Evaluation of Non-Certified ESFR Sprinkler Samples

Technical Report by UL LLC

for

International Fire Sprinkler Association

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EXECUTIVE SUMMARY

This report describes the results of UL's testing of unused Early Suppression Fast Response (ESFR) sprinkler samples that were reported to be representative of sprinklers installed in several existing storage facilities located in China. The sprinklers were not marked as being certified by UL or any other certification organization.

UL certified ESFR sprinklers are required to comply with ANSI/UL 1767-2013, Standard for Early-Suppression Fast-Response Sprinklers, which includes more than 35 performance tests to investigate the ability of the sprinkler to provide the intended level of safety when installed in field applications. Due to the small quantity of samples available for testing, the scope of the UL's investigation was limited compared to the extensive testing required for UL certification of an ESFR sprinkler. Many critical tests described in ANSI/UL 1767, including the tests to investigate the ability of the sprinkler to suppress a fire, were not conducted as a part of this investigation.

Two general types of upright style sprinklers, both marked as being ESFR sprinklers, were evaluated (20 samples of each construction). The first sprinkler construction was marked "ESFR-202/68°C," suggesting the sprinkler had a nominal discharge coefficient of K=202 L/min/(bar$^{0.5}$) (14.0 gpm/psig$^{0.5}$) with a temperature rating of 68°C (155°F). The second construction was marked "ESFR-363" and "74°C" suggesting the sprinkler had a nominal discharge coefficient of K=363 L/min/(bar$^{0.5}$) (25.2 gpm/psig$^{0.5}$) with a temperature rating of 74°C (165°F).

The following describes some of the key areas of potential safety deficiencies that were identified as a part of UL's investigation having a limited scope:

1. **O-ring Water Seals –** Both sprinkler constructions utilized an O-ring style water seal assembly. O-rings have not been permitted in UL certified sprinkler constructions since January 9, 2003 due to the potential for this type of water seal construction to leak or not permit the discharge of water from a sprinkler after exposure to field installation environments. Previous UL research indicated that elastomeric O-ring water seals used in sprinklers have the potential to adhere to the mating surface and are susceptible to the collection of corrosion and other products in the small annular spaces between the operating parts causing inhibited sprinkler operation. The following link provides an example of a product recall issued on O-ring sealed sprinklers: http://www.cpsc.gov/en/recalls/2001/cpsc-central-sprinkler-company-announce-voluntary-recall-to-replace-o-ring-fire-sprinklers/

2. **Upright Installation Orientation –** Both sprinklers were constructed to be installed in the upright orientation. Currently, there are no UL certified ESFR sprinklers intended to be installed in the upright orientation. Also, the Standard for the Installation of Sprinkler Systems, NFPA 13-2013, does not include sprinkler system design criteria for upright ESFR sprinklers having a nominal discharge coefficient of K=363 L/min/(bar$^{0.5}$) (25.2 gpm/psig$^{0.5}$). When installed in an upright orientation, the water discharged from the sprinkler is obstructed by the supply piping making it

more difficult for the sprinkler to suppress a fire when the fire origin is located directly beneath the supply piping. This is one of reasons why most ESFR sprinklers are generally designed to be installed in the pendent orientation.

3. **Water Deflector Constructed Similar to a Deflector Used for an Extended Coverage Sprinkler Rather Than an ESFR Sprinkler –** The upright ESFR sprinkler having a nominal discharge coefficient of K=363 L/min/(bar$^{0.5}$) (25.2 gpm/psig$^{0.5}$) was visually observed to be constructed in a manner similar to a currently UL certified extended coverage storage sprinkler having a nominal discharge coefficient of K=363 L/min/(bar$^{0.5}$) (25.2 gpm/psig$^{0.5}$). The water distribution pattern for an extended coverage sprinkler is significantly different compared to an ESFR sprinkler. Furthermore, the design criteria described in NFPA 13-2013 for extended coverage sprinklers for storage protection are substantially different from ESFR sprinkler system design criteria. As an example, the following table illustrates some of the differences in design criteria for ESFR and extended coverage sprinklers for storage protection at their maximum ceiling height and at 9.1 m (30 ft) ceilings:

Sprinkler Type	Type of Protection	Maximum Storage Height, m(ft)	Ceiling Height, m(ft)	Minimum Design Pressure, bar (psi)	NFPA 13-2013 Reference
Pendent K=25.2 ESFR	Cartoned, unexpanded Group A plastic in open racks	12.2 (40)	Maximum = 13.7 (45)	2.8 (40)	Table 17.3.3.1
Upright K=25.2 EC	Cartoned, unexpanded Group A plastic in open racks	9.1 (30)	Maximum= 10.6 (35)	2.8 (40)	Table 21.3.2
Pendent K=25.2 ESFR	Cartoned, unexpanded Group A plastic in open racks	7.6 (25)	9.1 (30)	1.0 (15)	Table 17.3.3.1
Upright K=25.2 EC	Cartoned, unexpanded Group A plastic in open racks	7.6 (25)	9.1 (30)	2.1 (30)	Table 21.3.2

4. **Inferior and Inconsistent Construction –** Inferior materials of construction were used for some of the components which may lead to premature sprinkler degradation and corrosion. The loading screws for both sprinklers were able to be removed with relative ease which indicated that they were insufficiently staked to maintain the factory applied load. Also, some of the components were visually observed to have inconsistent dimensional characteristics.

5. **Performance Test Results –** Limited testing conducted in general accordance with ANSI/UL 1767 yielded several non-compliant results such as (1) slow response

characteristics or non-operation, (2) lodgment of operating parts during activation which adversely impacted the sprinkler discharge characteristics, and (3) deformation of the sprinkler caused by the discharge of water at high pressure. A summary of the results is included in the following table:

Test Description (ANSI/UL 1767)	**K202 ESFR Samples**	**K363 ESFR Samples**
Flow Endurance in Upright Orientation (Sec 22)	Non-compliant	Non-compliant
Leakage & Hydrostatic (Sec 24 & 25)	Acceptable result	Acceptable result
Operating Temperature Bath (Sec 29)	Not tested	Non-compliant
Sensitivity Oven Heat (Sec 31)	Non-compliant	Non-compliant
Operation - Lodgment in Upright Orientation, 1.7, 3.4, 5.2, 6.9 and 8.6 bar (25, 50, 75, 100 & 125 psig) (Sec 32)	Non-compliant	Could not complete testing due to inability to operate some of the samples
Heat Resistance (Sec 34)	Acceptable result	Acceptable result
10 Day Salt Spray (Section 39.2)	Not tested	Non-compliant
Stress Corrosion Cracking Brass Parts - Parts made of high zinc brass (Sec 45)	No Stress Cracking Noted	Stress Cracking of Button
Stress Corrosion Cracking Stainless Steel Parts (Sec 46)	Stress Cracking of Lever	Stress Cracking of Strut

In summary, the potential safety deficiencies described herein are believed to raise serious concerns regarding the ability of these sprinklers to provide the level of protection intended for sprinkler systems referenced in NFPA 13. Some of these deficiencies are likely to cause failure of the sprinkler system to suppress or control a fire.

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1 INTRODUCTION

This report includes the results of UL's testing of unused Early Suppression Fast Response (ESFR) sprinkler samples that were reported to be representative of sprinklers installed in several existing storage facilities located in China. The sprinklers were not marked as being certified by UL or any other certification organization.

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Two general types of upright style sprinklers, both marked as being ESFR sprinklers, were evaluated (20 samples of each construction). The first sprinkler construction was marked "ESFR-202/68°C," suggesting the sprinkler had a nominal discharge coefficient of K=202 L/min/(bar$^{0.5}$) (14.0 gpm/psig$^{0.5}$) with a temperature rating of 68°C (155°F). The second construction was marked "ESFR-363" and "74°C" suggesting the sprinkler had a nominal discharge coefficient of K=363 L/min/(bar$^{0.5}$) (25.2 gpm/psig$^{0.5}$) with a temperature rating of 74°C (165°F).

NOTE

This Report was prepared as an account of a testing conducted by UL. In no event shall UL be responsible for whatever use or nonuse is made of the information contained in this Report and in no event shall UL, its employees, or its agents incur any obligation or liability for damages arising out of or in connection with the use, or the inability to use, information contained in this Report.

2 MATERIAL ANALYSIS

2.1 MATERIALS OF CONSTRUCTION:

METHOD

The materials of construction were identified using an X-ray fluorescence (XRF) analyzer in accordance with the procedures recommended by the analyzer manufacturer.

The components of one representative sample of each Model ESFR-363 and ESFR-202 sprinkler were tested. Where applicable, coatings were removed and the specimens cleaned to ensure that the base material was identified. Testing of each specimen was conducted in three different areas of the specimen.

RESULTS

The closest material match for each sprinkler part is referenced in Figure 1 and Figure 2.

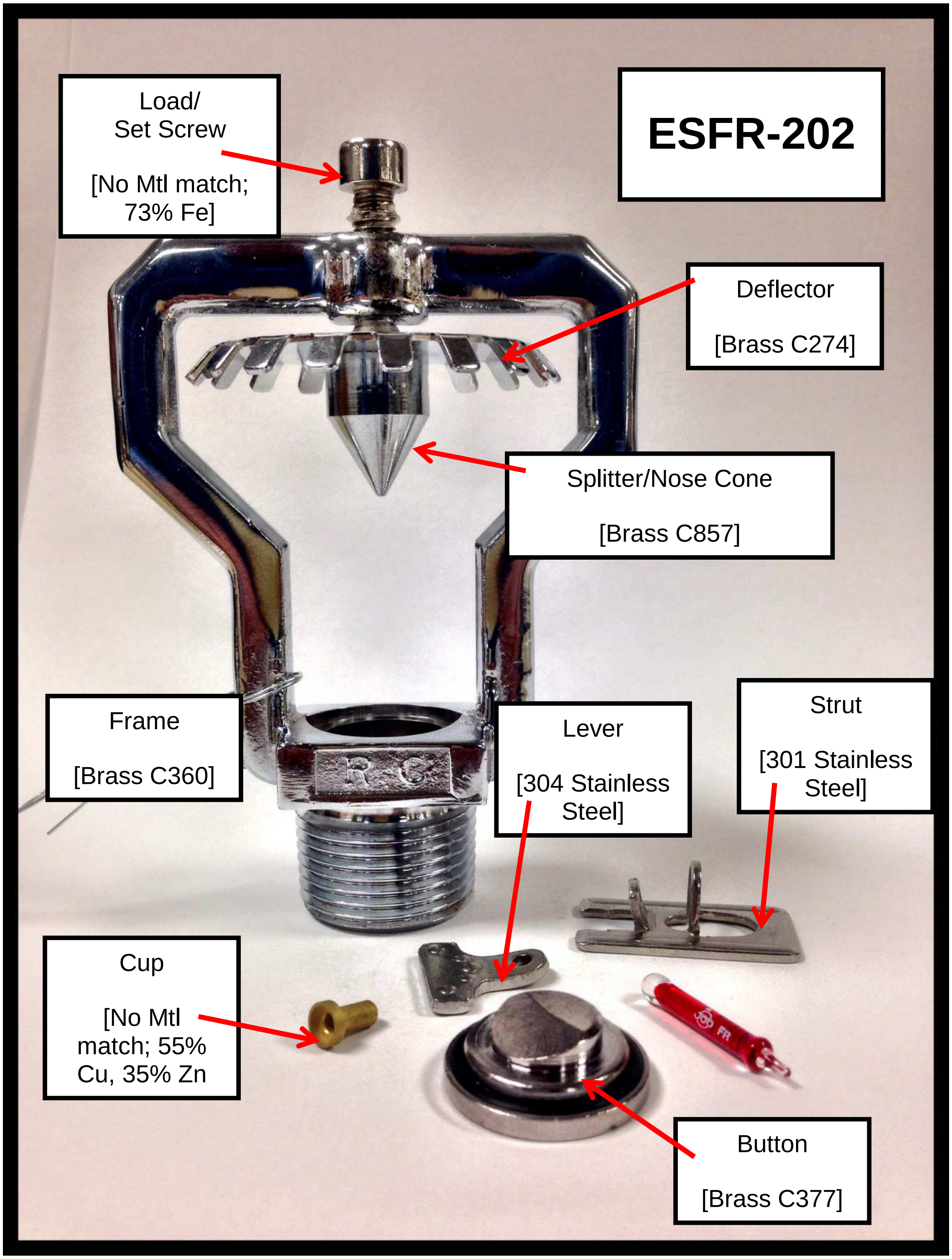

Figure 1 Model ESFR-202, Material Analysis

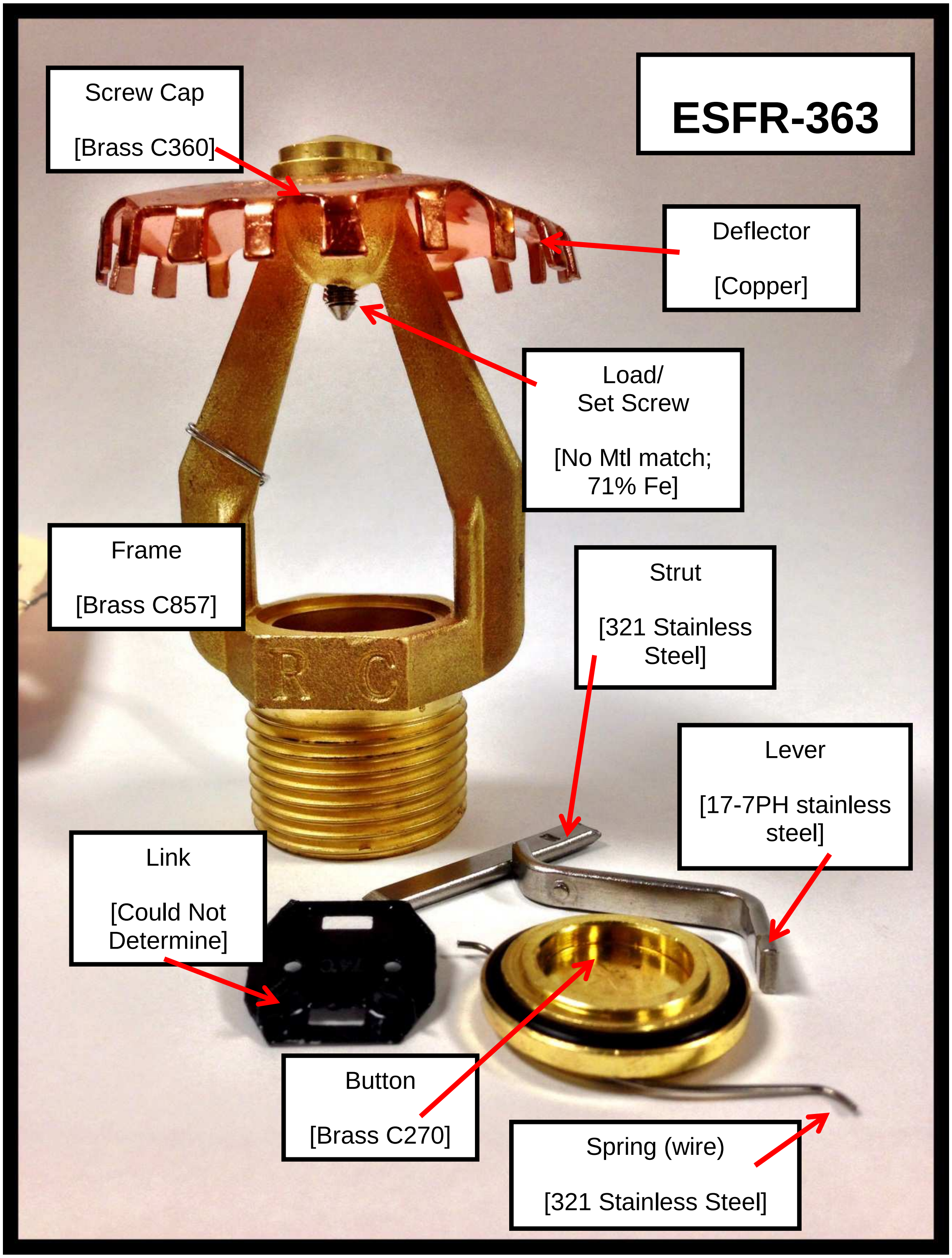

Figure 2 Model ESFR-363, Material Analysis

3 PERFORMANCE TESTING

3.1 EXAMINATION OF SAMPLES:

METHOD

Representative samples of both the Models ESFR-363 and ESFR-202 sprinklers were visually examined for any obvious differences in the construction within the two different ESFR sprinkler models.

RESULTS

The Model ESFR-363 sprinkler samples appeared to be constructed in a similar manner, with the exception of the loading screw lengths. See Figure 3 for an example of the varying difference in length amongst.

The ESFR-363 sprinkler utilized a deflector construction intended for use on an Extended Coverage Storage sprinkler, not an ESFR sprinkler as marked. See Figure 4 for a visual comparison of a UL certified ESFR sprinkler vs. the submitted ESFR-363.

The Model ESFR-202 sprinkler samples appeared to be constructed in a similar manner, with the exception of the loading screw lengths (similar to that shown in Figure 3) and two different cup constructions (See Figure 5).

Both of the Models ESFR-363 and ESFR-202 utilized a dynamic O-ring type water seal which has not been permitted in ANSI/UL 1767 since January 9, 2003.

During the examination and testing of sprinkler components, it was observed that the loading screw for both sprinkler constructions were removed with relative ease which indicated that they were insufficiently staked to maintain the factory applied load.

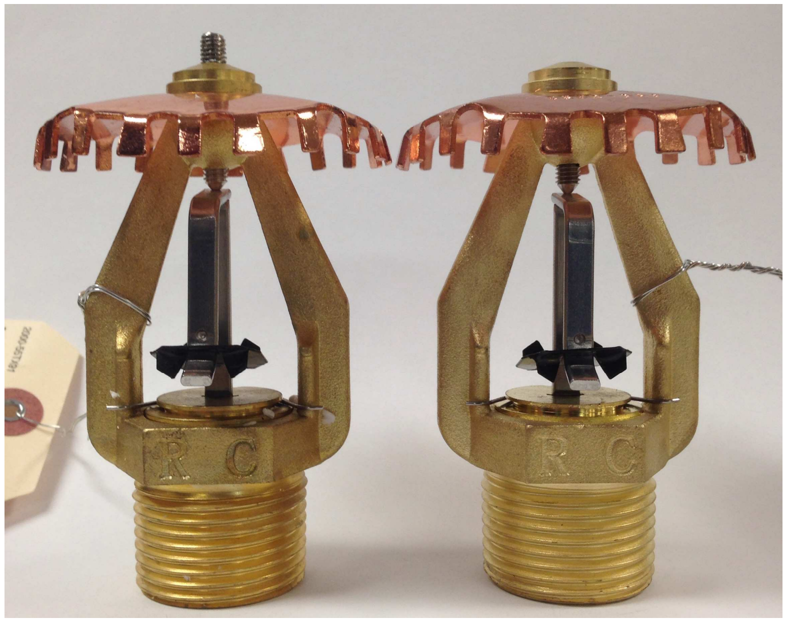

Figure 3 Model ESFR-363 Construction Inconsistencies – Load Screw

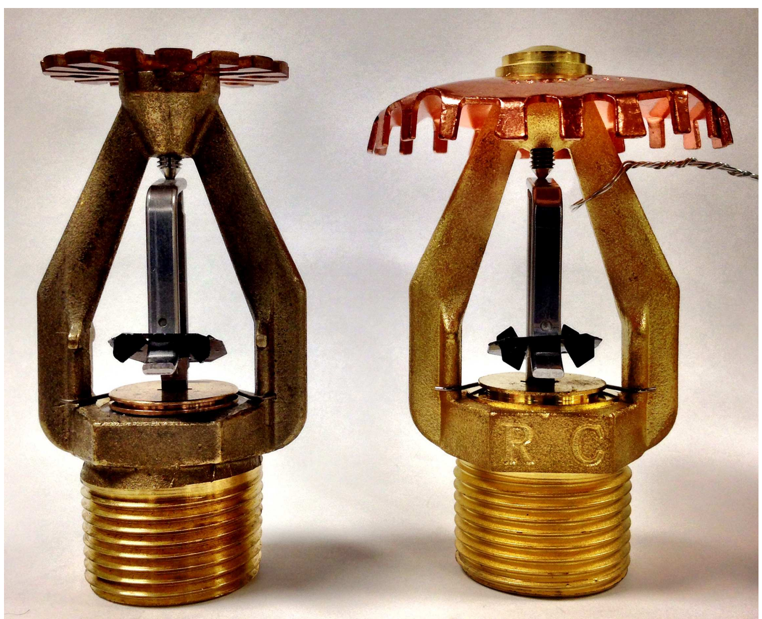

Figure 4 UL Certified ESFR sprinkler (left) vs. ESFR-363 (right) – Deflector

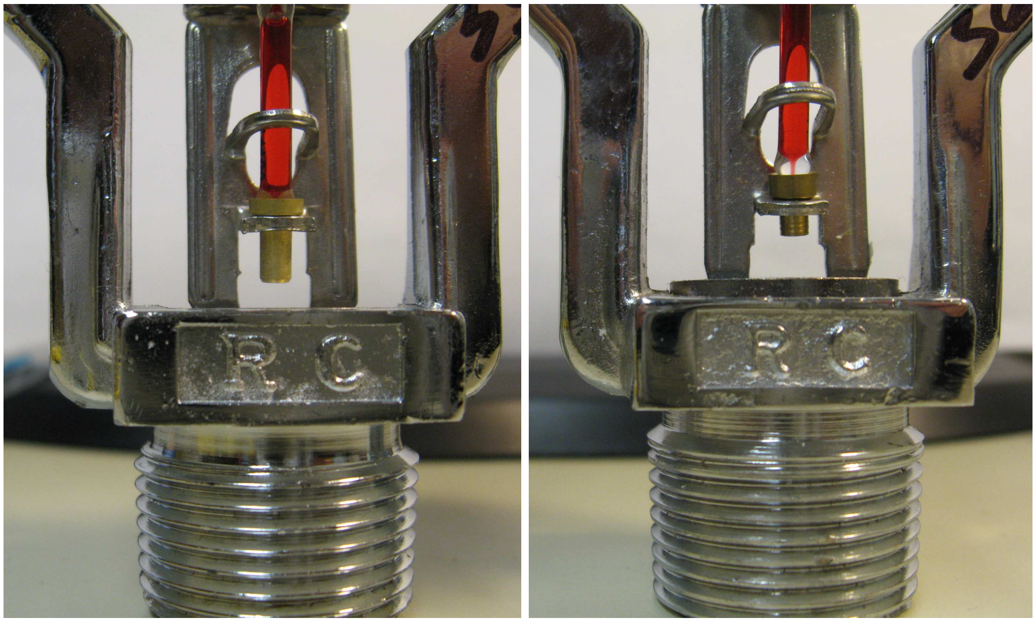

Figure 5 ESFR-202, Construction Inconsistencies – Cup

3.2 FLOW ENDURANCE TEST:

METHOD

One sprinkler sample of each Model ESFR-363 and ESFR-202 sprinkler was installed onto a piping arrangement and supplied with water at a service pressure of 13.8 bar (200 psig), which is 1.7 bar (25 psig) greater than rated pressure. Each sample was operated by exposing the heat responsive element to a uniform application of heat. Once each sample operated, the inlet pressure at the sprinkler was maintained at 13.8 bar (200 psig) for a period of 30 min.

RESULTS

Both sprinkler models showed substantial visual deformation as illustrated in the following photos designated as Figure 6 and Figure 7. This deformation significantly altered the distribution characteristics of each sprinkler model.

Note: For comparison purposes, the sprinkler shown on the left side of the photo was subjected to the Flow Endurance Test, while the sprinkler on the right was not.

Figure 6 ESFR-363, Post-Flow Endurance Test – Deflector Deformation

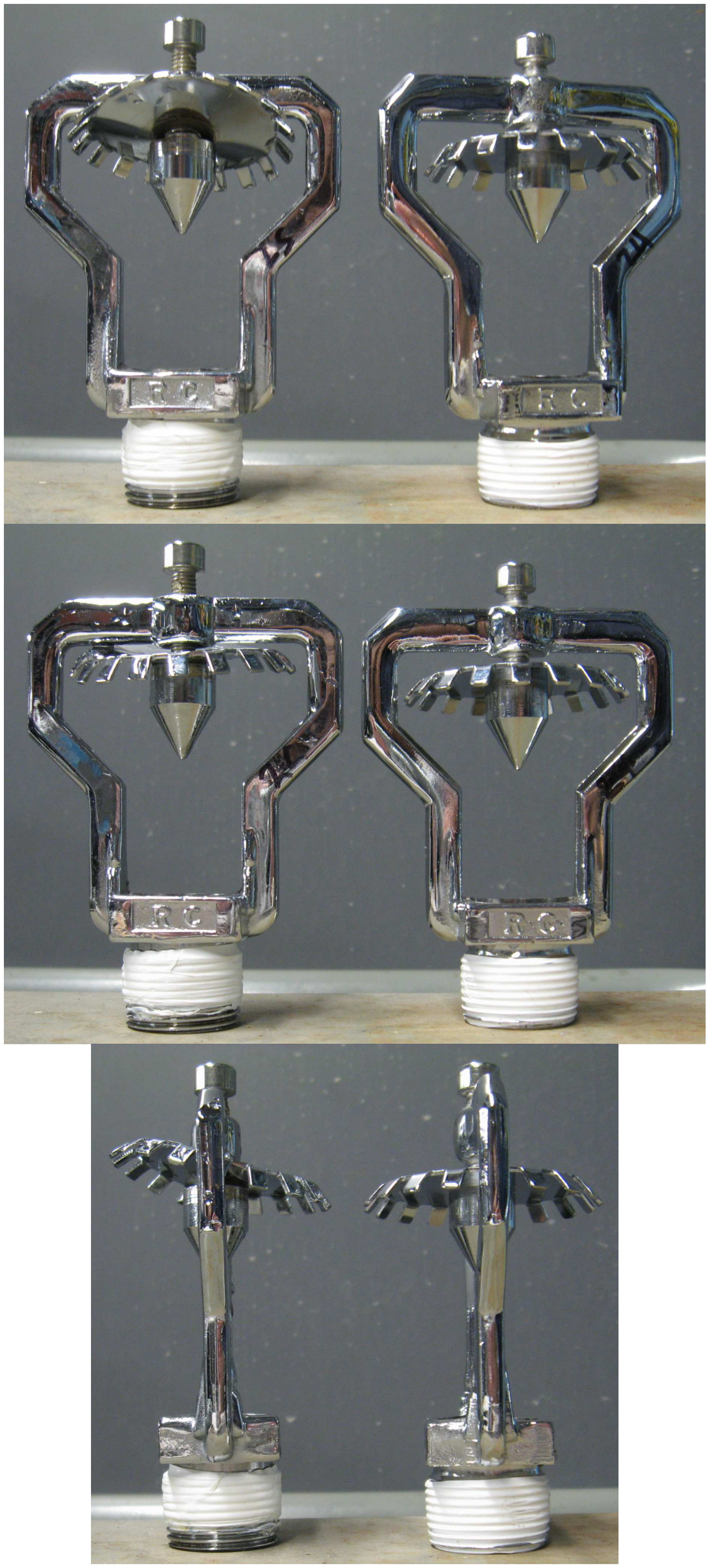

Figure 7 ESFR-202, Post-Flow Endurance Test – Deflector Deformation

3.3 LEAKAGE AND HYDROSTATIC STRENGTH TEST:

METHOD

One sample of each Model ESFR-363 and ESFR-202 sprinkler was individually subjected to a hydrostatic pressure of 34 bar (500 psig) for 1 min. Subsequently, the pressure was then gradually increased to 48 bar (700 psig) and held for 1 min.

RESULTS

No leakage was observed when 34 bar (500 psig) was applied to the inlet and no rupture occurred when 48 bar (700 psig) was applied to the inlet.

3.4 OPERATING TEMPERATURE (BATH) TEST:

METHOD

Two samples of the Model ESFR-363 sprinkler were placed in a liquid oil bath. The temperature of the bath was increased rapidly to within 20°F above the rated temperature of the sprinklers, and then gradually increased at a rate not exceeding 1°F/min until all samples operated. The temperature of the bath when each sample operated was recorded.

RESULTS

The results are presented in Table 1.

Table 1 OPERATING TEMPERATURE BATH TEST

Sprinkler Nominal			
Sample No.	Temperature Rating, °C (°F)	Operating Temperature, °C (°F)	Allowable Operating Range, °C (°F)
6	74 (165)	Did not operate – Test terminated at 100 °C (212 °F)	70 to 77 (159 to 170)
13	74 (165)	Did not operate – Test terminated at 100 °C (212 °F)	70 to 77 (159 to 170)

3.5 SENSITIVITY TEST:

METHOD

Two sample ESFR-363 and four representative sample ESFR-202 sprinklers were conditioned to approximately 24 °C (75 °F) for at least 2 h prior to testing. Each sample was connected to a source of air at a pressure of 0.28 ± 0.07 bar (4 ± 1 psig) and then plunged into a heated air flow in the pendent position at an air velocity of 2.54 m/s (8.33 ft/s) with the oven temperature at 135 °C (275 °F) as specified in the ANSI/UL 1767. The time required for each sprinkler to operate was electronically recorded. The response time index, RTI, for each sprinkler was calculated using the following equations:

$$\mathbf{RTI = Tu^{1/2}}$$

$$\mathbf{T = t_o / \ln [1-(Tr/Tg)]}$$

Where:

t_o = sprinkler operating time, seconds
Tr = mean sprinkler operating temperature from the operating temperature test less the conditioning temperature, °C
Tg = airstream temperature minus room ambient, °C
u = airstream velocity, in meter per second

RESULTS

The results are presented in Table 2.

Table 2 SENSITIVITY OVEN HEAT TEST

Sample No.	Sprinkler Identification	Temperature Rating, °C (°F)	Element Orientation to Air Flow	Operating Time, s	RTI, $(m\text{-}sec)^{1/2}$	Maximum RTI Permitted in UL 1767
3	ESFR-363	74 (165)	90° From Most Favorable	184.33	496	36
4				4 min DNO	-	36
23	ESFR-202	68 (155)	90° From Most Favorable	11.00	35	36
24				18.60	58	36
35	ESFR-202	68 (155)	Most Favorable	11.59	35	36
36				11.53	35	36

3.6 OPERATION - LODGMENT TEST:

METHOD

Sample sprinklers of each of the Model ESFR-363 and ESFR-202 sprinklers were used in this test. The sprinklers were individually installed in their intended operating position and supplied with water at pressures of 1.7, 3.4, 5.2, 6.9 and 8.6 bar (25, 50, 75, 100 and 125 psig). As noted, some samples were arranged with a single-feed water supply and some with a double-feed water supply. Each sprinkler was then operated by exposing the heat responsive element to a heated air stream discharging from an electric heat gun. The sprinkler inlet pressure and action of the operating parts, when released, were observed.

RESULTS

The results are presented in Table 3.

Table 3 OPERATION LODGEMENT TEST

<table>
<tr><th>Sample No.</th><th>Sprinkler Identification</th><th>Type of Water Supply Feed</th><th>Inlet Pressure, bar (psig)</th><th>Comments</th></tr>
<tr><td>5</td><td rowspan="7">ESFR-363</td><td>Single</td><td>1.7 (25)</td><td>Operated as intended</td></tr>
<tr><td>6</td><td>Double</td><td>1.7 (25)</td><td>Did not operate</td></tr>
<tr><td>7*</td><td>Single</td><td>3.4 (50)</td><td rowspan="4">Operated as intended</td></tr>
<tr><td>8*</td><td>Double</td><td>3.4 (50)</td></tr>
<tr><td>9*</td><td>Single</td><td>5.2 (75)</td></tr>
<tr><td>10*</td><td>Double</td><td>5.2 (75)</td></tr>
<tr><td>11*</td><td>Single</td><td>6.9 (100)</td><td>Testing discontinued due to inability to operate some of the sprinklers even when a propane torch was directed to the sprinkler’s heat responsive element</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td>25</td><td rowspan="9">ESFR-202</td><td>Single</td><td>1.7 (25)</td><td>Operated as intended</td></tr>
<tr><td>26</td><td>Single</td><td>3.4 (50)</td><td rowspan="8">The strut lodged on/against the splitter [See Figure 8], negatively impacting the water discharge pattern by causing a large quantity of water to be discharged above the deflector, as depicted in Figure 9.</td></tr>
<tr><td>27</td><td>Double</td><td>3.4 (50)</td></tr>
<tr><td>28</td><td>Single</td><td>5.2 (75)</td></tr>
<tr><td>29</td><td>Double</td><td>5.2 (75)</td></tr>
<tr><td>30</td><td>Single</td><td>6.9 (100)</td></tr>
<tr><td>31</td><td>Double</td><td>6.9 (100)</td></tr>
<tr><td>32</td><td>Single</td><td>8.6(125)</td></tr>
<tr><td>33</td><td>Double</td><td>8.6 (125)</td></tr>
</table>

* Due to the inability to operate Sample 6, some paint was removed from the link joints for Samples 7-11 to expose the solder.

Figure 8 ESFR-202, Non-compliant Lodgment Test

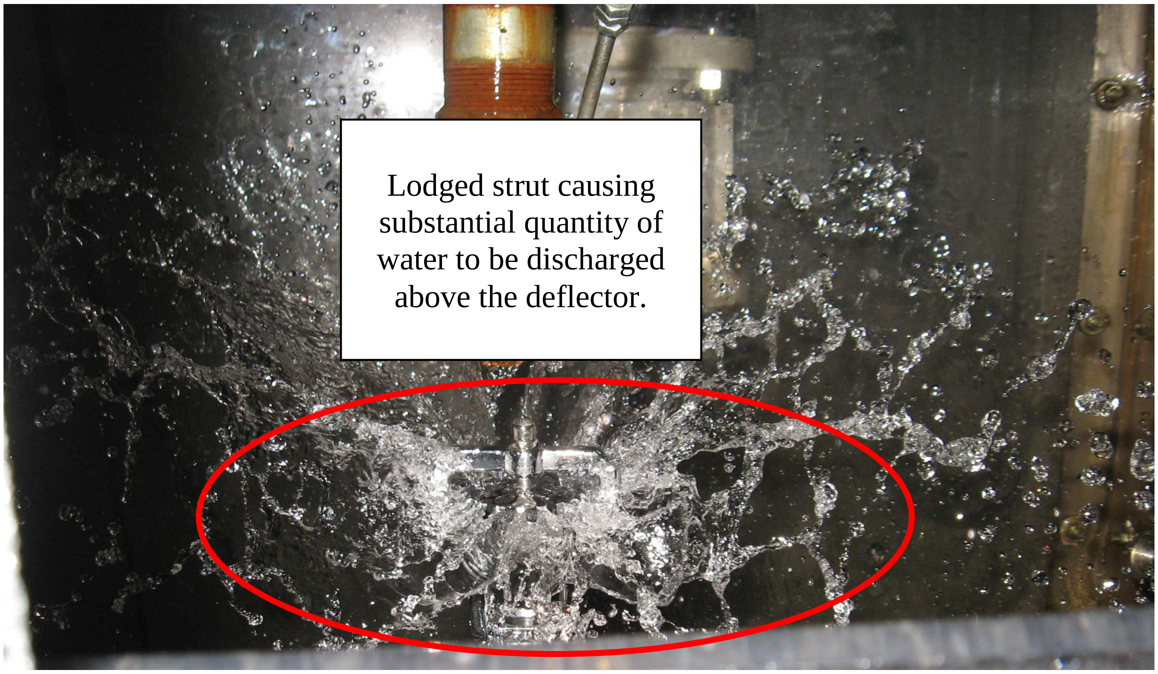

Figure 9 ESFR-202, Lodgment Test – Flow Pattern Impacted by Lodgment

3.7 HEAT RESISTANCE TEST:

METHOD

One sample of each of the Model ESFR-363 and ESFR-202 sprinklers, without operating parts, was placed vertically on its inlet in an oven heated to 650 ±10°C (1200 ±20°F) for 15 minutes, as shown in Figure 10. Following this exposure, each sample was removed from the oven and immediately submersed in a water bath having a temperature of 15 ±6°C (60 ±10°F). The samples were then examined for signs of fracture, deformation, or other damage, as specified in ANSI/UL 1767.

RESULTS

The samples withstood the exposure to the heat and subsequent water immersion without significant deformation, blistering, cracking or other damage which would impair its discharge characteristics. See Figure 11 for post-exposure photo of each tested sample.

Figure 10 Heat Resistance Samples – Test Set-Up

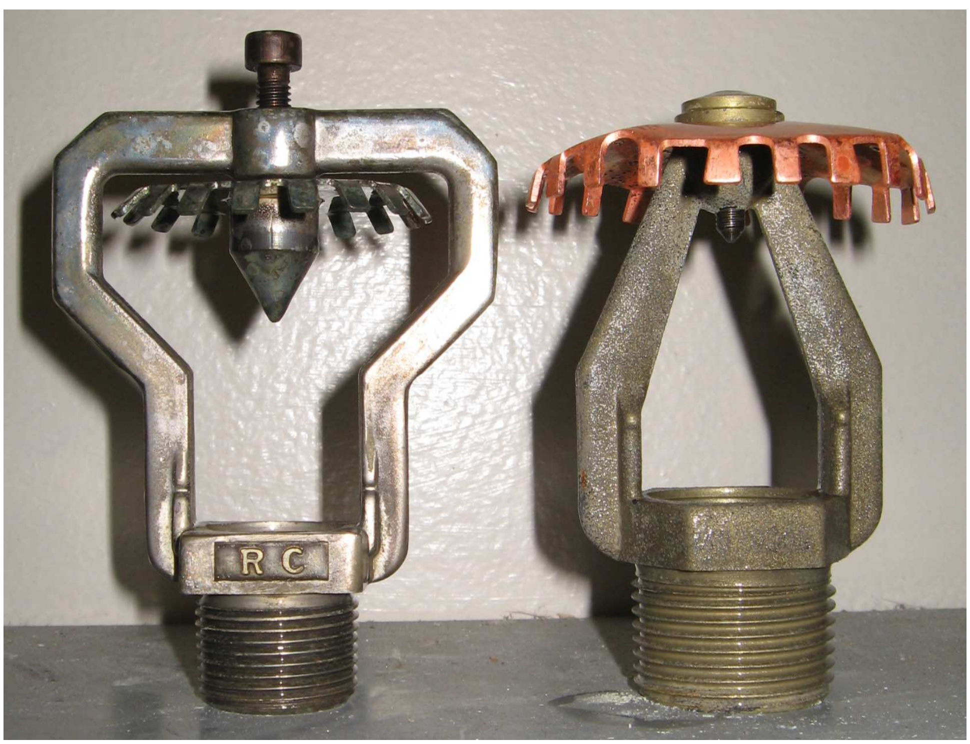

Figure 11 ESFR-202 & ESFR-363 – Post-Heat Resistance Test

3.8 10-DAY SALT SPRAY TEST:

METHOD

Five samples of the Model ESFR-363 sprinklers were supported vertically in a salt spray chamber as specified in ASTM B117, except that the salt solution consisted of a 20 percent by weight of common salt (sodium chloride) as specified in ANSI/UL 1767. Following the ten day exposure to the salt spray environment, the samples were subjected to the Sensitivity Test, per Section 31.

RESULTS

The Sensitivity Test results are presented in Table 4. See Figure 12 for a post-exposure photo of the sprinklers prior to Sprinkler Sensitivity testing. See Figure 13 for photos of the two sprinklers that did not operate after being subjected to the Sensitivity Test.

Table 4 RESPONSE TIME INDEX FOLLOWING 10-DAY SALT SPRAY EXPOSURE

Sample No.	**Sprinkler Identification**	**Temperature Rating, °C (°F)**	**Element Position**	**Operating Time, s**	**RTI, (m-sec)$^{1/2}$**	**Maximum RTI Permitted in UL 1767**
15	ESFR-363	74 (165)	Most Favorable	37.41	102	36
16				41.89	115	
17				DNO*	-	
18				DNO*	-	
19				73.85	202	

*Did not operate within 240 seconds at which point the test was terminated.

Figure 12 ESFR-363 Post-10-Day Salt Spray Exposure

Figure 13 ESFR-363 10-Day Corrosion Samples, Post-Sensitivity Test

3.9 STRESS CORROSION CRACKING TEST OF BRASS SPRINKLER PARTS:

METHOD

One sample of each brass component containing a high zinc content, from both the Models ESFR-363 and ESFR-202 sprinklers, was degreased and exposed to a moist ammonia-air mixture in a glass chamber. Aqueous ammonia having a specific gravity of 0.94 was placed at the bottom of the chamber approximately 38 mm (1 1/2 inch) below the bottom of the samples. The moist ammonia-air mixture inlet chamber was maintained at a temperature of 34°C (92°F).

After exposure to this atmosphere for a period of ten days, the samples were removed from the chamber and subjected to a visual examination for cracking of the parts tested using a 25X microscope.

RESULTS

The results are presented in Table 5.

Table 5 STRESS CORROSION CRACKING TEST OF BRASS SPRINKLER PARTS

Sample No.	**Sprinkler Identification**	**Brass Component Tested**	**Comments**
3	ESFR-363	Frame	No cracking was observed.
		Screw Cap	No cracking was observed.
		Button	Cracking observed. See Figure 14 for 25x magnified image confirming cracking.
23	ESFR-202	Cup	No cracking was observed.

Figure 14 ESFR-363 Button – Images of Post-Stress Corrosion Cracking of Brass Parts Test

3.10 STRESS-CORROSION CRACKING TEST OF STAINLESS STEEL SPRINKLER PARTS:

METHOD

One sample of each stainless steel part, from both the Models ESFR-363 and ESFR-202 sprinklers, was placed in a glass flask which was fitted with a thermometer and a wet condenser approximately 0.76 m (30 in.) long. The flask was filled approximately one-half full with a nominal 44 percent by weight magnesium chloride solution, placed on a thermostatically controlled electrically heated mantle; and maintained at a boiling temperature of 150°C (302°F) for 150 h.

The samples were removed from the boiling magnesium chloride solution, rinsed in de-ionized water, and subjected to a visual examination for cracking of the parts tested using a 25X microscope.

RESULTS

The results are presented in Table 6.

Table 6 STRESS CORROSION CRACKING TEST OF STAINLESS STEEL SPRINKLER PARTS

Sample No.	**Sprinkler Identification**	**Stainless Steel Component Tested**	**Comments**
3	ESFR-363	Strut	Cracking observed. See Figure 15 for 25x magnified image confirming cracking.
		Lever	No cracking was observed.
		Wire Spring	No cracking was observed.
23	ESFR-202	Strut	No cracking was observed.
		Lever	Cracking observed. See Figure 16 for 25x magnified image confirming cracking.

Figure 15 ESFR-363 Strut – Images of Post-Stress Corrosion Cracking of Stainless Steel Parts Test

Figure 16 ESFR-202 Lever – Images of Post-Stress Corrosion Cracking of Stainless Steel Parts Test

SUMMARY

The potential safety deficiencies described herein are believed to raise serious concerns regarding the ability of these sprinklers to provide the level of protection intended for sprinkler systems referenced in NFPA 13. Some of these deficiencies are likely to cause failure of the sprinkler system to suppress or control a fire.

The following describes some of the key areas of potential safety deficiencies that were identified as a part of UL's investigation having a limited scope:

1. **O-ring Water Seals –** Both sprinkler constructions utilized an O-ring style water seal assembly. O-rings have not been permitted in UL certified sprinkler constructions since January 9, 2003 due to the potential for this type of water seal construction to leak or not permit the discharge of water from a sprinkler after exposure to field installation environments. Previous UL research indicated that elastomeric O-ring water seals used in sprinklers have the potential to adhere to the mating surface and are susceptible to the collection of corrosion and other products in the small annular spaces between the operating parts causing inhibited sprinkler operation. The following link provides an example of a product recall issued on O-ring sealed sprinklers: http://www.cpsc.gov/en/recalls/2001/cpsc-central-sprinkler-company-announce-voluntary-recall-to-replace-o-ring-fire-sprinklers/

2. **Upright Installation Orientation –** Both sprinklers were constructed to be installed in the upright orientation. Currently, there are no UL certified ESFR sprinklers intended to be installed in the upright orientation. Also, the Standard for the Installation of Sprinkler Systems, NFPA 13-2013, does not include sprinkler system design criteria for upright ESFR sprinklers having a nominal discharge coefficient of K=363 L/min/(bar$^{0.5}$) (25.2 gpm/psig$^{0.5}$). When installed in an upright orientation, the water discharged from the sprinkler is obstructed by the supply piping making it more difficult for the sprinkler to suppress a fire when the fire origin is located directly beneath the supply piping. This is one of reasons why most ESFR sprinklers are generally designed to be installed in the pendent orientation.

3. **Water Deflector Constructed Similar to a Deflector Used for an Extended Coverage Sprinkler Rather Than an ESFR Sprinkler –** The upright ESFR sprinkler having a nominal discharge coefficient of K=363 L/min/(bar$^{0.5}$) (25.2 gpm/psig$^{0.5}$) was visually observed to be constructed in a manner similar to a currently UL certified extended coverage storage sprinkler having a nominal discharge coefficient of K=363 L/min/(bar$^{0.5}$) (25.2 gpm/psig$^{0.5}$). The water distribution pattern for an extended coverage sprinkler is significantly different compared to an ESFR sprinkler. Furthermore, the design criteria described in NFPA 13-2013 for extended coverage sprinklers for storage protection are substantially different from ESFR sprinkler system design criteria.

4. **Inferior and Inconsistent Construction –** Inferior materials of construction were used for some of the components which may lead to premature sprinkler degradation and corrosion. The loading screws for both sprinklers were able to be removed with relative ease which indicated that they were insufficiently staked to maintain the factory applied load. Also, some of the components were visually observed to have inconsistent dimensional characteristics.

5. **Performance Test Results –** Limited testing conducted in general accordance with ANSI/UL 1767 yielded several non-compliant results such as (1) slow response characteristics or non-operation, (2) lodgment of operating parts during activation which adversely impacted the sprinkler discharge characteristics, and (3) deformation of the sprinkler caused by the discharge of water at high pressure. A summary of the results is included in the following table:

Test Description (ANSI/UL 1767)	**K202 ESFR Samples**	**K363 ESFR Samples**
Flow Endurance in Upright Orientation (Sec 22)	Non-compliant	Non-compliant
Leakage & Hydrostatic (Sec 24 & 25)	Acceptable result	Acceptable result
Operating Temperature Bath (Sec 29)	Not tested	Non-compliant
Sensitivity Oven Heat (Sec 31)	Non-compliant	Non-compliant
Operation - Lodgment in Upright Orientation, 1.7, 3.4, 5.2, 6.9 and 8.6 bar (25, 50, 75, 100 & 125 psig) (Sec 32)	Non-compliant	Could not complete testing due to inability to operate some of the samples
Heat Resistance (Sec 34)	Acceptable result	Acceptable result
10 Day Salt Spray (Section 39.2)	Not tested	Non-compliant
Stress Corrosion Cracking Brass Parts - Parts made of high zinc brass (Sec 45)	No Stress Cracking Noted	Stress Cracking of Button
Stress Corrosion Cracking Stainless Steel Parts (Sec 46)	Stress Cracking of Lever	Stress Cracking of Strut

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