drawing provides details for chilled/tower water piping, including components such as chemical feeder and expansion tank.

D3050 FACILITY HVAC DISTRIBUTION SYSTEMS

1.0 GENERAL

A. Among the required NFPA National Fire Codes, the following are particularly applicable for ventilation systems. (Requirement 6-0140)

1. NFPA 30, Flammable and Combustible Liquid Code
2. NFPA 45, Fire Protection for Laboratories Using Chemicals
3. NFPA 55, Compressed and Liquefied Gasses in Portable Cylinders
4. NFPA 75, Electronic Computer/Data Processing Equipment
5. NFPA 90A, Installation of Air Conditioning and Ventilating Systems
6. NFPA 91, Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids

2.0 BUILDING THERMOSTATIC ZONES (REQUIREMENT 6-0141)

A. Permanent Partitions (floor-to-ceiling): Provide the following minimum thermostatic zones:

1. Each corner office on exterior walls
2. Each laboratory
3. Each conference room
4. Maximum of three (3) offices with similar exposure and/or internal loads
5. Each toilet room with a shower

B. Open Office Area (moveable partitions): Provide a thermostatic zone, 10-15 feet from the exterior wall, for each exposure (e.g., N, S, E, and W), and a thermostatic zone for the interior area unless Mechanical POC gives variance. Each VAV box within the zone shall serve no more than 6 supply air diffusers.

3.0 DIFFUSERS, GRILLES, REGISTERS, AND LOUVERS (B2070.10, C1090.15)

A. Select diffusers, registers, grilles, and louvers based on ASHRAE, SMACNA, and the manufacturer's recommendations. Give special attention to supply air diffusers and grilles in laboratory areas. Refer to latest ASHRAE Application Handbook chapter on laboratories. (Requirement 6-0142)

B. Base selection on air flow, noise criterion (NC) level, air pattern, throw, mounting height, face velocity, pressure loss, aesthetic, etc., requirements. (Requirement 6-0143)

C. Provide an integral opposed-blade damper only when a manual-balancing damper cannot be installed in the branch duct. (Requirement 6-0144)

D. Provide drainable blade louvers with bird-screen for outside air intake and discharge louvers to provide proper drainage of snow and rainwater. (Requirement 6-0145)

1. Louvers shall bear the AMCA Seal with ratings based on tests and procedures performed in accordance with AMCA Publication 511. The AMCA Certified Rating Seal applies to air performance and water penetration ratings. (Requirement 6-0146)

E. Do not use transfer grilles between areas where contaminant migration is possible. (Requirement 6-0147)

F. Return relief fans are required in building air handling systems with outside air economizers (gravity/barometric building relief is not allowed). (Requirement 6-0148)

4.0 HVAC AIR DISTRIBUTION (D3050.50)

4.1 General

A. Fabricate, seal, and test duct work to the applicable SMACNA standards. (Requirement 6-0149)

1. Seal ductwork and plenums to SMACNA Seal Class A. (Requirement 6-0150)

B. *Guidance: Consider the following when designing ductwork to control material and energy costs:*[19]

1. *Use the minimum number of fittings possible. Fittings may be expensive and the dynamic pressure loss of fittings is far greater than straight duct sections of equal centerline length*.
2. *Use round duct where space and initial cost allows, as round ductwork has the lowest possible duct friction loss for a given perimeter*.
3. *When using rectangular ductwork, maintain the aspect ratio as close to 1 to 1 as possible to minimize duct friction loss and initial cost*.
4. *Design the system to reduce the duct static pressure throughout the supply, return, and the exhaust side.*

C. Exit passageways, stairs, ramps, and other exits shall not be used as part of a supply, return, or exhaust air system serving other areas of the building. (Requirement 6-0151). Corridors used to convey air to and from rooms shall be approved by LANL Fire Protection Group. (Requirement 6-0152)

D. Connect outside air ducts for building makeup air systems directly to a fan system. Do not use mechanical rooms as air plenums. (Requirement 6-0153)

E. Provide duct systems constructed of metal except for return air sound traps (ST-D3040-2), flexible connections and flexible air duct connections to equipment and diffusers. (Requirement 6-0154)

1. A fabric air-dispersion systems (e.g., DuctSox©) may be used under the following conditions (Requirement 6-0155):

a. It is installed entirely in exposed locations,

b. It is used only for positive pressure systems,

c. Dispersion system will not pass through or penetrate fire-resistance-rated construction, and

d. Dispersion system is listed and labeled in compliance with UL 2518.

[19] SMACNA HVAC System Duct Design - 1990, pg. 2.3, Controlling Costs

F. *Guidance: Round ducts are strongly recommended for industrial exhaust systems because they provide a more uniform air velocity to resist settling of material and an ability to withstand higher static pressure.* (Requirement 6-0156)

G. Provide flexible connections immediately adjacent to the suction and discharge ends of moving equipment, e.g., fans, AHUs, etc. (Requirement 6-0157)

H. Construct exhaust systems with materials suitable for service, e.g., stainless steel, non-galvanized, etc. Ducts handling high abrasive, corrosive, or radiological materials shall be smooth (welded longitudinal seam) and free from obstructions, especially at joints. (Requirement 6-0158)

I. Provide minimum 18 gage material when arc welding black iron ductwork. (Requirement 6-0159)

J. Provide 100% full penetration welds for perchloric hood exhaust ductwork. (Requirement 6-0160)

K. Do not use galvanized construction for temperatures exceeding 400 degrees F. (Requirement 6-0161)

L. Route trunk ductwork parallel to building walls to conserve ceiling space and allow for future utilities. (Requirement 6-0162)

M. Minimize duct penetrations through security walls, floor, roofs, etc. Provide a security barrier when required by ESM Chapter 9 [e.g., when the penetration is greater than 96 square inches and more than 6 inches in its smallest dimension; human-proof using 1/2-inch diameter steel bars on 6-inch centers welded at each intersection; follow Mechanical Standard Drawing(s) ST-D3040-6. (Requirement 6-0163)

N. Provide an airflow indicator for new or modified fume hoods and other local exhausts such as welding bench hoods, etc. See Mechanical Standard Drawing(s) ST-D3040-1 for installation details on a hood static pressure gage. (Requirement 6-0164)

O. *Guidance: Limit duct velocities in ducts as required to help achieve design room criterion (RC) levels.*

P. Paint visible interior duct surfaces behind air terminal units flat black as required where reflection (dark rooms), or aesthetics is a concern. (Requirement 6-0165)

Q. Follow Mechanical Standard Drawing(s) ST-D3040 when penetrating a sensitive compartmented information facility (SCIF) area. See ESM Chapter 9, *Security*, and consult with LANL Security. (Requirement 6-0166)

4.2 Ceiling Plenums

A. Ceiling plenum return air systems (non-ducted) may be used when not prohibited by security, fire protection, electrical, etc., requirements. (Requirement 6-0167)

1. Provide a sound elbow to each return grille per LANL Mechanical Standard Drawing(s) ST-D3040-2. (Requirement 6-0168)

2. Coordinate the use of ceiling plenum with the electrical designer for specific requirements, e.g., plenum-rated cables, etc. (Requirement 6-0169)

B. G*uidance: Consider the following when providing a ceiling return air plenum:*

1. *Ceiling return air plenums require administration control throughout the life of the building to maintain the required fire hazard classification within the plenum. Plenums that do not meet the required classification will require fire protection sprinklers above the ceiling*.

2. *Indoor air quality issues may become a factor due to dust accumulation and rodent droppings*.
3. *With ceiling plenums, future modifications (adding additional piping and cables in the plenum) may block the air flow*.
4. *Ceiling plenums are cheaper to install and usually require less space above the ceilings*.
5. *Balancing is sometimes easier because you are only balancing one duct system, not two systems. However, rooms further away from the air handling unit may be more difficult to balance.*
6. *Consider smaller return air grilles in rooms/zones closer to the air handling unit. This will help prevent poor ventilation in distant rooms.*
7. *Open return air plenums are much easier to remodel because of lesser ductwork above ceiling system*.

4.3 Dampers

A. General

1. Provide opposed blade dampers for modulating (control) applications. (Requirement 6-0170)
2. Provide manual balancing dampers at each supply and return duct branch to control the total air and facilitate balancing. Do not use splitter-type dampers. (Requirement 6-0171)

B. Fire/Smoke

1. Provide a fire damper in ductwork penetrating 1-hour or greater rated barriers. Provide an access door to service fire damper. LANL Fire Protection Group (FP) shall approve preliminary and final designs. (Requirement 6-0172)
2. Fire dampers are not required when the duct is encased in a 2-hour or greater rated enclosure. (Requirement 6-0173)
3. Fire dampers may not be required in nuclear and hazardous exhaust systems. Consult with LANL Fire Protection Group. (Requirement 6-0174)
4. Provide out-of-air-stream-type fire/smoke dampers where required to minimize noise generation in duct systems. (Requirement 6-0175)
5. Provide smoke dampers where required by IBC, IFC, or NFPA 101. LANL Fire Protection Group shall approve preliminary and final designs. (Requirement 6-0176)
6. Refer to ESM Fire Protection Chapter 2 for additional requirements.
7. *Guidance: Refer to SMACNA Fire, Smoke, and Radiation Damper Installation Guide for HVAC systems*.

4.4 Duct Lining

A. Limit the use of duct lining as much as possible (due to potential IAQ issues). Document justification for its use. If its use is justified, limit use to the following: (Requirement 6-0177)

1. As an acoustical liner to absorb unwanted crosstalk, equipment, and air rush noise.
2. To no more than 10 feet downstream of the noise-generating equipment (fan, etc.) unless Mechanical POC approval is obtained. *If additional sound reduction is required, the use of manufactured sound attenuators may be required.*

3. As an insulator when ductwork is located outdoors and requires insulation but exterior insulation (ref LANL Master Specification Section 23 3101) is not practical

B. Select duct liner by referring to LANL Master Specification Section 23 3101, *HVAC Ducts.*

4.5 Duct Heat/Smoke Detectors

A. Location and installation details of detectors in ductwork shall be approved by a LANL Fire Protection Group representative to ensure code compliance. (Requirement 6-0178)

B. Duct detectors shall: (Requirement 6-0179)

1. Be provided where required by NFPA 90A.
2. Be provided where determined by a LANL Fire Protection Group representative for HEPA filter systems.
3. Not be provided for 100 percent exhaust systems.
4. Be provided for 100 percent outside air intake (once-through) systems per NFPA 90A and the UMC. The supply fan shutdown function specified by NFPA 90A may be omitted where determined by a LANL Fire Protection Group representative through analysis.
5. Do not specify duct smoke detectors that are provided as optional equipment by the vendor for air handling systems (will be provided by fire alarm system).
6. Provide photoelectric detectors. Ionization detectors are not acceptable because of less reliability at 7,500 feet elevation.
7. Refer to ESM Fire Protection Chapter for additional requirements.

5.0 FANS

A. Select fan construction based on system design conditions, corrosion resistance considerations, explosive/spark resistance criteria, etc. (Requirement 6-0180)

B. Provide fans that bear the Air Movement and Control Association (AMCA) seal. (Requirement 6-0181)

1. *Guidance: Refer to AMCA Pub. 302 for suggested limits for room loudness in sones*.

C. Select fan so that its minimum operating point, such as minimum airflow for VAV systems, falls on the negatively sloping portion of the pressure curve to prevent surging or pulsation. (Requirement 6-0182)

1. Do not use discharge dampers or inlet vanes on VAV air handling units for volume modulation. Use variable frequency drives or ECM motors. (Requirement 6-0183)

D. Carefully analyze system effect in fan sizing to minimize a "derating" of the HVAC system fan. Refer to SMACNA HVAC Systems Duct Design Manual. (Requirement 6-0184)

E. *Guidance: For critical equipment (e.g., fume hood exhausts, local exhaust, etc.) of 100 horsepower or greater, consideration should be given to providing temperature and vibration sensors to give early warning of problems.* (Requirement 6-0185)

F. When selecting a fan, specify, at minimum, the following (Requirement 6-0186):

1. Airflow, acfm

2. Total pressure at 7,500 feet elevation
3. Total pressure at sea level (catalog value)
4. Nameplate motor horsepower
5. Fan wheel diameter
6. Fan outlet velocity
7. Fan rpm
8. Rotation
9. Arrangement
10. Discharge Position (for centrifugal fans)
11. Sound rating in dBs for all eight octave band center frequencies from 63-8000 Hz and/or sone ratings.
12. Voltage, phase, HP, and calculated BHP.

6.0 FILTERS FOR HVAC SYSTEMS AND HEPA EXHAUST SYSTEMS

6.1 HVAC Systems

A. Pre-Filter: Provide a Minimum Efficiency Reporting Value (MERV) #8 filter, per ASHRAE Standard 52.2, unless usage of space dictates a higher efficiency and class of filter. Provide a minimum of MERV 13 for final filters. (Requirement 6-0187)

B. Follow ASHRAE HVAC Systems and Equipment Handbook on Air Cleaners for Particulate Contaminants, for Typical Filter Applications classified by Filter Efficiency and Type. (Requirement 6-0188)

C. Provide the maximum change-out pressure for filters on the construction drawings. (Requirement 6-0189)

D. When a BAS is present, include a pressure transmitter to report and alarm on plugged filters. (Requirement 6-0190)

6.2 HEPA Exhaust Systems (D3060.70)

A. When required by codes, standards, or a LANL OSH-ISH or EPC-ES representative, provide a high efficiency filtration system for the removal of radioactive, microbiological, carcinogenic, and other hazardous substances from exhaust air. (Requirement 6-0191)

B. *Guidance: The filter system (single or multiple units) may include a fire screen, moisture separators, pre-filter, post-filter, HEPA filters, chemical absorbers, in-place test sections, instrumentation, dampers, or other special features. Consult with a LANL* OHS-ISH or EPC-ES *representative for requirements*

C. Final HEPA filters shall be furnished by LANL due to the DOE requirement for acceptance testing filters at the DOE filter test facility prior to use and to ensure receipt inspection requirements are met. (Requirement 6-0192)

1. Temporary HEPA filters used for initial start-up and acceptance testing of the system do not require testing at a DOE filter test facility prior to use and are not furnished by LANL. Industrial grade (non-nuclear) type filter is acceptable for temporary HEPA filters.

2. For new projects, final HEPA filters are supplied and installed by the Subcontractor. This is a restricted procurement item, make sure Form 410 is reviewed and proper approvals are obtained.

3. For HEPA filter replacement, LANL supplies and installs the filters. This is a restricted procurement item, make sure Form 410 is reviewed and proper approvals are obtained.

D. Test (in-place) post-startup and replaced HEPA filters in accordance with P101-16, *Industrial Ventilation (non-HVACR)*. OSH-ISH Industrial Hygiene and Safety will provide in-place testing service when requested. Temporary HEPA filters installed for initial start-up and acceptance testing of the system during the construction phase do not require testing. (Requirement 6-0193)

E. Refer to the following LANL standards for additional guidance: [20]

1. Mechanical Drawing ST-D3040-5, Air Filter Pressure Drop Gauge
Mechanical Drawing(s) ST6700, Filter Train (Bag-out Housing) [may become Mechanical Drawing(s) ST-D3040-4, HEPA Filter Plenum]

2. Master Specification Section 23 3225, *Bag-in Bag-out Housings*

3. Master Specification Section 23 4133.13, *HEPA Filters – ASME AG-1, Section FC*

4. Master Specification Section 23 4133.16, *HEPA Filters – ASME AG-1, Section FK, Special*

5. Master Specification Section 23 4133.19, *HEPA Filters – Auxiliary Nuclear Grade*

6. Master Specification Section 43 3113.37, *High Efficiency Gas Purification Filters*

7.0 PRESSURIZING SPACES/BUILDING

A. Maintain office spaces under a positive pressure to prevent outside air infiltration and/or infiltration from laboratory spaces that adversely impact air quality. (Requirement 6-0194)

B. Maintain laboratory spaces under a negative pressure, minus 0.03 to minus 0.15 inches of water, in relation to non-laboratory spaces (offices, corridors, etc. and/or the outside environment). (Requirement 6-0195)

C. Maintain clean room laboratories under positive pressure to prevent contamination of samples. (Requirement 6-0196)

8.0 VARIABLE AIR VOLUME (VAV) BOXES

A. Provide pressure-independent VAV boxes, Air Conditioning, Heating, and Refrigeration Institute (AHRI) certified, and completely factory assembled. (Requirement 6-0197)

B. The minimum supply air set point at the VAV box shall not be less than the required minimum ventilation requirements of ASHRAE Standard 62.1. (Requirement 6-0198)

C. Provide a factory-mounted safety switch disconnect with thermal overload protection when selecting a 120V/277V terminal unit. (Requirement 6-0199)

[20] Standard drawings and specifications provide required instrumentation details, HEPA filter plenum details, and specification and installation requirements for filters and housings.

D. Provide separate electrical compartments for control wiring and power wiring. (Requirement 6-0200)

E. *Guidance: Use static regain duct design method for high velocity variable air volume systems.* (Requirement 6-0201)

D3060 VENTILATION

1.0 GENERAL

A. Provide ventilation to spaces that people may occupy in accordance with ASHRAE Standard 62.1, except where other applicable standards and requirements dictate larger amounts of ventilation. (Requirement 6-0202)

1. If it is stated in Project Documents or is suspected by the designer that the outdoor air is influenced by sources that cause substantial contamination, evaluation for acceptability is required.
2. When designing a Dedicated Outdoor Air System (such as for use with a Variable Refrigerant Flow system), ensure all spaces will receive the proper amount of ventilation air required by ASHRAE 62.1. Provide duct mounted airflow sensors to each room that can accurately measure the outside airflow and collect this data via the BAS.
3. *Avoid locating outside air intakes close to heavy vehicle traffic areas such as loading docks, near diesel generators, or near equipment that can produce objectionable odors or sprays, such as trash dumpsters, cooling towers, etc*.

B. Design with the assumption that smoking will be prohibited in or near buildings. (Requirement 6-0203)

C. *Guidance: Design the HVAC system with carbon dioxide (CO_2) monitoring sensors and integrate these sensors with the building automation system. Locate sensors in locations most likely to contain high levels (e.g., conference rooms) and as required to meet ASHRAE 62.1. Specify internal operational setpoint parameters that maintain indoor carbon dioxide levels no higher than outdoor levels by more than 530 parts per million at any time.* (Requirement 6-0204)[21]

D. Provide a mechanically-operated ventilation system for toilet rooms, janitor closets, and other malodorous spaces, connected directly to the outside. Point of discharge shall be at least 10 feet from any opening that allows entry into the occupied portions of the building. (Requirement 6-0205)

1. Exhaust at a rate as calculated from ASHRAE Standard 62.1, (Requirement 6-0206).

E. Equipment Room: Exhaust mechanical and electrical equipment rooms so that the room temperature does not exceed 95 degrees F. Where mechanical ventilation cannot maintain a satisfactory environment, provide mechanical cooling. (Requirement 6-0207)

1. Refer to the LANL Engineering Standards Manual, Electrical Chapter, for ventilation and/or cooling requirements for transformers, UPS systems, and battery areas. Refer to Chapter 19, *Communications*, for telecommunication rooms.

[21] Compliance will meet LEED Rating System 2.0 (prerequisite), Indoor Environmental Quality - Carbon Dioxide Monitoring.

2. Ventilate equipment rooms containing refrigeration equipment in accordance with ASHRAE Standard 15 including refrigerant leak alarms where required. (Requirement 6-0208)

3. Provide combustion air for fuel-burning equipment in accordance with the UMC and the equipment manufacturer's recommendations. (Requirement 6-0209)

F. *Biological/chemical/radiation airborne attack prevention guidance: The following NIOSH documents are available:*

1. *Guidance for Filtration and Air-Cleaning Systems to Protect Building Environments from Airborne Chemical, Biological, or Radiological Attacks, CDC/NIOSH Publication No. 2003-136*

2. *Guidance for Protecting Building Environments from Airborne Chemical, Biological, or Radiological Attacks, CDC/NIOSH Publication No. 2002-139.*

2.0 SUPPLY AIR INTAKES (D3060.10)

A. Locate intakes at least 24 inches above grade or roof level to prevent intake of snow (lower allowed with ESM Mechanical POC approval). (Requirement 6-0210)

B. For systems on large or high-visibility buildings that are not within secure areas, locate HVAC air intakes at least 10 feet above grade (lower allowed with ESM Mechanical POC approval). (Requirement 6-0211).

3.0 EXHAUST AIR (D3060.30)

A. Locate exhaust stacks to prevent the discharge air from entering the supply systems and to permit good dispersion of air. Design per ASHRAE Fundamentals Handbook (Airflow around Buildings) and ASHRAE HVAC Application Handbook (Building Air Intake and Exhaust Design). In addition (Requirement 6-0212):

1. Provide a minimum stack height of 10 feet above the highest point on the roof. Required stack height may be higher if necessary for dispersion of contaminants. (Requirement 6-0213)

2. Design stacks to meet project-specific wind load and seismic criteria. (Requirement 6-0214)

3. Comply with NFPA 780 for lightning protection and grounding requirements. (Requirement 6-0215)

4. Size exhaust stacks from fume hoods and other local exhaust systems such as welding benches, snorkels, and open surface tanks for a discharge velocity of 3000-4000 fpm, unless it can be demonstrated[22] that a specific design meets the dilution criteria necessary to reduce the concentration of hazardous materials in the exhaust to safe levels for all potential receptors.[23] (lower allowed with Mechanical POC approval). Converging outlet cones are acceptable, but not desirable. Base stack velocity calculations on the inside diameter of the stack. This does not apply to stacks from boilers, hot water heaters, furnaces, etc. (Requirement 6-0216)

5. For intermittently operated systems, and systems where the discharge velocity is less than 3000 FPM, provide protection from rain and snow by stack drains and stack

[22] "Demonstrated" means that a formal study, such as a wind tunnel model, has been commissioned and approved by LANL Engineering.
[23] Based on ANSI/AHIA Z9.5-2012. Incorps VAR on SmartLabs.

heads. Do not use a rain cap. Refer to Mechanical Standard Drawing(s) ST-D3040-3 for stack head detail. (Requirement 6-0217)

6. Consult with the Meteorology and Air Quality Team (EPC-CP-MAQ) for stack monitoring requirements if stack exhausts radioactive operations or other hazardous materials. NESHAP (40 CFR 61) permitting may be required. (Requirement 6-0218)

B. Refer to LANL Master Specification Section 23 3101, *HVAC Ducts*, for additional guidance.[24]

4.0 TESTING, ADJUSTING, AND BALANCING (TAB), D3060.90

A. Provide TAB for new HVAC and industrial exhaust equipment/systems in permanent, and for temporary buildings (i.e., trailers and transportables) with laboratories. (Requirement 6-0219)

1. Provide a written balance report for systems serving buildings over 5,000 square feet. (Requirement 6-0220)

2. *Guidance: TAB should be repeated for modified system and those systems affected by the modification. TAB may also be required for temporary buildings when requested by the building owner*.

B. The TAB Agency performing the work shall be certified by either the Associated Air Balance Council (AABC) or the National Environmental Balancing Bureau (NEBB). (Requirement 6-0221)

1. TAB Agency independence (i.e., first-tier subcontractor to LANL) is required when commissioning agent independence is required by ESM Chapter 15. (Requirement 6-0222)

2. *Guidance: The TAB Agency certification (members/directory) may be verified at* http://www.aabc.com/ *or* http:/www.nebb.org/

C. Provide permanent means for balancing the air and water systems. *Guidance: Devices can include, but are not limited to dampers, flow measuring stations, temperature and pressure test connections, gauges, balancing valves and flow sensors.* (Requirement 6-0223)

1. Install devices (pressure gauges, thermometers, etc.) on major equipment, e.g., water chillers, cooling towers, pumps, coils, heat exchangers, etc. Include temperature and pressure plugs (e.g., Pete's plugs) for smaller equipment such as reheat coils. (Requirement 6-0224)

D. Refer to LANL Master Specification Section 23 0593, *Testing, Adjusting, and Balancing for HVAC* and ASHRAE 90.1 (e.g., 6.7.2.3) for additional guidance.[25]

5.0 INSTRUMENTATION AND CONTROL, D3060.90

A. Follow ESM Chapter 8, I&C, where most requirements are given. Boiler controls are addressed in Subsection D3020 above.

6.0 FUME HOODS AND LOCAL EXHAUST DESIGN

A. The exhaust airflow from fume hoods and other local exhaust systems such as welding benches, snorkels, and open surface tanks must be determined carefully. Capture velocities and face velocities shall be as recommended in the latest ACGIH, *Industrial Ventilation* –

[24] LANL Master Specification 23 3101 includes duct materials and installation requirements
[25] LMS 23 0593 provides guidance for specifying the requirements of the TAB subcontractor and the scope of work to be performed.

A Manual of Recommended Practice for Design. The cfm/ft² or fpm values given shall be taken to mean acfm/ft² or fpm at elevation. When a range of capture velocities is given, the upper end of the range shall be chosen. (Requirement 6-0011)

B. For laboratory exhaust systems with a total exhaust rate greater than 5000 CFM, provide a supply and exhaust system that can reduce the exhaust and makeup airflow rates at least 50% below the design conditions. (Requirement 6-0012)

C. *Consider manifolding exhaust systems with the following exceptions per ANSI Z9.5: Each control branch shall have a flow regulating device to buffer the fluctuations in pressure inherent in manifolds. Perchloric acid hoods shall not be manifolded with non-perchloric acid hoods. Manifolded exhaust systems can use fewer fans, provide redundancy in vital systems, reduce roof penetrations and result in lower operating costs*.

D. Provide redundant fans for manifolded exhaust systems.[26]

E. The exhaust for other Local Exhaust Ventilation systems (LEVs), especially heated (i.e., furnaces), should not be connected to fume hood exhaust. Consult with the local ESH Professional prior to manifolding LEVs with fume hood exhaust.

F. Consider the use of low velocity (high performance) fume hoods. These hoods can provide safe containment at face velocities as low as 60 FPM. Care must be taken when considering these types of hoods, as the lower range of face velocities only allow adequate containment under relatively ideal conditions, thus requiring effective administrative controls in the laboratory.

G. Select fume hoods based on user requirements and on guidance from LANL Industrial Hygienists. Refer to LANL Master Specification Section 23 3816, *Fume Hoods*, for additional guidance. (Requirement 6-0225)

1. Submit edited LANL Specification Section 23 3816 with purchase request for hoods.

2. Fume hood selections should be reviewed by Engineering prior to purchase. This will ensure that the infrastructure (supply air, exhaust air, etc.) is adequate to support the fume hood operation.

H. Locate fume hoods per requirements in NFPA 45 and ANSI/AIHA Z9.5. *As a minimum, fume hoods should not be located closer than 10 feet to operable windows and routinely used swinging doors unless analysis indicates that cross draft limits will be met.* (Requirement 6-0226)

I. Fume hood face velocities shall be selected based on the hazard present, and coordination with the LANL Deployed ESH Manager. (Requirement 6-0227)

J. Specify an airflow monitor for all fume hoods. Refer to LANL Mechanical Drawing ST-D3040-1 for configuration. The minimum accepted airflow monitor is a magnehelic gage that measures the static pressure at the duct inlet from the fume hood. For certain applications audible and/or visual alarms may be warranted. Work with the area Industrial Hygienist to determine what type of device is needed. (Requirement 6-0228)

[26] Redundant fans help ensure continuity of operations for the fume hoods, and well as allowing repairs or maintenance to be performed without shutting down system.

K. For fume hoods, size fan for a normal operating sash height of 18 inches, unless project requirements differ. Size stack for normal sash height. (Requirement 6-0229)

L. Due to the proximity of the fan to the hood for perchloric acid operation, design to noise criteria in ESM Chapter 6, Section D10-30GEN. (Requirement 6-0230)

D3070 SPECIAL REQUIREMENTS FOR NUCLEAR-SAFETY-RELATED VENTILATION AND AIR TREATMENT SYSTEMS (PROGRAMMATIC AND FACILITY) [27]

Note: See also ESM Chapter 10, *Hazardous Process* (especially the "General" and "Effluent monitoring and Control" Sections) and Chapter 12, *Nuclear*.

1.0 General

A. Confinement ventilation systems in new nuclear facilities and "major modifications" in existing facilities shall comply with additional design and performance criteria in DOE O 420.1C and G 420.1-1A. (Requirement 6-0231)

B. *Guidance: Generally, the safety function of ventilation and offgas systems is to provide confinement integrity and to filter exhaust, thereby preventing or mitigating uncontrolled releases of radioactive and/or hazardous materials to the environment. Ventilation and offgas systems are included as a vital part of the primary and secondary confinement design.*

C. Provide designs for periodic maintenance, inspection, and testing of components. Include adequate shielding in the design of filters, absorbers, scrubbers, and other air treatment components to ensure that occupational exposure limits are not exceeded during maintenance and inspection activities.
Guidance: Recommended typical equipment layout details are available from the ESM Mechanical POC. (Requirement 6-0232)

D. Design to facilitate decontamination and demolition, including (Requirement 6-0233):

1. Location of exhaust filtration components of the ventilation systems at or near individual enclosures to minimize long runs of internally contaminated ductwork.

   Equipment, including effluent decontamination equipment, which precludes to the extent practicable, the accumulation of radioactive or other hazardous materials in relatively inaccessible areas, including curves and turns in ductwork. Accessible, removable covers for inspection and cleanouts are encouraged.

E. Airflow and other design requirements for specific types of ventilation systems shall comply with 29 CFR 1910, Subparts G and H. (Requirement 6-0234)
Guidance: Ventilation systems for hazardous material protection should use local exhaust ventilation (LEV) to control concentrations of hazardous materials from discrete sources or should control the number of air changes per hour for an entire room or bay (but avoid concentration control by dilution ventilation). Also, 29 CFR 1910, Subpart Z, provides requirements for monitoring and alarm systems for facilities that manage or use specific hazardous materials. Additional guidance on design of ventilation systems for hazardous material protection is provided in ANSI Z9.2 and ASHRAE 62.1.

F. *Guidance: Ventilation systems are engineering controls commonly used to prevent worker exposure to hazardous materials and may be used in combination with personal protective equipment and operational procedures. 29 CFR 1910, Subpart G, 1910.94, requires that*

[27] (a) DOE G 420.1-1A, Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide for use with DOE O 420.1C Facility Safety, Section 5.2 and (b) SRS Engineering Standards Manual WSRC-TM-95-1, Introduction Attachment 1, National Codes and Standards for Engineering/Design Tasks Matrix [required], 9/99.

where ventilation is used to control worker exposures, it is adequate to reduce the hazardous material concentrations of air contaminants to the degree that the hazardous material no longer poses a health risk to the worker (i.e., concentrations at or below the permissible exposure limits). 29 CFR 1910, Subpart Z, 1910.1000, requires that wherever engineering controls are not sufficient to reduce exposures to such levels, they must be used to reduce exposures to the lowest practicable level and supplemented by work practice controls. The design should ensure that respirators are not required for normal operating conditions or routine maintenance activities except as a precautionary measure.

G. *Guidance: Ventilation systems for hazardous material protection should use exhaust hoods to control concentrations of hazardous materials from discrete sources or should control the number of air changes per hour for an entire room or bay. Air flow and other design requirements for specific types of systems must comply with 29 CFR 1910, Subparts G and H. Also, 29 CFR 1910, Subpart Z, provides requirements for monitoring and alarm systems for facilities that manage or use specific hazardous materials. Additional guidance on design of ventilation systems for hazardous material protection is provided in ANSI Z9.2 and ASHRAE 62. Decontamination facilities, safety showers, and eyewashes to mitigate external exposures to hazardous materials must be provided where mandated by 29 CFR 1910, Subparts H and Z. These systems must be designed in accordance with the requirements of ANSI Z358.1 and ANSI Z124.2*

H. *Guidance: Directed ventilation flow paths should be used to move contaminants away from worker breathing zones. The design should ensure that ventilation flow will cascade from clean areas to contaminated areas to preclude contamination spread. Uniform distribution of incoming air and/or air mixing equipment should be provided to ensure that no pockets of stagnant air exist in areas where workers are present. If room air is recirculated in a nuclear or hazardous facility, e.g., Zone 3 maintenance rooms, at least one stage of HEPA filtration shall be provided in the circulation system, additional stages may be required per the hazard analysis.*

I. *Guidance: Occupied spaces should be designed to preclude locations where low oxygen content or air displacement may occur or where reactive, combustible, flammable, or explosive gas, vapor, or liquid accumulation might occur*

J. *Guidance: The design of airborne-effluent systems should preclude holdup of particulate materials in offgas and ventilation ductwork and include provisions to continuously monitor buildup of material and material recovery. The design of systems must also preclude the accumulation of potentially flammable quantities of gases generated by radiolysis or chemical reactions within process equipment.*

K. *Guidance: All airborne effluents from areas in which hazardous or radioactive materials are managed other than in closed containers should be exhausted through a ventilation system designed to remove particulate material, vapors, and gases, as necessary, to comply with applicable release requirements and to reduce releases of radioactive materials to levels ALARA.*[i]

2.0 Redundancy

Determine the need for redundancy and the degree of redundancy in these systems required by the safety analysis process and maintenance concerns for both active and passive components follow IEEE 379 for system reliability and IEEE 323 for Environmental Qualifications of Safety Class SSCs. (Requirement 6-0235)

3.0 Discharge Requirements

A. Process vent streams that potentially contain concentrations of radioactive and/or hazardous materials that are greater than acceptable through an offgas cleanup system before exhausting to the environment. (Requirement 6-0236)

1. *Guidance: Also follow the guidance contained in DOE Handbook 1132, Design Considerations.*

B. The design of safety-significant and safety-class offgas systems must be commensurate with the sources and characteristics of the radioactive and chemical components of the offgas air stream to prevent or mitigate the uncontrolled releases of radioactive and/or hazardous materials to the environment. (Requirement 6-0237)

C. HEPA filtering requirements are further addressed in Subsection D3040 herein, under the "Filters and HEPA Filter Housings" heading.

4.0 Standards

A. For the standards that shall be considered for Safety-Significant and Safety-Class Ventilation and Nuclear Air Treatment Systems (NATS) beyond those listed above or in other Mechanical Chapter sections, see Table D30GEN-3 above.

RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	6/28/99	Chapter 6 rewritten and reformatted to support LIR 220-03-01, FEM. Superseded Mechanical Facilities Engineering Standards, Volume 6, Manual Revision No. 15, dated 6/26/98.	Danny Nguyen, *PM-2*	Dennis McLain, *FWO-FE*
1	5/22/02	General revision, split into Uniformat-based sections, added endnotes. This LEM section replaced FEM Subsections 204.2-.6, 204.20-.21, and 204.25. Added pump requirements, 420.1B.	Tobin H. Oruch, *FWO-SEM*	Kurt Beckman, *FWO-SEM*
2	6/9/04	Combined D30GEN and D30 HVAC. Added full 1993 climate data. Modified req'ts: general and hood elevation correction, eyewash for chemical treatment stations, coils, use of de-ionized water for humidification, motor selection for fans. Made table of standards broadly applicable; changed LEM to ESM. Gave POC authority on low NOx waivers. Added req'ts on direct-fired heater, 2-way valves, steam constants, mech room heat, boiler types and control, relief air dampers, duct lining, independent TAB. Improved guidance on ceiling plenums, etc.	Charles DuPrè, *FWO-DECS*	Gurinder Grewal, *FWO-DO*
3	10/27/06	Administrative changes only. IMP and ISD number changes based on new Conduct of Engineering IMP 341. Master Spec number/title updates.	Charles DuPre, *FM&E-DES*	Kirk Christensen, *CENG*
4	9/29/09	Changed derating req'ts for fume hoods and local exhaust design, added design information for fume hoods, changed motor derating material, updated Table D30GEN-2, added additional fan info, added electrical resistance heating requirements.	Charles Dupre *ES-DE*	Larry Goen, *CENG*
5	9/29/14	DOE O 420.1C and G 420.1-1A updates, revised duct detectors for 100 percent outside air, minor admin and other changes.	Michael Ladach, *ES-EPD*	Mel Burnett, *CENG*
6	9/22/22	Added Smart Labs guidance, packaged equipment controls integration, use of condensing boilers. Updated NATS table including DOE-STD-1269 and DOE-HDBK-1169, plus AG-1 applicability to non-credited ventilation systems per variance VAR-10298. Other changes.	Michael Ladach, *ES-WPD*	Mike Richardson, *ES-DO*