CHAPTER 9

JUSTICE FACILITIES

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TECHNICAL and environmental factors and considerations for engineers designing HVAC systems that serve justice facilities are presented in this chapter. Most of the information presented is for facilities in the United States; regulations in other parts of the world differ significantly, and the authorities governing these facilities should be consulted directly. Refer to the 2012 *ASHRAE Handbook—HVAC Systems and Equipment* for further information on HVAC systems and equipment mentioned herein, and to other chapters of this volume for various space applications and design considerations.

1. TERMINOLOGY

The following terms are used throughout this chapter:

Justice Facility. Any building designated for purposes of detention, law enforcement, or rendering a legal judgment.

Cell. A room for confining one or more persons; it may contain a bed for each occupant and a toilet and wash basin.

Holding Cell. A room designed to confine a person for a short period of time; it may or may not contain a bed.

Small Jail. A facility consisting of up to 100 rooms and ancillary areas, designed for confining people.

Large Jail. A facility consisting of more than 100 rooms and ancillary areas, designed for confining people.

Prison. A facility consisting of one or several buildings and ancillary areas surrounded by high walls and/or fences, designed to confine a minimum of 500 people.

Minimum Security. A facility or area within a jail or prison that allows confined people to mix together with little supervision for periods of time during the day.

Medium Security. A facility or area within a jail or prison that allows confined people to mix together with some or total supervision for periods of time during the day.

Maximum Security. A facility or an area within a jail or prison that confines people to their cells with total supervision.

Work Release. A program that allows minimum-security occupants freedom during the day to work outside the facility, but requires them to return for the night.

Courthouse. A facility consisting of courtrooms, judges' chambers/offices, jury rooms, jury assembly rooms, attorney interview rooms, libraries, holding cells, and other support areas.

Police Stations. Facilities housing the various functions of local police departments. They may contain holding cells, evidence storage rooms, weapons storage, locker rooms, offices, conference rooms, interview rooms, and parking garages.

Juvenile Facilities. Also known as **family court** facilities, these facilities are for young offenders. Usually kept separate from adult facilities, they house their own court or hearing rooms, judges' chambers, offices for social workers and parole officers, conference rooms, waiting areas, classrooms, sleeping rooms, intake areas, libraries, exercise rooms/areas, kitchens, dining areas, and laundry.

Inmate. A person confined to a cell, jail, prison, or juvenile facility.

Correctional Officer. A trained law officer who supervises inmates.

Correctional Officer Facilities. Areas designated for use only by correctional officers, including control rooms, break rooms, locker rooms, and storage rooms.

Inmate Areas. Areas that inmates have access to, with or without supervision, including cells, day rooms, exercise areas, outside areas, and certain ancillary areas.

Day Rooms. A room where confined people can congregate for periods of time outside of their cells during the day under supervision. The room usually contains chairs, tables, TVs, and reading and game materials.

Exercise Areas. Gymnasiums or rooms used for exercise by staff members, and areas designated for use by inmates where they can mix and exercise for short time periods during the day. This inmate area is usually outdoors or has at least one wall or the roof exposed to the outdoors.

Ancillary Areas. Support areas, including offices, kitchens, laundry, mechanical rooms/plants, electrical rooms/plants, libraries, classrooms, and rooms for exercise, health care, visitation, interviews, records, evidence, storage, fingerprinting, lineups, inmate intake, etc.

Control Room. A room that allows viewing or monitoring of various areas of the facility by correctional officers and/or houses electronic or pneumatic controls for door locks, lights, and other functions.

Sally Port. A room or space that encloses occupants or vehicles and allows only one door at a time to open.

Forensic Lab. Laboratory where human remains and physical evidence are examined and tested to determine whether a crime has been committed, and to identify bodies and people.

2. GENERAL SYSTEM REQUIREMENTS

Outdoor Air. All areas require outdoor air for ventilation to provide good air quality and makeup air for exhaust systems, and to control pressures within facilities. Minimum outdoor air requirements for various areas in justice (correctional) facilities can be found in publications of the American Correctional Association (ACA) and in ASHRAE *Standard* 62.1.

Equipment Locations. Access to mechanical equipment and controls must be kept secure from inmates at all times. Equipment rooms should also be located where inmates do not have access to them. Where inmates do have access, security ceilings with lockable access panels must be used when mechanical equipment and components must be located in ceiling plenums. Equipment serving areas not accessible to inmates can be located as in other facilities, unless the owner has other specific requirements. Equipment near

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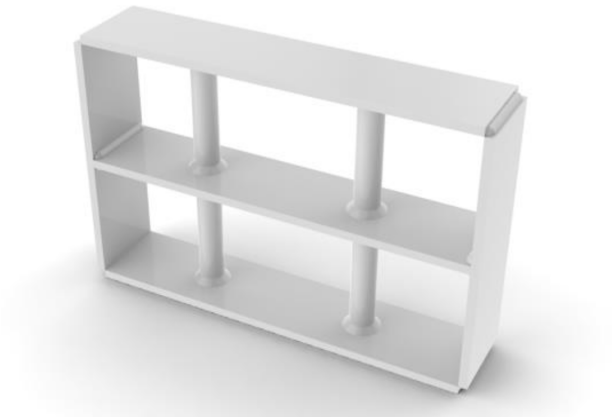

Fig. 1 Typical Security Barrier

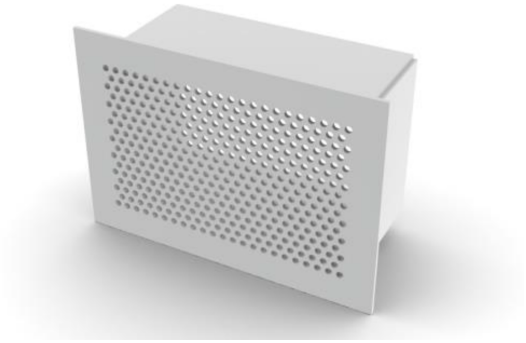

Fig. 2 Typical Air Grille

noise-sensitive areas (e.g., courtrooms, jury rooms, attorney interview rooms) should be isolated with vibration isolators and have sound attenuation devices on supply, return, and exhaust ducts; penetrations for ducts and pipes to those areas and out of mechanical areas should be sealed for sound as well as fire protection.

Security Barriers. Where ducts or openings pass into or out of secure areas, and at exterior intakes and exhausts, security barrier bars are usually installed in ducts or openings that are at least 100 mm high and 150 mm wide. Barrier bars (Figure 1) are usually solid steel bars or heavy-gage tubes mounted in a heavy-gage steel frame to match the duct or opening size. Space between bars or tubing must not exceed 125 mm. They must be installed as an assembly in a structural wall compartment whenever possible, much like a fire damper. Barrier locations should be coordinated with the facility's owner. Include the bars in static pressure calculations for airflow systems.

Air Devices. Grilles and registers are usually security-type devices constructed of heavy-gage steel and welded or built in place in the walls or ceilings of secure areas accessible to inmates, and are designed to reduce entry of obstacles into the grilles (Figure 2). Locations of these devices in secure areas should be coordinated with the facility's owner. Air devices serving areas not accessible to inmates may be standard grilles, registers, and diffusers. Standard diffusers may also be installed in secure areas with ceilings over 4.5 m above the floor.

Outdoor Air Intakes and Exhausts. Louvers and grilles associated with intake and exhaust air should be located at or above the roof level, and/or (1) where inmates do not have access to them and (2) where substances cannot be discharged into them to harm or disrupt services and personnel in the facility. Barrier bars are usually installed at these devices.

Filtration and Ultraviolet (UV) Lights. Most areas in justice facilities use pleated throwaway filters with a minimum efficiency reporting value (MERV; see ASHRAE *Standard* 52.2) of at least 8. Higher-efficiency filters, such as HEPA or MERV 14 filters, may be required for clinic areas and isolation cells, and UV lights may also be installed to reduce bacteria and the spread of disease. Grease filters must be installed in kitchen exhaust hoods over cooking surfaces. In lieu of bringing large amounts of outdoor air into the facility, normal outdoor air quantities may be used by installing gas-phase or carbon filters in recirculated air streams. Discuss filter applications with the owner and authorities having jurisdiction (AHJ). For more information on filters, see Chapter 29 of the 2012 *ASHRAE Handbook—HVAC Systems and Equipment*.

Energy Considerations

Some areas of justice facilities (e.g., cells, day rooms) are occupied 24 h/day year-round and require a large amount of outdoor air that is subsequently exhausted. Methods to recover exhausted tempered air and reduce the energy needed to cool and heat the outdoor intake air include the following:

- Total energy recovery wheels for sensible and latent heat recovery or heat exchangers may be used in air-handling systems with high ventilation loads, or as required by ASHRAE *Standard* 90.1.
- Runaround heat recovery coil loops may be used when exhaust and supply airstreams are separated.
- Thermal storage is available for heating and cooling.
- Variable-speed drives may be used on cooling towers, fans, pumps, supply and exhaust fans, and chillers.
- Variable-air-volume systems may be used in office spaces and other areas not requiring constant airflow.
- Supply temperature reset based on outdoor air temperatures may be used on heating and cooling systems.
- Air- or water-side economizer cycles may be used per ASHRAE *Standard* 90.1 and current codes.
- Heat captured from boiler stacks can preheat combustion air or makeup water.
- Free-cooling heat exchangers provide cooling water by using cooling towers in lieu of the chiller when outdoor air conditions allow.
- Where reheat is required, water rejected from mechanical cooling or recaptured heat sources (e.g., from laundries) may offer economical paybacks.
- Smaller local systems may be installed to serve areas that are occupied at all times or operate seasonally, so that larger equipment may be shut off at certain times. Modular systems allow various modules to be staged on and off as needed to serve the same purpose.
- Night and holiday setback temperatures at least 3 K above or below the normal occupied settings, with morning warm-up or cooldown, should be used wherever possible for areas that are not always occupied or have varying occupancies.
- Evaporative cooling systems may be used in arid climates to replace water chillers and/or cooling towers. They may also be used in other regions to provide makeup air for some facilities, such as kitchens and laundries.
- Heat pumps may be used wherever possible. See Chapter 9 in the 2012 *ASHRAE Handbook—HVAC Systems and Equipment* for a discussion of these systems.
- Combined heat and power (CHP) systems may be used in larger facilities. See Chapter 7 in the 2012 *ASHRAE Handbook—HVAC Systems and Equipment* for a discussion of these systems.
- Laundry water recycling to reduce water consumption by 50% and save energy by reusing laundry hot water.
- Geothermal loop for remote buildings on prison campus.

- Heat recovery chillers able to capture heat from chiller for reheating or boiler water preheating.
- An intelligent hood exhaust control system for kitchen makeup air units and exhaust fans.

Whatever form of energy recovery is used, all systems should be examined for the rates of return on the cost of implementing and operating the systems.

Heating and Cooling Plants and Mechanical Rooms

Most larger justice facilities have central heating and cooling plants, with mechanical rooms located throughout the facility. Smaller facilities generally use local systems, with mechanical rooms located throughout the facility or with a combination of rooftop units or split systems. For larger facilities, central plants with water chillers, cooling towers, and fuel- or dual-fuel-fired steam or hot-water boilers are normally used to serve air-handling units, fan-coil units, reheat coils, and other equipment in mechanical rooms throughout the complex. Primary/secondary or primary variable-speed hydronic pumping systems should also be considered.

The heating and cooling requirements are for continuous operation while there are occupants. Essential equipment should be backed up with standby units for use during maintenance or equipment failure. In addition, major components may need to be braced for seismic and/or wind restraint to ensure continuous service. For seismic design, HVAC systems and components need to be braced in accordance with local codes and the AHJ; see Chapter 55 and ASHRAE (2000) for details. Zoning of various areas for occupancy times and seasonal changes should be factored into system arrangements and types.

Plants and mechanical rooms should be preferably accessed from the outdoors and located in areas not accessible to inmates, unless supervised maintenance and/or operation is performed by inmates. Central utility plants (CUPs) serving very large facilities may be located away from the complex (outside the secure fences or walls). Some of these plants use underground distribution tunnels from the plant to the various buildings in lieu of direct burial of the piping. Access to these tunnels must be kept secure from inmates. Vertical duct and pipe chases in facilities are usually located adjacent to cell areas, incorporated in plumbing chases, and stacked to connect to the heating, cooling, and ventilating or exhaust equipment. Service to these chases must be from outside the cell areas.

Consider maintenance personnel's abilities and training in selecting the types of systems and equipment to be used in the design. Consult the owner and/or maintenance personnel to determine the best combination of components, systems, and location of the plants and mechanical rooms for the facility.

Mechanical equipment in central plants and mechanical rooms must have the proper vibration isolation, flexible pipe and duct connections, and duct-mounted sound attenuators (where needed) to prevent transmission of vibration and noise to sensitive spaces, such as inmate housing day rooms, where it is essential to meet American Correctional Association (ACA) acoustical requirements. Mechanical rooms may have to be sound treated with acoustical materials to prevent transmission of room noise to adjacent spaces. Equipment (e.g., fan types) may also have to be modified to reduce noise transmission. See Chapter 48 for vibration and noise applications.

Controls

Controls serving HVAC systems for small facilities can be local and consist of electric, electronic, pneumatic, or a combination of all of these, and may need to be located in lockable control boxes. Controls for larger facilities are usually direct digital control (DDC) or a combination of electronic/electric and pneumatic, and are connected to a central, computerized system or building automation system (BAS) so that operators can remotely manage and monitor systems more efficiently. Thermostats and other sensors in or near inmate areas should be inaccessible to inmates (e.g., located in return or exhaust ducts) and/or located with secure covers. Control panels are usually located in the locked mechanical rooms or should be located within secure areas. Conceal and secure all interconnecting wiring and pneumatic tubing from inmates.

Fire/Smoke Management

All confined occupants of justice facilities need to be kept safe from fire and smoke. Consider smoke purge in holding areas, dayrooms, cells, and any other areas of confinement. Outdoor recreation and other areas that are open to the outdoors are not considered for smoke purge. Early detection of fires should be considered in all facilities. Discuss installation of fire and smoke detectors with the owner: detectors must be installed in secure areas or in the air-conditioning units or ducts, and inaccessible to inmates. Quite often, smoke detection occurs in the ductwork, behind secure air devices. Typically, the fire alarm system notifies the building management system (BMS), which initiates the proper sequence of operation for smoke removal. In addition to automatic operation of the smoke purge system, most codes require a smoke management panel that provides ultimate override control by the fire department. Coordinate with the jail commission (if applicable) or the authorities having jurisdiction on whether this panel is required and where it should be located.

Smoke purge systems should be designed in accordance with all applicable standards, preferably federal design guidelines or a state jail standard. If there is no adopted state jail standard or jail commission to consult, good practice is considered to be 10 air changes per hour (ach) for the area where smoke has been detected. Some state jail standards require as many as 15 ach, so research standards applicable to the project and jurisdiction carefully. In smoke purge applications, use high-temperature fans that are intended for smoke removal.

Smoke purge systems should also be considered to facilitate evacuation of inmates to safe areas during an emergency, especially if the facility has no other means to evacuate the inmates to secure areas outside the buildings. The owner should be aware of the costs and complexity of smoke management before implementation. See Chapter 53 for information on fire and smoke management.

Tear Gas and Pepper Spray Storage and Exhaust

Tear gas and pepper spray are used to control people during riots and other uprisings by discharging an incapacitating gas that causes their tear ducts to generate tears, blinding them. (For details on how these agents work, see the section on Irritants in Chapter 59.) Tear gas is usually in grenade form or in canisters fired from shotguns, exploding on impact. Pepper spray can be contained in the same forms as tear gas, or in spray containers for use in close quarters. Once discharged, the gas must be evacuated from any enclosed space. Unlike smoke, both tear gas and pepper spray are heavier than air. The smoke purge system is often used to help evacuate the chemical agent from the space. Another alternative is to use separate, portable exhaust systems to direct the air outdoors (e.g., to an outdoor recreation space). The designer must consider the space geometry, openings to the outdoors, the staff emergency action plan, and any other requirements. It is also common to tie the chemical agent purge into the electronic security control panel or touch screen in direct supervision facilities. The sequence of operations in a gas/spray event differ from smoke purging: in the former, the HVAC systems are temporarily shut down and isolated with dampers while the agent is dispersed and the inmates are brought under control; then the agent is exhausted out. Without this delay, the gas/spray could be exhausted before it can work effectively. An automated purge through the smoke purge fans is usually preferred because it

does not require other equipment to be brought in from outside the perimeter, has fewer disruptions to the pod where the incident occurred, and requires little or no staff to implement. The system should also have a manual on/off switch in the mechanical room to ensure that the gases are exhausted after the event. No internal duct lining should be used in these types of exhaust systems.

Storage of tear gas and pepper spray containers must follow HAZMAT requirements: the chemicals must be stored for rotation from date of purchase and removed after about three years. Shelving should be ventilated and away from walls. All persons dealing with the chemicals should have immediate access to protective masks. The storage room should be secured and located away from occupied buildings, and exhaust a minimum of 12 ach from the floor. The room should be kept at negative pressure, and at about 21°C and 50% rh year-round. Supply air should be from the ceiling near the center of the room.

Health Issues

Large prison health facilities, health care areas in large facilities, and some cells or rooms used for isolation in small facilities should be designed for negative pressurization to provide isolation from other spaces for inmates with communicable diseases such as tuberculosis (TB). These spaces should have separate, dedicated exhaust systems, alarms, and controls. Application and component requirements should be discussed with the owner. See Chapter 8 for discussions of health care systems and applications.

3. JAILS, PRISONS, AND FAMILY COURTS

Jails may be a stand-alone structure or part of a larger facility that confines inmates. Some are totally self supported and have their own kitchen, laundry, intake room, fingerprinting, storage for personal belongings, sally ports, parking garage, central plants, and other support areas. Security may be anything from minimum to maximum, and may include a work release area, as well. Jails may be located within the city limits or outside of the city.

Prisons are large facilities that confine inmates for longer periods of time than jails, and may have all levels of security and fences or walls with guard towers. Prisons are usually totally self supported and have every facility required to serve their needs in one large or several small buildings, including laundries, kitchens, dining halls, library, gyms, auditoriums, cell blocks, health clinics, offices, interview rooms, visiting areas, storage rooms for personal belongings, sally ports, intake and release areas, isolation cells or areas, central heating and cooling plants, and correctional officer facilities. Prisons are generally located outside of cities and towns.

Family courts or **juvenile detention centers** are similar to jails but house young offenders up to the age of 18. These facilities include courtrooms, judges' chambers and offices, interview rooms, exercise areas, lockable sleeping areas, classrooms, offices for social workers, kitchens, laundries, and other support facilities. Generally, offices, courtrooms, judges' chambers, interview rooms, exercise areas, classrooms, kitchens, and laundry are unoccupied after working hours, so the mechanical systems for these facilities must be able to respond to various occupied hours of operation.

HVAC Design Criteria

- Use outdoor **summer temperature conditions** equal to ASHRAE 1% design dry bulb and mean coincident wet bulb. For outdoor **winter temperature conditions**, use ASHRAE 99% design dry bulb.
- **Indoor air** should be at 23 to 25°C and maximum 50% rh for summer conditions and occupancy, and 22°C ± 2 K and 20 to 35% rh for winter, unless otherwise noted.
- For **cells** or **sleeping rooms**, noise levels, use a maximum of 70 dBA (day) and 45 dBA (night), with minimum constant-volume airflows and outdoor airflow in accordance with ASHRAE *Standard* 62.1. Maintain negative room pressure and negative air pressures in accordance with that standard, especially when the room or cell contains a toilet.
- For **classrooms**, use noise levels between 25 and 30 RC, and airflows in accordance with ASHRAE *Standard* 62.1. See Chapter 7 for discussion of educational facilities.
- **Interview rooms** should have the same noise levels as for classrooms, with minimum airflows of 6 ach of supply air with a minimum of 0.3 L/(s·m^2) of outdoor air through low-noise diffusers and grilles.
- When **guard stations** are separate rooms for observing inmates, minimum airflow must be in accordance with ASHRAE *Standard* 62.1. Airflows should be constant volume, and noise levels should be 35 to 45 RC. This room may be occupied 24 h a day.
- **Control rooms** should be treated as guard stations. Room loads include computer equipment and video monitors, where required. This room is occupied 24 h a day. Provide a back-up direct-expansion (DX) system to maintain constant required temperature and humidity.
- **Laundries** are usually heated in winter when not used, and well ventilated to remove generated heat but not air conditioned when in use. All air supplied should be exhausted and the room kept at a negative pressure during operating hours. Maximum noise levels are about 45 to 50 RC. Energy conservation measures may include evaporative cooling if tempered air is supplied to the space; discharged warm laundry water may be recovered for preheating makeup water. See ASHRAE *Standard* 62.1 for ventilation and minimum airflow requirements.
- **Libraries** require close space temperature and humidity control, with 24°C db year-round and 40% (winter) to 50% (summer) humidity. Constant-volume airflow meeting ASHRAE *Standard* 62.1 is required. See Chapter 23 for details on libraries.

System Requirements

HVAC equipment is generally either a triple-deck multizone, constant-volume, or variable-air-volume (VAV) system. Constant-volume and triple-deck multizone systems are usually used in dayrooms, cells or sleeping quarters, and storage areas. VAV systems may be used in administrative offices, health services, factories, interview rooms, and visitor areas. Cells and sleeping areas are usually exhausted to comply with codes and ASHRAE *Standard* 62.1, and to help control odors. Intake rooms are also exhausted, with supply and exhaust air outlets located high and low to sweep the room and help control odors. Systems must be able to adjust to variable loads and occupancy times, and be zoned to meet the requirements of ASHRAE *Standard* 62.1. Back-up equipment should be provided to serve dayrooms, cells, and critical spaces.

Mechanical equipment must be located in perimeter mechanical rooms outside of areas occupied by inmates, but must be accessible for maintenance. Cells, sleeping quarters, and dayrooms are usually provided with maximum-security-type grilles for supply, return, or exhaust.

Jails, family courts, and prisons located within city limits or near neighborhoods need to be concerned about noise from mechanical equipment and inmates transmitted to the outdoors. Louvers for equipment, indoor exercise rooms, or windows where inmates congregate need noise abatement. Equipment needs to be examined not only for noise transmitting into the facility but transmitted to the outdoors. See Chapter 48 for information on noise and vibration control.

Dining Halls

Dining halls are usually located in large facilities. Space loads vary, depending on occupancy schedules for food preparation and eating. Food-warming station loads also need to be included in the

space loads. Smaller facilities use a central kitchen to prepare the food, which is then delivered to inmates on trays in warming carts and may then be reheated in ovens just before serving. If ovens are used, they must be included in the local space loads. Latent loads for eating must also be allowed for.

Kitchens

Kitchens are either centrally located and the prepared food is then transferred to the inmates, or they are associated with the dining halls. Kitchens are full service and include pantry, freezers, coolers, ovens, stoves, kettles, fryers, grilles, dishwashers, and exhaust hoods. In many justice facilities, inmates prepare food, so the kitchen should be designed as a secure area. See Chapter 33 and ASHRAE *Standard* 154 for information and requirements on kitchen ventilation.

Guard Stations

Guard stations either are located within the cell and dayroom area, where guards mingle with inmates, or they are remote and enclosed, where guards can observe cells and dayrooms through secure glass windows. Guard stations are staffed while inmates are awake and not in their cells, and may also be staffed during the night if the owner requires it.

Control Rooms

Control rooms use cameras to remotely monitor inmates, and control doors into and around inmate and other secure areas. These rooms are occupied at all times; room loads should include the control panels and video monitors.

Laundries

Laundries are usually located in their own building or separate rooms and contain washing machines, dryers, and pressing machines. The laundries are very warm places and may be tempered with evaporative cooling and outdoor air economizer cycles with full room exhaust. Spot cooling is recommended for personnel at work stations. Warm water discharged from the washing machines may be reused through laundry water recycling systems to reduce water and energy. Laundries usually have steam supplied from the central plant or their own boilers for heating the wash and rinse water and the pressing machines. Laundry service space should be designed as a secure area because of inmate movement.

4. COURTHOUSES

This section covers courtrooms in civil, bankruptcy, and criminal courthouses, as well as support divisions for judges' chambers, clerk of court, jury rooms, library, fitness center, marshal areas, jail cells, and administrative areas. Courtrooms generally do not have a clear schedule of operation; however, they generally operate between 9:00 AM until approximately noon. Support staff generally work between 8:00 AM and 5:00 PM, except in constant-occupancy spaces such as marshal areas, jail cells, and other administration areas. Jury areas are generally 9:00 AM to 5:00 PM, but may be occupied much longer, depending on the type of trial.

Courthouses (state, federal, and county) should be designed to suit operational hours and fluctuating visitors and staff occupancies for maximum energy conservation and optimum controls. Architectural features in courtrooms are generally above standard conventional design, and often include wood and ornate ceilings, which require both temperature and humidity control.

HVAC Design Criteria

- Use outdoor **summer temperature conditions** equal to ASHRAE 1% design dry bulb and mean coincident wet bulb. For outdoor **winter temperature conditions**, use ASHRAE 99% design dry bulb and mean coincident wet bulb.
- **Indoor air** should be at 23°C and 50% rh for summer conditions and occupancy, and 22°C and 20 to 35% rh for winter.
- If provided, the **smoke purge system** in the courtroom should be activated manually as well as automatically.
- All **openings** carrying piping through the slab or through partitions must be sealed with appropriate fire/smoke-resistive material. All air ducts leading to and from sensitive spaces must be acoustically treated with 50 mm thick, 48 kg/m^3 density duct lining for at least 3.5 m from the supply diffusers or return air intake.
- Design HVAC systems for **optimum flexibility in scheduling** use of courtrooms, chambers, and jury areas.
- All **fresh and exhaust air locations** should be at least 12 m above grade, or as high as possible to protect against terrorist attack (see Chapter 59 for more information).

System Requirements

HVAC equipment is generally either constant- or variable-volume air systems. The same independent system should be used for courtrooms, judges' chambers, and jury suites. Every courtroom should have an independent system that can maintain the required temperature and humidity set points in the space, using a thermostat and a humidistat designed to precool before scheduled occupancy. Controls for jury deliberation rooms and judges' chambers should be placed in the conditioned space and be adjustable for variable occupancy.

HVAC systems for courthouses should be zoned to meet fresh-air requirements of ASHRAE *Standard* 62.1. Central plant systems (including chillers, boilers, and air-handling units) should be designed for 24 h operation, intermittent occupancy, and after-hours activity. All VAV terminal units and reheat coils should be located outside courtrooms and deliberation rooms, and should be accessible for maintenance.

Courtrooms/Chambers

The HVAC system serving judges' chambers, courtrooms, and trial jury suites should provide an average occupied temperature of 23°C. The courtroom system zone should allow temperature sensors to be reset from the building automation system to precool to 21°C before scheduled occupancy. Humidity sensors should maintain minimum relative humidity at 20% (winter) to 50% rh (summer).

Provide a minimum of 6 ach for rooms with ceiling heights up to 4.5 m, and 8 ach for rooms with higher ceilings. Systems should be designed to meet these requirements when spaces are fully occupied. These airflows should be reduced during long unoccupied hours, at night, and on weekends and holidays.

Each courtroom should be served by a dedicated fan system, and return air from each courtroom and associated areas (jury rooms, judge's chambers, etc.) must be ducted directly back to the unit or system.

Jury Facilities

Trial jury suites should be served from the same system as the associated courtrooms. (A separate temperature and humidity control for each trial jury room is desirable.)

Air distribution systems must provide separate temperature control and a high degree of acoustical isolation, particularly in grand jury and trial jury rooms. Return air must be ducted directly back to the unit or exhaust air riser. Ductwork must be treated to meet the acoustical deliberation room design criterion of a maximum of 25 to 35 RC. Before recommending underfloor air distribution, filtration, temperature, distribution, air balancing, and commissioning method should be considered.

In the jury assembly room, deliberation room, and associated toilet rooms, the system must provide 10 ach with 80 to 85% return and exhaust.

Libraries

See the discussion of libraries in the section on Jails, Prisons, and Family Courts.

Jail Cells and U.S. Marshal Spaces (24-h Spaces)

A separate air-handling system tied to the main HVAC system should be able to operate independently after hours. A separate 100% fresh and exhaust air system should be provided to jail cells; it should have security grilles and barrier bars, and should maintain negative pressure.

Marshal spaces should be treated as normal office areas, except for cell areas and exercise rooms. Contents usually include computer and radio equipment, cells, exercise rooms, gun vaults, and perhaps sleeping rooms, and may be occupied 24 h a day. HVAC systems serving these areas should be separate from other systems.

Fitness Facilities

These facilities should be tied to the 24 h system and have a separate 100% fresh air unit able to dehumidify air to 10°C dp. Provide exhaust air and heat recovery systems, and maintain the space under negative pressure. See Chapter 5 for more information on gymnasiums.

Acoustic Performance

Acoustic performance should be a major consideration when selecting HVAC equipment. Systems serving courtrooms and auxiliary spaces should be designed with sound attenuation to provide consistent and acceptable sound levels (25 to 40 RC). This is particularly critical in court facilities that require extensive use of sound and audio/visual (A/V) equipment for recording and presentations. Vibration and acoustic performance should be in accordance with guidance in Chapter 48.

To control noise during all modes of operation and for all load conditions, HVAC systems should be provided with one or more of the following:

- Sound traps and acoustic lining in supply and return or exhaust ductwork
- Low-velocity, low-static-pressure fan systems (pay special attention to fan types for noise levels)
- Special low-noise diffusers

Return air should be ducted, especially in courtrooms and jury rooms. Special attention should be given to location of any partitions extending to the floor above and the acoustical treatment around the penetrations of these partitions.

HVAC equipment, including air-handling units (AHUs) and VAV boxes, should not be located close to courtrooms, jury rooms, and chambers. The minimum distance should be 7.5 m between the space and these units. General system design needs to provide appropriate treatment of mechanical supply/return ducts to minimize sound and voice transmission to surrounding areas.

Room criterion (RC) defines the limits that the octave-band spectrum of noise sources must not exceed; for court and jury facilities, it should range from 25 to 40. For sound level maintenance, the courtroom should be served by constant-volume air supply. The system must also support variable outdoor air requirements and variable cooling loads. Air ducts serving trial and grand jury suites must be lined with 50 mm thick, 48 kg/m^3 density acoustical absorption material for at least 3.5 m from the diffuser or return air intake.

5. FORENSIC LABS

In forensic labs, physical evidence is examined, autopsies may be performed, human remains are tested and identified, firearms are tested, evidence is stored, all aspects of suspected criminal activity are reviewed to determine whether a crime has been committed, and people are identified from evidence taken at crime scenes.

The labs contain many chemicals, fume hoods, ovens, centrifuges, microscopes, x-ray units, and other laboratory equipment that need to be considered in space loads and ventilation requirements. Some lab equipment is sensitive to changes in temperature and humidity. See Chapter 16 for more information on laboratories.

Forensic labs may be stand-alone facilities or part of other facilities, or specific departments may be separated and located in other facilities. Components may include offices, data rooms, storage rooms, laboratories, autopsy rooms, interview rooms, inspectors offices, mechanical and electrical rooms or central plants, firearms rooms, x-ray rooms, photo developing rooms, and body or evidence drying rooms.

HVAC Design Criteria

- Use outdoor **summer temperature conditions** equal to ASHRAE 1% design db and mean coincident wb. For outdoor **winter temperature conditions**, use ASHRAE 99% design dry bulb and mean coincident wet bulb.
- For **indoor air**, 23°C and 50% rh for summer conditions and occupancy, and 22°C and 20 to 35% rh for winter, depending on user requirements.
- **Nonhospital autopsy rooms** may require room temperatures as low as 16°C and airflows as high as 15 ach when the medical examiners are suited in heavy or rubber garments during an autopsy, or when odors are especially noticeable. Autopsy rooms must be kept under negative pressure at all times. Air should be exhausted high and low in the space when autopsies are being performed. Specific autopsy sinks may include their own exhaust grilles and need to be exhausted when they are in use. All outdoor air may be required for odor control when autopsies are being performed and for at least 30 min after autopsies are completed. Noise levels of 20 to 35 RC may be required, because of recordings made during autopsies.
- **Laboratories** should be kept at 21 to 22°C and at least 20 to 30% rh in winter, and 21 to 23°C and 50% rh in summer. These rooms often contain fume hoods and the supply, room exhaust, and hood exhaust airflows must all be controlled together to keep the space under a negative pressure, although some laboratory operations may require positive pressure. All room air must be exhausted and not recirculated. These spaces contain large equipment loads that produce high sensible and latent heat gains at various times. Systems serving these rooms must be flexible enough to react to these load changes and maintain their room sensor set points. Most labs require year-round cooling and dehumidification with reheat to prevent build-up of excessive humidity under some weather conditions. Clean steam may be required for the fume hoods and humidifiers serving the labs; fume hoods and lab benches may also require specially treated water [e.g., deionized (DI) water], inert gases, and natural gas supplies.
- **Microscope tables** need to be isolated from vibrations from mechanical equipment and from building vibrations; information on vibration isolation can be found in Chapter 48.
- Usually, **forensic labs** are occupied 24 h a day, with a small number of rooms that may only be occupied during normal business hours; equipment should be selected, zoned, and controlled to allow for these various occupancies.

System Requirements

Offices and general storage in forensic laboratories are served by normal air-handling systems and should maintain normal room airflows and temperature and humidity set points. Return air may be recirculated. Offices should be kept at positive pressure to keep odors out and to allow use as makeup air for negative-pressure

spaces (e.g., storage areas for formaldehyde, which should be exhausted to the outdoors). Systems serving the offices may be required to have their own independent heating and cooling units or terminal units, because their occupancy schedules may differ from those of the labs and other areas.

HVAC systems in cold climates that use 100% outdoor air may experience maintenance problems with frozen hydronic coils unless glycol is used in the water system or the cooling coils are drained in the winter. If internal face-and-bypass dampers are used, cold air can become stratified and freeze portions of the coils. External or integral coil face-and-bypass dampers often are a better application, because they allow cold air to move around the coil or pass through a tempered coil, which reduces the freezing potential.

Ducted supply and exhaust air systems should be used for labs and autopsy rooms. The amount of negative pressure should be maintained carefully in these rooms, so that doors open without excessive door-opening force, as required for smoke control systems (see Chapter 53).

Variable-volume control of supply and exhaust fans may be provided with variable-frequency drives (VFDs). Control of the VFDs should allow for offset of supply and exhaust airflows and to adjust for variances within the systems, such as for dirty filters.

Fume hood exhaust fans should be located on the roof at least 7.5 m from any outdoor air intakes, so they will discharge a vertical plume above and away from the roof. Exhaust fans should not be located inside the occupied space; this can produce a positive air pressure in the exhaust duct downstream of the fan, causing leakage back into the space. Consider using redundant exhaust fans or an $N + 1$ exhaust fan system for critical areas.

Exhaust duct and fan materials need to be checked for corrosion resistance against chemicals from fume hoods and laboratories. Coordinate with laboratory personnel about these fumes. Fiberglass, plastic, stainless steel, or coated galvanized duct materials should all be considered. Internal duct lining should never be used in exhaust ducts. Also, consider requiring the exhaust fan to be explosionproof and spark-resistant if materials exhausted may be explosive.

Use care in locating supply air diffusers in relation to the fume hoods, so that exhaust air flowing into the fume hood is not disturbed and does not create turbulence in front of the hood. Supply air should be introduced slowly in a semilaminar flow pattern away from the hoods.

Intake Air Quality

The quality of outdoor air brought into forensic laboratories should be carefully controlled. Usually, these labs are in urban environments close to traffic, parking garages, industrial areas, emergency generator exhausts, restaurant exhausts, and other contaminants. Also, risks from bioterrorism should be addressed by locating outdoor air intakes where they are inaccessible to the public (see Chapter 59). MERV 13 or 14 final filters may be required for critical lab areas, such as DNA extraction labs, autopsy rooms, and toxicology labs, to prevent cross contamination from other processes in the facility or from other outdoor air influences.

Firearms Testing Laboratories

Firearms testing labs often contain microscope rooms, firearms and ammunition storage rooms, bullet traps, workbench tool rooms, catalog reference rooms, and researcher offices.

Ballistic shooting trap areas are usually kept under negative pressures because of smoke emissions. These rooms should be treated for noise attenuation to prevent noise being transmitted to other spaces and reverberating within the room. Air should be supplied near the shooter's breathing zone and exhausted at or near the bullet trap and downstream of the muzzle of the firearm. Using two-speed supply and exhaust fans or fans with VFDs is recommended, so that fan speed is lower when no shooting is occurring. All exhaust systems should be ducted to roof-mounted fans.

Catalog reference rooms and all offices may operate at different hours than the labs, and may be served by their own HVAC systems or systems with equivalent occupancy schedules. Room temperature and pressures should be the same as for general offices, and return air can be recirculated back to the air-handling system.

Acoustic Performance

Acoustic performance should be a major consideration in selecting HVAC equipment. Systems serving laboratory and autopsy spaces should be designed with sound attenuation to provide consistent and acceptable sound levels (25 to 40 RC). This is particularly critical for autopsy rooms that require extensive use of sound and A/V equipment for recordings. Vibration and acoustic performance should be in accordance with Chapter 48.

To control noise during all modes of operation and for all load conditions, the HVAC systems should be provided with one or more of the following:

- Sound traps and acoustic lining in supply and return ductwork
- Sound trap in exhaust ductwork
- Low-velocity, low-static-pressure fan systems (pay special attention to fan types for noise levels)
- Special low-noise diffusers

Pay special attention to location of any partitions extending to the floor structure above and the acoustical treatment at penetrations of these partitions to provide sound attenuation around the perimeter of ducts and pipes to prevent noise transmissions.

Critical Spaces

Rooms containing freezers or coolers and critical computer rooms should be served by their own independent cooling systems with emergency power back-up, to ensure operation in the event of an extended power outage.

Room pressure controls and monitors should be provided in critical laboratory areas, autopsy rooms, firearms testing rooms, storage rooms that contain hazardous materials, DNA rooms, evidence vaults, trace evidence rooms, drying rooms, photo developing rooms (darkrooms), and other areas deemed necessary by the owner. Room pressures should be continually maintained by measuring supply and exhaust airflows to the room and varying the supply air rate to maintain a differential from the exhaust airflow rate.

Evidence Vaults. Humidity control and cross-contamination prevention are critical, as is exhausting odors from drugs stored in the vault. The room must be kept under negative pressure at 22 to 23°C and 30% rh in the winter and no more than 50% rh in the summer. Barrier bars must be installed on any duct penetrations for these rooms. Firestopping and combination smoke/fire dampers should be installed at duct penetrations.

Photo Developing. Photographic darkrooms must be kept under negative pressure and exhausted to the outdoors, because of the chemicals stored and used within the room. Exhaust should be located behind developing sinks and counters. Outdoor air should be supplied at a minimum of 2.5 L/(s·m^2), from low-velocity diffusers behind lab personnel. Exhaust ducts and fans must be corrosion resistant and contain combination fire/smoke dampers and firestopping at the penetrations. Exhaust fans should also be explosionproof and spark resistant. See Chapter 22 for information on temperatures and humidity levels.

Photo Studios. Photo studios have high heat loads because of their excessive lighting requirements. Systems serving these spaces should be designed to minimize noise and air motion and handle variable loads, because of the occupancy schedule and lighting levels.

Trace Rooms. Trace rooms are laboratories where very small amounts of evidence are examined and tested. Consequently, supply

airflows need to be low, laminar flow away from the work surfaces to prevent any disturbance of materials. These rooms should be treated as any other lab for temperature, humidity, pressurization, and airflows.

Drying Rooms. Some forensic labs have rooms where evidence must be dried very slowly, to preserve it. HVAC systems serving these rooms should be separate from other systems to prevent cross contamination; temperatures should be maintained between 24 and 27°C, pressure should be negative, and all air exhausted to the outdoors. Laminar air supply should be introduced into the room and high and low exhaust inlets should be installed. Supply air should receive final HEPA filtration.

Laboratory Information Management Systems (LIMS)

Many labs use a separate laboratory information management system to document temperature, pressure, and humidity levels in critical laboratory spaces for validation and certification purposes. System requirements need to be coordinated with the owner.

Historical data storage and retrieval of selected processes and system events, system documentation, and data should be required. This function should allow report formatting and generation from archived historical data. Typical reports consist of alarm summaries, limit summaries, report time reports, all-points logs, trend listing, time of day start/stop schedules, message summaries, energy logs, and maintenance reports.

An independent commissioning agent should be retained at the beginning of system design and should perform complete, detailed commissioning services, including system start-up services, operation and maintenance training and documentation, control of shop drawings, and operation and maintenance manuals. A validation procedure may also be required to ensure the system's operational effectiveness meets both the design intent and operator's requirements.

6. INDOOR SHOOTING RANGES

Indoor shooting ranges are used by law enforcement and the military for practice and to maintain accuracy and proficiency with their weapons.

These ranges must be well ventilated to remove gases and lead dust, at a low enough velocity so as not to disturb suspended targets. The range also must be soundproofed from adjoining or neighboring facilities.

Indoor ranges consist of shooting booths, shooting lanes, bullet trap area, range officer position area, weapon storage, ammunition storage, weapon cleaning, restrooms, classroom/lobby, and HVAC systems. The ventilation system must be in operation during all shooting times, cleanup time, and at least 30 min after shooting times.

Shooting booths are usually 1.1 to 1.2 m wide, 2.7 m high, and 1.8 m deep. Shooting booths are separated by soundproof partitions.

The shooting lanes are usually 1.1 to 1.2 m wide, 4.0 m high and 22.9 m long, with mechanical target moving systems. At the end of each shooting lane is a bullet trap.

The shooting range should have its own ventilation system. Some indoor ranges have entering outdoor air tempered for occupant comfort. If so, air delivered should be at least 18.3°C in winter and maximum of 26.7°C in the summer.

The total amount of outdoor air to be delivered depends on the number of shooting lanes installed. Typical airflows are based on 0.38 m/s at each firing lane, with some air exhausted at the ceiling 6.1 to 7.6 m from the booth and the remaining air exhausted at the bullet traps, or a minimum of 0.25 m/s at each firing lane and all air exhausted at the bullet traps. Supply air should be evenly distributed at the firing line about 4.6 m behind the shooters on the back wall in a laminar-flow plenum wall fashion, or along the ceiling above and behind the shooters. The range must be kept at a negative pressure at all times when in use and at least 30 min after use, with supply and exhaust fans interlocked. The minimum exhaust rate must be about 10% above supply rates.

Exhaust ducts must be located behind and at the apex of bullet traps or along the sides of the trap and slightly in front of the trap apex. Exhaust air must be filtered with HEPA filters.

Outdoor and exhaust air inlets and outlets must have sound traps to reduce any shooting noise emitted to the outdoors. Acoustical material must be applied to the exterior of the HVAC ducts. The maximum noise levels are about 165 dBA within the range.

If heat recovery from the exhaust is to used, it must be carefully planned to avoid reintroducing lead fumes and toxic gases into the facility. Inorganic lead exposures are about 50 mg/m^3 based on an 8 h time-weighted average. Again, at least 10% more air must be exhausted than supplied.

Use MERV 7 prefilters on once-through systems. Use MERV 14 prefilters and HEPA filters (bag-out removal) for recirculated air systems. On exhaust air, use MERV 6 prefilters and HEPA filters (bag-out removal). Check with local authorities about safe disposal of lead-contaminated filters.

The weapon cleaning and ammunition storage areas must be exhausted and kept at negative pressures. The other areas of the facility should be maintained at positive pressure to the shooting range, and the toilets at negative pressure to the classroom/lobby area.

The mechanical room or equipment should be accessible without going into the shooting range.

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