2019 ASHRAE® HANDBOOK

Heating, Ventilating, and Air-Conditioning APPLICATIONS

SI Edition

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Table 1 Design Criteria for Fuel-Fired Power Plant

Building/Area	Design Outdoor Cooling/ Heating Dry-Bulb[a]	Indoor Temperature, °C Maximum	Indoor Temperature, °C Minimum	Relative Humidity, %	Room Ventilation Rate, ach*	Filtration Efficiency, %	Pressurization	Redundancy[b]	Noise Criterion
Steam Turbine Area									
Suboperating level	0.4%/99.6%	Design outdoor + 6	7	None	30	None	None	Multiplicity	Background
Above operating floor	0.4%/99.6%	Design outdoor + 6	7	None	10	None	None	Multiplicity	Background
Combustion Turbine Area	0.4%/99.6%	Design outdoor + 5	7	None	20	None	None	Multiplicity	Background
Steam Generator Area									
Below burner elevation	0.4%/99.6%	Design outdoor + 6	7	None	30	None	None	Multiplicity	Background
Above operating floor	0.4%/99.6%	Design outdoor + 6	7	None	15	None	None	Multiplicity	Background
Other Non-Air-Conditioned Areas									
Shops	1%/99%	Design outdoor + 6	18	None	15	None	None	None	85 dBA
Air-Conditioned Areas[d]									
Control rooms and control equipment rooms containing instruments and electronics	0.4%/99.6%	24 ± 1	22 ± 1	30 to 65	ASHRAE *Std.* 62.1	85 to 90 (see text)	Positive	100%	NC-40[c]
Offices	1%/99%	26	21	30 to 65	ASHRAE *Std.* 62.1	ASHRAE *Std.* 62.1	Positive	None	See text
Laboratories	1%/99%	26	21	30 to 65	ASHRAE *Std.* 62.1	High	Positive	None	See text
Locker rooms and toilets	1%/99%	26	21	None	ASHRAE *Std.* 62.1	ASHRAE *Std.* 62.1	Negative	None	See text
Shops (air-conditioned)	1%/99%	26	18	None	ASHRAE *Std.* 62.1	None	None	None	85 dBA
Mechanical Equipment									
Pumps, large power	0.4%/99.6%	Design outdoor + 6	7	None	30	None	None	Multiplicity	Background
Valve stations, miscellaneous	0.4%/99.6%	Design outdoor + 6	7	None	15	None	None	None	85 dBA
Elevator machine rooms	0.4%/99.6%	32	7	None	None	Low	Positive	None	85 dBA
Fire pump area	0.4%/99.6%	NFPA *Std.* 20	NFPA *Std.* 20	None	NFPA *Std.* 20	None	None	None	85 dBA
Diesel generator area	0.4%/99.6%	Design outdoor + 6	7	None	30	None	None	None	Background
Electrical Equipment[d]									
Enclosed transformer equipment areas	0.4%/99.6%	Design outdoor + 6	7	None	60	Low	Positive	100%	85 dBA
Critical equipment	0.4%/99.6%	Design outdoor + 6	7	None	30	None	Positive	100%	85 dBA
Miscellaneous electrical equipment	0.4%/99.6%	Design outdoor + 6	7	None	20	None	None	Multiplicity	85 dBA
Water Treatment									
Chlorine equipment rooms									
When temporarily occupied	0.4%/99.6%	Design outdoor + 6	None	None	60	None	Negative	None	85 dBA
When unoccupied	0.4%/99.6%	Design outdoor + 6	16	None	15	None	Negative	None	85 dBA
Chemical treatment	0.4%/99.6%	Design outdoor + 6	16	None	10	None	None	None	85 dBA
Battery Rooms[e]	0.4%/99.6%	25[e]	25[e]	None	As required for hydrogen dilution	None	Negative or neutral	Multiplicity	85 dBA
Substations	0.4%/99.6%	24 to 27[f]	21	None	IEEE *Std.* C2; ASHRAE *Std.* 62.1	30 to 65%[g]	Positive	100%	NC-55[h]

*Listed numbers are for estimating purposes only. When heat gain data are available, use Equation (1) to calculate required ventilation rate.

[a]See Chapter 14 of the 2017 *ASHRAE Handbook—Fundamentals* for design dry-bulb temperature data corresponding to given annual cumulative frequency of occurrence and specific geographic location of plant.

[b]Multiplicity indicates that the HVAC system should have multiple units.

[c]See Figure 7 in Chapter 8 of the 2017 *ASHRAE Handbook—Fundamentals* for noise criterion curves.

[d]See ASHRAE research project RP-1104 (White and Pahwa 2003) and RP-1395 (White and Piesciorovsky 2010) for heat release values.

[e]See ASHRAE *Guideline* 21-2012 and section on Battery Rooms in this chapter.

[f]Substation temperature maintained for telecom equipment.

[g]Equivalent to rough-in MERV 6 prefilter and MERV 12 secondary filter.

[h]Lower criteria should be considered for occupied substations.

ventilation design criteria establish a temperature rise above the design outdoor temperature to produce an expected indoor temperature that matches the electrical equipment ratings. For example, an outdoor extreme design temperature of 44°C with a ventilation system designed for a 6 K rise would meet the requirements of 50°C-rated plant equipment. Because excursions above selected design outdoor air temperature are often brief (e.g., 2 to 3 h), the effect on room temperature is minimal. In addition, the electrical equipment temperature ratings are associated with design life, not sudden failures. In hot climates where outdoor temperatures may cause indoor temperatures to exceed electrical equipment ratings for extended periods, evaporative cooling or air conditioning of electrical equipment areas may be required to hold temperatures below the equipment design values. When high area temperatures are possible, the quality of environment for plant maintenance workers should also be considered. Velocity (spot) cooling may be necessary in some areas to support work activities.

Low temperatures may affect plant reliability because of the potential for freezing. Selection of the low design temperature should be balanced by selection of the heating design margin. The indoor design temperatures of 2 to 4°C may be used for providing for freeze protection. In the heating system design, credit is generally not taken for heat generated from operating equipment.

The selection of outdoor design humidity levels affects the selection of cooling towers and evaporative cooling processes and the sizing of air-conditioning coils for outdoor air loads. When values from Chapter 14 of the 2017 *ASHRAE Handbook—Fundamentals* are used for design, the mean coincident wet bulb is appropriate. If extreme dry-bulb temperatures are selected for the design basis, the use of extreme wet bulbs is too restrictive because the extremes are not coincident. It is prudent to use the wet bulb associated with the 1% dry bulb when extreme dry-bulb temperatures are used for design.

Indoor design humidity is not a factor in ventilated areas unless the plant is in a harsh, corrosive environment. In this case, lower humidity reduces the potential for corrosion. In air-conditioned areas for personnel or electronic equipment, ASHRAE *Standard* 62.1, Instrumentation, Systems, and Automation Society (ISA) *Standard* 71.04, and manufacturers' recommendations dictate the humidity criteria.

Equipment Selection

Equipment should be selected to successfully operate in the localized environment in which it is installed. This may require additional insulation (as opposed to that required for a typical commercial space) on equipment such as air handlers and piping located in hot areas (i.e., 43 to 49°C). Direct-expansion condensing units may need to be selected for ambient environments greater than 35°C if located on building roof decks or where higher than ambient temperatures can be expected.

In urban industrial areas, HVAC items such as copper coils and piping may need to be either coated with a polyurethane, polyester, or epoxy coating or special ordered using suitable materials to protect the equipment from corrosion caused by hydrogen sulfide, ammonia, and similar substances.

Equipment located inside powerhouses that may be subjected to the effect of flue gas, fly ash, coal dust, etc., should be specified to operate within that environment.

Ventilation Rates

Ventilation within plant structures provides heat removal and dilution of potentially hazardous gases. Ventilation rates for heat removal are calculated during HVAC system design to meet summer indoor design temperatures.

The numbers in Table 1 for air change rates are for estimating approximate ventilation needs. Actual heat emission rates should be obtained from equipment manufacturers (White and Piesciorovsky 2010; White et al. 2004). American Boiler Manufacturer's Association (ABMA) heat loss curves (Stultz and Kitto 2005) can be used to approximate heat loads from boiler casings if better information is not available.

The ventilation rate for room heat removal is

$$Q = \frac{q}{(t_r - t_o)(\rho c_p)} \tag{1}$$

where

Q = ventilation rate, m^3/s
q = room heat, kW
t_r = suggested room temperature from Table 1, °C
t_o = outdoor air temperature, °C
ρ = air density, kg/m^3
c_p = specific heat of air = 1.0 kJ/(kg·K)

Hazardous gases are mostly handled by the process system design functions. Natural gas and other combustible fuel gases are controlled by ignition safeties and may contain odorants for detection. Hydrogen and other gases used for generator and bus cooling are monitored for leakage by pressure loss or makeup rates. Escaped gases are diluted by outdoor air infiltration. For a building with very tight construction (i.e., very little natural infiltration), perform an analysis to verify that dilution rates are acceptable.

Flue gas is confined to the boiler and flue gas ductwork and generally poses no hazard. In some types of boilers and associated gas ducts, however, flue gas is at a higher pressure than the surroundings and can leak into occupied areas. Also, special-treatment gases such as ammonia or sulfur compounds encountered in flue gas conditioning systems can leak into the boiler building, depending on the location of the treatment device in the flue gas stream. In these cases, gas detection monitors should be used.

Some areas containing combustible liquids may require a minimum ventilation rate of 5 L/(s·m^2) as required by NFPA *Standard* 30, with compressed gas storage areas falling under NFPA *Standard* 55.

Chlorine Room Ventilation

Chlorine gas is often used in power generation facilities for treatment of raw water coolant, cooling tower/condenser water, potable water, and sanitary sewage treatment. Based on an **immediately dangerous to life or health (IDLH)** concentration of 10 mg/kg, chlorine is classified as corrosive and a highly toxic chemical, and the ventilation system designer should review the latest safety data sheets and recommended/required exposure/control limits before undertaking a ventilation design (NIOSH 1994).

The chlorine storage room is required to have a dedicated exhaust designed to operate anytime the room or facility is occupied and to operate in the event a leak is detected. The ventilation system should consist of supply and exhaust fans. The ventilation system should not be operated continuously unless required to maintain the storage room at a slight negative pressure with respect to an adjoining space. Any chlorine leak in the room should be contained and exhausted to the environment in a controlled manner. Exhaust intakes should be located within about 305 mm of the floor because chlorine is heavier than air. The supply air source should be located high and designed to provide a clean sweep of the room, ensuring good air distribution.

A minimum ventilation rate of 5 L/(s·m^2) or 30 air changes per hour (whichever is higher) for the chlorine room is recommended. The fan switches with indicating lights, along with the light switch, should be located just outside the chlorine room entry door, which should have a small transparent glass window. Because chlorine gas is corrosive, the exhaust fan should be designed with a totally