

Maintaining a High Level of Fire Sprinkler Performance

For decades fire sprinklers have proven to be an effective and invaluable tool for protecting property and life from the potentially devastating effects of fire. With the increased awareness and public concern for building safety, there is a growing need for buildings to be fitted with reliable security and safety systems.



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While fire sprinklers have been used to reduce the loss of life and property from fires for more than 100 years, the expanded end use applications and changing installation environments for these products require on-going monitoring and assessments of the construction and performance requirements included in safety standards to maintain the desired high level of safety. As a part of Underwriters Laboratories Inc's (UL's) standards development process, UL routinely considers new technology and performance in field use environments to assess the need for revision of product requirements or installation standards. Since the year 2000, UL has identified several opportunities for these improvements, and took action to enhance the performance requirements for fire sprinkler products.

Sprinkler Standards and Requirements

On a global basis, there are several product standards for sprinklers published by various organizations. For example, ISO recently published new editions of the International Standards, ISO 6182-1, "Fire protection – Automatic sprinkler systems – Part 1: Requirements and test methods for sprinklers"¹ and ISO 6182-10, "Fire protection – Automatic sprinkler systems – Part 10: Requirements and test methods for domestic sprinklers"². The European standard for sprinklers published in the English language is BS EN 12559-1, "Fixed firefighting systems- Components for sprinkler and water spray systems – Part 1: Sprinklers"³.

This article is focused on requirements included in sprinkler standards published

by UL. Currently, UL publishes several standards addressing fire sprinkler products, but the three primary standards include the following:

- Standard for Automatic Sprinklers for Fire-Protection Service, ANSI/UL199⁴
- Standard for Residential Sprinklers for Fire-Protection Service, ANSI/UL1626⁵
- Standard for Early-Suppression Fast-Response Sprinklers, ANSI/UL1767⁶

The sprinklers covered by UL's standards are generally intended to be installed in accordance with the nationally recognized installation standards published by the National Fire Protection Association (NFPA) including the Standards for Installation of Sprinkler Systems, NFPA 13⁷; Installation of Sprinkler Systems in One-and Two-Family Dwellings and Manufactured Homes, NFPA 13D⁸; and Installation of Sprinkler Systems in Low-Rise Residential Occupancies, NFPA 13R⁹. The Standard for Inspection, Testing and Maintenance of Water-Based Fire Protection Systems, NFPA 25¹⁰, contains comprehensive requirements for assessing the ability of the sprinkler system to operate as intended on an on-going basis.

The fire sprinkler community is generally aware of the fact that the industry has been very active within the last 20 years or so in developing new sprinkler technology, including a broad range of large K-factor storage sprinklers. While it is important for the product standards to be updated to address new technologies, the context of this article is focused on several requirements that have been adopted into UL's standards that are intended to enhance the general

operating performance of sprinklers in field environments.

As would be expected, UL's sprinkler standards contain tests to evaluate the capability of these products to distribute water in such a manner that will control or suppress fires. However, many are not aware that these standards also include a broad range of tests to investigate the ability of sprinklers to operate and perform as intended under stressed and adverse field conditions. In fact, each of these standards contains more than 35 different performance tests. The following is a brief description of just a few of the tests that have been in the sprinkler standards for decades:

- Resistance to leakage and rupture
- Tests to evaluate the ability of a sprinkler to control or suppress a fire
- General corrosion tests that expose samples to salt spray, hydrogen sulfide and carbon dioxide-sulfur dioxide atmospheres.
- Stress corrosion tests for copper alloy and stainless steel components.
- Exposure of samples to 98% relative humidity at 93 °C (200 °F).
- High temperature exposure tests for each temperature rating
- Vibration exposure
- Impact resistance
- Rough usage

Although these tests are considered to be very challenging, it is important to continuously monitor the performance of sprinklers in actual field use environments to maintain a level of confidence that the sprinkler standards continue to be relevant and effective in achieving the desired level of safety and performance.

Examples of Revisions to UL's Sprinkler Standards

Based upon reports from property owners, sprinkler contractors, authorities having jurisdictions and others, fortified by UL's testing of thousands of sprinkler samples from hundreds of installation locations, two key areas for enhancing sprinkler operation performance were identified in the early 2000's. These revisions included new additional construction and performance criteria related to the release of the water seal assembly and resistance to premature (unwanted) sprinkler operation.

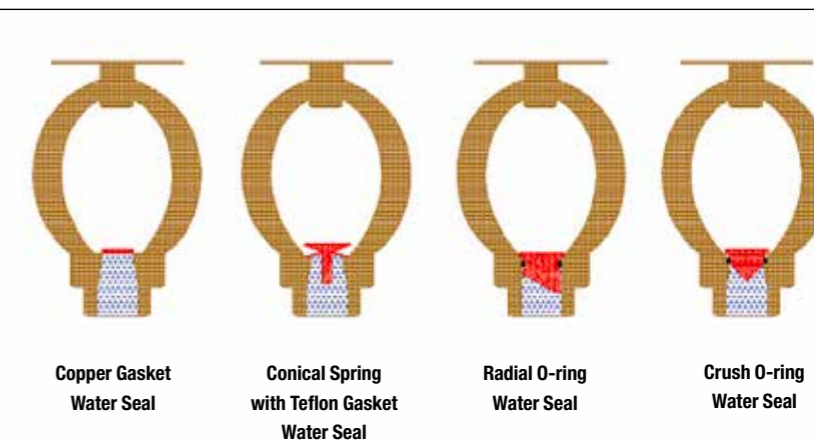


Figure 1: Typical sprinkler water seal designs that have been used over the years. Note the small annular clearances between the O-ring water seal assembly and sprinkler orifice.

Release of Water Seal Assembly

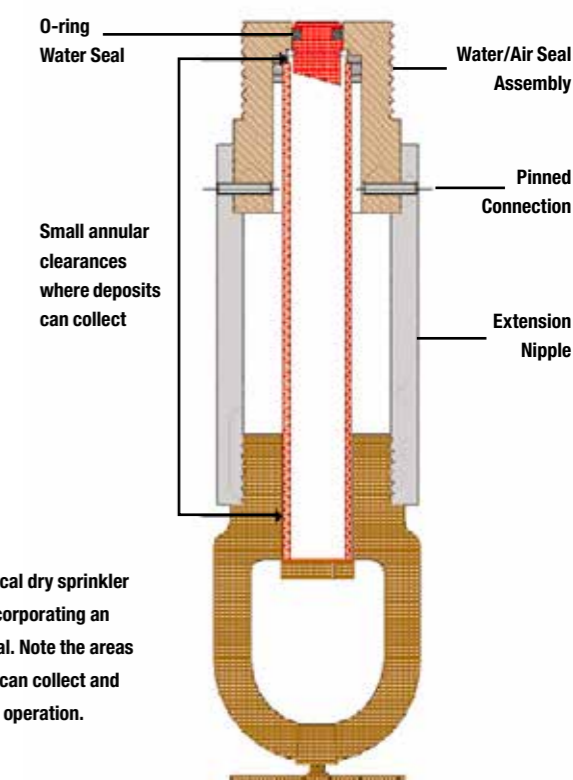
Until the early 1960's, the prevention of leakage from sprinklers was primarily achieved through the use of a metal-to-metal compression seal arrangement typically employing the use of a copper gasket. Today, a conical spring with a Polytetrafluoroethylene (PTFE) film gasket is the most prevalent means used in sprinklers to prevent leakage. A schematic of typical water seal configurations used over the years is provided in Figure 1.

Since the late 1990's, UL has conducted operational tests on a large

number and type of O-ring sealed sprinklers sampled from field installations. In some locations all samples operated as intended, and in others, all samples experienced elevated operating pressures. While the operational test results of these sprinkler types varied substantially in the different installation locations UL's testing of these sprinklers revealed that a large number of sprinklers utilizing a dynamic O-ring type seal required elevated inlet pressures for the water seal to release from the sprinkler and allow it to discharge water. In fact, in some cases the O-ring



Figure 2: Photograph illustrating the level of deposits commonly found in sprinkler inlets.



► Figure 3: Typical dry sprinkler construction incorporating an O-ring water seal. Note the areas where deposits can collect and inhibit sprinkler operation.

type water seal did not release even when 6.8 bar (100 psig) was applied to the inlet.

While O-ring seals were utilized in both wet and dry type sprinklers, the majority of dry sprinklers manufactured between 1970 to the early 2000's were constructed with O-ring water seals. Accounting for a small percentage of all installed fire sprinklers, dry sprinklers are generally found in locations having harsh environmental conditions, characterized by wide variations in temperature, humidity and corrosive conditions, such as car ports, parking garages, loading docks, outdoor canopies and walkways. Results from operational tests conducted on thousands of O-ring sealed dry sprinklers sampled from field installations indicate that approximately 50 percent of the sprinklers experienced inhibited operating characteristics primarily due to the water seal assembly not releasing in the intended manner. The analyses of

wet and dry sprinkler samples received from the field installations indicated that a broad, but not clearly defined, spectrum of materials and chemicals may reside within sprinkler inlets including various types of oils, surfactants, chemicals associated with water potability and pipe sealing compounds, hard water deposits, sand, dirt, etc. These materials and chemicals may act to accelerate the corrosion process and inhibit the intended movement of sprinkler operating parts.

Based upon these analyses, UL identified four key factors considered to be contributing to the inhibited sprinkler operation:

- The collection of corrosion and other products in the small annular clearances between operating parts.
- Transfer (sticking) of the O-ring material to the mating sealing surface.
- Dezincification

- Micro-leakage past the O-ring water seal causing corrosion and deposits to form on the non-water side of the seal.

To address these concerns, several revisions to UL's sprinkler standards were adopted in 2001. The table below summarizes the revisions that were adopted related to enhancing the operating performance characteristics of the water seal assembly. Extensive data generated as a result of UL's operational testing of sprinklers from field installations subsequent to the implementation of these revisions have confirmed the need for these additional requirements.

Resistance to Premature Sprinkler Operation

In the early 2000's, UL received an increased number of field reports of sprinklers discharging water without an apparent cause for the operation. These situations are commonly referred to as premature sprinkler operation. Dry sprinklers installed in cold storage facilities and glass bulb sprinklers were the focus of many of those concerns.

In regard to dry sprinklers installed in freezers, it was determined that ice build-up external and internal to the sprinkler had the potential to apply excessive stresses to the operating parts. Concerning the potential for the build-up of ice external to the sprinkler, proper installation of the sprinkler is important. It is critical for the hole that accommodates the installation of the dry sprinkler to be properly insulated and sealed. If the annular space between the sprinkler and freezer is not sealed properly, substantial quantities of ice can build-up around the sprinkler due to condensation and hot, moist air entering the freezer. Figure 5 is a photograph of a dry sprinkler that was not properly sealed around the sprinkler penetration. These situations should be readily visible during periodic sprinkler system inspections.

Based upon the same air movement principle, ice may build-up internal to the dry sprinkler if a sprinkler's water seal assembly and extension nipple connection is not completely sealed. To prevent air interchange within the sprinkler and the resulting build-up of ice internally, UL's sprinkler standards require this connection to be completely airtight. More detailed information on dry sprinklers installed in

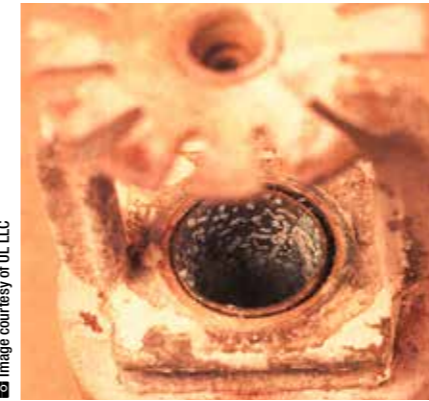


Image courtesy of UL LLC

▲ **Figure 4: Photograph illustrating the level of deposits created by the new laboratory deposit-forming test. After exposure to the deposit-forming atmosphere, the water seal assembly is required to release as intended with an inlet air pressure of 0.48 bar (7 psig).**

freezers is contained in a paper entitled "A Technical Analysis: The Use and Maintenance of Dry Type Sprinklers."¹¹

While glass bulbs have been used as heat responsive elements in sprinklers for decades, these bulbs have been miniaturized in recent years to enhance the sensitivity to fire conditions. Considering the typical phases of a sprinkler's life, there is ample opportunity for damage or overstressing of glass bulb to occur. Figure 6 illustrates several potential sources of damage to glass bulb heat responsive elements and causes for the premature sprinkler operation.

To address the potential source of damage related to manufacturing, UL's sprinkler standards include a test to determine that the integrity of the glass bulb is maintained after the sprinkler has been fully assembled and subjected to all the other production testing at the factory. This requirement provides a level of assurance that sprinklers are shipped from the factory with a damage-free, fully functional glass bulb. Also, to minimize

▼ **Figure 6: Chart of several potential sources of damage to glass bulb heat responsive elements and causes for unwanted discharge of sprinkler system water.**



▲ **Figure 5: Photograph of dry sprinkler not properly sealed around the sprinkler penetration causing external ice build-up. This condition should be readily visible during an inspection of the sprinkler system.**

the potential for glass bulb damage due to the extensive handling that typically occurs after the sprinkler has left the manufacturing facility, UL's sprinkler standards require all glass bulb sprinklers be fitted with protective covers.

Summary

The timely updating of requirements in safety standards is imperative to maintain the Standards' relevancy toward achieving safety objectives. While UL's sprinkler standards were the first to include the requirements described in Tables 1 and 2, the importance of applying these requirements to sprinklers has been freely shared with the fire protection community. Just recently, most of the additional sprinkler construction and performance requirements described in this article have also been adopted into the latest editions of the ISO 6182-1¹ and ISO 6182-10².

Fire sprinklers have established an outstanding record of protecting property and life over many decades, and the overall effectiveness of sprinkler system protection continues to be at a very high level. With the vigilance and collaboration of enforcers, insurers, designers, installers, manufacturers, standards

References

- 1 ISO 6182-1, "Fire protection – Automatic sprinkler systems – Part 1: Requirements and test methods for sprinklers", International Organization for Standardization, Geneva, Switzerland, Third Edition Dated 2014-01-15
- 2 ISO 6182-10, "Fire protection – Automatic sprinkler systems – Part 10: Requirements and test methods for domestic sprinklers", International Organization for Standardization, Geneva, Switzerland, Second Edition Dated 2014-05-15
- 3 BS EN 12559-1:1999, "Fixed firefighting systems- Components for sprinkler and water spray systems – Part 1: Sprinklers", British Standards Institute, London, United Kingdom
- 4 "Standard for Automatic Sprinklers for Fire-Protection Service", ANSI/UL199, Underwriters Laboratories, Inc., Northbrook, IL, 2013.
- 5 "Standard for Residential Sprinklers for Fire-Protection Service", ANSI/UL1626, Underwriters Laboratories, Inc., Northbrook, IL, 2012.
- 6 "Standard for Early-Suppression Fast-Response Sprinklers, ANSI/UL1767, Underwriters Laboratories, Inc., Northbrook, IL, 2013.
- 7 "Standard for the Installation of Sprinkler Systems", NFPA 13, National Fire Protection Association, Quincy, MA, 2013 Edition.
- 8 "Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes", NFPA 13D, National Fire Protection Association, Quincy, MA, 2013 Edition.
- 9 "Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies", NFPA 13R, National Fire Protection Association, Quincy, MA, 2013 Edition.
- 10 "Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems", NFPA 25, National Fire Protection Association, Quincy, MA, 2014 Edition.
- 11 Golinveaux, James, "A Technical Analysis: The Use and Maintenance of Dry Type Sprinklers," Tyco Fire & Building Products, Lansdale, PA, 2002.

development organizations, certifying organizations and others, the high level of safety provided by fire sprinkler systems can be maintained and enhanced even though fire challenges and installation environments continue to evolve. The on-going efforts to expand the usage of the fire sprinklers as a protection tool will make our world a safer place to live.

For further information, go to www.ul.com

Summary of Revisions to UL Sprinkler Standards Related to Enhancing Sprinkler Operating Characteristics	
Revisions Adopted in 2001	Rationale for New Requirement
Hydrocarbon and Water Immersion Exposure	Significant levels of hydrocarbons and water deposits have been found in sprinkler inlets sampled from field locations. Sprinklers are required to operate as intended after these exposures.
Ban on Use of Dynamic O-ring Water Seals	The primary contributor to elevated operating pressures measured in O-ring sealed sprinklers were (1) the collection of corrosion and other deposits in the small annular clearances provided between the operating parts, (2) transfer (sticking) of the O-ring material to the mating surface and (3) small leakage past the O-ring water seal causing deposits to develop. Figure 1 illustrates the small annular clearances typically associated with O-ring sealed sprinklers. Figure 2 illustrates the level of deposits commonly built-up in the inlet of a sprinkler. This type of water seal has not been permitted in UL certified sprinklers since 2003.
Dry Sprinkler Deposit Loading Test	Dry sprinklers are can be installed in harsh environments and corrosion deposits have been observed on the internal operating components. Figure 3 illustrates the areas within the dry sprinkler assembly where deposits have been observed. Figure 4 is a photograph of a dry sprinkler that was subjected to the laboratory deposit-forming test. After this exposure, the sprinkler is required to operate as intended.
Dezincification Test	Some sprinklers received from field installations showed evidence of dezincification, which is the selective removal of zinc from a copper alloy. Dezincification can weaken the pressure retaining capabilities of sprinkler parts, and potentially cause leakage, loss of structural integrity or inhibited operation. This test establishes a minimum level of resistance to dezincification and is applicable to all copper alloy materials containing more than 15% zinc exposed to the sprinkler system water.

