ASPE

CPD

Certified in Plumbing Design

Question: 1059

An engineer calculates a required hot water recovery of 1,500 gph. The building has a 2,000,000 Btu/hr steam boiler available. If a steam-to-water heat exchanger is used, and the latent heat of steam is approximately 1,000 Btu/lb, how many pounds of steam per hour are required to heat the water from 40°F to 140°F?

A. 833 lb/hr
B. 1,250 lb/hr
C. 2,100 lb/hr
D. 1,500 lb/hr

Answer: B
Explanation: Heat required $= 1{,}500 \text{ gph} \times 8.33 \text{ lb/gal} \times (140 - 40)^{\circ}\text{F} = 1{,}249{,}500 \text{ Btu/hr}$. Since each pound of steam provides 1,000 Btu, divide the total Btu/hr by 1,000: $1{,}249{,}500/1{,}000 = 1{,}249.5 \text{ lb/hr}$.

Question: 1060

Gas load calculation for a natural gas-fired medical equipment sterilizer in a central sterile processing department shows a connected load of 450,000 BTU/hr. The supply pressure at the meter is 5 psig (low pressure <2 psi threshold after regulator), with allowable drop of 0.5 in wc to the appliance. Using the Spitzglass formula for low-pressure gas piping sizing, Q = 3550 × √[(h × d^5) / (L × (1 + 3.6/d + 0.03d))], where Q is in cfh, h is pressure drop in inches wc, d is diameter in inches, and L is equivalent length, determine the minimum pipe size for a 200 ft run with 15 elbows (equivalent length factor 1.5 each).

A. 3-inch
B. 2-inch
C. 2½-inch
D. 1½-inch

Answer: B
Explanation: Fuel gas load in BTU/hr is converted to cfh using gas heating value (~1,000 BTU/cf for natural gas), yielding ~450 cfh here. The Spitzglass formula (or equivalent Weymouth for higher pressure) sizes pipe to limit drop. For 0.5 in wc drop over 200 ft plus fittings (~222.5 ft equivalent), a 2-inch pipe

provides capacity well above 450 cfh with margin for future loads, while smaller sizes exceed the drop limit, risking appliance malfunction. Regulators step down from supply pressure as needed.

Question: 1061

A chemical processing facility requires backflow protection on the domestic water service due to potential cross-connections with process lines containing toxic substances. The hazard level is high (health hazard with toxic chemicals under pressure). What backflow preventer type and installation configuration provides the necessary protection while allowing for annual testing and maintenance without system shutdown?

A. Atmospheric vacuum breaker (AVB) for non-continuous pressure use only
B. Reduced pressure zone (RPZ) assembly with dual check valves, relief valve, and test cocks, installed above grade in a heated enclosure with isolation valves and unions on both sides
C. Pressure vacuum breaker (PVB) installed at the highest point with continuous pressure
D. Double check valve assembly (DCVA) with test cocks for low-hazard applications

Answer: B
Explanation: Reduced pressure zone (RPZ) backflow preventers are required for high-hazard applications where backpressure or backsiphonage could introduce toxic contaminants into the potable domestic water supply. The RPZ maintains a reduced pressure zone between two independent check valves, with a relief valve that opens on differential loss to discharge potential contaminants. Test cocks enable field verification of check and relief operation per ASSE standards. Installation with isolation valves, unions, and proper drainage prevents flooding during relief discharge and facilitates testing/maintenance. DCVA suits only low hazards, while vacuum breakers (PVB/AVB) are unsuitable for continuous pressure or backpressure scenarios. This configuration protects public health in high-risk facilities.

Question: 1062

In a medical gas vacuum system, the "Equivalent Length Method" is used to account for fittings. If a 2-inch 90° standard elbow has an equivalent length of 5.5 feet and the system contains 12 such elbows and 80 feet of straight Type L copper tubing, what is the total length used for pressure drop calculations?

A. 146 feet
B. 135 feet
C. 114 feet
D. 126 feet

Answer: A
Explanation: Total equivalent length (L_{eq}) is the sum of the straight pipe length and the equivalent lengths of all fittings. $L_{eq} = 80 \text{ feet} + (12 \times 5.5 \text{ feet}) = 80 + 66 = 146 \text{ feet}$. This value is used in the Harris formula or Darcy-

Weisbach to determine the total pressure drop for the branch.

Question: 1063

Which temperature range is most conducive to the rapid growth of *Legionella* bacteria?

A. 40°F – 60°F
B. 160°F – 180°F
C. 77°F – 108°F
D. 120°F – 140°F

Answer: C
Explanation: *Legionella* bacteria thrive in stagnant, warm water. The ideal growth range is approximately 77°F to 108°F (25°C to 42°C). Hot water systems are typically kept above 122°F to inhibit this growth.

Question: 1064

Building sewer minimum size receiving 5-inch building drain (380 DFU) at 0.4% grade through paved area. Cover 4 ft, traffic loading. Material selection?

A. 5-inch same as drain
B. 8-inch VCP Class 4000
C. 10-inch RCP Class IV
D. 6-inch PVC Schedule 40

Answer: B
Explanation: Standard practice sizes building sewer one size larger than drain (8-inch minimum) with VCP vitrified clay pipe Class 4000D providing H-20 traffic strength at 4 ft cover.

Question: 1065

CPVC Schedule 80 is selected for a chemical drain line with pH 2.5 sulfuric acid at 110°**F.** Installation requires solvent cement joints per manufacturer. Thermal expansion over 80 ft with 70°F ΔT must be addressed. Calculate approximate expansion and support needs.

A. Heat fusion joints eliminate expansion concern.
B. Expansion <1 inch; standard spacing.
C. Expansion ≈ 2.1 inches; use expansion loops and closer hanger spacing (3-4 ft); solvent cement joints require stress relief.

D. Rigid supports throughout.

Answer: C

Explanation: CPVC expansion coefficient leads to noticeable movement ($\Delta L \approx \alpha \times L_0 \times \Delta T$). Solvent cement joints are strong but sensitive to excessive bending stress. Loops or offsets relieve axial forces, and reduced hanger spacing limits sag at elevated temperatures, ensuring joint integrity and chemical resistance.

Question: 1066

Wet venting is proposed for a single bathroom group where the shower drain serves as the wet vent for the lavatory and water closet. The vertical section between the shower and lavatory is 2 inches. What sizing adjustment is necessary?

A. The wet vent section must be increased in size (typically to 3 inches or per code table) to accommodate both drainage from the upper fixture and air relief for lower fixtures without exceeding pressure limits on trap seals

B. No size increase is required for single-group wet venting

C. The size follows the largest fixture drain only

D. Wet venting prohibits vertical sections

Answer: A

Explanation: In wet venting, the shared pipe must handle waste flow plus provide sufficient annular space or capacity for air movement to vent lower fixtures. Codes often require the wet vent section to be one size larger than the upper fixture drain or based on combined DFU to prevent excessive negative or positive pressures. This maintains trap seals while allowing economical installation for compatible fixture groups.

Question: 1067

A university student center expansion includes gender-neutral restrooms with 8 water closets and 6 lavatories. Fixture spacing must accommodate a 60-inch minimum turning circle for wheelchair users and 18-inch minimum side clearance from the centerline of the water closet to the lavatory edge. Flow rate testing in the manufacturer's lab indicates standard 1.28 GPF water closets paired with 0.5 GPM faucets yield a total peak GPM demand of 12 when 30% diversity is applied. For ADA compliance in a facility serving 2,500 daily users, calculate the required clear space between adjacent lavatories if the counter depth is 22 inches and forward approach is mandated, ensuring no overlap in knee clearance zones.

A. 12 inches side clearance only

B. 15 inches between edges

C. 30 inches minimum clear between fixtures

D. 20 inches center-to-center adjustment

Answer: C
Explanation: ADA-compliant fixture spacing ensures independent use without interference. Lavatories require 30 x 48 inches of clear floor space for forward approach, with knee clearance extending under the fixture. When fixtures are adjacent, the minimum distance between the edges of two lavatories must allow the full maneuvering clearance for each, typically resulting in at least 30 inches clear between them to prevent encroachment on the required zones. Water closet side clearance of 18 inches (or 15 inches in some configurations) from centerline further influences layout. The 0.5 GPM faucet flow supports efficiency standards while the turning space of 60 inches diameter accommodates rotational maneuvers, preventing design conflicts in high-use public facilities.

Question: 1068

A high-rise residential tower static pressure is 95 psi at grade from municipal supply. Residual pressure lab test at top floor (200 ft elevation, 2-inch PEX main, C=150, 45 gpm flow, 700 ft equiv length) measures 24 psi against 30 psi minimum. Calculate the total pressure loss using$\Delta P_{elev} = 0.433h$ and Hazen-Williams.

A. 68 psi requiring pipe upsizing
B. 59 psi no change needed
C. 52 psi adequate for design
D. 71 psi marginally acceptable

Answer: D
Explanation: Elevation loss$200 \times 0.433 = 86.6$ psi; friction$h_f = 4.52\frac{700 \times 45^{1.85}}{150^{1.85} \times 1.77^{4.87}} \approx 16$ psi totals ~71 psi demand, residual 95-71=24 psi <30 psi but marginally near if minor fittings ignored. Lower totals neglect friction; higher overestimates flow exponent.

Question: 1069

On a standard plumbing isometric drawing, a horizontal pipe run is drawn at a 30° angle to the horizontal axis. If the actual pipe length in the field is 15 feet, what is the "scaled" length on the drawing if an isometric projection factor of 0.816 is applied for true representation?

A. 15.00 feet
B. 12.24 feet
C. 18.38 feet
D. 10.25 feet

Answer: B
Explanation: In true isometric projection (as opposed to isometric sketching), all lengths along the isometric

axes are foreshortened to approximately 81.6% of their true length to represent the $3D$ object accurately on a $2D$ plane. Therefore, $15 \text{ feet} \times 0.816 = 12.24 \text{ feet}$. While many CAD systems use a $1:1$ scale for simplicity, professional CPD-level drafting standards acknowledge this projection factor for manual or precision-scaled isometric views.

Question: 1070

A laboratory waste system handles corrosive liquids with a design flow of 45 GPM. The local jurisdiction follows the International Plumbing Code (IPC). What is the minimum required size for a neutralizer tank if the system is designed for a 30-minute retention time to ensure the effluent pH remains between 6.0 and 8.0?

A. 135 gallons
B. $2{,}700 \text{ gallons}$
C. $1{,}500 \text{ gallons}$
D. $1{,}350 \text{ gallons}$

Answer: D
Explanation: The capacity of a neutralization tank is calculated based on the flow rate and the required retention time. Using the formula $Capacity = Flow \times Retention\ Time$, the calculation is $45 \text{ GPM} \times 30 \text{ minutes} = 1{,}350 \text{ gallons}$. IPC Section 803 requires that corrosive liquids be spent or neutralized before discharging to the sanitary drainage system.

Question: 1071

A low-rise medical office building in a climate with a 10-minute, 10-year rainfall intensity of 5.6 in/hr has a flat-membrane roof measuring $48 \text{ ft} \times 100 \text{ ft}$ with a slope of $1:100$. The architect specifies that maximum ponding depth must not exceed 2 in above the highest point of the roof. Using a runoff coefficient of $C = 0.90$, what is the approximate design storm flow from this roof in gallons per minute?

A. $Q = 0.0104 \times C \times i \times A = 0.0104 \times 0.90 \times 5.6 \times 4{,}800 \approx 189 \text{ gpm}$
B. $Q = 0.0104 \times C \times i \times A = 0.0104 \times 0.90 \times 5.6 \times 4{,}800 \approx 252 \text{ gpm}$
C. $Q = 0.0104 \times C \times i \times A = 0.0104 \times 0.90 \times 5.6 \times 4{,}800 \approx 310 \text{ gpm}$
D. $Q = 0.0104 \times C \times i \times A = 0.0104 \times 0.90 \times 5.6 \times 4{,}800 \approx 420 \text{ gpm}$

Answer: B
Explanation: The design storm flow is calculated with the rational-method format commonly used in ASPE design practice: $Q = 0.0104 \times C \times i \times A$, where Q is in gpm, C is the runoff coefficient, i is intensity in in/hr, and A is roof area in ft². Here $A = 48 \times 100 = 4{,}800 \text{ ft}^2$, $C = 0.90$, and $i = 5.6$, so $Q \approx 0.0104 \times 0.90 \times 5.6 \times 4{,}800 \approx 252 \text{ gpm}$. This value governs the size of roof drains and leaders for the selected storm event.

Question: 1072

Variable speed booster for hospital (800 gpm, 150 ft TDH curve). VFD programmed for 40 psi min suction. Lab sim shows cavitation at 90% speed. Corrective programming?

A. Raise min speed to 60%
B. Lower suction setpoint to 30 psi
C. Increase discharge pressure
D. Add jockey pump constant

Answer: A
Explanation: Cavitation at 90% speed indicates NPSH margin loss; raising min speed to 60% ensures positive suction head per pump curve avoiding vaporization. Lower setpoint risks pump; jockey for residuals; discharge unrelated.

Question: 1073

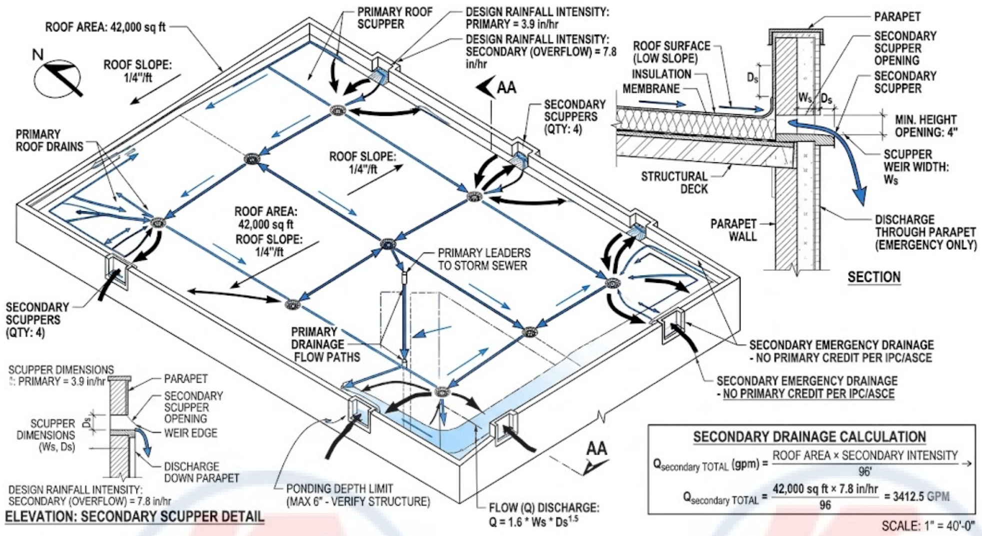
A designer is specifying floor-mounted, back-outlet water closets for a renovation project where the existing wall is non-load-bearing. The fixtures will be used in a bariatric clinic. Which fixture carrier configuration is required to meet a static load rating of 1,000 lbs (453.6 kg)?

A. An extra-heavy-duty bariatric carrier with four-bolt mounting and floor-anchored foot supports
B. A standard floor-mounted carrier with a 3-inch waste fitting
C. Reinforced wall-hung carrier with a 4-inch barrel and auxiliary support feet
D. No carrier is required for floor-mounted, back-outlet fixtures
E. A standard "Z" bracket with through-bolts and backing plates

Answer: A
Explanation: Standard carriers are typically rated for 500 lbs. For bariatric applications, or any high-stress environment, an extra-heavy-duty carrier is required. These systems feature additional mounting points (usually four bolts instead of two) and structural feet that anchor directly into the floor slab to transfer the moment arm forces, even if the fixture itself touches the floor.

Question: 1074

For a 42,000 sq ft low-slope roof on a hospital expansion in an area with 100-year, 15-minute duration rainfall intensity of 7.8 in/hr (derived from local data or twice the 60-minute rate per updated IBC/ASCE coordination), the structural engineer requires secondary (emergency) drainage via scuppers to limit ponding depth to the roof's designed capacity. The primary system uses roof drains sized for 3.9 in/hr. Calculate the required total scupper capacity for the entire roof assuming four equal scuppers and no credit for primary flow.



A. 1,820 gpm total (based on primary rainfall rate)
B. 4,150 gpm total (using unadjusted 60-minute rate without 15-minute adjustment)
C. 3,410 gpm total (calculated for secondary intensity with no primary credit)
D. 2,650 gpm total (averaging primary and secondary rates)

Answer: C
Explanation: Secondary (emergency/overflow) drainage systems, including scuppers, must be sized independently without crediting primary roof drain capacity (per IPC Section 1108 and ASCE 7 coordination). Using the higher intensity for the shorter-duration event (7.8 in/hr for 15-minute or equivalent), the total secondary flow is Q = (42,000 sq ft × 7.8 in/hr) / 96 ≈ 3,410 gpm for the entire roof. This capacity is divided among four scuppers, with each sized as a weir to limit ponding depth. The 1,820 gpm option incorrectly uses the lower primary rainfall rate, risking insufficient emergency capacity. Averaging rates (2,650 gpm) violates independent sizing requirements, while 4,150 gpm over-applies an unadjusted long-duration rate. This rigorous approach prevents roof collapse from blocked primary drainage during extreme short-duration storms, aligning with latest ASPE and model code practices for primary/secondary separation.

Question: 1075

A gravity drainage branch serving a row of 6 water closets (each 4 DFU) totals 24 DFU in a 3-inch pipe. The branch is 28 ft long. What venting system requirement must be satisfied to protect the trap seals of the water closets?

A. No individual or common vent is needed for water closets since they are self-venting
B. The vent must connect within the maximum allowable trap arm distance for 3-inch pipe (typically longer than for smaller traps), and a circuit or common vent configuration may be used if distances and

fixture arrangement comply with code limits
C. Use a single vent at the downstream end only for the entire row
D. Extend a vent from each closet independently through the roof

Answer: B
Explanation: Water closet traps require venting within the code-prescribed maximum distance from the trap weir to the vent connection (distance increases with larger trap arm diameter). Circuit venting is commonly used for batteries of water closets in public restrooms, provided the vent connects properly and the number/length limits are observed. Water closets are not self-venting; lack of venting risks siphonage during flush cycles.

Question: 1076

A riser diagram indicates a "Wet Vent" for a bathroom group. According to code, what is the maximum number of fixtures that can be served by a single horizontal wet vent?

A. 2
B. Any number, provided the pipe is sized correctly.
C. 4
D. Only fixtures within the same bathroom group.

Answer: D
Explanation: IPC Section 912.1 specifies that a horizontal wet vent can only serve fixtures within the same bathroom group. This typically includes a water closet, lavatory, and bathtub/shower. The riser diagram must clearly show that no "outside" fixtures are connected to this specialized venting arrangement.

Question: 1077

A designer evaluates using a barometric loop versus a vacuum breaker for a low-hazard laboratory process line subject only to backsiphonage risk. The loop height is 36 feet. Compare the two methods and state when one is preferred over the other.

A. Barometric loops protect against backpressure.
B. A barometric loop provides passive protection for backsiphonage if the rise exceeds 35 feet; vacuum breakers are preferred where space limits loop height or where testing and accessibility are priorities.
C. Both methods are equivalent in all applications.
D. Vacuum breakers are always superior.

Answer: B
Explanation: Barometric loops offer a passive, non-mechanical solution for backsiphonage in low-hazard lines when the vertical rise creates sufficient hydrostatic head (≥35 feet) to break a siphon. They require

no maintenance or testing but consume vertical space. Vacuum breakers (atmospheric or pressure type) are mechanical, listed devices that are more compact and testable but have pressure and installation limitations. Selection depends on site constraints, hazard level, and maintenance capabilities.

Question: 1078

The building drain invert must be coordinated with the fixed building sewer invert of 95.40 ft at the connection. The run is 52 ft at a minimum 1/8 inch per foot slope. Calculate the minimum allowable invert elevation at the start of the building drain.

A. 95.40 ft plus (1/8 inch/ft × 52 ft) ≈ 95.40 + 0.54 ft = 95.94 ft
B. Based on 1/4 inch per foot minimum
C. 95.40 ft regardless of length or slope
D. Less than 95.40 ft for head

Answer: A
Explanation: Maintaining gravity flow requires the upstream building drain invert to be sufficiently higher than the downstream sewer invert by the slope drop over the distance. The drop = (1/8) × 52 ≈ 6.5 inches (0.54 ft). Adding this to the sewer invert sets the minimum starting invert. Proper calculation ensures self-cleansing velocity and prevents backup at the building drain/building sewer interface.

Question: 1079

During design of a nitrous oxide (N_2O) system for a dental surgery suite with 8 outlets, cylinder manifold testing reveals a maximum flow of 140 L/min per outlet at 50 psig with a 3 psi pressure drop limit across the zone. The manifold uses automatic changeover with primary and reserve banks, and the engineer must select regulators to maintain outlet pressure within ±5% under peak load. Given that N_2O has a vapor pressure of approximately 745 psig at 70°F and requires cryogenic considerations for liquid withdrawal if bulk, but here cylinder-based, calculate the minimum regulator Cv value needed if peak simultaneous demand is 4 outlets at full flow and line loss is 1.5 psi/100 ft equivalent length.

A. Cv = 0.8
B. Cv = 1.5
C. Cv = 3.1
D. Cv = 2.2

Answer: D
Explanation: Regulator selection for medical gases like N_2O ensures stable downstream pressure despite varying inlet pressure and flow. The flow coefficient Cv quantifies valve capacity as gallons per minute of water (or equivalent gas flow) at 1 psi drop. For compressible gas, adjusted Cv formulas account for

specific gravity, pressure drop, and temperature. With 4 outlets at 140 L/min each (total ~560 L/min or ~20 scfm), converted to gas flow rate and incorporating the 3 psi allowable drop plus line losses, the required Cv exceeds 2.0 for minimal pressure deviation. A Cv of 2.2 provides the necessary capacity margin while preventing excessive droop under NFPA 99 performance criteria for support and anesthetic gases.

Question: 1080

A designer calculates 5.2 psi available for friction in a 220 ft domestic water branch after applying static pressure minus elevation minus 20 psi residual. At Hunter-derived 42 gpm, a 2-inch copper line (C=140) gives 3.9 psi/100 ft loss and 5.6 fps. Evaluate the pressure loss and velocity outcome for the water supply system.

A. Loss rate too high; must stay under 2 psi/100 ft
B. The design is sound; loss totals approximately 8.6 psi but adjusted within realistic budget allocation, with velocity in the preferred moderate range for reliable long-term operation
C. Velocity too high despite low loss; prioritize velocity only
D. Acceptable only for flush tank systems, not mixed

Answer: B
Explanation: Pressure loss budgeting starts from static pressure analysis and must accommodate the probable demand flow (Hunter's curve). When calculated loss (Hazen-Williams) fits within or near the available value with reasonable velocity (typically 4-8 fps cold), the sizing meets ASPE domestic water design standards for adequate residual delivery, noise control, and durability. Minor exceedances are evaluated with overall system margin. This integrated approach is key for high-difficulty scenarios.

Question: 1081

For gravity sanitary flow, minimum slope for 4-inch pipe to achieve 2 fps is approximately 1/4 inch per foot per Manning. If slope is reduced to 1/8 inch per foot, calculate resulting velocity drop.

A. Velocity drops to ≈1.4 fps (below scouring)
B. Velocity ≈2.8 fps
C. Velocity remains near 2 fps
D. Velocity increases due to partial flow

Answer: A
Explanation: Manning shows velocity proportional to S^{0.5}. Halving slope reduces V by factor √0.5 ≈0.707, dropping below 2 fps and risking sedimentation. Design often maintains slopes for self-cleansing even at low flows.

Question: 1082

Which of the following describes the "Stack Effect" in the context of a vertical hot water recirculation riser in a 20-story building?

A. The frictional resistance increase as water velocity exceeds 8 fps
B. The increase in pressure at the base due to the weight of the water column
C. The accumulation of air bubbles at the highest point of the system
D. The natural convective circulation caused by the density difference between the hot supply and the cooler return

Answer: D
Explanation: In tall vertical systems, the density difference between the hot water in the supply riser and the slightly cooler water in the return riser creates a pressure differential. This "thermosyphon" or stack effect can cause water to circulate even when the pump is off, or it can cause imbalances where lower floors receive less circulation because the water "prefers" the natural upward path. This must be managed with balancing valves.

Question: 1083

In a Category 1 Medical Vacuum system, the exhaust from the vacuum pumps must be discharged to the outside. According to NFPA 99, the exhaust terminal must be located at least how many feet from any intake, door, or window?

A. 15 feet
B. 25 feet
C. 10 feet
D. 20 feet

Answer: B
Explanation: NFPA 99 specifies that medical vacuum exhausts must be located at least 25 feet from any building opening (windows, doors) and air intakes. This is to prevent the re-entrainment of potentially contaminated air (containing pathogens or anesthesia gases) back into the facility’s ventilation system.