INDUSTRIAL EXHAUST SYSTEMS

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1.0 SCOPE

This data sheet provides recommendations to reduce fire hazards and prevent fire spread in chimney liners and industrial exhaust systems, which are engineered systems designed to convey fumes or particulates in suspension to the atmosphere or a location where they may be modified, treated, or converted prior to release to the atmosphere.

This data sheet does not include process piping.

Industrial exhaust systems include ductwork, intermediate equipment, and waste emission equipment or systems located indoors and outdoors. They are commonly associated with industries involving plating, printing, ovens, oil cookers, painting, mining, metallurgy, chemical, pulp and paper, and food processing.

Although exhaust systems in commercial cooking operations, such as restaurants and cafeterias, are similar, losses in those occupancies are predominantly due to inadequate inspection and cleaning. Only the quarterly inspection and cleaning recommendations in Section 2.4.1.2 should be applied to commercial cooking operations in restaurants and cafeterias; other provisions of this data sheet do not apply.

If occupancy- or equipment-specific data sheets provide different guidance relating to exhaust systems, apply the recommendations in those data sheets.

1.1 Hazard

Industrial exhaust systems are critical to many facility operations. Removal of flammable vapor, corrosive or noxious fumes, dust, lint, or other particulates may be necessary for production or personnel safety, or may be required for environmental reasons. If inoperable due to damage or maintenance issues, the lack of a functional industrial exhaust system can halt facility operations for an extended period of time until repairs are made.

Ductwork in industrial exhaust systems is often fabricated from plastic materials, such as polypropylene, polyvinyl chloride (PVC), or fiberglass-reinforced plastic (FRP), many of which will readily support the spread of fire on the duct interior or exterior. Plastic liners can be installed in both noncombustible and plastic ducts due to the corrosive nature. These liners alone can propagate a fire through a duct. In addition, combustible deposits from vapor or particulates transported through the ducts can contribute to fire spread. Fire originating outside the exhaust system can be drawn into the ductwork, or a fire originating inside the exhaust system can quickly spread via the ductwork, and may also spread to the surrounding occupancy and building.

Selection of noncombustible or FM Approved ductwork, proper design and maintenance of the system, and good housekeeping can help to reduce the hazard of a fire in an industrial exhaust system. Where combustible ductwork or deposits are unavoidable, fire protection is necessary to ensure a fire is quickly controlled and damage is kept to a minimum.

1.2 Changes

October 2024. The changes include the following:

A. Reduced sprinkler discharge requirements.

B. Removed the requirement for increased spacing inside ducts.

C. Included a new section on chimney liners from FM Property Loss Prevention Data Sheet 1-13, *Chimneys*.

D. Clarified that process piping is not covered.

E. Moved duct test information regarding FM Approval standard 4922 from Data Sheet 1-4, *Fire Tests*.

2.0 LOSS PREVENTION RECOMMENDATIONS

Industrial exhaust systems, liners or stacks should be designed by licensed professional engineers experienced in the design and construction of such systems.

Industrial exhaust systems should be designed to be self-contained and independent from other ventilation control systems. The following should be included in the design:

- Appropriate ductwork, equipment, and airflow to properly entrain fumes and particulates such that accumulation of deposits is prevented or minimized

- Adequate strength and rigidity for operating and upset conditions, temperature swings, and other system-specific considerations
- Protection for natural hazard exposures where appropriate, including wind and seismic (see Data Sheet 1-28, *Wind Design*, and Data Sheet 1-2, *Earthquakes*)

2.1 Construction and Location

2.1.1 Use metal or noncombustible materials for ducts and equipment. If plastic ducts or ducts with plastic liners must be used, ensure they are FM Approved. If FM Approved materials are not available, protect in accordance with this data sheet.

2.1.2 Design the industrial exhaust system with the minimum amount of ductwork and most direct path to reach the end of the system and exhaust to atmosphere, as practical.

2.1.3 Locate waste emission equipment outdoors in an area accessible for manual firefighting and that minimizes exposure to other buildings, equipment, and processes.

2.1.4 Locate industrial exhaust systems away from exposures such as oil-filled transformers, combustible storage, vehicle parking, or adjacent buildings, etc. If this is unavoidable, provide automatic sprinkler protection or water spray nozzles to protect the industrial exhaust system.

2.1.1 Insulation

2.1.1.1 Provide noncombustible or FM Approved insulation on ducts and other industrial exhaust system equipment, as needed, to reduce sound or heat transfer and prevent condensation where significant temperature changes occur.

2.1.2 Fire Penetrations

2.1.2.1 Avoid penetration of maximum foreseeable loss (MFL) walls with ductwork. Where unavoidable, keep penetrations to a minimum and arrange in accordance with Data Sheet 1-42, *MFL Limiting Factors*.

2.1.2.2 Avoid penetration of vertical and horizontal fire barriers with ductwork. Where unavoidable, provide a fire damper of equivalent fire resistance rating in each duct at the point of penetration.

2.1.2.2.1 Where the use of a damper is not allowed by code for industrial exhaust systems conveying hazardous materials, reroute the system to avoid penetration of a fire barrier.

2.1.2.2.2 Where it is not possible to reroute ductwork or provide dampers, provide a shaft of equivalent fire resistance rating around the duct extending 25 ft (7.6 m) in each direction from the fire barrier. Seal the perimeter of the duct-to-shaft connection at each end with an FM Approved firestop of equivalent rating. No inlets to the industrial exhaust system should be located within the portion encased in the shaft. This arrangement is not acceptable for an MFL wall.

2.1.2.3 Ducts should not pass-through combustible construction. If necessary, and when carrying high-temperature contents, protect the penetration with an FM Approved firestop or the installation of a metal collar with appropriate space separation clearance.

2.2 Fire Protection

2.2.1 General

2.2.1.1 Provide fire protection for industrial exhaust systems, intermediate devices, waste emission equipment or systems that are constructed of combustible materials or that contain combustible deposits.

2.2.1.2 Provide protection using wet-pipe sprinkler systems, such as standard or deluge, where possible. In areas subject to freezing, dry-pipe sprinkler systems, preaction, deluge, or antifreeze, are acceptable. See Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*, for recommendations on the design and installation of these systems.

2.2.1.3 Use FM Approved fire protection equipment.

2.2.1.4 In corrosive environments, use FM Approved equipment with appropriate corrosion resistance.

2.2.1.5 Equip each water supply line to industrial exhaust system fire protection systems with an accessible FM Approved sprinkler control valve and waterflow alarm, as applicable. Isolate sprinkler protection between multiple industrial exhaust systems by providing a separate sprinkler control valve for each system.

2.2.2 Protection of Systems Located Indoors

2.2.2.1 Provide ceiling-level automatic sprinkler protection for the occupancy in accordance with Data Sheet 3-26, *Fire protection for Nonstorage Occupancies*, or other applicable data sheet. If sprinkler protection is not required for the occupancy, but exhaust system ducts or equipment are of sufficient quantity, concentration, or size to generate a self-propagating fire, then install automatic sprinkler protection directly above the ducts and equipment. Space sprinklers a maximum of 12 ft (3.7 m) on center horizontally, and design based on 15 gpm (57 L/min) per head with 8 heads operating, using 165°F (74°C) quick-response sprinklers with a minimum K-factor of 5.6 (80).

2.2.2.2 Provide automatic sprinkler protection or water spray nozzles inside industrial exhaust system ductwork where ducts have a cross-sectional area greater than or equal to 80 in^2 (516 cm^2), or a diameter greater than or equal to 10 in. (254 mm), **and:**

A. The ducts contain, or are expected to contain, combustible deposits greater than 1/16 in. (1.5 mm) throughout, **or**

B. The ducts are combustible, such as non-FM Approved plastic ducts or metal ducts with plastic liners.

2.2.2.3 Locate sprinklers or water spray nozzles inside ducts as follows:

A. Within 3 ft (0.9 m) of the intake point

B. Within 3 ft (0.9 m) of entrance and exit of any intermediate device, equipment, or building

C. Within 3 ft of any change in direction greater than or equal to 90°

D. At 12 ft (3.7 m) on-center in horizontal ducts, and 24 ft (7.4 m) on-center in vertical ducts, including at the top of vertical ducts

E. Locate the fire protection inside the duct at the 12 o’clock position. If the duct is greater than 12 ft (3.7 m) provide additional fire protection at the same spacing. For round ducts, position the lines of sprinklers at 2 o’clock and 10 o’clock.

F. Use FM Approved corrosion-resistant upright sprinklers installed in the pendent position or corrosion-resistant water spray nozzles with a nominal spray angle of greater than 140°.

Replace water spray nozzles or pendent heads during the next maintenance cycle in accordance with this data sheet.

When installing fire protection outdoors, consider freeze during the design.

2.2.2.4 If installation of a sprinkler or water spray nozzle at a location recommended in 2.2.2.3 is not possible due to small duct size or flexible duct material, locate the sprinkler or water spray nozzle at the connection point to the main duct.

2.2.2.5 Design sprinkler or water spray protection for inside ducts, for a minimum of 15 gpm (57 L/min) per sprinkler. The design should be based on 8 sprinklers operating, using 165°F (74°) quick-response sprinklers and a minimum K-factor of 5.6 (80).

2.2.2.6 Sprinklers with a higher temperature rating, up to 50°F (27°C) above duct or equipment internal ambient temperature, are acceptable to protect ducts or equipment.

2.2.2.7 Do not use extended coverage sprinklers to protect ducts.

2.2.2.8 Design the fire protection for inside ducts with extremely corrosive environments in accordance with Table 2.2.2.8.

Table 2.2.2.8. Extremely Corrosive Duct Nozzle Criteria

Nozzle Design	
Duct Diameter[1]	Water Flow
Less than or equal to 4 ft (1.2 m)	20 gpm (75 L/min)
Greater than 4 ft (1.2 m) and less than or equal to 8 ft (2.4 m).	20 gpm (75 L/min)
Greater than 8 ft (2.4 m) less than or equal to 16 ft (4.8 m)	20 gpm (75 L/min) for two nozzles

Note 1. Ducts larger than 16 ft will need special design consideration.

2.2.2.9 Provide automatic sprinkler protection or water spray nozzles inside combustible equipment, intermediate device, and waste emission equipment or systems.

2.2.2.10 Locate sprinklers or water spray nozzles above all packings or obstructions, but below the exhaust stack. Provide intermediate levels of sprinkler protection in multiple packed beds.

2.2.2.11 Design sprinkler protection or water nozzles inside equipment for 25 gpm (90L/min). Sprinkler or nozzle patterns should meet or overlap.

2.2.2.12 Arrange sprinkler protection or water spray nozzles in industrial exhaust systems containing baffles so the water distribution pattern is not obstructed. If obstructed, add protection on both sides of the baffle.

2.2.3 Protection of Systems Located Outdoors

2.2.3.1 Provide automatic sprinkler protection or water spray nozzles inside industrial exhaust system ductwork and equipment located outdoors in accordance with protection recommendations for systems located indoors, Section 2.2.2.

2.2.3.2 Provide external fire protection for industrial exhaust system ductwork and equipment located outdoors when it is constructed of combustible materials.

2.2.3.2.1 Use automatic fire protection to protect combustible industrial exhaust systems or equipment when they:

- Are located in an inaccessible area or highly congested area where manual fire suppression would be ineffective, **or**
- Are constructed of highly combustible thermoplastics, such as polypropylene or polyethylene, **or**
- Expose a combustible wall or roof.

An area is considered inaccessible or highly congested when industrial exhaust system ducts and equipment, or other neighboring equipment, is in close proximity, such that the arrangement would limit the application of water from fire hoses or monitor nozzles, or impact manual firefighting. This arrangement would obstruct the ability to provide coverage of the equipment or area with fire protection water (e.g., when there is approximately 3 ft (0.9 m) or less of separation or when it is difficult to walk through the area).

2.2.3.3 When external fire protection is required, provide one of the following outside the entire system:

A. Automatic sprinkler protection or water spray nozzles.

B. A combination of automatic sprinkler protection or water spray nozzles and fixed monitor nozzles if ducts and equipment are of lower combustible thermoset plastics such as FRP. Use automatic sprinklers or water spray nozzles to protect portions of the system located in process structures or other areas where existing framing can readily support fire protection piping.

C. External protection consisting solely of fixed monitor nozzles if all the following conditions are met:

1. Ducts and equipment are constructed of low combustible thermoset plastics, such as FRP.
2. Ducts and equipment are located on a noncombustible roof or FM Approved Class 1 roof, if applicable.
3. Ducts and equipment are easily accessible for manual firefighting on at least two sides (i.e., not located on a high roof or near the edges of a large roof, and not in a highly congested area).
4. Fixed monitor nozzles are located to ensure complete water coverage.

5. An onsite industrial fire service is present and trained in the use of fixed monitor nozzles and other firefighting equipment.

6. Fire response scenarios involving the industrial exhaust system have been developed in conjunction with FM and are part of annual fire service training and drill.

2.2.3.4 Locate automatic sprinkler or water spray nozzles and/or fixed monitor nozzle fire protection to prevent propagation of fire along the industrial exhaust system to surrounding construction and occupancy. Locate protection at the following:

- Intake points
- Where ducts enter and exit equipment and buildings
- Changes in direction greater than or equal to 90°
- Combustible equipment, intermediate equipment or waste emission equipment

Additional sprinklers, water spray nozzles or fixed monitor nozzles should be provided to maintain complete coverage in and around projections or other obstructions.

2.2.3.5 Design water spray nozzle fire protection for the outside of ducts and equipment to provide a density of 0.25 gpm/ft^2 (10 mm/min) over the exposed surface area.

2.2.3.6 Locate water spray nozzles outside ductwork or equipment as follows:

- Twelve (12) ft (3.7 m) vertically on-center or in accordance with the approval.
- A distance that will allow the discharge patterns to meet or overlap horizontally.

Provide additional sprinklers or water spray nozzles to maintain complete coverage in and around projections or other obstructions.

2.2.4 Chimney Liners

2.2.4.1 Use noncombustible or FM Approved products for chimney liners.

2.2.4.2 No additional fire protection is needed for free-standing fiberglass reinforced stacks used in conjunction with small package boilers installed straight through the roof (see FM Property Loss Prevention Data Sheet 6-4, *Oil- and Gas-Fired Single-Burner Boilers*).

2.2.4.3 Provide protection at the base of the liner (entry point) in areas that are points of ignition and at any connections to hot gas streams preceding the combustible liner in accordance with Section 2.2.2.

2.2.5 Activation and Control

2.2.5.1 When installing linear heat detection inside ducts for activation of fire protection systems, install a loop of wire at the top of the inside of the duct at the same spacing as the water spray nozzles. Locate the linear heat detection loops within 3 ft (0.9 m) upstream and prior to the water spray nozzles (see Figure 2.2.5.1).

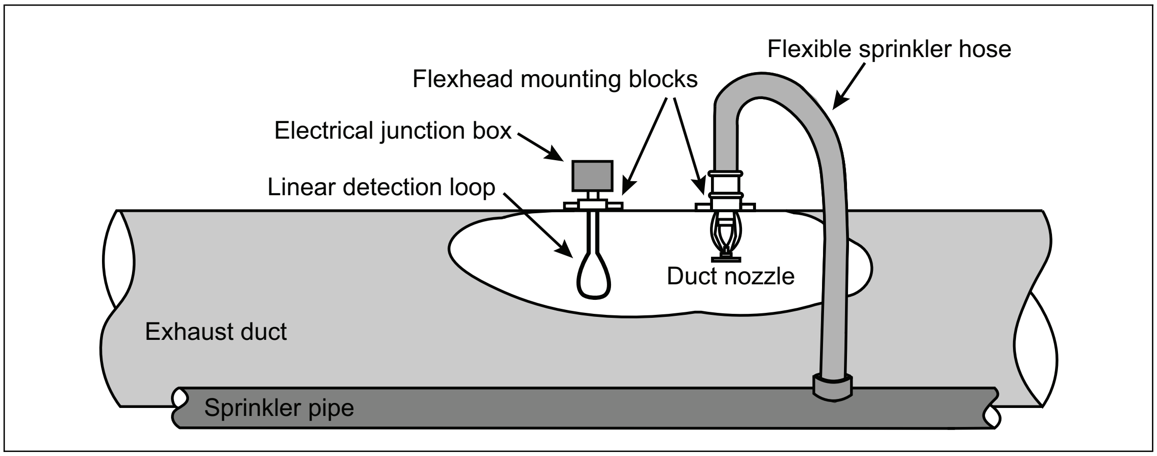


Fig. 2.2.5.1. Typical layout of linear heat detection

2.2.5.2 When using fixed temperature or rate-of-rise detection for activation of fire protection systems outdoors, reduce the spacing by 50% from smooth ceiling spacing.

2.2.5.3 When using pilot sprinklers for activation of fire protection protecting outdoor equipment, use quick response sprinklers located within 6 inches (15 cm) of the equipment.

2.2.6 Hydrant, Extinguishers and Hose Stream Allowance

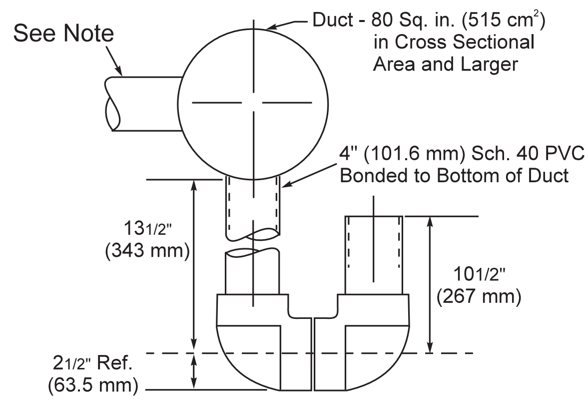
2.2.6.1 Provide hose connections with 1-1/2 in. (150 mm) fittings indoors for adequate manual response. See Data Sheet 4-4N, *Standpipe and Hose Systems*, for additional guidance.

2.2.6.2 Provide fire extinguishers appropriate for the occupancy. See Data Sheet 4-5, *Portable Extinguishers*.

2.2.6.3 Provide a minimum hose steam allowance of 250 gpm (946 Lpm) for all protection designs. Additional water supply beyond the required hose stream allowance is required when using fixed monitor nozzles as part of the fire protection system (see Section 2.2.3.3).

2.2.7 Drainage

2.2.7.1 When sprinkler protection or water spray nozzles are installed in an industrial exhaust system, provide low-point drains (Figure 2.2.7.1) or a comparable releasing mechanism to reduce the possibility of duct collapse. Design the drains to ensure sufficient removal of water discharge. Base flow capacity on rates provided in Table 2.2.7.1, assuming a 4% slope (1/2 in./ft [13 mm/305 mm]).



Note: Inlets to main horizontal runs should be located on side or top of main duct to provide invert elevation for sprinkler water to prevent drainage backflow into the equipment.

Fig. 2.2.7.1. Typical drain configuration

Table 2.2.7.1. Flow Capacity for Low-Point Drains

English Units		
Diameter of Drain or Pipe (in.)	Low-Point Drains (gpm)	Horizontal Drainage Piping (gpm) Slopes ½ in./ft - 4% Slope
3	90	69
4	180	157
5	360	278
6	540	446
Metric Units		
Diameter of Drain or Pipe (mm)	Low-Point Drains (L^3/min)	Horizontal Drainage Piping (L^3/min) 4% Slope
75	340	260
100	680	595
125	1360	1050
150	2040	1690

2.2.7.2 Locate branch-duct inlets near the top of the main duct to lessen the possibility of fire protection discharge flowing back through the branches into critical processes.

2.2.7.3 Arrange drains to discharge to a safe location so as not to affect the occupancy. In cases where drainage would not cause water damage, use friction-retained caps or equivalent. Ensure the drains are designed to minimize air leakage into the ducts. Expected air leakage should be included in the ventilation calculations.

2.2.7.4 Where hazardous residue or material will be present in the discharge, and there are environmental concerns with its release, provide a drainage and containment system designed for the actual sprinkler or water nozzle system discharge for 20 minutes.

2.3 Equipment and Processes

2.3.1 Arrangement

2.3.1.1 Do not manifold industrial exhaust systems for operations that generate sparks (e.g., sanding machines, grinding wheels) with exhaust systems that handle combustible particulates, unless inherent to the process (e.g., exhaust systems for woodworking operations). Reference Data Sheet 7-73, *Dust Collectors and Collection Systems.*

2.3.1.2 Ensure incompatible materials are not mixed in ductwork (e.g., oxidizers and organics).

2.3.1.3 Provide fire dampers on equipment inlet and outlet points to isolate the equipment from ductwork and prevent fire spread between the equipment and ductwork.

2.3.1.4 Provide a noncombustible insulating blanket or wrap-around combustible flexible couplings where they cannot be eliminated.

2.3.1.5 Protect exposed outdoor industrial exhaust system intake and discharge openings with metal screens or gratings to prevent the entry of foreign material such as leaves and branches. If located in a wildland fire area, see Data Sheet 9-19, *Wildland Fire*, for additional guidance.

2.3.1.6 Locate exhaust ducts so their discharge is greater than 6 ft (1.8 m) from any combustible construction, including the wall from which the duct protrudes. Ensure the exhaust duct discharge outlet is more than 25 ft (7.6 m) from unprotected openings in noncombustible exterior walls of nearby buildings or structures.

2.3.1.7 Maintain an airflow design velocity throughout the industrial exhaust system that prevents vapor or particulates from settling in the ducts. See Table 2.3.1.7 for recommended duct airflow velocities for typical operations. Base the design velocity on expected resistance tolerated at the time of filter change or cleaning.

Table 2.3.1.7 Range of Minimum Duct Velocities (From ACGIH®, Industrial Ventilation: A Manual of Recommended Practice for Design, 30th Edition. Copyright 2019. Reprinted with permission.)

Nature of Contaminant	*Examples*	*Design Velocity*
Vapor, gases, smoke		Any desired velocity (economic optimum velocity usually, 1,000–2,000 fpm) [5.08–10.16 m/s]
Fumes, metal smokes	Welding	2,000–2,500 fpm [10.16–12.70 m/s]
Fine light dust	Cotton, lint, wood flour, litho powder	2,500–3,000 fpm [12.7–15.24 m/s]
Dry dusts and powders	Fine rubber dust, Bakelite molding powder dust, jute lint, cotton dust, shavings (light), soap dust, leather shavings	3,000–3,500 fpm [15.24–17.78 m/s]
Average industrial dust	Grinding dust, buffing lint (dry), wool jute dust (shaker waste), coffee beans, shoe dust, granite dust, silica flour, general material handling, brick cutting, clay dust, foundry (general), limestone dust, packaging and weighing asbestos dust in textile industries	3,500–4,000 fpm [17.78–20.32 m/s]
Heavy dusts	Sawdust (heavy and wet), metal turnings, foundry tumbling barrels and shakeout, sand blast dust, wood blocks, hog waste, brass turnings, cast iron boring dust, lead dust.	4,000–4,500 fpm [20.32–22.86 m/s]
Heavy or moist dusts	Lead dust with small chips, moist cement dust, buffing, lint (sticky), quick-lime dust.	4,500 fpm [22.86 m/s] and up

2.3.1.8 Install vapor or particulate intake points as close as practical to the point of vapor liberation or particulate generation. See Table 2.3.1.8 for capture velocities at the point of intake for typical operations.

Table 2.3.1.8. Recommended Capture Velocities (From ACGIH®, Industrial Ventilation: A Manual of Recommended Practice for Design, 30th Edition. Copyright 2019. Reprinted with permission.)

Energy of Dispersion	*Examples*	*V_x fpm [m/s]*
Little motion	Evaporation from tanks, degreasing	75–100 [0.38–0.51]
Average motion	Intermittent container filling; low speed conveyor transfers; welding; plating; pickling	100–200 [0.51–1.02]
High	Barrel filling; conveyor loading; crushers	200–500 [1.02–2.54]
Very high	Grinding; abrasive blasting; tumbling	500–2000 [2.54–10.2]
<u>Factors Affecting Choices within Ranges</u> Strength of cross drafts due to makeup air, traffic, etc. Need for effectiveness in collection: ° Toxicity of contaminants produced by the source ° Exposures from other sources that reduce acceptable exposure from this source, quantity of air contaminants generated - i.e., production rate, volatility, time generated *see also ANSI Z9.2-19917		

2.3.1.9 If transporting ignitable vapor, design the industrial exhaust system to maintain a lower explosive limit (LEL) atmosphere below 25% under normal operating conditions.

2.3.2 Access Ports

2.3.2.1 Provide readily accessible access ports for inspection and cleaning of the industrial exhaust system, including junctions, turns, intermediate runs of ducts, and equipment. Openings for fire protection system components can serve as access ports if of adequate size.

2.3.3 Fans

2.3.3.1 Use fans of noncombustible construction. If the use of combustible fans is unavoidable, install fire protection directly over the fan housing. For additional information, see Data Sheet 13-24, *Fans and Blowers*.

2.3.3.2 Use housings or casings of substantial construction to prevent distortion and loss of alignment under operating conditions. Use blades, impellers, and shafts designed with adequate clearance to prevent contact with casings under conditions of deposit loading.

2.3.4 Interlocks

2.3.4.1 Provide an audible alarm for industrial exhaust systems conveying flammable vapor. Design the alarm to sound at 25% of the lower explosive limit (LEL). See Data Sheet 7-32, *Ignitable Liquid Operations*.

2.3.4.2 Monitor airflow velocity and provide a low airflow alarm to notify personnel of the need to change filters or other media at 95% of the design velocity or as specified by the designer.

2.3.4.3 Design interlocks in accordance with Data Sheet 7-45, *Safety Controls, Alarms, and Interlocks (SCAI)*.

2.4 Operation and Maintenance

2.4.1.1 Manage change to industrial exhaust systems to ensure changes in processes, upset conditions, or exhaust system parameters do not create unsafe operating conditions or accumulation of deposits in ductwork. Examples of changes that may cause this to occur include adjustment of application flow rates, changes in process or environmental temperatures, changes to chemicals used in the process, the addition or removal of intake points, changes to fans or fan speeds, etc.

2.4.1.2 Regular inspection, testing, and maintenance of industrial exhaust system ducts and equipment is critical to identify issues and make adjustments or repairs in a timely manner. Have inspection, testing, and maintenance programs documented and audited by management for compliance.

2.4.1.2.1 Include the following in these programs:

A. **Ongoing** monitoring and inspection of filters for accumulation of deposits and resistance to airflow. Clean or replace filters as necessary.

B. **Monthly** temperature checks of fan and motor bearings using a hand-held temperature device.

C. **Quarterly** visual inspection of ductwork, equipment, and fire protection components for excessive combustible deposits. This inspection applies to commercial cooking operations.

If combustible deposits greater than 1/8 inch (3mm) are found in ducts or equipment, they should be cleaned using appropriate safety tools or another acceptable method. Do not use cleaning methods that produce an ignition source (i.e., open flames, power sanding, grinding).

Replace any sprinklers or water spray nozzles found to have significant deposits. Sprinklers or water spray nozzles with light deposits can be temporarily removed, cleaned with a plastic brush and water, and reinstalled for continued use.

Quarterly inspections may be increased or decreased in frequency after one year of successive inspections. The adjustment should be in consultation with the FM field engineer and set to ensure that deposits don't exceed 1/8 inch (3 mm) between inspections and cleaning.

D. **Annually** or per manufacturer's recommendation, conduct inspection, testing, and maintenance of the following:

1. Fans and blowers for tightness of connections, lubrication of bearings, and vibration check
2. Motors for inspection of belts, lubrication of bearings, and vibration check
3. Operating controls and alarms, interlocks, and safety switches
4. Ductwork, chimney liners and flexible connection integrity
5. Damper operation and tightness of close
6. Potential ignition sources such as improper wiring splices, loose wires, open junction boxes, and friction

E. **Every 1 to 3 years**, infrared scans on all motors and adequacy of grounding and bonding.

2.5 Contingency Planning

2.5.1.1 When breakdown of an industrial exhaust system or waste emission equipment would result in an unplanned outage to key processes or production, develop and maintain a formal contingency plan in accordance with Data Sheet 9-0, *Asset Integrity*. Include consideration for sparing, rental, and redundant equipment.

2.5.1.2 Develop a pre-incident plan in accordance with Data Sheet 10-1, *Pre-Incident and Emergency Response Planning*. Review and update this plan annually.

2.6 Ignition Source Control

2.6.1 Electric Wiring and Equipment

2.6.1.1 Install electrical wiring and equipment in accordance with NFPA 70, *National Electrical Code*, or equivalent international standard.

2.6.1.2 Locate motors outside rooms in which flammable vapor or combustible dust is generated. If inside the room, ensure motors and other equipment are properly classified for the environment in accordance with Data Sheet 5-1, *Electrical Equipment in Hazardous (Classified) Locations*.

2.6.2 Control of Static Charge

2.6.2.1 Electrically bond all metal parts of ducts or other apparatus used for the removal of flammable gas or vapor, combustible dust, or other combustible materials, and ensure the duct system is grounded. When metallic contact is broken at duct joints or at other points, install metal straps to effectively bond connections (see Figure 2.6.2.1). Conduct a check of grounding and bonding adequacy during initial startup or after equipment changes or revisions. See Data Sheet 5-8, *Static Electricity*.

Fig. 2.6.2.1. Bonded metal ductwork

2.6.3 Hot Work Management

2.6.3.1 Industrial exhaust system ducts and equipment are a high-risk area for hot work. Apply the appropriate precautions in Data Sheet 10-3, *Hot Work Management*, and use the FM Hot Work Permit System.

3.0 SUPPORT FOR RECOMMENDATIONS

Many industrial processes require the removal of hazardous fumes or particulates for personnel and environmental reasons. Therefore, industrial exhaust systems are critical to operations. Removal of flammable vapor, corrosive or noxious fumes, dust, or lint is usually so critical that production stops if the industrial exhaust system is damaged or becomes inoperable.

Industrial exhaust systems can be constructed of metal, or combustible materials, such as fiberglass-reinforced plastic (FRP), polypropylene (PP), polyvinyl chloride (PVC), or plastic-lined. The material of the exhaust system is dependent upon the fumes being exhausted.

A poorly maintained industrial exhaust system without regular filter maintenance or the presence of deposits can lead to a decrease in airflow. The decrease in airflow will allow deposits to accumulate within the ductwork, due to lack of proper entrainment of the fume or particulate in the airflow. The longer deposits are allowed to build up, the more combustibles available for fire propagation. These deposits can sometimes spontaneously combust or if ignited becomes fuel to feed and quickly spread a fire throughout the industrial exhaust system. Deposits are hidden, and the hazard can often be overlooked. The inspection and maintenance of industrial exhaust systems is important to ensure proper operation of both the fire protection and the exhaust system, and that deposits are not building up. If deposits are found, it is necessary to clean the ductwork and review airflow velocities for proper design and operation.

Costly fires have occurred in industrial exhaust systems that were not adequately protected or maintained, forcing operations to shut down. Large diameter or specialty ducts can have a long lead time, resulting in extended production interruption.

Fires involving industrial exhaust systems and chimney liners can spread both inside and outside of the ductwork or equipment, which is why it is important to install fire protection both inside and outside of combustible industrial exhaust systems or systems that have deposits. Industrial exhaust systems, which have automatic sprinklers or water spray nozzles installed inside need to be reviewed, to ensure the fire protection water can be safely removed from the ductwork to prevent collapse and that the water is released to an appropriate location.

An additional concern with fires involving industrial exhaust systems is the continued removal of fumes, particulates or smoke. If the fumes or particulates can't continue to be removed by the industrial exhaust system, this can lead to increased or extended cleanup time, especially when handling hazardous materials.

The inaccessibility of industrial exhaust systems for the fire service, and lack of access panels makes firefighting, inspection, and maintenance difficult. Fires are difficult to extinguish because they travel rapidly and extensively through the ducts, feeding on deposits or combustible construction. Interconnected ducts can carry the fire to locations remote from its origin, and often involve other equipment.

3.1 Causes of Duct or Chimney Liner Fires

Most fires involving ductwork start in process equipment, which is outside of the industrial exhaust system. The fire is carried into and spread through the system due to its inherent design. Once inside due to combustible construction or combustible deposits, it will rapidly spread. Common ignition sources are electrical short circuits, cutting or welding, static electricity, spontaneous ignition of deposits, friction, burner flames, overheating and electrical immersion heaters in process equipment. Fires can occur from overheated gases when water quench systems don't work properly and hot waste gas enters combustible equipment, such as scrubbers.

Spontaneous ignition of deposits is common in ducts that handle ventilation from coating and finishing processes. The longer a deposit is allowed to build up, the greater the accumulation, and the greater the chance of spontaneous ignition.

3.2 Illustrative Losses

3.2.1 A consumer food manufacturing facility experienced a power interruption causing all three food dryers to shut down. The operators tried to restart the dryers unsuccessfully and took no action to try and clear the in-process material from the dryers and conveyor belts. The product left in the dryers, including the cooling zones appear to have spontaneously ignited in the dryer system and cooling zones. This resulted in embers flowing through the exhaust ducts and into the bag house dust collectors, thereby igniting the deposits.Several automatic sprinklers above the dryers operated along with most of the sprinklers in the bag house area, that contained four dust collectors. There was no automatic sprinkler protection in the dryer and exhaust ducts. The local fire service responded and took quick action to extinguish fire inside the cooling zone and the dryers.

The lack of sprinkler protection in the dryers and exhaust ducts, along with combustible accumulations were negative factors.

3.2.2 A fire occurred at an unsprinklered automatic nickel-plating line. The fire was discovered by the operator after a trouble alarm on the plating line was received. The fire quickly spread due to the combustible (plastic) baths, fume exhaust ducts, scrubber, insulated metal sandwich panels, skylights, and combustible roof. The fire consumed the building of origin and then spread to the adjacent building.

3.2.3 A plastic bottle manufacturing plant had a process upset condition take place within a production machine resulting in a fire within the machine. This machine was located in a common clean room with nine other production machines. The fire resulted in ignition of accumulated plastic in the area. The fire then extended into a metal exhaust duct on top of the machine, which contained deposits. The fire then extended and propagated through the exhaust duct to an exhaust fan at the roof line, involving resin deposits within the fan housing. Burning resin dripped from the fan housing onto the combustible occupancy below, resulting in a secondary fire. Ceiling automatic sprinklers operated over the machine controlling both fires. Non-thermal damage (water and smoke) was extensive in all exposed areas. Production operations were interrupted as a result of the fire incident. There were no automatic sprinklers located within the ductwork.

3.2.4 A fire occurred at this unsprinklered food processing facility inside an oven. The oven was not operating properly and eventually lead to a loss of flame condition. An attempt was made to relight the oven, but the oven continued to have operating temperature issues. As maintenance was investigating, a fire was discovered in the exhaust ductwork of the oven. The fire in the ductwork then spread to the plastic ceiling panels eventually consuming the entire ceiling area. The fire eventually self-extinguished, as the remaining building areas were of noncombustible construction. Significant smoke and water damage was throughout the facility.

3.2.5 A fire occurred at this unsprinklered heat treating facility, which spread to the ductwork and combustible building. An operator observed flames in the furnace exhaust duct at the ceiling level. Maintenance responded and tried to fight the fire unsuccessfully. The fire spread across three furnaces and is believed to have started due to combustible deposits within the ductwork. The fire spread igniting combustible deposits on the underside of the building roof.

3.2.6 A fire occurred in this unsprinklered titanium dioxide manufacturing plant. The incident is believed to have started in and around the electrostatic precipitator. The process is considered non-flammable, but acidic and corrosive. Ductwork and equipment are plastic or plastic-lined in most cases. The significant amount of large plastic or plastic-lined ductwork, coupled with combustible construction presented a continuity of combustibles across the majority of the facility. The fire spread rapidly through the combustible ductwork on the roof and spread to a wooden roof and concealed space. The elevated roof height and limited access made firefighting very difficult. The main section of factory around 143,000 sq ft (13,300 m^2) was heavily damaged.

3.2.7 A fire occurred at a plating facility involving an outside scrubber and associated ductwork. The most likely cause of the fire was a fault in an electric motor for the water recirculating pump. The fire involved the scrubbers and adjacent polypropylene ducts and exhaust fan located on a concrete roof. The concrete roof received no damage. Sprinklers were provided inside the ducts and scrubbers, but no fire protection was installed outside over the ducts or scrubbers. The ductwork located inside the building leading to the scrubber was non-combustible and protected by fire protection located inside the ductwork. While the outside equipment and ductwork was fully consumed, the fire didn't spread back into the ductwork or the building.

3.2.8 A significant fire incident occurred at a copper smelter, in the fume duct collection system downstream of the flash smelting furnace. A series of seemingly unrelated and random failures of process interlocks, safety systems, equipment and operator response caused cooling water pumps to fail, which resulted in extreme temperatures occurring in a section of FRP ductwork. This caused ignition and destruction of the FRP ductwork and an attached FRP vessel. There was no fixed fire suppression inside the FRP vessel or ductwork. The fire was stopped from entering a several hundred foot long FRP duct by an intermediate noncombustible vessel. The fire resulted in shutting down the entire smelter complex for 11 days.

3.3 Construction of Industrial Exhaust System

Materials used for the construction of industrial exhaust systems are dependent upon the operational needs or products being transported. In some cases, the use of a non-combustible ductwork system is not practical, due to the corrosiveness of the products being exhausted by the system. In some cases, a product can encounter a temperature change, which will cause condensate. The condensate can provide greater damage to the industrial exhaust system than the product being transported. Temperature changes to avoid condensate can be managed several ways.

3.3.1 Insulation

When a duct passes through a zone of temperature change, condensation of vapor may occur. FM Approved insulation can be added to industrial exhaust systems at temperature changes to minimize condensation.

The corrosive action of an environment increases when the moisture content is high and encounters a temperature change. If the condensate is corrosive, it will rapidly deteriorate the fire protection system, other equipment in the duct, and possibly the duct itself. The designer should appropriately protect against sudden temperature changes. Some examples of ways to minimize the corrosive effect associated with temperature change are as follows:

A. Use an FM Approved plastic duct that does not require fire protection.

B. Heat the environment in the duct system to a temperature above the dew point of the corrosive medium and/or insulate the duct system to prevent cooling of the corrosive medium to its dew point.

C. Cool the corrosive medium below its dew point before it enters the duct and drain it to a safe location.

3.3.2 Types of Plastic and Industrial Exhaust Systems

Industrial exhaust systems are designed to remove corrosive vapor from the production area, which are then treated or cleaned prior to release in the environment. The corrosiveness of the products requires the use of plastics in some industrial exhaust systems. Plastics may be used in ducts, hoods, fans and blowers, scrubbers, absorbers, and mist eliminators. Common plastics are polypropylene, polyvinyl chloride (PVC), and FRP. PVC and FRP are often used in large fume removal systems due to low fabrication costs relative to corrosion-resistant alloys, rigidity, ease in handling.

Thermoplastic refers to plastics that soften when heated and harden when cooled, regardless of how many times the process is repeated. Examples of thermoplastics are polypropylene (PP), polyethylene (PE) and polyvinyl chloride (PVC). Industrial exhaust systems and equipment using this material are susceptible to a severe fire due to the ability of the plastic to melt, soften and develop pool fires. Burning thermoplastic debris can drop or fall and ignite combustible materials below. Thermoplastics are typically used in metal processes (e.g., plating and electronics manufacturing).

Without fire protection, thermoplastics represent a severe fire hazard once ignited and can rapidly propagate a fire into the attached exhaust systems, adjacent equipment, nearby combustibles and even the building. Severe damage to equipment and structures may result. With fire protection, the goal is to limit the severity of a fire to a piece of equipment and adjacent ductwork, which is likely to be destroyed with additional thermal damage to surrounding equipment.

Thermoset refers to plastics that set into permanent shapes from the head and pressure applied during manufacturing. Reheating will not soften the material, and they generally burn less readily than thermoplastics. Thermoset plastics in industrial exhaust systems generally incorporate glass fibers to reinforce the plastic (e.g., fiberglass reinforced plastics [FRP]). Thermoset plastic will remain rigid and in place when burning and there should be minimal to no dropping or melting of burning debris.

In corrosive environments, FRP is common due to the manufacturing flexibility and ability to make the supporting structure from the same material. Large process equipment, such as gas cleaning plants, corrosive waste gas systems in the chemical industry, and air pollution control systems are often constructed of FRP.

3.3.3 Plastic-Lined Ducts and Chimneys

Plastic-lined ducts are used because they are corrosion-resistant and less expensive than non-corrosive metals and alloys or lined metal ducts.

Non-FM Approved Lined Ductwork is considered combustible. The liner is expected to contribute to fire spread throughout the ductwork.

Concrete and metal chimneys are often lined with plastic materials such as fiberglass reinforced plastic. This construction is due to the corrosives gases generally found within the combustion products of oil, gas, coal and other industrial gas processes. These by-products become an issue when the corrosives combine with moisture to produce acids. Moisture occurs when the temperature inside the chimney surpasses the acid dew point and creates condensation.

FM Approval Standard 4929, *Chimney and Flue Liner Materials*, covers FM Approved products for chimney liners. When relining a chimney, an FM Approved product should be utilized.

3.4 FM Approval of Duct Systems

The use of FM Approved ductwork is important to help limit fire spread within ductwork. FM Approved ductwork can be metal with a thin plastic liner or plastic of limited combustibility. Based on the FM Approval test, a fire involving the ductwork will not propagate.

Ductwork, in order to meet FM Approval, can contain no combustible deposits. FM Approved ductwork containing combustible deposits needs to be protected in accordance with this data sheet.

The FM Approvals Duct Test (4922) is designed to test a representative section of duct for which FM Approval is desired. The fire test is intended to simulate actual fire conditions. A fire exposure is placed directly below the inlet of a duct. During the test, the fire is drawn into the duct where it can ignite the duct and propagate along its entire length.

This test uses a 24 ft (7.32 m) length of the specimen duct placed in a horizontal position (Figure 3.4-1). The ducts are tested with a maximum diameter of up to 12 in. (305 mm), and then Approval can be granted up to 60 in. diameter (1.5 m) per FM Approval Standard 4922. The duct is supported 32 in. (813 mm) above the floor. The duct intake end is inserted into a draft shield, flush with the inside surface of the enclosure wall.

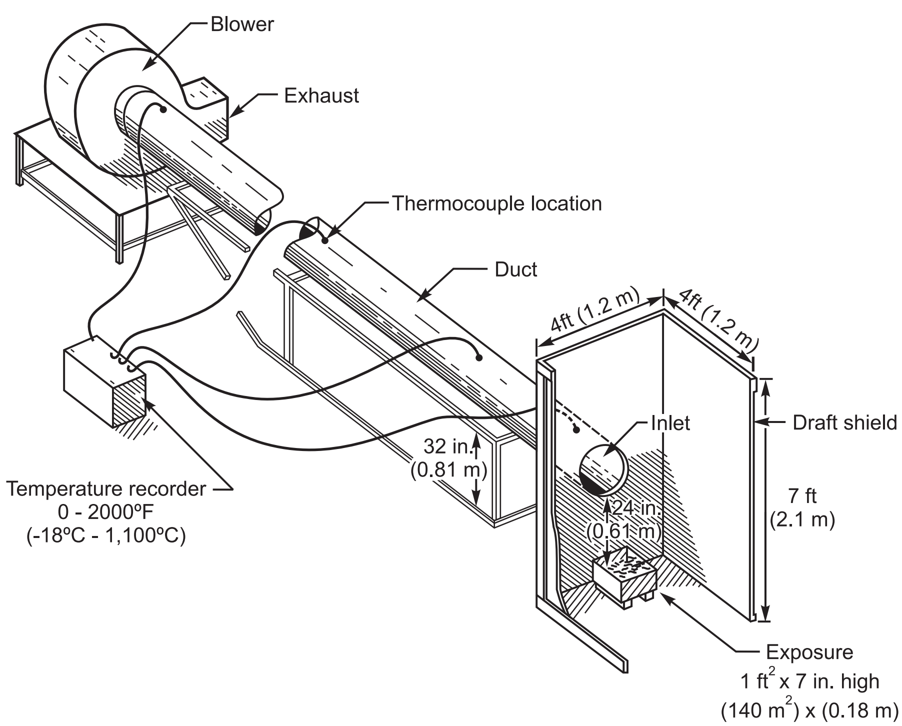


Fig. 3.4-1. FM apparatus for the evaluation of ducts

The exhaust end is connected through a steel transition piece to a blower which pulls air through the duct at specified air velocities.

The fire exposure consists of a 4 in. (102 mm) depth of heptane in a 12 in. (305 mm) square pan. Heat output from the heptane is approximately 10,000 Btu/min (176 kW).

The ducts have an induced draft velocity of 600 linear ft/min (3.05 m/s).

The performance is considered satisfactory if, during all tests, flame does not spread from the fire end to the 243 ft (7.32 m) mark during the 15-minute test, and interior duct temperatures recorded at the 23-foot mark do not exceed 1000°F (538°C).

A large number of plastic ducts have been tested and failed the duct test. For the most part, the materials from which the ducts were made had low ASTM E-84 flame spread ratings of 25 or less.

Fig. 3.4-2. A plastic duct that failed this test, despite a flame spread rating of 25 per the ASTM E-84 test

FM also conducts a horizontal/vertical fire test, where a 24 ft (7.3 m) long horizontal segment is connected to a 15 ft (4.6 m) vertical segment by an elbow. See Figure 3.4-3. The two ducts shall be 12 in (305 mm) in diameter. The ignition source is the same as the horizontal duct test. A custom vertical duct fire test can also be conducted per FM 4922 to assess vertical runs greater than 15 ft (4.6 m).

Neither the American Society for Testing Materials (ASTM) nor Underwriters' Laboratories, Inc. (UL) presently have fire tests that bear any similarity to the FM Duct Test.

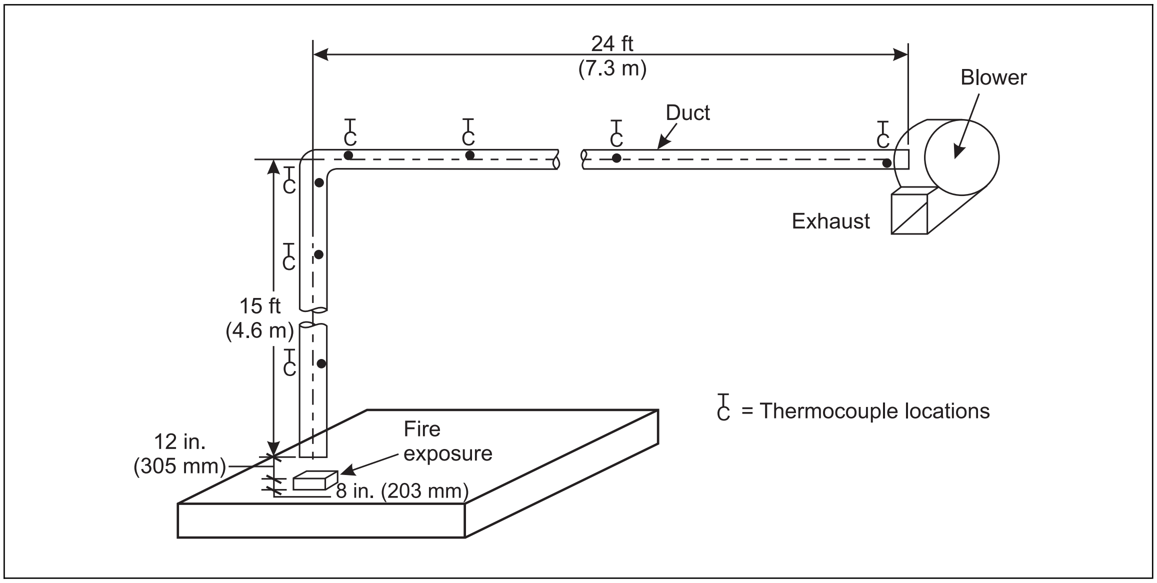


Fig. 3.4-3. FM vertical/horizontal duct test

3.5 Fire Protection

3.5.1 Fire protection is to be installed throughout combustible industrial exhaust systems. The installation of fire protection, as outlined in this datasheet, at specific locations, is to help mitigate and control a fire within the ductwork. The locations identified in Figure 3.5.1-1 are an example of fire protection, installed at certain locations. Once protection is applied at the specific locations, fire protection should then be spaced based on the maximum spacing requirements contained in the Data Sheet, depending upon the design chosen. Fire protection is specifically placed at these locations, as they are likely areas to find accumulation of deposits within the ductwork.

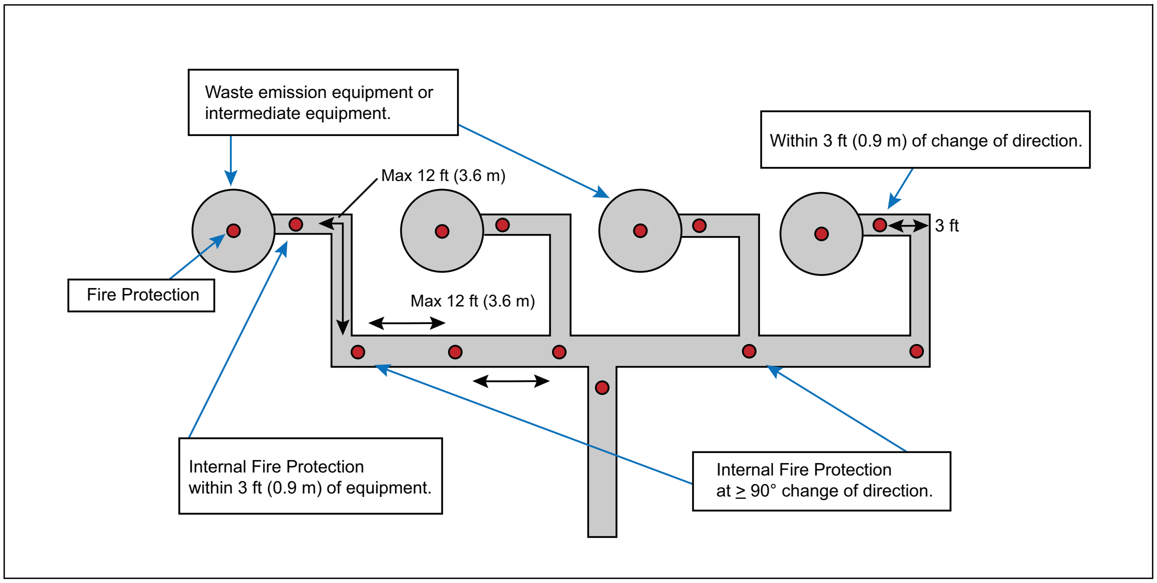


Fig. 3.5.1-1. Sample sprinkler or water spray nozzle location layout for ductwork

Baffles (see Figure 3.5.1-2) are sometimes installed in industrial exhaust systems, especially in auto manufacturing engine-testing, to reduce noise levels. The baffles are constructed of sheet metal and their positioning can obstruct sprinkler or water spray nozzles. (Applications of noise reduction systems are highly customized and engineered for the specific equipment and environment. The photo provided is an example only.)

Fig. 3.5.1-2.Typical baffle (courtesy of dB Noise Reduction Inc.) Applications of noise reduction systems are highly customized and engineered for the specific equipment and environment. The photo provided is an example only.

3.5.2 Figures 3.5.2-1 through 3.5.2-7 deal with open, congested, and inaccessible areas.

Fig. 3.5.2-1. A fixed monitor nozzle

Fig. 3.5.2-2. Example of large open area that could be protected with monitor nozzles

Fig. 3.5.2-3. Examples of open areas where monitor nozzles could be used

Fig. 3.5.2-4. An object protected by a monitor nozzle must be accessible

Fig. 3.5.2-5. An object protected by a monitor nozzle must be accessible

Fig. 3.5.2-6. An example of a congested area that is not accessible for manual suppression

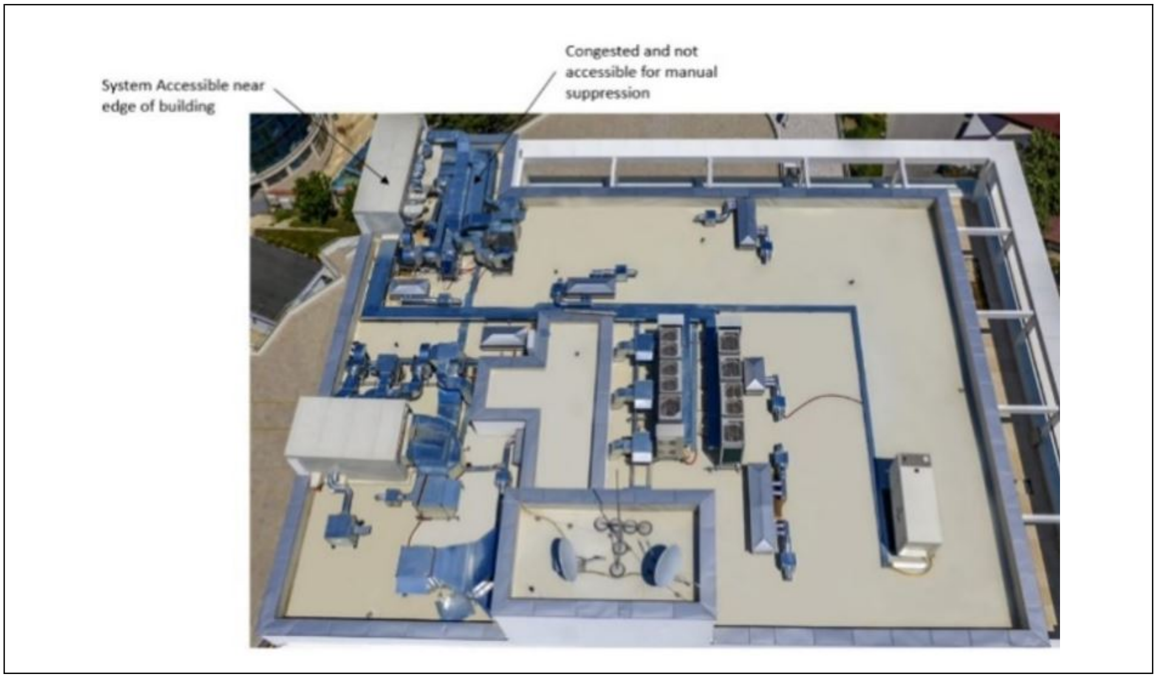


Fig. 3.5.2-7. A rooftop congested area that is not accessible for manual suppression

3.6 Corrosion Protection for Duct Sprinkler Systems

Duct environments can be considered corrosive or highly corrosive. Ordinary fire protection equipment used in these ducts will have a very short life span. FM Approved water spray nozzles are ideal for extremely corrosive environments but will still need to be replaced regularly. When installing sprinklers in ducts they should be rated 50°F (22°C) higher than normal operating temperature of the exhaust in the system.

One must understand the corrosion problem by first determining what corrosive media is formed by the process. One the corrosive media is determined then the proper corrosion-resistant material can then be selected either to protect the base metal or the whole sprinkler for the expected corrosive environment. The sprinkler manufacturer is generally in the best position to assist in the proper selection of the type of corrosion protection.

A corrosive atmosphere within the industrial exhaust system affects fire protection systems performance and overall maintenance requirements. The following sections describe some ways of providing corrosion protection.

3.6.1 FM Approved Sprinklers

FM Approved wax, lead, or wax-over-lead coated sprinklers can be used with or without plastic bags (described below). The temperature of the environment in the industrial exhaust system should not exceed 150°F (66°C).

3.6.2 Plastic Bags

For non-corrosive environments, the FM Approved sprinkler in the duct can be protected with double polyethylene bags. Each bag should be maximum 4 mils (0.1 mm) thick and arranged to open to the outside, as shown in Figure 3.6.2.

Teflon tape can be applied around the sprinkler deflector to limit abrasion of the bag. The temperature of the environment in the duct should not exceed 150°F (66°C).

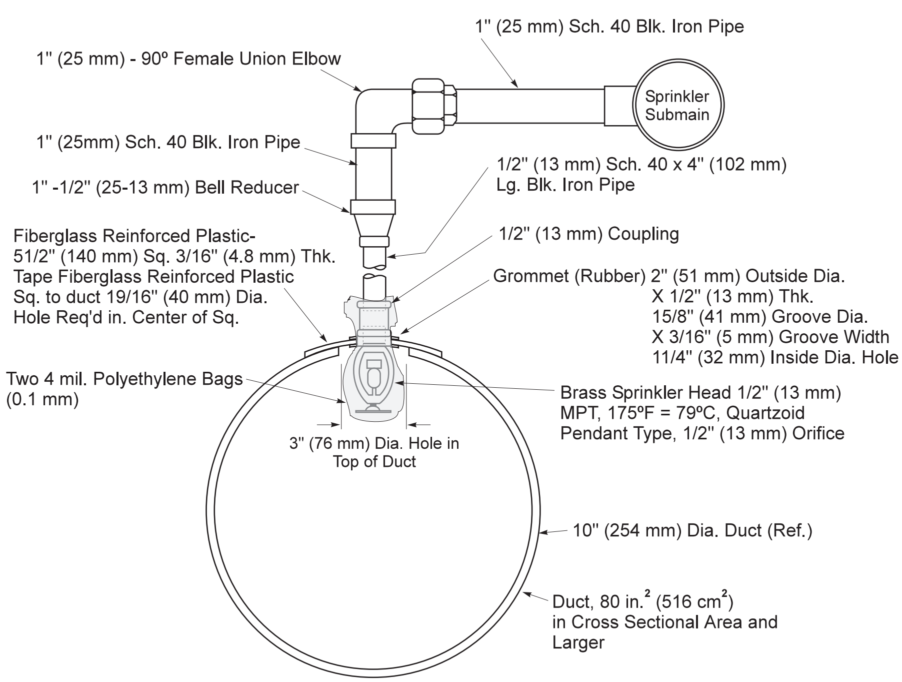


Fig. 3.6.2. Typical hard-piped sprinkler installation

3.6.3 Plastic-Coated Sprinklers

Sprinklers and piping can be coated with epoxy, tetrafluoroethylene (TFE) resin, or other plastic resistant to the more mildly corrosive atmosphere.

The two coatings most frequently used on sprinklers are epoxy resins and TFE. Epoxy resins are resistant to most alkalis and to many other chemical media. They adhere well to metal surfaces. Like other plastics, they are attacked by ketones, aromatics, and chlorinated hydrocarbons.

TFE is also resistant to a wide variety of chemicals. It is known to react only with elementary fluorine and with molten sodium. Some slight discoloration may occur in the TFE coating after extended periods at up to 250°F (121°C), but this will not affect the corrosion resistance.

The fusible element of the sprinklers should be of the center-strut, glass-bulb, or quartzoid type. The fusible element should not be coated because the temperature rating would be affected. The exposed surface of the center-strut fusible assembly, if used, should be made of a metal alloy resistant to the exposing corrosive medium. To ensure durability, the coating should be a minimum 5 mils (0.13 mm) thick. The sprinkler manufacturer can select the best coating thickness to provide with the concentration and temperature of the corrosive environment involved. Special care must be used during sprinkler installation, so the finish is not chipped or scratched.

When open coated sprinklers are installed, the heat detectors should be fabricated of corrosion-resistant metal alloys such as Hastelloy, stainless steel, Inconel, or their equivalent. The sprinklers should be covered with blow off caps, and corrosion-resistant piping should be used.

3.6.4 Special Alloy Sprinklers (Corrosion Resistant)

Sprinklers of metal alloys (such as Inconel, Monel, Hastelloy, etc.) or FM Approved sprinklers of stainless steel (Figure 3.6.4) can be used. These are effective against certain mildly corrosive environments, but not for extremely corrosive acidic environments. The manufacturers' specifications should be consulted. Sprinkler manufacturers also need to be consulted on their ability to produce sprinklers out of these special metal alloys.

The fusible assembly for these heads should be of the center-strut, glass-bulb type, or any equivalent arrangement resistant to the environment. The valve cap of the head should be made of the same material as the sprinkler frame. The sealing between the sprinkler frame orifice and the valve cap can be provided with an O-ring arrangement made of a compound resistant to the exposing corrosive medium, or equivalent sealing arrangement.

Selection of the optimum construction material requires careful analysis of corrosion resistance, material cost, practicability of fabrication, installation, and maintenance.

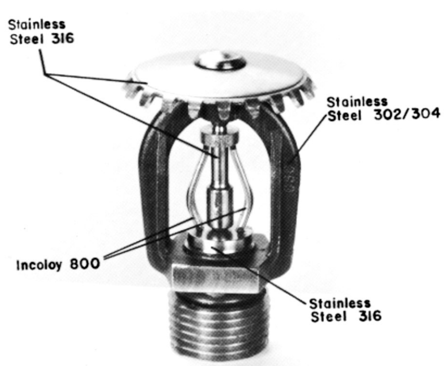


Fig. 3.6.4. Corrosion-resistant sprinkler

Alloy manufacturers have researched the corrosive action of over 500 corrosives. A list of metal alloys has been selected that presumably would withstand the attack of approximately 90% of these. The following alloys are resistant to the greatest variety of corrosives:

- Inconel
- Types 316, 304/345, and 20Cb3 stainless steel
- Hastelloy
- Monel
- Incolloy

3.6.5 Special Coated Duct Nozzles (Extremely Corrosive Environments)

Based on industry feedback, FM research was initiated due to the need to find suitable alloys or materials that would stand up in large industrial metallurgical smelters, steel industry pickling lines, semiconductor fabrication facilities, pulp, and paper plants (including bleach plants), inorganic chemical facilities, and the mining industry. These extremely corrosive environments typically involve acids such as sulfuric, hydrochloric, nitric, or hydrofluoric. The industries indicated that for a sprinkler alloy to be a viable product it would need to be able to stand up to the corrosive environments for at least one year.

Research concluded that prototype nozzles fabricated from alloy C22 coated with ECTFE and ETFE coatings acceptably resist corrosion involving mixed nitric/hydrofluoric acids/sulfuric acids environment. FM Approvals partnered with nozzle and heat detection manufacturers to develop a viable and marketable system, which was introduced in 2008.

To date (2020), only one corrosion-resistant duct nozzle is FM Approved and commercially available. This is an open, directional spray nozzle designed for use in water spray fixed systems for fire protection applications in extremely corrosive duct environments.

3.7 Equipment

This section is provided for information only. The designer will need to determine when to provide additional protection from collapse or explosion as part of the design.

3.7.1 Duct Collapse

It is possible to collapse ductwork inward on the pressure side of the fan in a high-velocity system. The installation of pressure relief vents should be determined by the designer. The conditions for this type of duct failure can be initiated by a fire damper slamming shut. The rapidly moving air mass develops a tremendous vacuum behind this sudden tight shutoff. This may be possible in duct systems with transport velocities greater than 3,600 ft/min (1100 m/min). If necessary, the duct system can be protected against the possible collapse from this type of stress by pressure relief vents as shown in Figure 3.7.1.

3.7.2 Explosions

All industrial exhaust systems handling combustible dust are potentially explosive. This includes ducts handling flour starch, grain sugar, milk powder, ground spices, phenolic molding powder, pulverized fuel, wood flour, aluminum buffings, and rubber dust. Explosion doors, as shown in Figure 3.7.2, can be effective in reducing the amount of damage caused by an explosion. Refer to Data Sheet 7-76, *Prevention and Mitigation of Combustible Dust Explosions and Fires*, for additional information.

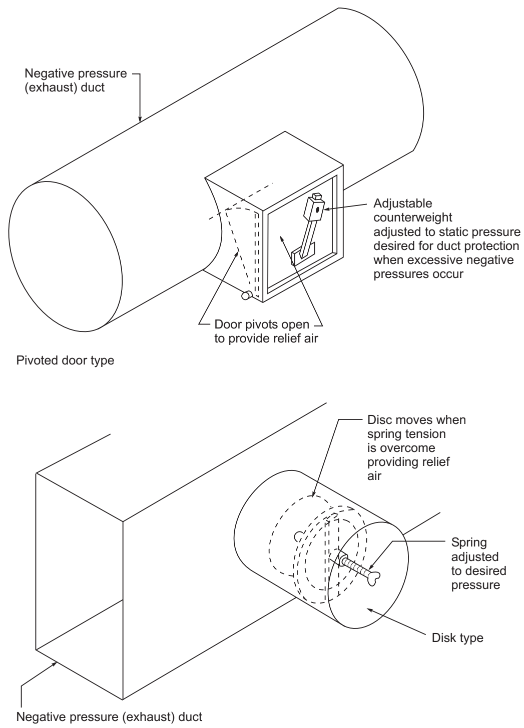


Fig. 3.7.1. Pressure relief vents (Sheet Metal and Air Conditioning Contractors' National Association, Inc. Used with permission.)

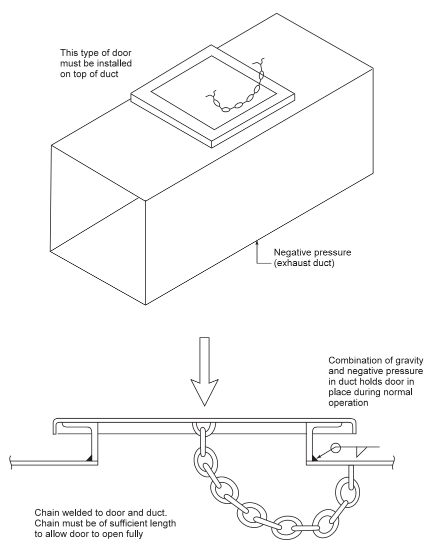


Fig. 3.7.2. Explosion door (Sheet Metal and Air Conditioning Contractors' National Association, Inc. Used with permission.)

3.8 Inspection and Access Ports

Inspection and access ports are important for several reasons. The first is access for inspection and cleaning, but the ports can serve as access for the fire service.

The installation of the sprinkler head or water spray nozzles, as indicated in Figure 3.8.1, shows a flexible sprinkler connection. These flexible sprinkler connections, if large enough allow for easy removal for inspection and cleaning.

Fig. 3.8.1. FM Approved flexible sprinkler hose connection (courtesy of Anvil International, LLC)

3.9 Routine Spares

Ensure the viability of routine spares by storing and maintaining them in accordance with the original equipment manufacturer's instructions. Refer to Data Sheet 9-0, *Asset Integrity*, for additional guidance.

4.0 REFERENCES

4.1 FM

Data Sheet 1-6, *Cooling Towers*
Data Sheet 1-22, *Maximum Foreseeable Loss*
Data Sheet 1-24, *Protection Against Liquid Damage in Light-Hazard Occupancies*
Data Sheet 1-42, *MFL Limiting Factors*
Data Sheet 1-54, *Roof Loads and Drainage*
Data Sheet 1-56, *Cleanrooms*
Data Sheet 1-57, *Plastics in Construction*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 2-81, *Fire Protection System Inspection, Testing and Maintenance*
Data Sheet 3-26, *Fire Protection for Nonstorage Occupancies*
Data Sheet 4-4N, *Standpipe and Hose Systems*
Data Sheet 4-5, *Portable Extinguishers*
Data Sheet 5-1, *Electrical Equipment in Hazardous (Classified) Locations*
Data Sheet 5-48, *Automatic Fire Detection*
Data Sheet 5-49, *Gas and Vapor Detectors and Analysis Systems*
Data Sheet 6-9, *Industrial Ovens and Dryers*
Data Sheet 6-11, *Thermal and Regenerative Catalytic Oxidizers*
Data Sheet 6-13, *Waste Fuel-Fired Facilities*
Data Sheet 6-21, *Chemical Recovery Boilers*
Data Sheet 7-6, *Plastic and Plastic-Lined Tanks*
Data Sheet 7-7/17-12, *Semiconductor Fabrication Facilities*
Data Sheet 7-12/17-17, *Mining and Mineral Processing*
Data Sheet 7-73, *Dust Collectors and Collection Systems*
Data Sheet 7-76, *Prevention and Mitigation of Combustible Dust Explosions and Fires*
Data Sheet 7-111, *Chemical Process Industries*
Data Sheet 13-24, *Fans and Blowers*

Understanding the Benefit: *FM Approved Fume and Smoke Exhaust Ducts* (P10224)
Understanding the Hazard: *Fire in Industrial Exhaust Systems* (P0351)

4.2 Other

National Fire Protection Association (NFPA). NFPA 70, *National Electrical Code*.

U. S. Code of Federal Regulations, Title 40, Part 63. 40 CFR Part 63 - *National Emission Standards for Hazardous Air Pollutants for Source Categories*.

APPENDIX A GLOSSARY OF TERMS

Downstream: The area away from the source of fire entry.

Extremely corrosive environment: Highly acidic process environments such as those found in flue gas desulphurization systems, metal acid pickling ducts, chemical industry exhaust systems, metallurgical gas cleaning, and acid plants. The corrosive environments encountered are typically sulfuric, hydrochloric, nitric, or hydrofluoric acids, and can also include a mixture of these acids.

FM Approved: Products and services that have satisfied the criteria for FM Approval. Refer to the *Approval Guide*, an online resource of FM Approvals, for a complete listing of products and services that are FM Approved.

Industrial exhaust system: An engineered system designed to convey fumes or particulates in suspension to the atmosphere or to a location where they may be modified, treated, or converted prior to release to the atmosphere. An industrial exhaust system typically includes capture points, ductwork, hoods, and intermediate devices, and it may also include waste emission equipment.

Intermediate device: A piece of equipment in an industrial exhaust system that is located between the capture point and release to fresh air and is not part of the waste emission equipment (e.g., filter, cyclones, bag houses, kilns, etc.).

Liner (lining): Operational element of a chimney designed to resist chemical and physical actions of combustion gases. Generally used inside a brick or concrete chimney.

Upstream: The area towards the source of fire entry.

Waste emission equipment or system: Equipment that cleans or removes fumes or particulates prior to further processing or prior to release to the atmosphere (e.g., regenerative thermal oxidizers, scrubbers, electrostatic precipitators). Also known as “pollution control” equipment or system.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

October 2024. The changes include the following:

A. Reduced sprinkler discharge requirements.

B. Removed the requirement for increased spacing inside ducts.

C. Included a new section on chimney liners from FM Property Loss Prevention Data Sheet 1-13, *Chimneys*.

D. Clarified that process piping is not covered.

E. Moved duct test information regarding FM Approval standard 4922 from Data Sheet 1-4, *Fire Tests*.

October 2021. This document has been completely revised. Significant changes include the following:

A. Added guidance for metallurgical smelters, refineries, and acid plants.

B. Added new criteria related to fire protection placement, operation and maintenance.

C. Clarified exterior fire protection options.

January 2017. Revisions were made to Table 1 and Table 2 based on more current editions of the ACGIH®, *Industrial Ventilation Manual*.

July 2016. A complete review of this document was performed and editorial changes were made. Recommendations were added for the protection of runs of exterior combustible ductwork, plastic scrubbers, and plastic vessels.

July 2011. Recommendations have been added for the protection of combustible duct systems exposed to extremely corrosive environments.

January 2007. Editorial corrections were made to this document.

September 2000. This revision of the document has been reorganized to provide a consistent format.