O&M Issues for Fire Sprinklers

Regular Testing and documentation are essential.

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PHOTO 1. Pipe with significant scale buildup.

Sprinkler systems are one of the most reliable life-safety and property-protection systems available today. By nature of their reliability and performance, building codes allow a number of exceptions to specific code requirements. These tradeoffs may be in the form of a larger building footprint, additional height allowances, or increased exiting distances. The track record of sprinkler systems is excellent for limiting losses and casualties from fire in buildings. While this can be attributed to an outstanding history of performance, sprinkler systems also require adherence to a comprehensive and regular maintenance program. Most failures can be attributed to a lack of maintenance.

Current testing and maintenance requirements for water-based systems are derived from NFPA 25 (formally NFPA 13A). NFPA 25 bears strong language and allows for adoption by Authorities Having Jurisdiction (AHJ). If the requirements contained in NFPA 25 are followed, many potential failures can be averted.

WHY IS TESTING NECESSARY?

Routine testing and inspection can identify potential system failures, which could lead to catastrophic failure. Many components of a sprinkler system can be compromised as the system and the building itself ages. Room functions change, walls are relocated, and even the building may change use altogether. Though the testing process can identify potential problems such as a deteriorating water supply, supply-valve closures, scale buildup, etc., an aggressive and proactive approach to maintenance ultimately will limit risk.

Inspection, testing, and maintenance practices typically are required through fire codes and insuring authorities. Even with AHJ-mandated requirements, several owners are reluctant to provide these services. This can be attributed to continuing cost for this service, lack of understanding of the requirements, or simply overlooking the installation. The "out of sight, out of mind" adage holds true in this scenario. Since sprinklers are not part of the environmental and building-system controls, they often are overlooked or considered only a property-protection system instead of a life safety system.

Modifications to building systems, occupancies, or the building itself that, to the untrained eye, appear to have nothing to do with the sprinkler systems may, in fact, jeopardize the ability of the sprinkler systems to control a fire. One may not think that relocating a storage room within a facility could have detrimental effects on the system, but the addition of fuel load that was not accounted for in the original system design may cause the sprinkler system to be overwhelmed.

WHO CONDUCTS THIS INSPECTION-AND-MAINTENANCE SERVICE?

When establishing a fire-protection inspection program, the success of identifying deficient issues is directly tied to the knowledge of the individuals conducting the inspection. Even the best program will fail if the individuals conducting the testing do not understand or properly document the findings. As a result, an inspection program also should assess the qualifications of the individuals involved.

Although sprinkler-inspection services usually are provided by a sprinkler contractor, they can be provided by any qualified person. When engaging a service provider for testing and maintenance, a thorough interview is essential. Firms may not provide all of the services the end user may require. For example, there is an overlap in the requirements of suppression systems and the fire-alarm systems that monitor them. Without proper coordination, a few items tend to be overlooked.

For instance, a facility hires a fire-pump testing firm to provide the annual performance test. The firm performs the task and clearly and accurately documents the findings. Yet this may not be enough. Questions arise, such as whether all the supervisory signals (phase reversal, pump running, power supplies) were checked and whether the transfer (from a permanent to temporary power source) switch was checked. Often, the answers are "no", and, as a result, these items remain unchecked because these functions are not within the scope of a fire-pump contractor's test procedures. Fire-alarm contractors tend to check the alarm devices, but rarely check the entire required sprinkler-monitoring points.

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Sprinkler contractors tend to check mechanical components, but rarely check all of the required fire-alarm monitoring points. In other words, each contractor typically checks components of the individual system they are most familiar with, but not the crossover with other systems that may be dependent upon full functionality.

In another example, a fire-alarm contractor who normally is expected to test the sprinkler-system alarm-initiating devices, may overlook the sprinkler-system backflow preventers, as testing of these system devices typically is conducted by certified plumbers. To avoid overlaps or prevent testing deficiencies, particular attention must be paid to the scope of services actually being provided by each contractor.

Based on the potential interaction of many different individuals and companies, the scope of desired services becomes very important. Another consideration, of course, is cost. Although it is an important consideration, it should not be the most important. In today's environment of risk management, the question is how much does risk cost? Firm qualifications, the end product, the thoroughness of service, and scheduling flexibility are, in fact, more important considerations than the bottom-line cost. Money spent for the right service is better than spending less money for the wrong or incomplete service.

PHOTO 2. Scale buildup in this pipe led to freeze and pipe burst.

WHAT CAN I EXPECT AN INSPECTION SERVICE TO IDENTIFY?

Typical concerns that a qualified inspection firm should identify are water-supply issues, fire-pump performance, hazard identification, fire-alarm annunciation, and painted or improperly installed sprinkler heads or fire-alarm devices.

Each type of sprinkler system, be it wet, dry, pre-action, or deluge, may have inherent problems that require special care to keep it in optimum working condition. The reliability increases as the frequency of

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VAV Diffusers

How to troubleshoot irregular conditions

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Proper operation of a system with VAV diffusers requires a knowledge of both the system and how a VAV diffuser works. VAV systems, unlike constant-volume systems, operate with a constant supply-air temperature. VAV diffusers vary the volume of air according to the room temperature. The sources of heating and cooling are controlled for a constant supply-air temperature by a sensor that usually is set between 55 and 65 F for cooling and 80 to 90 F for heating. Any reset of supply-air temperature should be to another constant temperature.

System static pressure is controlled below 0.25 in.WG at the inlet of VAV diffusers to minimize noise. A variable-speed drive on the fan is the preferred method of static control. The control point is the static-pressure sensor located downstream in the ductwork. Operators should know the proper static-pressure setpoint to avoid noisy VAV diffusers. Like all VAV systems, the fan should operate continuously during occupied hours.

The good temperature-control and good air-movement characteristics of VAV diffusers minimize the need for frequent temperature-setpoint adjustments. VAV diffusers with built-in thermostats are adjusted by a knob located in the diffuser. See your manufacturer's instructions for details.

MAINTENANCE

VAV diffusers require minimal maintenance beyond cleaning. We have designed systems with thermally powered versions that have operated in New York for almost 15 years without any replacement or repair. Where VAV diffusers are provided with wall-mounted thermostats, periodic recalibration of the space-temperature sensor or thermostat is recommended.

TROUBLESHOOTING

Troubleshooting procedures for VAV-diffuser systems are similar to the other VAV systems in that they require examination of the system as a whole. Before checking the VAV diffusers for failure, confirm that the basic air delivery is functioning properly.

Occupant complaints such as, "My feet are too hot," when there is a heater under the desk may have nothing to do with the VAV-diffuser operation. Education may be necessary if expectations of the VAV-diffuser system are incorrect. Careful examination must be performed to define the actual problem. Fixing or adjusting the VAV diffuser when the problem lies elsewhere may cause additional problems.

A system check should verify that:

• Supply-air temperature is cold enough when in the cooling mode and hot enough when in the heating mode.

• Static pressure at the inlet of the VAV diffuser is high enough to achieve design air flow.

• The supply-air fan is running continuously during occupied hours.

If the system conditions are OK, measure and record the items listed in the troubleshooting checklist below. You may want to do this yourself to make sure the data is correct. Making a data-log sheet in advance will make the job easier.

CONCLUSION

Proper operation of a system with VAV diffusers requires a knowledge of both the system and how a VAV diffuser works. The system must provide a constant supply-air temperature and proper static-pressure control. VAV diffusers require minimal maintenance. Troubleshooting should begin with a system check followed, if necessary, by logging the data shown in the troubleshooting checklist.

TROUBLESHOOTING CHECKLIST: RECOMMENDED ADJUSTMENTS FOR VARIOUS CONDITIONS

	Room temperature	Damper position	Recommended action
Cooling mode	Too cold	Open	Adjust cooling thermostat in VAV diffuser for higher room-temperature setpoint.
		Closed	The VAV diffuser is correct. Check supply-air temperature and reset higher. If heating is required, check the system-changeover thermostat.
	Too warm	Open	The VAV diffuser is correct. Check for lack of air or for high supply-air temperature.
		Closed	Adjust cooling thermostat in VAV diffuser for lower room-temperature setpoint.
Heating mode (for VAV heating models only)	Too cold	Open	The VAV diffuser is correct. Check for lack of air or for high supply-air temperature.
		Closed	Adjust heating thermostat in VAV diffuser for higher room-temperature setpoint.
	Too warm	Open	Adjust heating thermostat in VAV diffuser for lower room-temperature setpoint.
		Closed	The VAV diffuser is correct. Check supply-air temperature and reset lower. If heating is required, check the system-changeover thermostat.
Too noisy	Any	Any	Reduce static pressure. Recommended static pressure is 0.05 to 0 .25-in. WG at the inlet of the diffuser. If lower noise level does not result from lower static pressure, check for and correct noise-generating restrictions such as large pressure drops over dampers, heaters, etc., in the duct upstream.

Turning Noises Off

The O&M challenges posed by noisy equipment

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Most operations-and-maintenance issues regarding noise and vibration have to do with fixing noise problems that arise after construction is complete and people are in the building. The really unfortunate thing about this is that once occupants are exposed to real noise and vibration problems, they become sensitized and more heroic solutions are required than would have been the case had the problem been corrected during the commissioning phase.[1]

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Many of the noise problems encountered in an office environment have obvious sources: the vending machine around the corner, the guy in the next office who keeps tapping the wall with his foot in time with the music deafening him through his headphones, and so on. I recently designed an office building for a computer company whose business changes faster than they can get a building built. They came to us and said: "We know we need a building, and we know how big it has to be. But we don't yet know who we are going to put in the building. We want you to design the shell of this building and start construction while we decide who will occupy it. Then you can design the tenant finish while the shell is under construction."

This is not too unusual of a request, particularly from developers of spec office buildings, and it led us into a fairly common problem encountered with this type of two-stage design/construction. After the steel had been erected, the floors poured, and most of the exterior walls erected, tenant finish began to be nailed down. One area was designated for a computer lab, with the area surrounding it to be occupied by the offices of the engineers who would work in the lab. The lab was located as well as could be expected with corridors on three sides and another lab on the fourth side. The heat load in the lab was such that we had to install a 20-ton computer-room air-conditioning (CRAC) unit. Since the tenant finish was done after the shell, there was no provision for a raised floor, so the CRAC unit became an up-flow unit installed directly on a floor that the structural engineer designed for a normal office load. Due to the delivery time of the CRAC unit (30 weeks at the time) it wasn't installed until just after the building was occupied. Soon thereafter, the facility engineer's phone began to ring.

I investigated the complaint and found the CRAC unit emitting a rumble that could have competed with the tympani section of the New York Philharmonic Orchestra. In the office directly across the corridor from the location of the CRAC unit, a framed photograph placed on a shelf in a wall-hung bookcase literally danced in place. In this case, the source was obvious, as was the cause: an out-of-balance fan wheel. The fan assembly was replaced under warranty and all returned to normal, though the occupant of the office with the dancing photograph still claims that his feet tingle from time to time. Unfortunately, you can't always count on the source being so easy to find or the problem so easy (and cheap) to fix.

Table 1. Noises Commonly Associated with HVAC Equipment

Noise	Possible causes
Rumble	Usually fans, turbulent air flow, excessive static pressure, loose drive elements, or duct oil-canning.
Roar	Excessive air velocity, closely located duct fittings in high-velocity duct, poor fan selection.
Hiss	Poorly sealed ductwork, undersized VAV box or grille.
Buzz or hum	Electrical transformers, misaligned fan, ineffective or missing vibration isolation, short circuit between equipment and structure.
Whine	Pumps or fans, inadequate isolation at equipment or downstream.
Squeal	Belt drives, loose belts.
Click or tap	Loose fittings or panels, leftover construction debris.
Surge or throb	Fans or pumps, equipment operating in unstable region.
Whistle	Valves and dampers, too small for flow, uneven flow through outlet or inlet, unfinished duct or pipe edges exposed to flow.
Drumming	Reciprocating compressors, direct contact with wall or floor, wall or floor too lightly constructed, inadequate isolation or short-circuiting.

Procedures

It always helps to have written procedures for tackling a complex problem. If nothing else, it helps decrease the headless-chicken response. Figure 1 (page 80) is a checklist I use as a starting point when investigating a noise problem. This constitutes the first step in a four-step procedure to address noise/vibration problems: Properly define the complaint.[2] Often, just going through the checklist will lead you directly to the source of the problem. Certain noises are indicative of their source. Table 1 gives some of the most common associations.[2]

Noise problems, however, can be quite complex with the more intractable ones requiring the services of an acoustician. If this should be the case, the completed checklist often will save the acoustician some time.

Once the problem is properly defined, the next step is to isolate the source. This isn't always as easy as it sounds. Most sounds and vibrations can be caused by any number of things because there usually are many pieces of equipment operating at any given time—from pumps and fans to vending machines. The most logical course of action is to start turning pieces of equipment off and on individually. Sometimes, this isn't possible. It's not a good idea to run a boiler with its circulating pump turned off. The resultant noise could be a lot louder than the problem you are investigating.

Once you've isolated the source, your task is to find out why that piece of equipment is noisy and discover the path the noise takes to the problem area. The majority of noisy equipment contains rotating elements of some kind. This means that the noise can be caused by bearings, out-of-balance rotating elements, rubbing, short-circuiting isolators, improperly sized isolators, irregular inlet and/or outlet conditions, and on and on. If the equipment speed varies, as with a VFD, or the inlet or outlet conditions change, as with inlet vanes or outlet dampers, you need to determine precisely what conditions exist when the problem is present.

Now that you've found the source, how is the sound or vibration getting to the problem area? One of the most common sound-transmission paths when there is a problem with roof-mounted packaged AC units is the duct penetration through the roof. Often, these holes are cut extra large to allow for some fudge factor in final positioning. If the roof penetrations are not sealed with some kind of resilient caulking, noise can pass from the floor of the A/C unit through the hole into the space below. Another common path is the ceiling grid. If a ceiling-support wire contacts a fan-powered VAV box, the vibration can pass through the grid until it reaches a loose connection or a light troffer that was installed with a misaligned gasket, causing a rattle across the building from the source.

The final step is to carefully consider what you are going to do to fix the problem. Let's consider a rooftop unit that was located in the middle of the joist span. The shipping blocks were never taken out of the fan section. Instead of cutting holes in the roof for the ducts, they simply didn't install any roof deck inside the confines of the roof curb. Also, the ceiling space was so limited that the tinner had to make an abrupt elbow right out of the bottom of the unit and didn't install any turning vanes. You can address any of these inadequacies and still have a noise problem. You have to consider the system as a whole and consider how any remediation efforts will affect the performance of the system. For instance, if you decide to install a duct silencer, how will that affect the system static pressure and the performance of the fan? It could move the fan into a less-efficient operating condition, causing it to produce more noise.

Troubleshooting a noise problem is difficult, expensive, and time-consuming—a problem worthy of Sherlock Holmes himself. It is not, however, impossible. When (you'll notice I didn't say "if") you are confronted with one, don your deerstalker cap, grab your trusty meerschaum pipe, and, with ASHRAE as your Dr. Watson, apply some common sense. You'll be successful more often than not.

REFERENCES

1) ASHRAE 1999. *HVAC Applications Handbook.* American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Atlanta, GA.

2) Schaffer, Mark E. *A Practical Guide to Noise and Vibration Control for HVAC Systems.* American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Atlanta, GA.

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surveys increases. Visual identification of deficient control devices, such as valve closures, is easily identified. The same goes for hazard identification. The surveyor should pay particular attention to rooms (occupancy modifications), which may have a detrimental effect on design. For example, one hospital relocated 2,000 sq ft of high-piled storage into a light-hazard design area without any consideration for the existing sprinkler design. The important questions that need to be answered during each survey are, whether the occupancy of any space changed since the last survey and whether the current design is adequate for the respective hazard.

Dry systems need to have the interior and exterior piping visually inspected for scale. Scale which can clog a sprinkler orifice during discharge can build up in these systems. Additionally, since warm, moist air typically is introduced though the air compressor, moisture always is a problem. This can lead to freezing, as well as accelerated scaling. Annual trip tests can reveal conditions that may lead to requiring internal examination of the piping. See examples of piping problems in Photos 1and 2.

The goal is not just to provide the test, but to interpret the findings. Inspections should be regular. They should be organized and methodical and should account for required maintenance, repair, or remedies.

Each type of sprinkler system, be it wet, dry, pre-action, or deluge, may have inherent problems that require special care to keep it in optimum working condition.

WHAT ABOUT DOCUMENTATION?

Documentation is one of the most important aspects of this process. An inspection, testing, and maintenance firm must address the issues, identify corrective action, and record its completion. Typical contractor-inspection forms are set for "yes/no" responses, requiring further explanation of all "no" (deficient) responses. But where do you document the correction of deficient items? The report rendered should not only include the good and the bad, but the corrective action required to make the deficient items compliant again. Additionally, to limit risk, this corrective action should occur immediately. Building owners should not be discouraged if corrective action is identified. This reinforces the fact that the inspector is providing a valuable service. Time and time again, survey reports indicating no deficiencies are produced by inspection firms and become another collection of papers in a file. Demand more.

A good approach to continuing documentation is an electronic building-maintenance program, which allows easy updates of deficient items and documents corrective actions. As with anything else, these programs vary in their effectiveness. A thorough evaluation of the program should be performed before investing time and money that increases effort but provides marginal benefit. Ultimately though, we are managing risk and must ask ourselves, "What is the cost of risk?"

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NOISE/VIBRATION COMPLAINT FORM

DATE:________________ TIME:_____________ ROOM NUMBER:_______________

BUILDING ADDRESS:____

TYPE OF COMPLAINT:

❍ Noise ❍ Vibration ❍ Felt ❍ Heard

DESCRIPTION:

❍ Rumble	❍ Roar	❍ Hiss	❍ Buzz
❍ Whine	❍ Squeal	❍ Click or tap	❍ Hum
❍ Surge or throb	❍ Whistle	❍ Drumming	
❍ Continuous	❍ Intermittent	❍ Other	If Other, describe:

If intermittent, how often and when? ____

Does the intensity vary? If so, when is it the greatest and the least?____________________

Can the problem be associated with a particular piece of equipment? ❍ Yes ❍ No

If yes, describe:____

Recommendation:____

Action taken:____

Figure 1. Checklist for investigating noise problems.