PROTECTION AGAINST LIQUID DAMAGE IN LIGHT-HAZARD OCCUPANCIES

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1.0 SCOPE

This data sheet provides recommendations for the prevention and mitigation of losses associated with liquid release and subsequent damage which may originate from multiple sources such as domestic waterlines and systems, drains, sewage systems, cooling and heating piping, fire protection systems, leaky roofs and windows. This data sheet should be applied at all light-hazard occupancies.

This data sheet is not intended to be applied at manufacturing, storage or high-hazard type occupancies. See Section 4.0, References, for FM Property Loss Prevention Data Sheets that provide additional information about occupancies not covered by this data sheet.

1.1 Hazards

Leaks and spills can cause severe damage at locations with finished interiors such as healthcare, education facilities, offices, hotels, apartments, condominiums, shopping centers, and retail stores. In facilities with drywall, floor coverings, ceiling tiles, insulation, cabinetry, elevators and computer equipment, liquid damage can cause business interruption while affected areas are shut down for renovations and critical equipment is repaired or replaced.

Leaks and spills can cause considerable harm to stored raw or finished goods, as can equipment malfunction and impairment. Healthcare and education facilities with concentrated areas housing high-value medical equipment, laboratory equipment and devices are especially susceptible to liquid damage interruptions.

Multiple story buildings add a level of complexity; because domestic water systems are often more complex, operate at higher flows and pressures, and may lack adequate valving arrangements. Without adequate valving the remaining water at higher levels will drain from the higher levels even after closing the main shutoff valve. Leaks and spills often flow down multiple building levels below the origination point, greatly increasing the area of wetting.

Basements are also particularly susceptible due to high-value equipment often stored there, and mechanical and elevator pits that can collect water.

1.2 Changes

October 2026. Interim revision. The following changes were made:

A. The naming convention for leak detection and flow detection was changed to better describe the systems. The new terminology is discrete leak detection systems and flow-based leak detection systems.

B. Clarification was made to indicate discrete leak detection and flow-based leak detection systems should be deployed concurrently to address this hazard. This revision does not change the original intent.

C. Clarified that use of non-FM Approved leak detection systems or devices is tolerable if FM Approved options are not available in the local market.

D. Glossary of Terms section was expanded.

E. Minor editorial changes were made.

2.0 LOSS PREVENTION RECOMMENDATIONS

There are several factors to consider when assessing potential liquid damage risk at a non-manufacturing or non-storage facility. These factors include but are not limited to environment/building envelope, critical room exposure, presence of leak detection/protection devices, emergency response, inspection, testing and maintenance of equipment and piping.

Use FM Approved equipment, materials, and services whenever they are applicable. For a list of products and services that are FM Approved, see the *Approval Guide*, an online resource of FM Approvals.

2.1 Construction and Location

2.1.1 Do not construct or locate critical rooms below grade or in basements. Critical rooms include the following:

- Telephone and data transmission rooms
- Electrical and alarm system rooms

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- Data rooms containing mainframes and servers
- Rooms containing high-value items such as research freezers, electron microscopes, MRI machines, CT scan machines, ultrasound equipment, medical device/implant storage, and other items with high operational impact.
- Diagnostic equipment rooms
- Pharmacy
- Sterile environments and clean rooms
- Medical records

2.1.2 Provide adequate heating and weather sealing to prevent cold air penetration via doors, windows, and other unsealed gaps, especially in out-of-the-way areas susceptible to freezing, such as stairwells, above ceilings, and other concealed spaces, particularly for areas that have exterior walls. For more detailed recommendations, refer to Data Sheet 9-18, *Prevention of Freeze-Ups*.

2.1.3 Do not place high-value equipment or critical rooms directly below floors and occupancies in which leaks and spills may occur, such as residential area bathrooms, kitchens, and other domestic water sources, cafeterias, restrooms, and mechanical rooms.

2.1.4 Route steam lines around rooms with critical equipment.

2.1.5 Route domestic and chilled waterlines around rooms with critical equipment.

2.1.6 Do not locate roof drain piping above or through rooms containing high-value equipment or contents designated as critical.

2.1.7 Seal perimeter walls and ceilings of critical rooms to reduce the likelihood of leaks and spills in adjacent areas from entering. Use water-resistant materials for the first 1 ft (0.3 m) of the wall and seal the wall and floor intersection with a water-resistant material. Seal pipe, electrical, and other penetrations through walls and ceilings to prevent water and liquid intrusion; use FM Approved fire-resistant and water-tight materials. Refer to Data Sheet 1-3, *High-Rise Buildings*.

2.1.8 Use FM Approved roofing systems designed for local wind speeds and hail exposure. Refer to Data Sheets 1-28, *Wind Design*; 1-29, *Roof Deck Securement and Above-Deck Roof Components*; and 1-34, *Hail Damage*, for design criteria.

2.1.9 Conduct negative pressure uplift testing or utilize a visual construction observer for newly installed, adhered roof systems to ensure proper installation. Follow test procedures and recommendations as outlined in Data Sheet 1-52, *Field Verification of Roof Wind Uplift Resistance*.

2.1.10 Size roof drainage systems based on the rainfall intensity for the (respective) design storm event. Provide secondary emergency drainage where blockage of primary drains allows water to accumulate. Refer to Data Sheet 1-54, *Roof Loads and Drainage*, for design criteria.

2.1.11 Equip fire protection systems, including piping, fire pumps, and pump controllers, in recognized seismic areas, to meet earthquake protection requirements per Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*.

2.1.12 Install FM Approved backflow prevention where the potential for backflow flooding into buildings exists via sewer lines where urban street flooding occurs and street runoff is routed to combined sanitary sewers.

2.1.13 Design the site to direct rainwater, roof drainage, and storm water drainage away from buildings. Refer to Data Sheet 1-40, *Flood*, for design criteria.

2.1.14 Provide exterior doors and windows with seals or weather stripping to prevent rain or snow from entering the building.

2.2 Occupancy

2.2.1 Arrange domestic and chilled water systems as follows:

A. In multi-story buildings, provide each floor with a well-marked, easily accessible manual shutoff valve, capable of isolating liquid flow to that floor/level in the event of a leak. Where recirculating systems are used, provide an isolation valve or non-return valve capable of preventing back-flow on each floor. Use

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polytetrafluoroethylene (PTFE) lined, quarter-turn valves for floor shutoffs.

B. If domestic water lines must pass through areas containing high-value or critical equipment, provide a manual shutoff valve capable of isolating the flow of liquid to the critical equipment room or area.

C. Do not locate domestic water shutoff valves above suspended ceilings or in locations which are not easily accessible. Avoid multiple interconnections.

D. Do not create connections of dissimilar metals.

E. In areas where significant fluctuations in municipal water supply pressure occur or where static water pressure approaches maximum allowable pressure of system components, provide over-pressure protection (e.g. pressure relief valves) in accordance with FM Property Loss Prevention Data Sheets 2-0, *Installation Guidelines for Automatic Sprinklers*, and 3-11, *Flow and Pressure Regulating Devices for Fire Protection Service*.

2.2.2 Where items particularly susceptible to liquid damage are already located in basement areas of existing buildings, do one of the following:

A. Remove stock from the below-grade area.

B. Raise stock above the anticipated water level.

Where practical, provide racks, skids, or pallets at least 4 in. (100 mm) high for storage of valuable stock or equipment susceptible to liquid damage, particularly those that would topple or collapse if wet by a few inches of liquid.

2.2.3 In upper stories, seal building walls to floors to eliminate flow paths. Keep storage racks at least 4 to 6 in. (100 to 150 mm) away from building walls. If a metal screen or similar device is attached to the back of the racks to prevent storage from being pushed against the wall, the distance may be reduced to 2 in. (50 mm).

2.2.4 In residential buildings or facilities such as hotels, hospitals, and dormitories where occupants are not necessarily familiar with the operation of automatic sprinklers, provide labeling to indicate a warning to avoid contact with sprinklers.

2.2.5 Locate main emergency power equipment and associated electrical equipment outside areas susceptible to liquid damage.

2.2.6 Provide dishwashing and clothes washing machines with braided stainless steel fill hoses and collection pans that drain to a safe location.

2.2.7 Provide hot water heaters with water collection pans that drain to a safe location.

2.3 Protection

Leak detection systems are designed to rapidly identify and alert personnel to unintended liquid releases. While point detectors are effective in select areas, comprehensive protection typically requires a combination of technologies.

A cost-effective approach integrates discrete leak detection (spot or linear sensing) with flow-based leak detection systems. Flow monitoring systems can identify leaks throughout the facility, including concealed spaces; while localized sensors confirm impact to critical areas and enable rapid response. More advanced systems may also provide automatic valve shutoff to limit damage.

2.3.1 Provide discrete leak detection systems that alarms to a constantly attended location, building management system or a monitored mobile device. Use FM Approved equipment when available. At a minimum, protect the following areas:

A. High value equipment areas: Discrete leak detection devices should be provided directly under or adjacent to water leakage sources. For ceiling level piping, sensing cable should be attached to the underside of the piping above high valued equipment.

High-valued equipment areas include (but are not limited to) the following:

- Telephone and data transmission rooms
- Critical electrical and alarm system rooms

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- Hospital and research areas containing high-value items such as research freezers, diagnostic equipment, ultrasound equipment, medical device/implant storage, pharmacies, sterile environments and other items with high operational impact
- MRI and CT scan machines, or machines outside of the MRI room but immediately adjacent to this area
- Critical rooms having equipment and/or materials required for business continuity

B. Rooms immediately adjacent to or above high-valued equipment areas

C. Building mechanical rooms, including:

- Areas of likely water accumulation, including building basements, elevator pits or drainage pits
- Rooms/areas containing water-handling equipment such as domestic water pumping and distribution headers, HVAC equipment, automatic sprinkler system riser rooms, entry locations of domestic water and fire protection services, etc.
- Locations where the pressure or temperature of liquids changes (e.g., boilers, hot water heaters, chiller plants, etc.)
- Rooms containing electrical distribution equipment including transformers, electrical switchgear, UPS systems, etc.
- Around or under the fire protection water storage tanks (typical within multi-zoned, high-rise fire protection systems)

D. High water usage areas, including:

- Bathroom and kitchen areas, including under or immediately adjacent to dishwashing machines
- Laundry rooms, including under or immediately adjacent to clothes washing machines
- Food service areas
- Floor drains
- Below roof drainage systems

2.3.1.1 Arrange discrete leak detection devices near potential water leakage sources to promptly notify site personnel of an emergency condition. Typical leakage points include near equipment, tanks, pipe fittings, valves, joints and couplings. Additionally, water tends to travel from the leak source to the lowest elevation within a room; therefore, placement of leak detection devices at low points is needed.

2.3.1.2 In rooms with multiple potential leak sources, place discrete leak detection devices strategically to increase the likelihood of a prompt alarm. For example, place one or more detectors at the room low point (typically where floor drains are located), as well as within any curbed/diked areas around individual pieces of equipment. Consider providing additional detectors at equipment prone to leakages such as pumps, water heaters, etc.

2.3.2 Provide flow-based leak detection system(s) that can detect unusual flow events and that alarms to a constantly attended location, building management system or a monitored mobile device. Use FM Approved equipment when available. At a minimum, provide flow-based leak detection on the following piping/systems:

A. Incoming domestic and make-up lines on closed loop systems including chilled water, hot water (hydronics), ground source heat pump loops systems to the building,

B. On supply line of each floor for offices, hotels and apartments/condominiums

2.3.3 In geographic areas subject to freezing temperatures (locations where the 100-year return period daily minimum temperature [100-year DMT] is 20ºF (-6.7ºC) or colder as shown in the FM Worldwide Freeze Map), complete a process freeze hazard analysis; and provide freeze protection and low temperature monitoring alarms in accordance with FM Property Loss Prevention Data Sheet 9-18, *Prevention of Freeze-Ups*. Ensure attic spaces, mechanical spaces with exterior wall louvers, concealed spaces, stairwells and vestibules that contain water and liquid lines (including fire sprinkler lines) are considered. Arrange for low temperature alarm signals to be sent to a monitoring system or constantly attended location when temperatures fall below 40°F (4°C).

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2.3.4 Where domestic and chilled waterlines are directly above high-value equipment, provide lines with secondary containment, such as concentric piping. Arrange secondary containment to drain to a safe location and provide discrete leak detection systems with monitoring at the draining point.

2.3.5 Provide FM Approved sump pumps near points of water ingress or collection (i.e., low points or around open floor drains near backflow prevention valves). Use pumps that are minimum 50 gpm (189 L/m) and connected to an appropriately sized power supply with a connection to emergency power. Provide high water-level alarms monitored at a constantly attended location.

2.4 Operation and Maintenance

Establish and implement an inspection, testing and maintenance program for liquid piping systems to verify piping integrity and reduce the water damage exposure. See Data Sheet 9-0, *Asset Integrity*, for guidance on developing an asset integrity program.

2.4.1 Implement a freeze prevention and mitigation program in accordance with Data Sheet 9-18, *Prevention of Freeze-Ups*. Implement a freeze response program in accordance with FM Property Loss Prevention Data Sheet 10-1, *Pre-Incident and Emergency Response Planning*.

2.4.2 Identify and label all domestic water, chilled water services, steam, and fire protection system valves preferably using a numbering system.

Keep a list of these valves in the facilities, engineering, maintenance, and/or security offices. The valve list should contain each valve number, description of the valve (size and type), description of where the valve is located, the area the valve services, and shutoff instructions. FM's Domestic Water Shutoff Valve tag W00555 is available to attach to domestic water valves, see Figures 2.4.2-1 and 2.4.2-2.

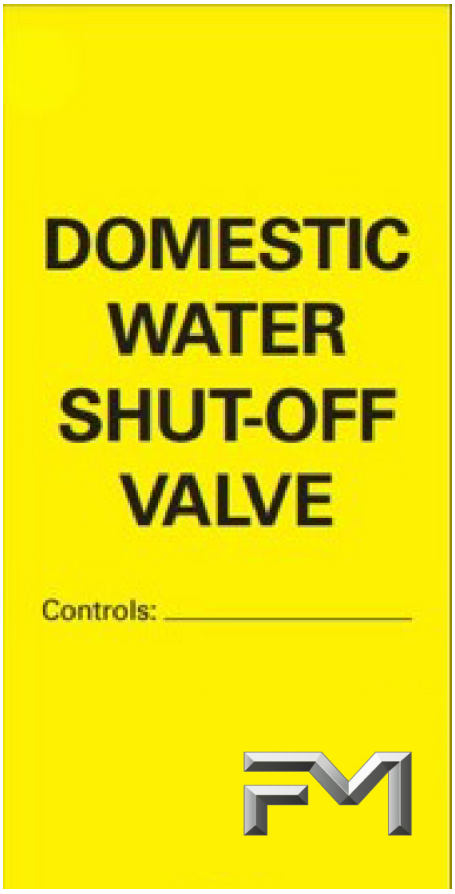


Fig. 2.4.2-1. FM's domestic water shutoff valve tag W00555

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Fig. 2.4.2-2. Brass label showing water shutoff valve above drop ceiling

2.4.3 Label supply lines for chilled water services indicating the direction of water flow.

2.4.4 Lock all fire protection valves in the open position to prevent unauthorized tampering. Maintain strict key control so only authorized and trained personnel can impair fire protection in case of a leak.

2.4.5 Develop a policy to ensure that dead-ended, unused but charged, domestic and chilled water piping systems are removed during renovations.

2.4.6 Inspect the exterior seals of window frames, sliding doors, and HVAC units annually, and repair deteriorated seals.

2.4.7 Inspect roofing systems quarterly and after hailstorms, windstorms, and other severe weather events. The inspection should look for the following:

- Roof drains free and clear of debris
- Roof covering and seams in good condition
- Loose debris and materials that could cause roof damage (screws and nails) or that could obstruct roof drains removed
- Flashing properly attached
- Mechanical equipment securely fastened
- Skylights, roof hatches, and vents are in good condition

2.4.8 Inspect the liquid damage control cart quarterly and ensure supplies are replenished.

2.4.9 Clean main sewer lines using a pressurized water system quarterly if there is a history of clogged main sewer lines.

2.4.10 Test sump pumps quarterly.

2.4.11 Check the condition of water heaters quarterly.

2.4.12 Check water pumps for excessive vibration quarterly.

2.4.13 Test leak detection, flow alarms, and monitoring quarterly.

2.4.14 If connections of dissimilar metals cannot be avoided/removed, develop a list of their locations and inspect them for signs of corrosion quarterly.

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2.4.15 Inspect HVAC condensate drains monthly.

2.4.16 Visually inspect and clear inlets and catch basins if storm drains are present monthly.

2.4.17 Ahead of freezing temperatures, winterize the facility as follows:

A. Ensure the heating systems are maintained and working.

B. Confirm appropriate heat is provided for sprinkler, chilled, and domestic water systems. Consider the following areas:

1. Tops and bottoms of stairwells where exterior doors are present
2. Atriums and porticos (especially above suspended ceilings)
3. Near loading dock doors
4. Near large air intakes or exhaust ports
5. Diesel generator rooms
6. Fire pump and sprinkler riser rooms
7. Trailers and temporary housing/office structures
8. Penthouses

C. Inspect and confirm good condition of non-freeze and dry-pipe sprinkler systems:

1. Drain all low points
2. Verify adequate air pressure is being maintained
3. Verify adequate antifreeze charge in non-freeze systems.

2.4.18 Inspect and exercise domestic and chilled water control valves annually to verify good working order of the valves.

2.5 Pre-Incident and Emergency Response Planning

Effective loss prevention measures to minimize liquid leaks and spills and subsequent damage include establishing and maintaining an emergency response plan that outlines actions to be taken during and after a water damage event occurs. With proper planning, both property damage and business interruption may be reduced following a liquid damage loss.

See Data Sheet 10-1, *Pre-Incident and Emergency Response Planning*, for details on emergency planning.

3.0 SUPPORT FOR RECOMMENDATIONS

While the majority of liquid damage losses are below US$1 million, FM loss statistics have shown that locations with multiple escaped liquid losses are very likely to have a large loss that could have been avoided. Frequency of losses often leads to a more severe loss; it is only a matter of time before a large loss is suffered.

Inferior or non-existent domestic water and escaped liquids response plans increase the severity and likelihood of the loss. Recurring escaped liquids losses in older facilities are an indicator that the piping and HVAC systems may be coming to the end of their useful life.

A written, well-thought-out domestic water and water-based heating and cooling systems response plan will help minimize the loss. Installing discrete leak detection systems and flow-based leak detection systems that monitor for and alert a person in charge to a leak will further increase the likelihood of reducing the loss. Minutes equal millions; the longer the leak takes to be detected and eliminated, the more millions the loss will cost.

Water leakage scenario:

The types of equipment that can fail and release water are numerous and can include the chilled water system, heating system, domestic hot and cold-water systems, automatic sprinkler couplings that separate, wet fire standpipes, etc. The leaks can occur in any part of the building and on any floor. Mechanical rooms that use water can be located in basements, in mid-level floors, on the top floor or in a rooftop penthouse.

Typically, the floor of origin and the floor immediately below have the most water spread. Then, the water will find flow paths to reach many of the floors below and often may find a direct path to the lowest floors via elevator shafts, utility chases, stairwells or at exterior building curtain walls. Loss history has also shown that the leakage often impacts the valuable equipment, leading to even larger losses.

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A documented, well-trained response is needed to quickly find the location of the leak and know the correct control valve to close. This preparation is critical to ensure a timely response to an actual leak event. Once the leak is stopped, clean up begins; and a documented plan that was carefully prepared prior to the loss reduces downtime. Take immediate steps to clean up the leak; however, do not try to remediate damage yourself. FM's best advice is to contract with an established remediation company that is IICRC qualified (Institute of Inspection Cleaning and Restoration Certification) well ahead of the event, especially for locations in areas where outside temperatures can drop below freezing. Reference Data Sheet 10-1, *Pre-Incident and Emergency Response Planning*, for more information.

Efforts for loss prevention and mitigation of a liquid damage loss vary depending on the occupancy of the building or facility. For non-manufacturing and nonstorage facilities such as healthcare, education facilities, offices, hotels, apartment/condominiums, shopping centers and retail stores, and data centers, the focus should be on critical rooms that contain diagnostic equipment, pharmacies, research laboratories, highly sensitive operating equipment and building finishes (ceilings, floors, walls).

3.1 Preplanning

Effective loss prevention measures to minimize liquid leaks and spills and subsequent damage include establishing and maintaining an emergency response plan that outlines actions to be taken during and after a liquid damage event occurs. With proper planning, both property damage and business interruption may be reduced following a liquid damage loss.

See Data Sheet 10-1, *Pre-Incident and Emergency Response Planning*, for details on emergency planning.

Actions taken before a liquid leaks and spills event happens can significantly reduce the magnitude of the property damage and minimize business interruption. For quick response to a leaks and spills , keeping a mobile liquid damage cart in multiple locations of your facility can be useful during the first hours of an event. Below is a sample list of tools and materials to have on hand to absorb and/or contain leaks and spills:

- Plastic tarps
- Acoustic leak listening device
- Wet/dry vacuums
- Portable sump pumps and hoses
- Dehumidifiers
- Fans
- Pipe leak diverters
- Containment socks, flood sacks
- Latex gloves
- Caution tape
- Duct tape
- Facemasks
- Safety glasses
- Hose clamps
- Buckets
- Sponges, squeegees
- Engineered devices to plug automatic sprinkler heads*

*Once the fire company turns the area back to the building management.

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3.2 Discrete Leak and Flow-Based Leak Systems

Leak and flow detection and monitoring systems are becoming more affordable. Smart devices are now able to learn normal characteristics and respond to unusual conditions. Detection can come in the form of monitoring flow or pressure in piping, or detecting liquids on the floor using floor pads, wire grids, linear cables or point source detectors. These devices are designed to quickly respond to a change in state and respond within 30 seconds.

This section will focus on the most common type of leak and flow detection systems for light hazard occupancies, point source and linear cable systems.

The type and placement of the devices should be based on how to most efficiently and reliably detect leaks and spills before significant damage occurs. For example, areas with high-value equipment may be effectively monitored with discrete leak detection devices installed on the floor adjacent to piping or equipment that could leak or at low spots. Residential or retail locations may be more effectively covered by devices that monitor for abnormal flow conditions, supplemented by use of floor-mounted detection devices, including a point source detector or linear cable sensor. Using multiple flow devices will help identify the area of the leak, thereby reducing the amount of time required to find it.

In multi-story buildings, key building water and chiller infrastructure may be located on the upper floors. FM Approved discrete leak detection systems should be provided within these mechanical rooms, ideally directly adjacent/below boilers, circulation pumps and liquid holding tanks. These areas are critical, as a leak on an upper floor will cause significant damage on multiple floors below.

Using a combination of linear cable sensors, point source sensors and flow-based leak detection systems will provide the best coverage and enable the leak to be detected quickly. Low points within a room should be considered when determining the best locations for leak detection device placement. In rooms with multiple potential leak sources, detection should be placed strategically to increase the likelihood of a prompt alarm to a leak. For example, place detectors at the room low point (typically where floor drains are located), as well as within any curbed/diked areas around individual pieces of equipment. Consider providing additional detectors at equipment prone to leakages such as pumps, water heaters, etc.

In addition, room/floor penetrations (cable pass-throughs, pipe chases, air plenums) that can convey liquid from one area of a facility to another should be sealed and provided with discrete leak detection devices.

3.2.1 Point Source Leak Detection

Point source sensor (discrete) technologies include conductive, cable type and optical devices. Point source leak detection (i.e., spot or flood sensors) provides notification of water leaks at a single or multiple points.

Conductive sensors use stainless steel probes to detect the presence of water. Cable type point sensors use short lengths of sensing cable, less than six inches, to detect the presence of water. Optical sensors use a fiber optic guide cable to emit and receive a light signal that detects the presence of water based on the difference in refraction from air.

Other less common types of sensors include float sensors and tuning fork sensors, typically used in water level applications.

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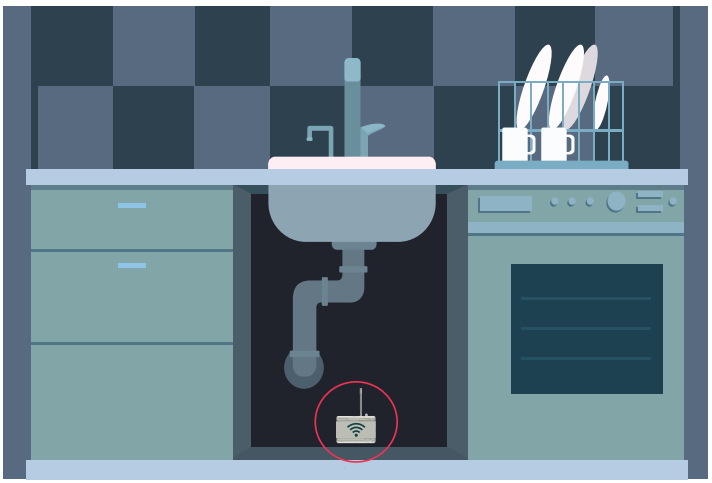


Fig. 3.2.1-1. Spot detector in sink cabinet



Fig. 3.2.1-2. Spot detector near floor drain

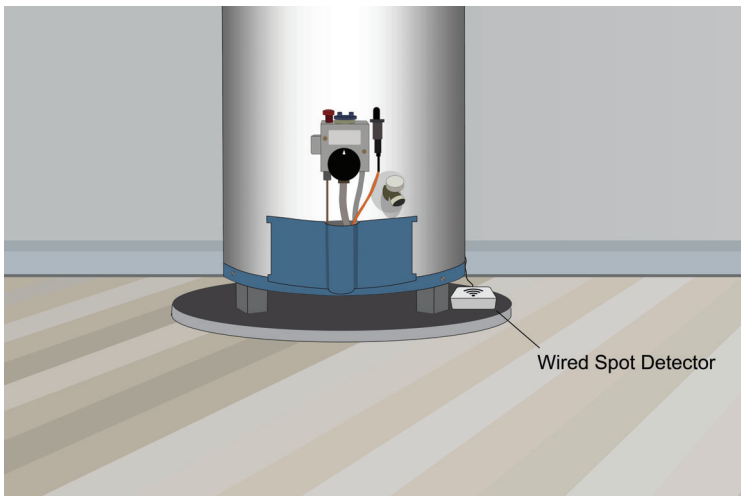


Fig. 3.2.1-3. Spot detector in collection tray of hot water tank

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3.2.2 Linear Cable Leak Detection

Linear cable sensors provide leak detection notification along the cable's length. The cable can:

1. Be comprised of multiple wires that supply power
2. Allow for daisy chaining of lengths of cables with jumper wires
3. Provide supervision of the cable (breaks/faults)
4. Provide leak detection sensing wires

These sensors also come in rugged versions that are able to withstand more corrosive atmospheres and are more impact/cut resistant for industrial applications. See Figure 3.2.2-1.

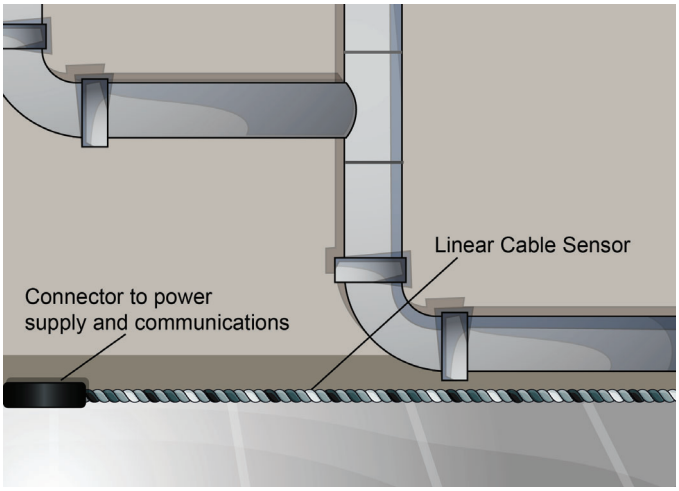


Fig. 3.2.2-1. Cable sensor example, multi-wire type

Use the type of detection system that provides the best solution for the area or equipment needing protection. Depending on the likely water leakage scenarios within an area, point leak detection, sensing cable or a combination of both systems will provide optimal protection.

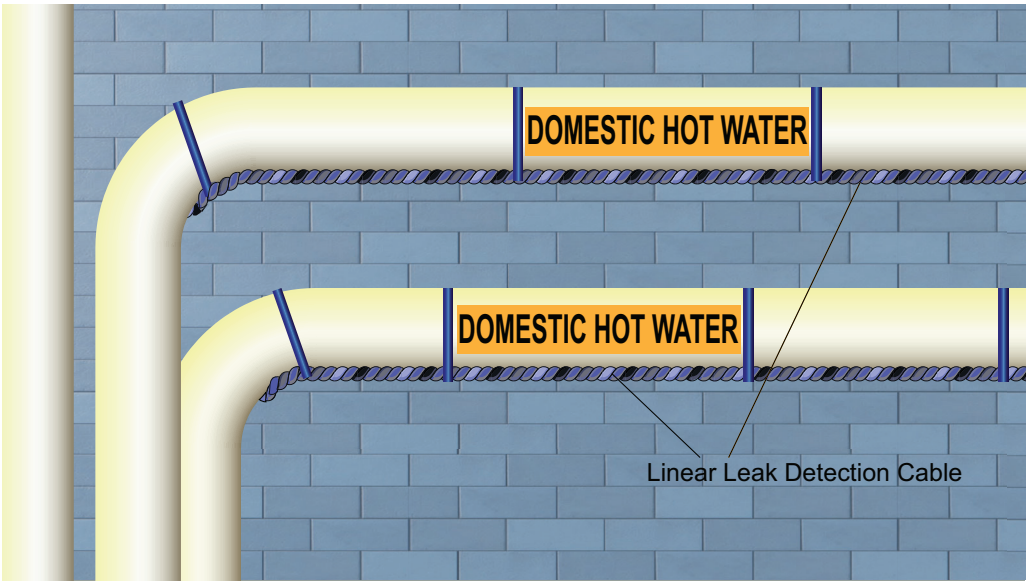


Fig. 3.2.2-2. Cable sensor on bottom of pipe

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3.2.3 Flow-based Leak Detection System(s)

Flow-based leak detection systems continuously monitor liquid flow through a system and look for abnormal flow patterns that could indicate a leak. Traditional systems employ standard programmable logic controllers and/or embedded systems to establish parameter thresholds and control logic to provide an alarm to site personnel. More advanced "learning" flow detection systems use artificial intelligence, data analysis and pattern recognition to monitor a site's usage patterns and provide notification of unusual water use. Systems that use in-line flow sensors typically include shutoff valves that are either automatically controlled by the system or are remotely controlled through a web portal and cloud management system. Automated controls are typically switched off by default, so the user can implement the controls that are best suited for their system installation. Flow sensing can be via ultrasonic flow detection or turbine flow detection.

Ultrasonic flow detection systems can be mounted outside of a pipe (clamp on) or installed inline of the supply pipes. These sensors have no moving parts and use the transit time of ultrasonic waves from two sensors to calculate the flow rate by continuously measuring the time difference between the sensors.

Turbine flow detection systems are installed inline of the supply pipes. These assemblies use an impeller and Hall effect sensor to create a pulsed square wave signal proportional to the flow rate. See Figures 3.2.3-1 and 3.2.3-2.

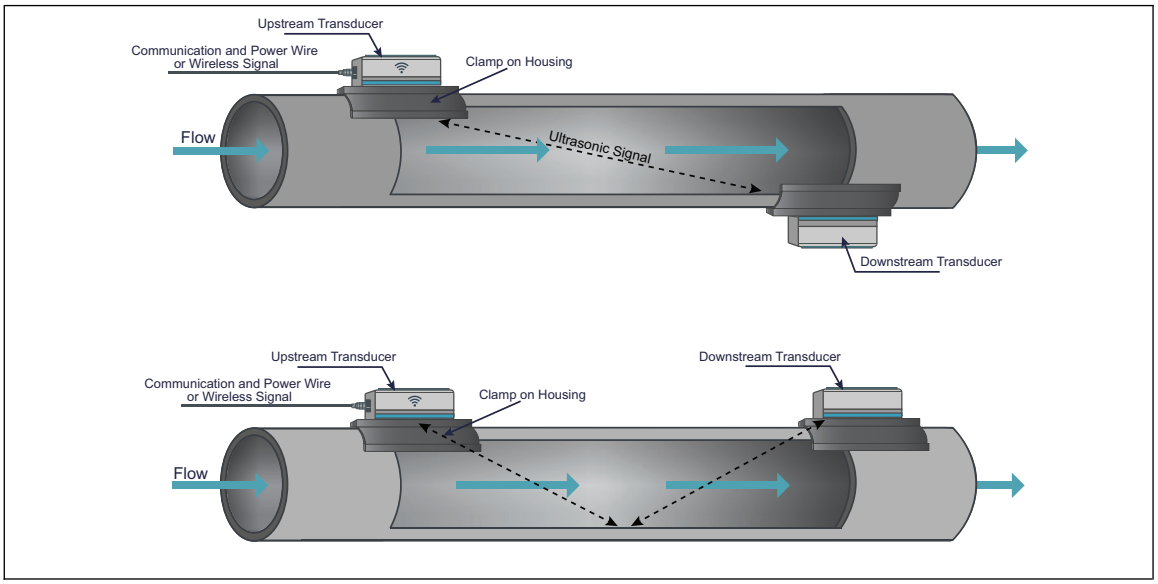


Fig. 3.2.3-1. Ultrasonic sensor examples - downstream transducer mountings different

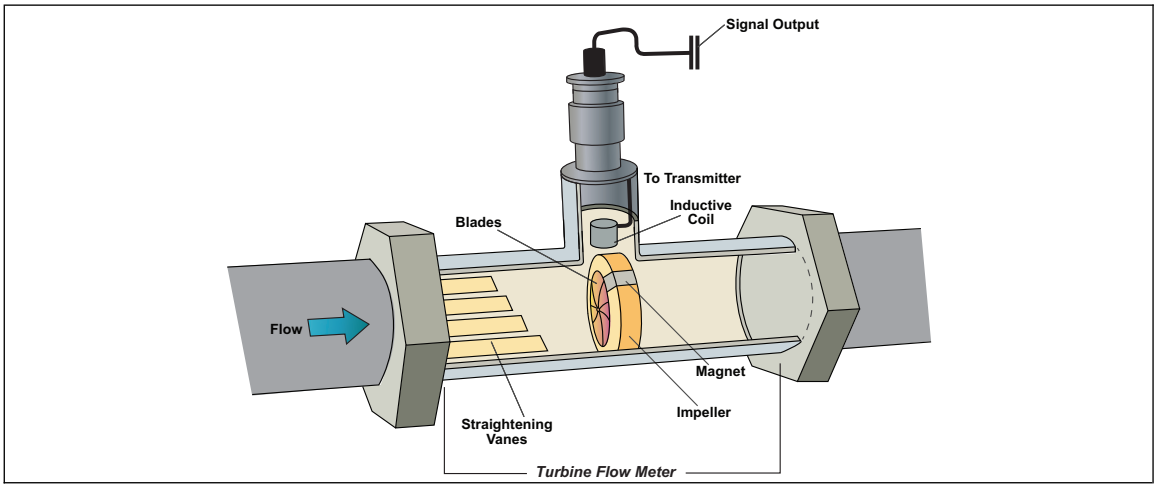


Fig. 3.2.3-2. Turbine flow sensor example

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3.2.4 Water Supply Shut-Off Valves

Water supply shut-off valves used in leak detection systems consist of two parts - the valve body and the valve actuator. In wireless systems, shut-off valves are normally connected to a valve controller to power the actuator.

The valve can be set up to automatically close upon leak detection or to require manual acknowledgement of a leak before closing. Exercising of valves on an automatic basis is available in most systems, as is the supervision of the valve state. See Figure 3.2.4-1.

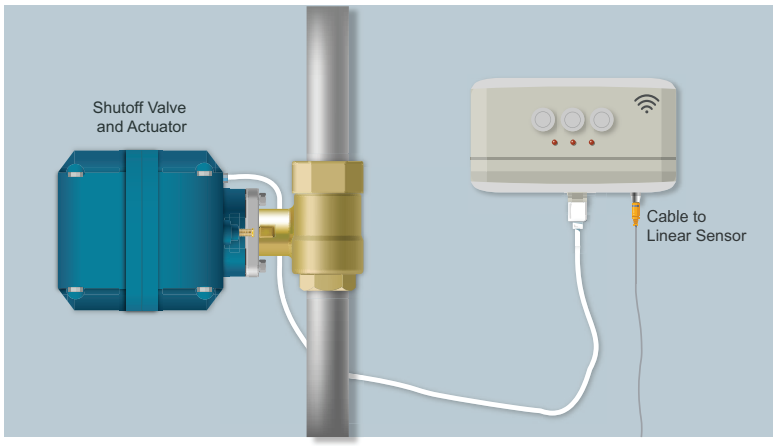


Fig. 3.2.4-1. Shut-off valve and wireless valve controller example

Combination shut-off valve and flow sensors are available but are not commonly used.

3.2.5 Discrete Leak Detection Controllers

3.2.5.1 Wired Leak Detection Controllers

Wired systems can use point, cable and/or in-line sensors with optional shut-off valves. A standalone controller or control equipment mounted within an industrial panel acts as the hub for the connections to the sensors. These systems are mains powered and can be supplied with optional inputs for battery backup. Multiple zones or areas can be connected to the system from one to 200 + zones. Wired systems can utilize remote detection panels that communicate back to the controller or control panel by serial communication, relay contacts or other proprietary protocols.

These systems are typically connected to the building management system directly; and do not connect to the internet, although smaller 2-4 zone systems can include Wi-Fi, cellular or ethernet connections managed through a web portal and connection to a cloud management system. These smaller systems are also typically provided with battery backup in case of power loss. See Figure 3.2.5.1-1.

Wired systems can be complex to install retroactively, and wiring run distances can require multiple remote detection panels to be connected, as cable run limitations can affect operation of the system.

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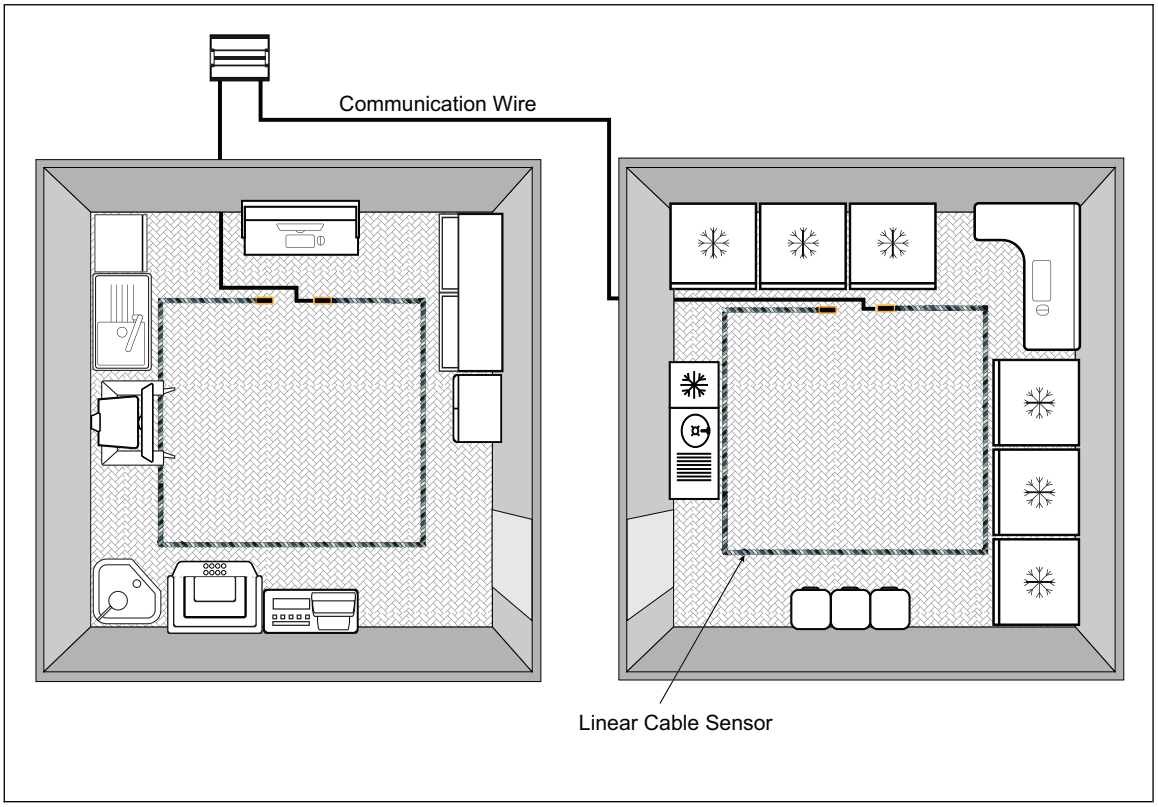


Fig. 3.2.5.1-1. Wired system example, multizone layout with output to building management system

3.2.5.2 Wireless Leak Detection Controllers

Wireless systems can use point, cable and/or inline sensors with optional shut-off valves. Point and cable sensors are normally battery powered, and inline sensors are typically mains powered. Base stations, hubs and valve controllers are normally AC powered with battery backup. Shut-off valves are normally connected to a valve controller that sends commands to the valve actuator to open and close.

Wireless systems can include a wireless hub and base station design where the base station communicates to multiple hubs, and the hubs communicate to multiple sensors/valve controllers wirelessly. Typically, all components of the system include battery backup in case of a power outage.

These systems are generally connected directly to the internet by Wi-Fi, cellular or ethernet connections managed through a web portal and connection to a cloud management system. Most wireless systems include a subscription service for the cloud management option. Some systems are designed for standalone applications and provide only a local alarm or relay output for detection.

Wireless systems are less complex to install than wired systems. They can be limited by the transmission distance of the wireless signal. See Figure 3.2.5.2-1.

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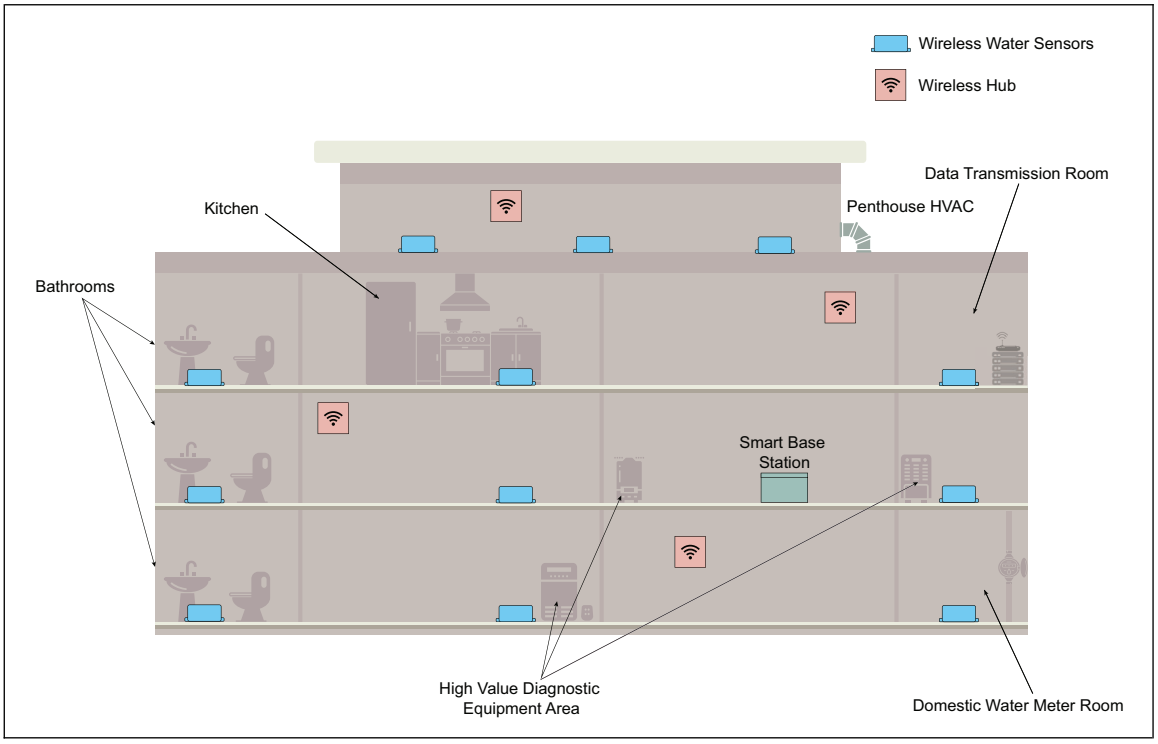


Fig. 3.2.5.2-1. Wireless system example with output to cloud management system

3.3 Loss History

FM loss history shows that, by frequency, liquid damage is a key loss driver and the leading cause of property losses in light hazard occupancies. Figure 3.3-1 shows that liquid damage losses account for 52% of the losses indicating a high likelihood that the next property loss and claim will be water-related. See Figure 3.3-1.

Figure 3.3-2 shows that offices have the highest frequency of losses, followed by hospitals and then apartment/condominium occupancies. A review of the largest losses found the following items in common: the losses frequently happen on weekends, often early in the morning or late in the evening, and the discovery of the leak and subsequent response was delayed. These losses occurred in facilities that did not have leak or flow detection, and the liquid damage response plan was non-existent or did not adequately cover the weekend periods. See Figure 3.3-2.

FM clients have experienced nearly 20,000 liquid damage, natural hazard, fire and equipment damage losses with a gross loss of 3.6 billion dollars over a recent 10-year period.

Escaped liquids losses involving domestic water systems follow the typical “bathtub curve” common to any type of mechanical equipment with a higher frequency (likelihood) of losses at both the beginning and the end of the equipment lifecycle. Thus, a water loss is more likely to occur when a building is new and the weak points/installation errors have not yet been “found” or, conversely, at the end of a lifespan, when in-service failures due to corrosion or fatigue problems begin appearing.

Some regions have public or private water supplies containing certain minerals that increase the corrosion rate of water, thus increasing the likelihood of a pipe leak or break.

Buildings constructed prior to the 1980s typically featured dedicated mechanical rooms (often on each floor) which housed pressurized water system equipment such as pumps, heaters and pressure-reducing stations. These robust rooms were typically designed to handle leakages and were provided with sufficient containment and drainage features to prevent a liquid release escaping the room. As real estate has become more valuable, with leasable square footage a primary motivator, the replacement of robust mechanical rooms with lighter-duty mechanical “closets” that lack such features has become more prevalent.

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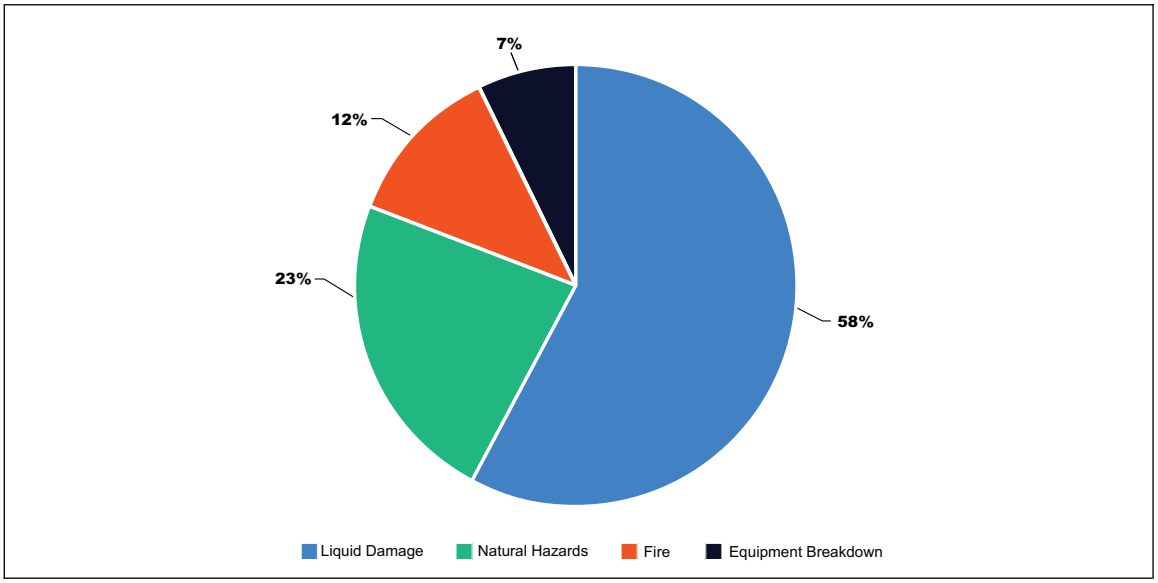


Fig. 3.3-1. Causes of loss in finished facilities by frequency over a ten-year period (2012 to 2022)

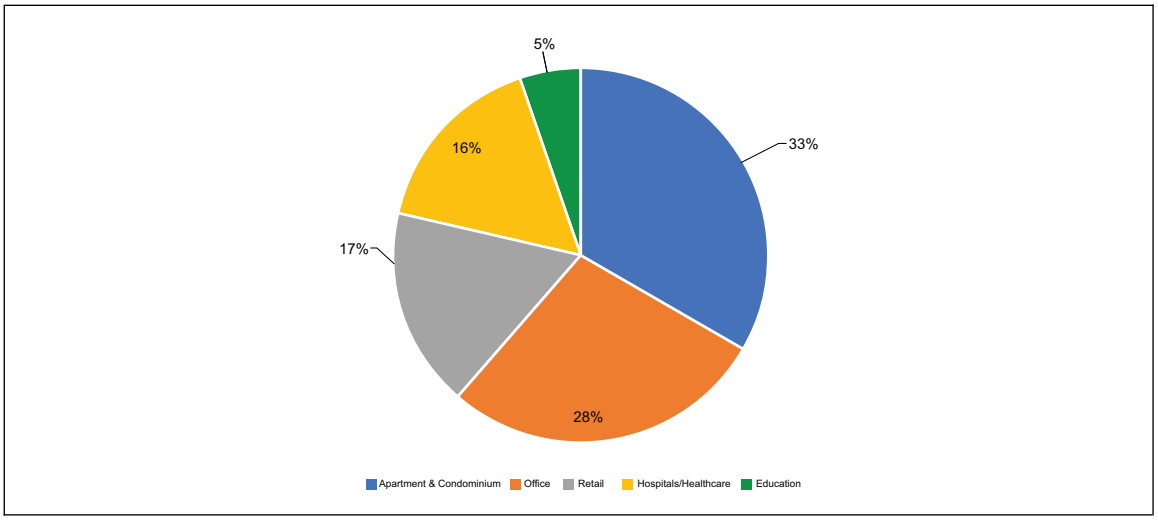


Fig. 3.3-2. Precent frequency of loss by occupancy (2012 To 2022)

Another significant factor is the use of compression fittings to replace traditional threaded, brazed or soldered (“sweated”) pipe joints. Certain types of compression fittings are more prone to installation errors, which reduce the mechanical integrity of the connection. Sudden changes in temperature or pressure can then cause the fitting to prematurely fail.

Common causes of escaped liquids events include:

- Poor design/use of inadequate materials
- Installation/workmanship errors
- Corrosion
- Operation beyond recommended service life

Many escaped liquids losses were initially caused by freeze events. If a building or area loses sufficient heat to maintain piping above freezing (typically caused either by building envelope issues such as poor insulation of concealed spaces, open windows, etc. or by a heating service interruption) piping will freeze and burst, wetting the area and floors below until the water is shut off and the systems drain out.

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3.3.1 Illustrative Losses

3.3.1.1 Frozen Pipes Lead to Escaping Liquids at 10-Story Residential Complex for Retirees

Early on a weekend winter morning, a resident contacted facilities to indicate they had no water in their unit. The building personnel responded and found water leaking from the ceiling in the common space hallway. The main domestic water valve was closed within 10 minutes of discovery of the leak. A second check of the area 20 minutes later revealed no further issues. One hour after the initial discovery, more water was discovered leaking from the ceiling, and a sprinkler alarm was received. The main fire protection valves were then closed, and the fire department arrived shortly thereafter to verify no fire existed.

A water pipe ruptured on the seventh floor above the ceiling near the corner of the building. Additionally, CPVC automatic sprinkler pipes froze and ruptured on four floors. All ruptured pipes were adjacent to a vertical air ventilation shaft. Water damaged 50% of the units on each floor, including the basement level.

This location did not have a liquid damage response plan or leak/flow detection systems. Reportedly, the low temperature sensors on the rooftop air handling unit did not provide a signal to close the louvers.

3.3.1.2 Failed Chilled Water Coupling at Hotel

Late one evening, this high-end, resort hotel had a 2.5 in. (63.5 mm) pipe coupling separate due to a failed bolt on a chilled water line. The pipe was above the hallway ceiling on the fifth floor of this 56-story hotel. The chilled water escaped from the pipe for 40 minutes at 250 psi (1724 kN/m^2). The response team had difficulty finding the shutoff valve.

Several inches of water inundated this floor and the two floors beneath, wetting building and contents. The total wetted area was over 40,000 ft^2 (3,716 m^2) also collected in the lowest parking area where it entered elevator shafts, exposing the elevators, hoist cables and electrical components. Several banks of elevators were taken out of service for inspection and repair. A well-thought-out and practiced liquid damage emergency response plan with trained personnel and a map showing shutoff valve locations would have significantly reduced the amount of water that discharged into the building.

3.3.1.3 Loss at Hospital as 1 Inch (25.4 mm) Water Line Broke

Early in the evening on a weekend a one-inch water pipe broke at an elbow. The loss occurred above a patient's room on the sixth floor. Water flooded over 30,000 ft^2 (2787 m^2) and eventually reached the basement.

A nurse promptly reacted to the leak but did not have a ladder tall enough to reach the shutoff valve that was above the ceiling. Maintenance was called and shut down the water 30 minutes after the leak occurred. The hospital had a remediation service with the hour to begin cleanup operations. Damage was sustained to walls, ceilings, electrical outlets, and an elevator.

The site had an established emergency response but due to the lack of a tall ladder the shut off of water was delayed.

3.3.1.4 Loss at Medical Office Building

This medical office building is only occupied weekdays and has an outpatient surgery facility on the first floor. On a Sunday morning, a leak was discovered by doctor upon arrival. The medical staff notified security, who in turn notified off site facilities staff. Water was determined to be leaking from a toilet on the third floor.

Water from the overflowing toilet spread approximately 5,000 ft^2 (464 m^2) on the top floor, 8,000 ft^2 (743 m^2) on the floor directly below, and 12,000 ft^2 (1115 m^2) on the lowest floor. Flooring, walls, and ceiling tiles were wetted and had to be removed and replaced. Furniture in the area also was damaged by the water, needed replacement.

This site did not have leak or flow detection systems, a liquid damage control cart or an emergency response plan for water leaks.

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3.3.1.5 Delayed Discovery of Steel Cap Failure on Copper Water Line at Medical Office

A six-story building housed doctors' offices and various clinics with a medical records department located in the basement. It was built in the 1950s as a dormitory and converted to medical offices in 1993. During the conversion, most waterlines for the dormitory room fixtures were cut, capped and abandoned in place.

A steel cap on a copper waterline failed, allowing water to escape at some point during a three-day weekend. It is likely the use of the steel plugs on the copper pipes accelerated corrosion and led to this failure. The leak occurred on the second floor in a medical office waiting area. The second, first, and basement levels were all affected: approximately 35,000 ft^2 (3252 m^2) of the facility. Eight inch (20 cm) of water had accumulated in the basement. Drywall, floor coverings, ceiling tiles, insulation, cabinetry, elevators, alarm systems, and business and medical records were all damaged. The affected clinics and offices had to be shut down for 9 business days and repairs took almost a month to complete, even with cleanup conducted around the clock.

3.3.1.6 Corrosion of Copper Pipe End Cap of a Domestic Water Line at Medical Office Building

A two-story medical office building built around 1980 had reinforced concrete construction, a basement level and about 100,000 ft^2 (9290 m^2) of outpatient office space. Twelve tenants occupied the building.

A 1 in. (2.54 cm) copper pipe failed during the weekend and allowed water to escape behind a wall in one of the second-story offices. Corrosion of the pipe end cap of a domestic water line appears to have caused the leak.

The ensuing water from the broken pipe traveled all the way down to the basement, damaging sheetrock, wall and floor coverings, ceiling tiles, furniture and fire protection equipment. About 75,000 ft^2 (6968 m^2) of the facility experienced some amount of damage. Fortunately, the fire service responded after receiving an alarm on Sunday evening, preventing more extensive damage. Apparently, water damage to the fire alarm panel activated the flow alarm.

An emergency mitigation company began immediate efforts to dry the wettest areas. It took about eight weeks to complete the drying process and finish the necessary building repairs. This downtime was extended due to the need for asbestos abatement in the basement area and environmental clearance testing.

4.0 REFERENCES

4.1 FM

Data Sheet 1-2, *Earthquakes*
Data Sheet 1-3, *High-Rise Buildings*
Data Sheet 1-28, *Wind Design*
Data Sheet 1-29, *Roof Deck Securement and Above-Deck Roof Components*
Data Sheet 1-31, *Panel Roof Systems*
Data Sheet 1-34, *Hail Damage*
Data Sheet 1-35, *Vegetative Roof Systems, Occupied Roof Areas and Decks*
Data Sheet 1-36, *Mass Engineered Timber*
Data Sheet 1-37, *Hospitals*
Data Sheet 1-40, *Flood*
Data Sheet 1-52, *Field Verification of Roof Wind Uplift Resistance*
Data Sheet 1-54, *Roof Loads and Drainage*
Data Sheet 1-56, *Cleanrooms*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 2-1, *Corrosion in Automatic Sprinkler Systems*
Data Sheet 2-8, *Earthquake Protection for Water-Based Fire Protection Systems*
Data Sheet 3-11, *Flow and Pressure Regulating Devices For Fire Protection Service*
Data Sheet 5-12, *Electric AC Generators*
Data Sheet 5-23, *Design and Protection for Emergency and Standby Power Systems*
Data Sheet 5-32, *Data Centers and Related Facilities*
Data Sheet 6-4, *Oil- and Gas-Fired Single Burner Boilers*
Data Sheet 6-5, *Oil- or Gas-Fired Multiple Burner Boilers*
Data Sheet 6-21, *Chemical Recovery Boilers*
Data Sheet 7-2, *Waste Solvent Recovery*
Data Sheet 7-7, *Semiconductor Fabrication Facilities*

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Data Sheet 7-13, *Mechanical Refrigeration*
Data Sheet 7-25, *Blast Furnace Ironmaking and Basic Oxygen Steelmaking*
Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*
Data Sheet 7-32, *Ignitable Liquids Operations*
Data Sheet 7-33, *Molten Metals and Other Materials*
Data Sheet 7-36, Pharmaceutical Operations
Data Sheet 7-64, *Aluminum Smelting*
Data Sheet 7-85, *Combustible And Reactive Metals*
Data Sheet 7-83, *Drainage and Containment Systems for Ignitable Liquids*
Data Sheet 7-110, *Industrial Control Systems*
Data Sheet 9-0, *Asset Integrity*
Data Sheet 9-18, *Prevention of Freeze-Ups*
Data Sheet 10-1, *Pre-Incident and Emergency Response Planning*
Data Sheet 10-8, *Operators*

Healthcare and Education Liquid Damage Guidelines (P14004)
Liquid Damage Guidelines for Commercial Properties (W151500)
Protecting Your Facilities from Winter Storms (P0101)
Freeze-up Checklist (P9521)
Understanding the Hazard: Liquid Damage (P10086)
Understanding the Hazard: Freeze (P0148)
Understanding the Hazard: Idle, Vacant, or Strikebound Facilities (P0274)
Understanding the Hazard: Lack of Emergency Response (P0034)
Pocket Guide to Emergency Response (P9914)
The Emergency Response Team (P8116)

FM online water damage resources:

https://web.email.fm.com/LiquidDamage

APPENDIX A GLOSSARY OF TERMS

Abnormal Flow Detection Systems: These systems establish baseline flow characteristics by monitoring water usage over time. Normal flow ranges (minimum and maximum) can be defined for operating and non-operating hours and adjusted seasonally if needed. Flow conditions that fall outside these established ranges are identified as abnormal and automatically reported to a central station, guard station or building management system.

Acoustic Leak Detection Systems: These systems listen for the distinct sound frequencies of escaping water. Thay are often used in conjunction with flow monitors.

Asset Integrity Program: A management system which uses design, operational, and inspection, testing and maintenance (ITM) data to ensure the integrity and reliability of systems and equipment throughout their service life.

The goal of an asset integrity program is to ensure systems and equipment operate reliably and remain fit-for-service, thus reducing the likelihood of equipment breakdown, and keeping media or energy sources contained. Refer to FM Property Loss Prevention Data Sheet 9-0, *Asset Integrity*, for further information.

Building Management System (BMS): A system of sensors, devices, and control and automation systems which work together to maintain and optimize building functions and performance.

Commercial Water Leak Monitoring Systems: Water flow monitoring systems that continuously track water usage and identify unusual patterns detect leaks.

Critical Equipment: Equipment which is vital to maintaining operational continuity of key business processes. Typical examples include main electrical or signal rooms and elevator pits in high-rise buildings.

Critical Rooms: Rooms that contain equipment vital to keeping day-to-day operations or key business processes running.

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Discrete Leak Detection Systems: Point source sensor technologies include conductive, cable type and optical devices with monitoring systems that report leakage to a central station, guard station or building management system. Point source leak detection (i.e., spot or flood sensors) provides notification of a water leak at single or multiple points.

Domestic Water: Water used for domestic purposes such as cooking/consumption, laundries, bathroom facilities, etc. Water used in climate control systems (e.g. chilled or heating water) is considered domestic for the purposes of this data sheet.

Domestic Water Emergency Response Plan (DWERP): A written plan that details how a site will respond to a water leak.

Flow-Based Leak Detection Systems: A water monitoring system that detects leaks by measuring flow through piping and identifying flow patterns that are abnormal for the building or process. Flow-based systems can detect leaks anywhere downstream of the flow meter – even inside walls, ceiling or concealed spaces. These systems can also be called intelligent leak detection and abnormal flow detection systems.

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

High-Value Equipment: Equipment with an unusually high-value relative to the rest of the occupancy. Examples include hospital medical imaging equipment (MRI, CAT Scan, etc.), medical reference libraries, etc.

High-Rise Building: Typically, a multi-story building which meets the definition of “high-rise” provided in FM Property Loss Prevention Data Sheet 1-3, *High-Rise Buildings*.

IoT Water Management Systems: Systems that utilize the Internet of Things (IoT) to continuously track usage, analyze flow rate data in real-time, and send alerts to building operators.

Intelligent Leak Detection: A type of leak detection system which can monitor and sense unusual or abnormal flow or pressure conditions in a pressurized water system, and report a potential leak. To implement this type of system, more sophisticated instrumentation is needed, such as flow and pressure transducers, level sensors (where gravity or expansion tanks are employed) or combinations thereof. Data logging equipment and specialized software is typically needed.

Leak Detection, Linear: A rope style cable that is able to detect water along its entire length.

Leak Detection, Point (Spot): A type of leak detection system which utilizes local detectors, typically at floor level, which monitor a local area such as a room or part of a room.

Leak Detection Systems: For the purpose of this data sheet, a leak detection system refers to any active system which can detect and report a potentially damaging release of liquid. This classification includes both discrete leak detection systems (spot, linear, area) and flow-based leak detection systems (intelligent, abnormal, acoustical, etc.).

Light-Hazard Occupancy: Non-manufacturing and non-warehousing occupancies. Typically, these occupancies are locations where people are coming for an event, medical appointment, housing, etc.

Mechanical Integrity Program: A subset of an overall asset integrity program which focuses on preventing the mechanical failure of a piece of equipment, typically piping or vessels, and the release of the material (e.g. liquid) within.

Piping and Instrumentation Diagram (P&ID): A detailed schematic diagram which shows the piping and associated equipment, together with the instrumentation and control devices.

Pressure Relief Valve: An automatic operating valve that will react rapidly to pressure buildup within a sprinkler system and relieve the pressure to atmosphere. The goal of the device is to maintain the internal pressure of a sprinkler system at or below a pre-set value, typically 175 psi (12.1 bar).

Sewer System, Combined: Combined sewer systems are sewer systems that contain stormwater, sanitary water and sewage. Combined sewers may also contain industrial wastewater.

Shut-off Valve, Automatic: A valve used for the purpose of shutting off a domestic water system that closes automatically when a leak is detected. Typical examples include quarter-turn ball valves, butterfly or disc valves, or gate valves (typically used on mains or larger size piping).

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Shut-off Valve, Manual: An isolation valve for a domestic water system that can only be closed manually by an operator or other person.

Shut-off Valve, Manual, Remotely Operated: An isolation valve for a domestic water system which can be closed upon command from a remote location, typically through the building management system (BMS).

Smart Water Flow Monitoring Systems: Water flow monitoring systems that continuously track water usage and identify unusual patterns to detect leaks.

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 2026. Interim revision. The following changes were made:

A. The naming convention for leak detection and flow detection was changed to better describe the systems. The new terminology is discrete leak detection systems and flow-based leak detection systems.

B. Clarification was made to indicate discrete leak detection and flow-based leak detection systems should be deployed concurrently to address this hazard. This revision does not change the original intent.

C. Clarified that use of non-FM Approved leak detection systems or devices is tolerable if FM Approved options are not available in the local market.

D. Glossary of Terms section was expanded.

E. Minor editorial changes were made.

July 2024. Interim revision. The following changes were made:

A. The title of this data sheet has changed to ″Protection Against Liquid Damage in Light-Hazard Occupancies″ from ″Protection Against Liquid Damage″.

B. A liquid flow detection and monitoring recommendation was added.

C. Recommendations for where to provide point source and linear cable leak detection have been consolidated. Guidance of where to place these devices was improved to be more specific.

D. Loss examples were added.

E. The Support for Recommendations section was expanded to help the data sheet audience understand the recommendations and exposure.

F. The glossary was expanded to help drive consistency and eliminate confusion.

July 2022. Interim revision. Improved asset integrity program guidance for liquid piping systems for additional clarity.

July 2021. Interim revision. Emergency Response recommendations were relocated to Data Sheet 10-1, *Pre-Incident and Emergency Response Planning,* or to Section 2.4, Operation and Maintenance of this data sheet.

July 2020. Interim revision. Minor editorial changes were made.

April 2020. Interim revision. The following changes were made:

A. Highlighted the need to quickly discover and stop a liquid leak in order to minimize damage and the impact on normal operations.

B. Revised several recommendations to address the need to recommend FM Approved equipment for leak detection and backflow devices.

C. Added new recommendations to address temperature monitoring of key spaces and providing heat to those areas with low temperature alerts.

D. Added new recommendation to address protection of dish washing and clothes washing machines.

E. Added new recommendation to address hot water tanks in occupancies with frequent losses.

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F. Revised liquid cart recommendation include equipping the cart with an acoustic leak listening device.

G. Revised recommendation 2.3.1 to include specific areas where leak detection and monitoring is recommended.

H. Revised the recommendation of valve labeling to include chilled water and steam.

I. Revised the recommendation for the availability of drawings to include plumbing riser diagrams.

April 2018. This document has been completely revised. Major changes include the following:

A. Moved all guidance related to ignitable liquids to Data Sheet 7-29, *Ignitable Liquid Storage in Portable Containers*, and Data Sheet 7-83, *Drainage Systems for Ignitable Liquids*.

B. Expanded recommendations related to the prevention and mitigation of liquid damage losses.

April 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

June 2009. Editorial changes were made for this revision.

July 1999. This revision of the document has been reorganized to provide a consistent format.

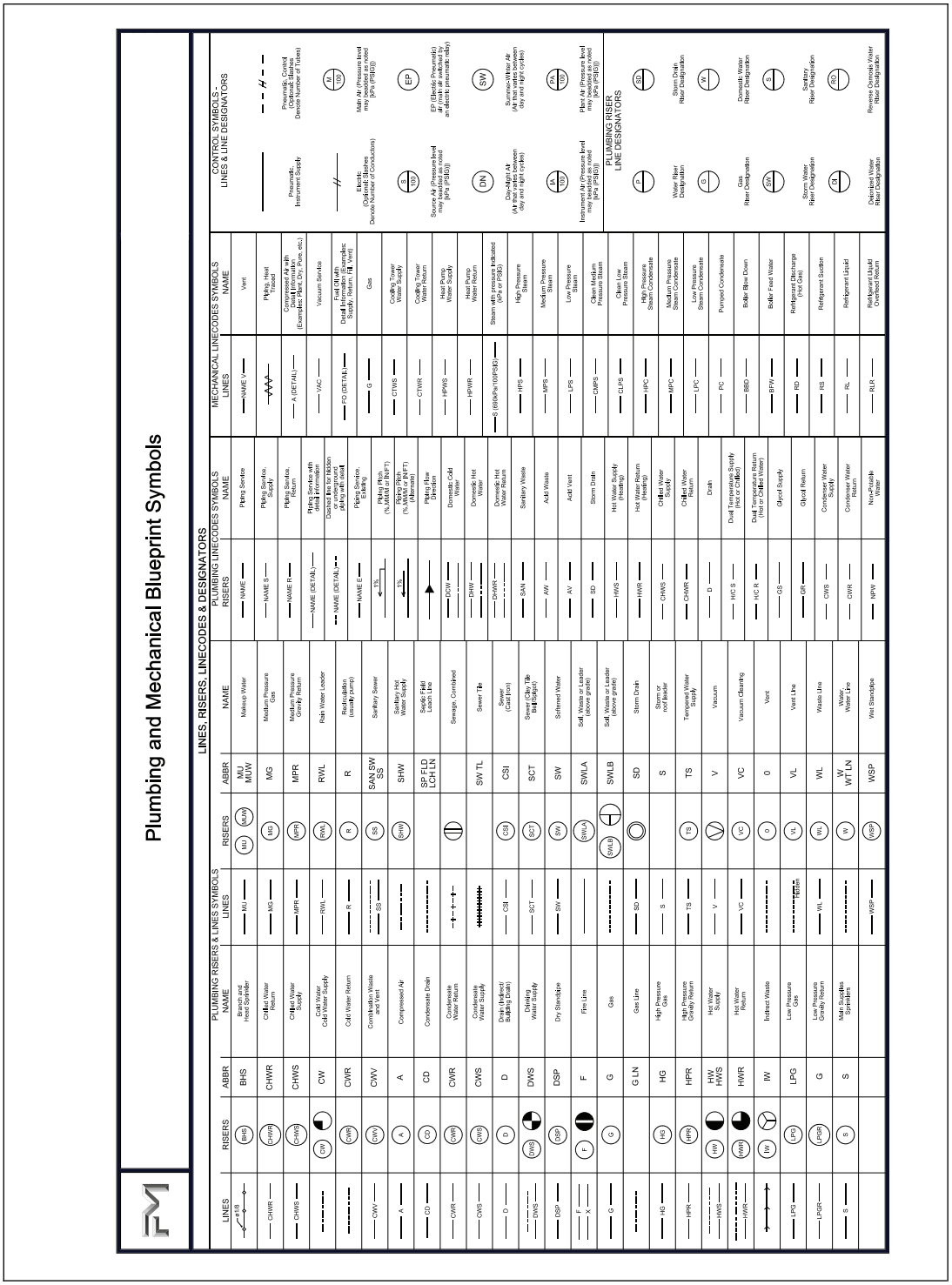
May 1998, Reformatted

Sept. 1997 Data Sheet 1-24 is a revision of Handbook Chapter 9.

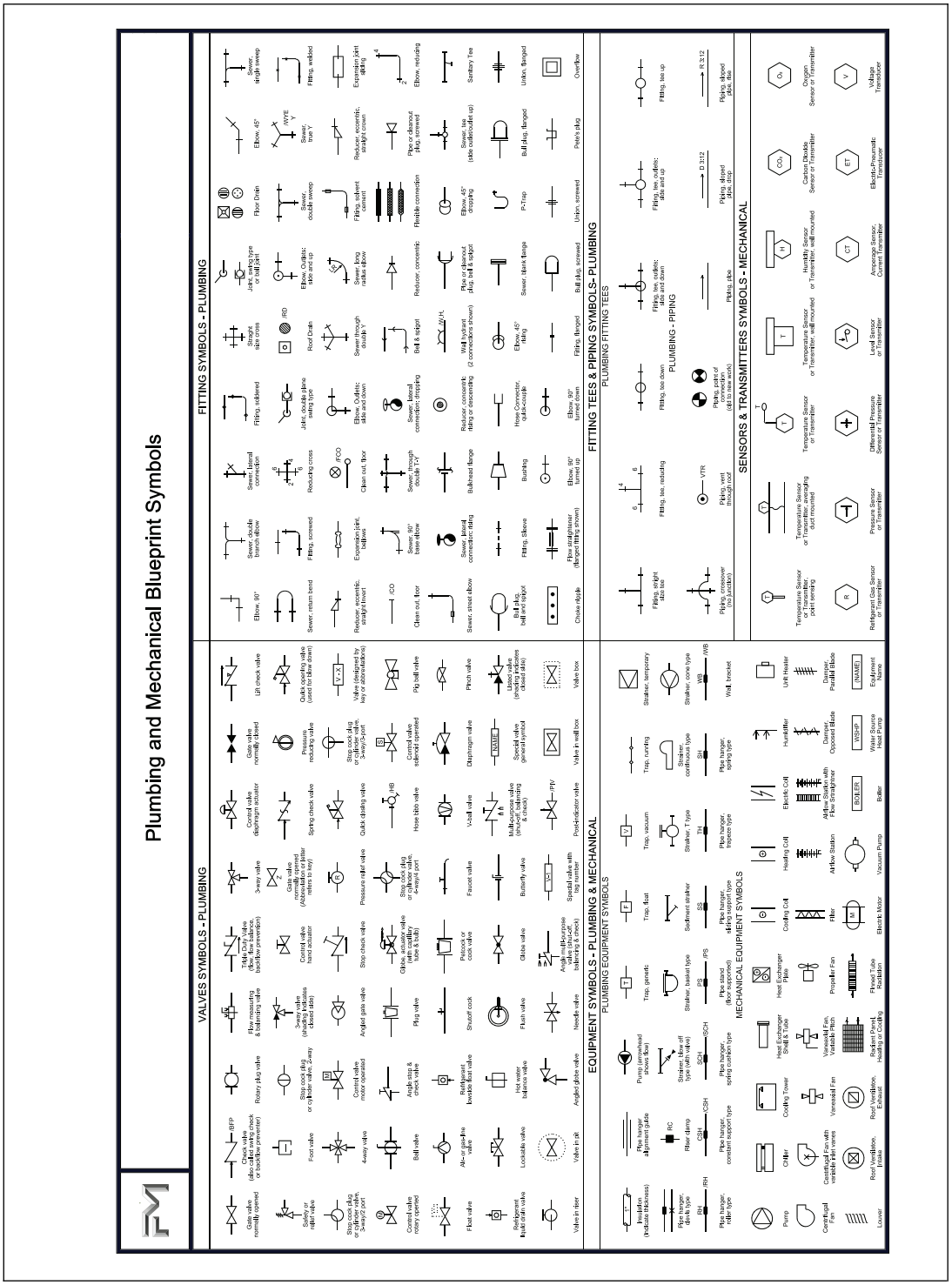
APPENDIX C PLUMBING AND MECHANICAL BLUEPRINT SYMBOLS

Common plumbing and mechanical symbols used in blueprints are provided in this appendix.

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