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

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 Superseded Mechanical Facilities Engineering Standards, Volume 6, Manual Revision No. 15, dated 6/26/98.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 altitude 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*

CONTACT THE MECHANICAL STANDARDS POC

for upkeep, interpretation, and variance issues

Ch. 6, D30	**Mechanical POC and Committee**

This document is online at http://engstandards.lanl.gov/

D30GEN ADDITIONAL GENERAL HVAC REQUIREMENTS

Note: Refer to the Mechanical Chapter Section D10-30GEN for general mechanical and 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.

1.1 ACGIH (American Conference of Governmental Industrial Hygienists)

A. Industrial Ventilation – A Manual of Recommended Practice for Design.[1]

NOTE: Many national standards are available for LANL here.

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

A. http://ahrinet.org/

1.3 ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers)

A. As a reference only: HVAC Handbooks.[1]

B. Standard 15, Safety Code for Mechanical Refrigeration.[1]

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

D. Standard 62, Ventilation for Acceptable Indoor Quality

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

1.4 LANL

A. Comply with all applicable LANL Master Specifications including:

1.5 NFPA (National Fire Protection Association)

A. National Fire Codes and Standards (all except NFPA 5000).

[1] Nationally recognized standards. Also, when systems exceed the temperature and pressure ratings of the UMC or UPC, nationally recognized standards are used per IAPMO UMC 2009, Section 1201.1 on hydronic piping.

B. *Listing of current NFPA codes and standards are also available at*: http://www.nfpa.org/catalog/catalog_home.asp?cookie_test=1

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

A. HVAC Duct Construction Standards, Metal and Flexible. [1]

B. HVAC Systems, Duct Design. [1]

C. Seismic Restraint Manual, Guideline for Mechanical Systems [1]

D. Rectangular Industrial Duct Construction Standards. [1]

E. Round Industrial Duct Construction Standards. [1]

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

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

2.0 ALTITUDE/CLIMATIC CRITERIA AND HEAT GAIN EQUATIONS

A. See Chapter 1 Section Z10 for altitude, 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. [2]

C. Cooling Degree-Days (annual mean): 2187 at 50 degrees F base, 272 at 65 degrees F base [2]

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

Q (sensible heat)(Btu/hr) = 0.82 (@W = 0) X cfm X Δt (at sea level 0.82 would be 1.08) [3]

Q (latent heat)(Btu/hr) = 0.52 X cfm X ΔW (gr.) (at sea level 0.52 would be 0.68) [3]

Q (total heat)(Btu/hr) = 3.42 X cfm X Δh (at sea level 3.42 would be 4.50). [3]

Where:

cfm = Air flow Rate, cubic feet/min.

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

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

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

Δ t = Temperature Difference, degrees F.

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[2] LANL Calculation No. 00-0000-CALC-M-0006

[3] 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.

E. Use Table D30GEN-1 local climate information for HVAC system sizing/design. *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. [Guidance: 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.].*

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	
				Design		Design Dry Bulb and			Mean	Design					Median of	
State/Station	Lat.	Long.	Elev.	Dry-Bulb		Mean	Coincident	Wet-Bulb	Daily	Wet-Bulb			Winter	Summer	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[4]			5	9	89/60	87/60	85/60	32	62	61	60			89.8	-2.3

[4] Use ESM Chapter 1 Section Z10 Constants

3.0 ALTITUDE CORRECTION

A. *Guidance: At LANL's altitude, the air pressure and density is 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 altitude. The spec should either (1) be clear that output ratings are already adjusted for altitude and should not be further adjusted by the vendor, or (2) leave correction up to the vendor (e.g., "Achieve XXX Btu/hr at 7500 feet"). 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 altitude," since this could result in a doubly-corrected outcome.*

B. *Ideally, **only** the calculated actual operating parameters (capacity, static pressure, cooling/heating loads) required at 7500 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 7500 FT ELEVATION" should be included in the drawings or specifications. It should be the responsibility of the Contractor or the equipment manufacturer to make the needed adjustments to their equipment to meet the requirements at the 7500 ft elevation. The equipment manufacturer should be asked to provide submittal (fan curves, performance data) to back up their selection.*

3.1 Fans

A. Correct catalog data before applying it at LANL's 7,500 foot altitude. *Guidance: Failure to correct for altitude will result in undersized equipment. An increase in altitude 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 Altitude (Guidance)

A. *Determine the actual volumetric flow rate (acfm) at 7500 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 altitude 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 altitude conditions by dividing these values by the air density ratio at 7,500 feet (nominal 1.32 at 70 degree F). This yields the static pressure that the fan will produce at altitude and the BHP required at altitude. Refer to Table D30GEN-2 when installation environment involves non-standard temperatures at 7,500 feet elevation.*

TABLE D30GEN-2 [2]

Air Density Correction Factor at 7,500 Feet Altitude		
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 Air Conditioning and Refrigeration Equipment, Etc.

A. Derate air-cooled equipment (e.g., chillers, coils, condensers, cooling towers, VAVs, VFDs) for altitude. *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 Fume Hood 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 – A Manual of Recommended Practice for Design. The cfm/ft² or fpm values given shall be taken to mean acfm/ft² or fpm at altitude. When a range of capture velocities is given, the upper end of the range shall be chosen.

3.5 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. [5]

B. Derate gas-fired heating units and atmospheric boilers catalog output rating by 30 percent.[6]

C. Specify gas fired units that will be operating at 7500 feet altitude (see Chapter 1, Z1010 Constants, for altitude exceptions) so the manufacturer can factory install the correct gas orifices.

D. For forced-draft boilers, consult with manufacturer for derating criteria.

3.6 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., steams, hot water, heating, cooling systems, etc. to address LANL's higher-than-neutral pH and silica scaling problems.

1. Consult the ESM Mechanical POC for specific requirements, such as type of treatment system, chemicals, etc. *For existing facilities the LANL System Engineer will be consulted to determine preferred chemicals.*

B. Provide biocide products that are registered with the EPA, with the registration number clearly shown on the drum.

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

D. Chemical formulations used in water treatment require LANL Water Quality Group (ENV-RCRA) approval.[7]

E. Provide an emergency eyewash per OSHA 10CFR 1910.151 and 1450 if required after an evaluation/analysis by LANL IHS-IP. Consult IHS-IP Industrial Hygiene and Safety for additional emergency equipment requirements.

1. *Guidance Note: Potable eye station may be acceptable in lieu of permanent.*

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[5] Per LANL Utilities & Infrastructure Group Gas Representative, "By contract, the gas supplier must furnish natural gas with a minimum heating value of 1,000 btu/ft^3."

[6] Carrier publication "Engineering Guide for Altitude Effects." (derate 4 percent for each 1,000 feet above sea level.) (EMref-9)

[7] The LANL Water Quality Group (ENV-RCRA) is responsible for submittal of compliance data to the EPA and NMED as required for NPDES permits.

F. Refer to the following LANL Engineering Standards:[8]

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 23 2500, HVAC Water Treatment.

5.0 COILS - HEATING/COOLING

5.1 General

A. Provide Air Conditioning and Refrigeration Institute (ARI)-certified heating and cooling coils for central station HVAC units and field built-up systems.[13]

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. http://ahrinet.org

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 HVAC applications, except outside air preheat coils, use a minimum tube water velocity of 2 fps.[9]

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

1. *Guidance: For comfort applications, wet coils are frequently selected in the range of 400-500 fpm air face velocity.* [10]

E. Provide coils with copper tubing and aluminum fins where coil selection and design pressures permit. [11]

F. 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. Provide an approved P-trap at drip pan and pipe drip pans to floor drains. [12]

1. *Guidance: For best indoor air quality choice, slope drip pans in 2 directions.*

G. Properly size and configure condensate traps in accordance with the UMC [11] and the manufacturers' recommendations.[13]

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[8] The drawings and specification provide piping details, additional design guidance, and specifications for equipment and chemicals.
[9] 2012 ASHRAE HVAC Systems and Equipment Handbook, Air Conditioning and Dehumidifying Coils
[10] 2012 ASHRAE HVAC Systems and Equipment Handbook, Performance and Ratings
[11] Most common combination (industry standard)
[12] IAPMO UMC 2009, Section 309
[13] Trane Catalog CLCH-DC-7, Central Station Air Handlers, Application Considerations, recommended procedures for sizing condensate trap piping (EMref-13)

H. *Guidance: Use hot water for final heating coils.* [14]

I. Refer to the following LANL standard drawings for additional requirements:[15]

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. The preheat coil shall be sized to heat building from initial 40 degrees to 55 degrees within one hour while 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). [16]
2. Operate face and bypass coils with constant steam or water flow. Do not modulate flow.
3. Provide a sensor in the discharge air stream to maintain a constant discharge air temperature, regardless of variations in inlet air temperature.

B. Design

1. Design coils for an entering air temperature of minus 10 degrees F for 100 percent outside air systems. For steam coils, oversize condensate return piping to handle large condensate flow at startup.[17]
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:
   a. 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. [18]

[14] 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.
[15] The coil piping details provide piping details for different applications and additional design requirements.
[16] Basis: Preheat enables reasonable time for cold weather startup and restart. Buildings would not be expected to drop below 40 deg since space heaters or the like would be deployed; similarly, above 55 degrees the reheat coils would continue warm-up. Lessons learned from MST Office Building.
[17] Entering air design temperature based on lessons learned and historical climatic conditions.
[18] 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.

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

A. Winter: 5 degrees F dry bulb

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

6.2 Indoor (Dry-Bulb)[19]

A. Cooling:

1. General Comfort: 75 degrees F.
2. Mechanical/Electrical Rooms: Refer to ESM Mechanical Section D30, Ventilation.

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
5. Kitchens: 60 degrees F
6. Change Rooms: 75 degrees F

C. **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).

1. Comply with ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy.[20]
2. Provide humidity monitoring system to automatically adjust building conditions as appropriate.[20]

[19] The heating and cooling design temperature for general comfort is within the acceptable ranges of ASHRAE Standard 55-2004, Figure 5.3.1. The remainder of the heating temperatures is based on previous designs.
[20] Provides for a thermally comfortable environment that supports the productive and healthy performance of the building occupants. Compliance meets LEED Rating System 2.0 (2 points), Indoor Environmental Quality - Thermal Comfort.

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.

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.

D. Provide humidification units with deionized water; Mechanical POC and FOD approval required for other sources.[21] Consult with humidifier representative for water quality requirements (conductivity in micro-ohms).

E. When using boiler steam for humidification, provide a steam-to-steam converter.[22]

F. When using a mechanical cooling system for dehumidification, install the heating coil downstream of the cooling coil to provide reheat.

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 altitude-derated motors at any point on the pump curve.

B. Fans: Do not overload altitude-derated motors beyond the design operating conditions of the fan curve.

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

8.2 Enclosures

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

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

C. Provide TEFC motors for outdoor applications and for indoor applications in damp or dusty locations.

[21] Tap water at LANL is high in silica and scale deposits will cause operational and maintenance issues. DI systems contain scale in vessels relatively easy to change/maintain.
[22] Steam boilers are chemically treated and the chemicals used for treatment are most likely not suitable for breathing air.

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

E. In hazardous locations use explosion-proof motors that are UL labeled for the location hazard classification.

8.3 Selection

A. For motor selection, refer to motor selection chart (Minimum Full Load Efficiency and Maximum Load) in LANL Master Specification 26 0700, *Induction Motors* – 500HP and Smaller. [23]

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

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.

B. Pumps shall be accessible for maintenance.

C. 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.

D. Provide a steam-powered pump when condensate must be moved to a higher elevation or great distances.[24]

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.

E. Provide flexible couplings in the water circulating piping to prevent the transmission of sound and vibration throughout the building.

F. 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.*[25]

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

[23] ASHRAE STD 90-2010, Table 10.8
[24] Steam-operated pumps provide energy savings over electric ones, and are used when electricity is not available or prohibited.
[25] Pumping costs are reduced on larger systems by the addition of variable speed drives.

10.0 SYSTEM DESIGN

A. **Primary/Secondary Systems; Unoccupied Operation:** Primary HVAC systems for office areas shall be designed to allow unoccupied shutdown and temperature setback and shall not serve 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. The Mechanical POC can grant variance from this requirement.[26] See also ESM Chapter 7 Electrical Section D5030 Communications for additional HVAC requirements on such rooms.

B. **Heat Recovery:** Heat recovery systems 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.

C. **Alarm Monitoring:** Facilities with a value greater than $1M shall be provided with a connection to the Equipment Surveillance System (ESS) or shall be provided with web-based monitoring and alarm paging. 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.

D. Follow applicable sections of the standards for HVAC and nuclear air treatment systems (NATS) in Table D30GEN-3 which follows. 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.

[26] 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.

TABLE D30GEN-3

Required Standards for HVAC and Nuclear Air Treatment Systems (NATS)				
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-HDBK-1169*; DOE-HDBK-1132*	DOE G 420.1-1A. Ref only: DOE-HDBK-1132, DOE-HDBK-1169	DOE G 420.1-1A. Ref only: DOE-HDBK-1132, DOE-HDBK-1169
Air Handling Units (HVAC only)	AHRI Standards	AHRI Standards	ASME AG-1	ASME AG-1
Adsorbers (NATS only)	N/A	ASME AG-1	ASME AG-1	ASME AG-1
Breathing Air	See Section D20 and ESM Chapter 11 - Radiation Protection			
Coils	AHRI 410	ARHI 410	ASME AG-1	ASME AG-1
Controls	See ESM I&C Chapter 8			
Dampers	SMACNA; NFPA 90A; UL 555/555S; NFPA 801	SMACNA; NFPA 90A; UL 555/555S; NFPA 801	ASME AG-1	ASME AG-1
Ducts	SMACNA	SMACNA	ASME AG-1	ASME AG-1
Fans	Reference only: ASHRAE Handbooks	Reference only: ASHRAE Handbooks	ASME AG-1; Reference only: ASHRAE Handbooks	ASME AG-1; Reference only: ASHRAE Handbooks
Filtration	ASHRAE 52.2	ASHRAE 52.2	ASME AG-1	ASME AG-1
HEPA Filtration	N/A	ASME AG-1; DOE STD-3020	ASME AG-1; DOE STD-3020	ASME AG-1; DOE STD-3020
Lab Ventilation	AIHA Z9.5, NFPA 45 and 91. Reference only: ASHRAE Applications Handbook, 'Laboratories'	AIHA Z9.5, NFPA 45 and 91. Reference only: ASHRAE Applications Handbook, 'Laboratories'	ASME AG-1	ASME AG-1
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	ASME AG-1
Off-gas treatment	Reference only: ASHRAE Handbooks	DOE-HDBK-1132. Ref only: ASHRAE Handbooks	ASME AG-1	ASME AG-1
Refrigeration units	AHRI Standards	AHRI Standards	ASME AG-1	ASME AG-1

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

N509, Nuclear Power Plant Air Cleaning Units and Components

N510, Testing of Nuclear Air Treatment Systems

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-HDBK-1169, Nuclear Air Cleaning Handbook

DOE-STD-1132, Design Considerations

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)

UL – Underwriters Laboratories

555, Safety -- Fire Dampers

555S, Safety -- Smoke Dampers

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 IHS-EAQ with a description of the equipment or modification; listing size, rating, manufacturer, model number, fuel, etc.[27]

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.[28]

C. Design low temperature heating hot water systems for a maximum of 180 degrees F supply temperature.[29]

D. Two-way valves: All heating water systems shall be designed to maximize the number of 2-way valves (versus 3-way valves) in order 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.[30]

E. For 100% outside air systems, use hydronic heating. Steam, electric resistance, and other methods are allowed only with ESM Mechanical POC permission.[31]

F. Electric resistance heating systems shall not be used for space heating, except where proven to be life cycle cost effective.[32]

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

[27] P 408, Air Quality Reviews. ENV-EAQ is responsible for reporting equipment and activities that increase air emissions to the New Mexico Environment Department (NMED). Under 20NMAC 2.72, sources may require permitting.
[28] Equipment generally is not running during off-hours
[29] 2012 ASHRAE HVAC Systems and Equipment Handbook, Low Temperature Heating Systems
[30] Pumping costs for small systems are reduced by lowering flowrate
[31] Hydronic systems are more cost effective to install and maintain than steam systems. Electric systems are expensive to operate.
[32] Electricity costs about 4 times as much as natural gas at LANL (per LANL Sustainable Design Guide). The first cost savings for installing electric resistance heating are rarely life cycle cost effective.

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.

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

H. *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.

I. When using TA-3 Powerhouse steam, design for incoming temperature of 500 deg F and150 psig with ability to handle 80 psig. Civil POC may grant variance to this (*pressure is normally 100-115 psig at time of writing but may be increased to about 140 psig in the future*).[33]

J. 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.

K. 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.[34]

L. Mechanical rooms shall have redundant heating to prevent freeze-up in case of a boiler malfunction (e.g., gas heat, electric heat or multiple boilers).

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.

M. Entry vestibules: Provide a source of heat to prevent freezing of water on floor and reduce cold drafts in lobbies during peak use times.

N. 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.

O. Stairwells: Provide a thermostatically controlled source of heat to prevent freezing of water on floor or in standpipes. [35]

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[33] Email Parker to Sokoloff, 5/9/2003, and Oruch conversation with Parker notes 3/9/04. [EMref No.22] *(**Note:** In endnotes.)*

[34] Improper installation or maintenance can result in CO in workplace. Lessons learned, CO exposure suspected in TA-15-563 carpenter shop 11/20/03, ALO-LA-LANL-FIRINGHELAB-2003-0013.

[35] MSTOB Lesson Learned. Variance possible for glassed-in, southern exposures where calculated solar gain is sufficient

P. Refer to the following LANL standards for additional requirements: [36]

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 23 2113, Hydronic Piping
8. Master Specification 23 2215, Steam and Condensate Heating Piping & Specialties
9. Master Specification 23 7413, Packaged, Outdoor, Central Station Air-Handling Units
10. Master Specification 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 altitude. Refer to Altitude Correction article above.

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).[37]

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.[38]

E. Provide boiler water treatment. Refer to Chemical Water Treatment article above.

F. *Guidance: Condensing boilers: Condensing boilers with peak efficiency greater than 90% and modulating burners and ducted combustion air should be used. Flue material should be stainless or other non-corrosive material and appropriate condensate drain shall be provided.*[39] *If using a condensing boiler, design all heating coils for 140°F entering water temperature, to allow boiler to operating at all times in condensing mode.*

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[36] The drawings and/or specifications provide piping installation details, material specifications, and additional design requirements.
[37] ASME B&PV Code (required by 10CFR851) and NB-23 are nationally recognized inspection codes providing uniform rules
[38] To ensure the boiler and controls have been properly installed and adjusted per the manufacturer's safety and operating requirements
[39] Condensing boilers are generally 10% more efficient than non-condensing boilers at low loads and heating water boilers run at low loads a majority of the time. Ducting combustion air minimizes the chances of freezing mechanical room piping with un-ducted combustion air and reduces mechanical room heating costs.

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.[40]

1. Refer to the above Subsection D3020, Heating Systems - General, for ENV-EAQ (Ecology and Air Quality Group) reporting requirements.

H. Provide boilers with minimum refractory.[41]

I. Stacks: Design per the boiler manufacturer's requirements; e.g., do not exceed maximum stack weight on boiler, required draft at flue outlet, etc.

1. Group all gas vents and pipe one vent to atmosphere above roof to minimize roof penetrations.
2. Size vent piping through roof at least one pipe size larger than the largest vent connection.
3. Provide vent caps on boiler stacks to keep rain, birds, and debris out of the stack. *To prevent downdrafts and to induce draft (regardless of wind conditions) on atmospheric-type boiler stacks, provide aerodynamic-type vent caps (e.g., www.fieldcontrols.com, navigate to venting/vent caps).*

2.2 Controls

A. Provide automatically fired boilers with controls and safety devices per ASME CSD-1.[42]

B. Provide controls for gas-fired boilers approved and labeled by a nationally recognized testing agency.[43]

C. Water and steam boiler trim shall include, but is not limited to, the following components.[44]

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 manual reset (pipe blowdown to floor drain)
4. Water Boiler: Float-operated low water cutoff with manual reset (pipe blowdown to floor drain).
5. Steam Boiler: High limit pressure control with manual reset (pipe blowdown to floor drain).
6. Steam Boiler: Two float operated low water cutoffs (primary and secondary) with a manual reset on the secondary. (pipe blowdown to floor drain)
7. Pressure gauge.

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[40] Low NOx burners are more efficient, generate lower nitrogen oxide emissions, and may alleviate ENV-EAQ air quality permitting requirements with NMED.
[41] Based on previous experience from LANL's SSS boiler crew, boilers with minimum refractory require less maintenance and are cost-effective.
[42] ASME CSD-1 is a nationally recognized standard for controls and safety devices for automatically fired boilers. The standard is intended to enhance public health and safety.
[43] IAPMO UMC 2009, Section 1004.2
[44] Minimum controls required by the IAPMO UMC 2009 Chapter 10, ASME CSD-1, and LANL

8. Temperature gauge.
9. Safety relief or safety valve.

D. *Guidance: If non-condensing boilers are allowed by the POC and used, hot water boiler piping may require controls, (e.g., 3-way modulating valve, circulating pump, etc.) to prevent boiler return water temperature from falling below the combustion chamber condensation temperature, typically never below 140 degrees F. Consult with boiler manufacturer for specific requirements.*

E. Where required, provide two or more boilers with the determination of the proportion of load each handles based on energy, redundancy, and maintenance requirements. *Guidance examples:*

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

F. Provide controls that automatically reset hot water for building heating by building loads or by outside temperature. Refer to ASHRAE Standard 90.1 (*e.g., Section 6.5.4.4*), for requirements.

G. Heating water temperature reset: Whenever possible, 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 140 degrees F. [45]

H. 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.[46]

I. On boilers with power burners, provide a temperature indicator on the boiler exit breaching.[47]

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.[48]

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[45] This provides boiler efficiency savings in addition to pipe heat loss energy savings. The low temperature limit of 140 degrees will prevent condensation in a non-condensing boiler.
[46] IAPMO UMC 2009, Section 1011. IRI is the nationally recognized standard required by LANL for the gas fuel train.
[47] Required for maintenance. Stack temperatures are an effective means for monitoring boiler tube cleanliness.
[48] Based on feedback from field engineers, absorption chillers require more maintenance than mechanical vapor (refrigerant) compression chillers. Also, evaporative condensers require freeze protection and close control of water treatment (LANL water is high in silica) for a successful operation. Therefore, increased maintenance costs over the life of the equipment must be factored in when selecting absorption chillers or evaporative condensers.

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. Refer to Design Guidance Manual for evaporative cooling design guidelines.*

C. Provide controls that automatically reset building chilled water cooling by building load or by outside temperature. Refer to ASHRAE Standard 90.1 (*e.g., Section 6.5.4.4*), for requirements.

D. Comply with LANL Master Specifications 23 6200, Packaged Compressor and Condenser Units; 23 7413, Packaged, Outdoor, Central Station Air Conditioning Units; and 23 8123, Computer-Room Air-Conditioners.

2.0 COOLING TOWERS

2.1 Design Conditions

A. Select cooling tower based on the following:

1. Ambient wet bulb temperature (AWB), 65 degrees F. [49]
2. Tower operation at elevation per ESM Chapter 1 Section Z10 (**Note**: altitude correction required)

B. Select the following, based on project requirements:

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. [50]

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.[51]

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 specifications referenced below for additional requirements.

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[49] AWB temperature is based on specific site conditions and previous designs

[50] CTI establishes standard testing and performance analysis for CTI certified independent inspectors to inspect towers to ensure manufacturers stated performance

[51] Memo from Harvey Decker, ESH-18 (ENV-RCRA), dated 8/29/00, states: (EMref-5)

> "As for cooling tower construction materials; several years ago the Laboratory experienced NPDES Permit exceedences for arsenic at several older cooling towers. After investigating several possible reasons it was discovered the wood in these cooling towers was pressure treated with an Arsenic compound and this As was leeching into the water, eventually concentrating to a level that exceeded the NPDES permit for As."

D. Refer to Mechanical Chapter, Section D10-30GEN, Meters subsection, 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.

F. Chemically treat water both in open cooling towers and the sumps of closed circuit cooling towers.

G. Provide overflow drain piping and sump drain piping to an approved drain.

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

I. Refer to the following LANL Standards for additional requirements:[52]

1. Mechanical Drawing(s) ST-D3030-1, Cooling Tower and Chiller Piping Component Diagram (Future).
2. Mechanical Drawing(s) ST-D30GEN-1, Open Cooling Tower Water Treatment.
3. Master Specification 23 6509, Steel Induced Draft Cooling Towers.
4. Master Specification 23 6511, Fiberglass Induced Draft Cooling Towers.

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.[53]

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.

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.

B. Comply with UMC and ASHRAE Standard 15, Safety Code for Mechanical Refrigeration, including the special requirements for modern refrigerants.[54]

[52] The drawings and specifications provide piping details, tower and water treatment specifications, and additional design requirements
[53] IAPMO UMC 2009, Section 1131
[54] ASHRAE Standard 15 is a recognized national standard for safe design, construction, installation, and operation of refr. systems

C. 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 in new equipment is prohibited.[55]

1. For a list of EPA acceptable substitutes for ozone depleting substances refer to: http://www.epa.gov/ozone/snap/lists/index.html#refac

2. Provide systems that do not contain CFCs or HCFCs.

D. 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.

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.

E. 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. For additional requirements refer to Mechanical Chapter, Section D10-30GEN, Sound and Vibration Control Subsections.

F. Route refrigerant pressure relief valve venting to the outside of the building. Size and locate line in accordance with UMC.[56] For low pressure refrigerants (15 psig and below), provide a rupture disk/PRV combination.[57]

G. 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.

1. Unit control panel shall display chiller refrigerant and temperature data per ASHRAE Guideline 3.[58]

H. Comply with LANL Master Specification 23 2300, Refrigerant Piping.

3.2 Air-Cooled

A. Select air-cooled systems for operation at 95 degrees F outside air temperature entering the condenser.[59]

B. Provide low ambient options for refrigeration units with air-cooled condensers operating year-round and select equipment for 0 degree F minimum operating temperature.[59]

C. Derate air-cooled equipment for altitude. Refer to Altitude Correction article above.

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

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[55] Section 601-607 of the Clean Air Act
[56] IAPMO UMC 2009, Sections 1117.8 and 1118.0.
[57] RD is fast-acting; PRV minimizes loss.
[58] ASHRAE Guideline 3 is a recognized national guideline. Refer to it (e.g., Section 8.1.4) for monitoring and operation of chillers.
[59] Based on LANL site conditions and previous designs

3.3 Water-Cooled

A. Select the following water-cooled systems based on project requirements.

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 requirements.[60]

D3050 FACILITY HVAC DISTRIBUTION SYSTEMS

1.0 GENERAL

A. Among the required NFPA National Fire Codes, the following are particularly applicable for ventilation systems.

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 [61]

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.

[60] The drawing provides details for chilled/tower water piping, including components such as chemical feeder and expansion tank.
[61] The zone requirements are based on previous experience due to building variations created by internal loads, and variations of solar load due to building orientation.

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.

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

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

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

   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.

E. Do not use transfer grilles between areas where contaminant migration is possible.

F. Return relief fans are required in office building air handling systems with outside air economizers (gravity/barometric building relief is not allowed without ESM Mechanical POC approval).[62]

4.0 HVAC AIR DISTRIBUTION (D3050.50)

4.1 General

A. Fabricate, seal, and test duct work to the applicable SMACNA standards.

B. *Guidance: Consider the following when designing ductwork to control material and energy costs:*[63]

   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. *Seal ductwork to minimize air leakage*.

   3. *Use round duct where space and initial cost allows, as round ductwork has the lowest possible duct friction loss for a given perimeter*.

   4. *When using rectangular ductwork, maintain the aspect ratio as close to 1 to 1 as possible to minimize duct friction loss and initial cost*.

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.[64] Corridors used to convey air to and from rooms shall be approved by LANL Fire Protection Group.

[62] Consensus of several Mechanical Technical Committee members concerns with TA-63-111 Office Building design
[63] SMACNA HVAC System Duct Design - 1990, pg. 2.3, Controlling Costs
[64] NFPA 90A-2012, Section 4.3.11.2

D. Connect outside air ducts for building makeup air systems directly to a fan system. Do not use mechanical rooms as air plenums.[65]

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.[66]

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.*[67]

G. Provide flexible connections immediately adjacent to the suction and discharge ends of moving equipment, e.g., fans, AHUs, etc.

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.[68]

I. Provide minimum 18 gage material when arc welding black iron ductwork.[69]

J. Do not use galvanized construction for temperatures exceeding 400 degrees F.[76]

K. Route trunk ductwork parallel to building walls to conserve ceiling space and allow for future utilities.

L. 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; manproof using 1/2-inch diameter steel bars on 6-inch centers welded at each intersection; follow Mechanical Standard Drawing(s) ST-D3040-6 [70]].

M. 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.

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

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

P. Comply with LANL Master Specification Section 23 3300, Air Duct Accessories.

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.

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65 A direct duct connection provides proper air distribution to the air handling unit and prevents bad odors from the mechanical room from entering the distribution system.
66 IAPMO UMC 2009, Section 602.1
67 ACGIH Industrial Ventilation Manual, 25th Edition, Section 5.12
68 Smooth ductwork will minimize material buildup, and facilitate decontamination and decommissioning activities
69 ACGIH Industrial Ventilation Manual, 25th Ed, Section 5.19.1
70 DOE M473.1-1-2002, pg. X-I, 2. Mesh and expanded metal not used due to air resistance

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.

1. Provide a sound elbow to each return grille per LANL Mechanical Standard Drawing(s) ST-D3040-2.
2. Coordinate the use of ceiling plenum with the electrical designer for specific requirements, e.g., plenum-rated cables, etc.

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.*
6. *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.[71]
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.[72]

B. Fire/Smoke

1. Provide a fire damper in ductwork penetrating a 2-hour or greater rated barriers. Provide an access door to service fire damper.[73] LANL Fire Protection Group shall approve preliminary and final designs.
2. Fire dampers are not required when the duct is encased in a 2-hour or greater rated enclosure.[74]
3. Fire dampers may not be required in nuclear and hazardous exhaust systems.[82] Consult with LANL Fire Protection Group.
4. Provide out-of-air-stream-type fire/smoke dampers where required to minimize noise generation in duct systems.

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[71] 2006 SMACNA HVAC System Duct Design Manual, Figure 6-4
[72] 2006 SMACNA HVAC System Duct Design Manual, Chapter 10.3.1.f
[73] NFPA 90A–2012, Section 5.3.1.1
[74] DOE STD 1066–1999, Section 4.4.3.2.6

5. Provide smoke dampers where required by IBC, IFC, or NFPA 101. LANL Fire Protection Group shall approve preliminary and final designs.

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:

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 22 0713) is not practical

B. When justified, provide duct liner as specified in LANL Master Specification 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 Division representative to ensure code compliance.

B. Duct detectors shall:

1. Be provided where required by NFPA 90A.

2. Be provided where determined by a LANL Fire Protection Division 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 Division representative through analysis [83].

5. Provide photoelectric detectors. Ionization detectors are not acceptable because of less reliability at 7,500 feet altitude.

6. Refer to ESM Fire Protection Chapter for additional requirements.

7.0 FANS

A. Select fan construction based on system design conditions, corrosion resistance considerations, explosive/spark resistance criteria, etc.[75]

[75] IAPMO UMC 2009, Section 503.0

B. Provide fans that bear the Air Movement and Control Association (AMCA) seal.[76]

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.

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.

E. Comply with LANL Master Specification Section 23 3400, HVAC Fans.

F. *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.*[77]

G. When selecting a fan, specify, at minimum, the following: [78]

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.

8.0 FILTERS FOR HVAC SYSTEMS AND HEPA EXHAUST SYSTEMS

8.1 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.[79]

B. Follow ASHRAE HVAC Systems and Equipment Handbook on Air Cleaners for Particulate Contaminants, for Typical Filter Applications classified by Filter Efficiency and Type.

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[76] The AMCA seal assures that the product line has been tested to the appropriate AMCA standards and the manufacturer's cataloged ratings have been submitted to AMCA for approval before publication
[77] ANSI/AIHA Z9.5-2012 , Section 8.9
[78] Fan criteria will aid designer in reviewing and comparing submittals to select the fan meeting the design criteria
[79] Filter class per ASHRAE Handbook HVAC Systems and Equipment, 2012. Providing a minimum 30% efficient filter requires less filter replacement based on previously documented maintenance records from David A. McIntosh, FWO-SEM (became MSS-MSE)

8.2 HEPA Exhaust Systems (D3060.70)

A. When required by codes, standards, or a LANL IHS-IP or ENV-EAQ representative, provide a high efficiency filtration system for the removal of radioactive, microbiological, carcinogenic, and other hazardous substances from exhaust air.

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* IHS-IP or ENV-EAQ *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.

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.
3. For HEPA filter replacement, LANL supplies and installs the filters.

D. Test (in-place) post-startup and replaced HEPA filters in accordance with P101-16, *Local Exhaust Ventilation and HEPA Filtration Systems.* IHS-IP, 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.

E. Refer to the following LANL standards for additional requirements: [80]

1. Mechanical Drawing ST-D3040-5, Air Filter Differential Pressure Gauge
2. Mechanical Drawing(s) ST6700, Filter Train (Bag-out Housing) [may become Mechanical Drawing(s) ST-D3040-4, HEPA Filter Plenum]
3. Master Specification 23 3225, Bag-in Bag-out Housings
4. Master Specification 23 4133, High Efficiency Particulate Filtration
5. Master Specification 23 3225, Bag-in Bag-out Housings
6. Master Specification 43 3113.37, High Efficiency Gas Purification Filters

9.0 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.[81]

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).[82]

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[80] Standard drawings and specifications provide required instrumentation details, HEPA filter plenum details, and specification and installation requirements for filters and housings.
[81] IAQ issue, supports LEED.

10.0 VARIABLE AIR VOLUME (VAV) BOXES

A. Provide pressure-independent VAV boxes, Air Conditioning, Heating, and Refrigeration Institute (AHRI) certified, and completely factory assembled.[83]

B. The minimum supply air setpoint at the VAV box shall not be less than the required minimum ventilation requirements of ASHRAE Standard 62.

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

D. *Guidance: Use static regain duct design method for high velocity variable air volume systems.*[84]

D3060 VENTILATION

1.0 GENERAL

A. Provide ventilation to spaces that people may occupy in accordance with ASHRAE Standard 62, except where other applicable standards and requirements dictate larger amounts of ventilation.[85]

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. *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.[86]

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.*[87]

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[82] Negative pressure values based on 2011 ASHRAE Applications Handbook, Nuclear Facilities, page 28.4 , DOE Facilities "Secondary Confinement"

[83] In pressure independent VAV boxes, the design air flow does not fluctuate due to a change in duct pressure. AHRI certification assures that the product has been tested to appropriate AHRI standards and the performance ratings are as specified in catalog data.

[84] 1990 SMACNA, HVAC System Duct Design Manual, 3rd Edition, page 4.3, Static Regain

[85] Complying with ASHRAE STD 62 supports LEED.

[86] Practically banned by Executive Order 13058, and to lesser extent by LANL IMP 909.1. Total ban supports LEED.

[87] CO_2 monitoring sustains long-term occupant health and comfort. Compliance will meet LEED Rating System 2.0 (prerequisite), Indoor Environmental Quality - Carbon Dioxide Monitoring. Location note lessons *learned, C-Div Office Bldg.*

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. [88]

1. Exhaust at a rate of not less than 2 cfm per square foot or as specified in ASHRAE Standard 62, using greater airflow rate.

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.

1. Refer to the LANL Engineering Standards Manual, Electrical Chapter, for ventilation and/or cooling requirements for transformers, UPS systems, battery areas, telecommunication rooms, etc.
2. Ventilate equipment rooms containing refrigeration equipment in accordance with ASHRAE Standard 15 including refrigerant leak alarms where required.
3. Provide combustion air for fuel-burning equipment in accordance with the UMC.

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 136
2. Guidance for Protecting Building Environments from Airborne Chemical, Biological, or Radiological Attacks, CDC/NIOSH 139.

2.0 SUPPLY AIR INTAKES (D3060.10)

A. Locate intakes at least 24 inches above grade to prevent intake of snow.

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 Mechanical POC approval).[89]

3.0 EXHAUST AIR (D3060.30)

A. Locate exhaust stacks to prevent the discharge air from entering into 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:

1. Provide a minimum stack height of 10 feet above the highest point on the roof.[90]
2. Design stacks to meet project-specific wind load and seismic criteria.
3. Comply with NFPA 780 for lightning protection and grounding requirements.

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[88] Section 408.3 of the New Mexico Mechanical Code allows 3 feet clearance. LANL has increased clearance to 10 feet based on previous problems.
[89] Protect against contaminants like pesticides, chem/bio/rad; ASHRAE Report of Presidential Ad Hoc Committee for Building Health and Safety under Extraordinary Incidents on Risk Management Guidance for Health, Safety and Environmental Security under Extraordinary Incidents 26 January 2003.
http://www.ashrae.org/content/ASHRAE/ASHRAE/ArticleAltFormat/2003716113740_347.pdf
[90] To protect personnel on the roof. (NFPA 45-2011, Para. A.8.4.12). ANSI/AIHA Z9.5 Para. 5.4.6 also supports the 10 foot req't.

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. 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. [91]

5. For intermittently-operated systems, provide protection from rain and snow by stack drains and stack heads. Do not use a rain cap. Refer to Mechanical Standard Drawing(s) ST-D3040-3 for stack head detail. [92]

6. Consult with the Air Quality group for stack monitoring requirements if stack exhausts radioactive operations or other hazardous materials. NESHAP (40 CFR 61) permitting may be required.

B. Refer to LANL Master Specification 23 3100, HVAC Ducts and Casings, for additional requirements.[93]

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

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

1. *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).[94]

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

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.*

1. Install devices (pressure gauges, thermometers, etc.) on major equipment, e.g., water chillers, cooling towers, pumps, coils, heat exchangers, etc.

D. Refer to LANL Master Specification 23 0593, *Testing, Adjusting, and Balancing* for additional requirements.[95]

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[91] ACGIH Industrial Ventilation Manual, 26th Ed, Section 5.12
[92] ACGIH Industrial Ventilation Manual, 26th Ed, Figure 5-18
[93] LANL Master Specification 23 3100 specifies duct materials and installation requirements
[94] ASHRAE Standard 90.1-2010, Section 6.7.2.3 requires HVAC systems to be balanced in accordance with generally accepted engineering standards. NEBB and AABC are nationally recognized organizations that maintain uniform standards for the testing, adjusting, and balancing of environmental systems.
[95] LMS 23 0593 specifies the requirements of the TAB subcontractor and the scope of work to be performed.

5.0 INSTRUMENTATION AND CONTROL, D3060.90

A. Follow ESM Chapter 8, I&C, where the majority of requirements are given. Boiler controls are addressed in Section D3020 above.

6.0 FUME HOODS

A. Select fume hoods on the basis of user requirements and on guidance from LANL Industrial Hygienists. Refer to LANL Master Specification 23 3816, Fume Hoods, for additional requirements.

B. Locate fume hoods per requirements in NFPA 45 and ANSI/AIHA Z9.5.[96] 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.

C. Fume hood face velocities shall be selected as follows:

1. For areas operating under a Chemical Hygiene Plan use 100 FPM for the design face velocity. (The allowable operating range is 80 to 120 FPM.)[97]

2. For areas operating under a Hazard Communication Plan use 138 FPM for the design face velocity. (The allowable operating range is 125 to 150 FPM.)[98]

D. Specify an airflow monitor for all fume hoods. Refer to LANL Mechanical Drawing ST-D3040-1 for additional requirements. 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.

D3070 SPECIAL REQUIREMENTS FOR NUCLEAR-SAFETY-RELATED VENTILATION AND AIR TREATMENT SYSTEMS (PROGRAMMATIC AND FACILITY) [99]

Also see 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.[100]

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[96] Sound engineering practice includes Z9.5

[97] LANL LIHSM, Chapter 39, Table 1-2

[98] LANL LIHSM, Chapter 39, Table 1-2

[99] (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.

[100] Also refer to FAQs on these directives; e.g., Q-6: What does *Very High Assurance* mean in the following passage regarding confinement ventilation?

> An active confinement ventilation system as the preferred design approach for nuclear facilities with potential for radiological release.3 Alternate confinement approaches may be acceptable if a technical evaluation demonstrates that the alternate confinement approach results in very high assurance of the confinement of radioactive materials.
>
> The guidance for confinement ventilation systems and evaluation of the alternatives, is provided in DOE Guide (G) 420.1-1A, *Nonreactor Nuclear Safety Design Guide for Use with DOE O 420.1C, Facility Safety*."

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.*

D. Design to facilitate decontamination and demolition, including:

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. *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.* [29]

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 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*

A: Alternate approaches to an active confinement ventilation system are containment and passive confinement. A containment approach differs from a confinement approach in that the goal of containment is 100% containment of radioactive materials. In reality, even a containment approach results in some level of leakage but this is managed to an absolute minimum by code compliance which requires periodic penetration leak rate tests and full building leak rate tests (ANS 56.8, *Containment System Leakage Testing Requirements*).

Passive confinement involves dependence on minimization of paths of leakage of hazardous materials when a ventilation system is not running. The DOE Toolbox Code MELCOR provides a tool for analyzing a building leak path factor (LPF). Very high assurance of adequate confinement under passive confinement conditions means a technically defensible analysis of the LPF and comparison of the results with applicable dose limits under normal and accident conditions. See *MELCOR Computer Code Application Guidance for Leak Path Factor in Documented Safety Analysis*, May 2004.

Leak path Factor (LPF)

For mitigated analysis, analytical tools used in calculating the LPF shall be appropriate to the physical conditions being modeled, including the use of conservative parameters, such that the overall LPF would be conservative. [DOE-STD-3009-(DRAFT), *DSA Preparation Guide*] *design should ensure that respirators are not required for normal operating conditions or routine maintenance activities except as a precautionary measure*[30]

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*[30]

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*[30]*. 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.*[31]

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

A. 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.[101]

[101] Safety analysis requirements/guidance documents are available at http://int.lanl.gov/orgs/ps/ps4/index.shtml

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.

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.

C. HEPA filtering requirements are further addressed in Section D30, Subsection D3040, under the "Filters and HEPA Filter Housings" heading.

4.0 Standards

A. *Guidance:* LANL P 101-16, Local Exhaust Ventilation and HEPA Filtration Systems, *should be reviewed for requirements potentially affecting designs for local exhaust equipment.*

B. *For the standards that should be considered for Safety-Significant and Safety-Class Ventilation and Nuclear Air Treatment Systems (NATS) beyond those listed above or in other Mechanical sections, see Table D30GEN-2 above.*