Evaluation of Model ZSTX-15 SSP and ZSTZ-15 SSU Non-Certified 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 standard spray pendent (SSP) and standard spray upright (SSU) sprinkler samples that were reported to be removed from a parking garage in Brazil, South America. The sprinklers were not marked as being certified by UL or any other certification organization.

UL certified standard spray automatic sprinklers are required to comply with ANSI/UL 199, Standard for Automatic Sprinklers for Fire Protection Service, which includes more than 40 performance tests to investigate the ability of the sprinkler to provide the intended level of safety when installed in field applications. Due to the quantity of and condition of some of the samples available for testing, the scope of the UL's investigation was limited compared to the extensive testing required for UL certification.

The SSP sprinkler deflector was marked "ZSTX-15 68°C SSP 2010," which suggested a model designation of ZSTX-15, a temperature rating of 68°C (155°F) and 2010 as the year of manufacturer. The SSU sprinkler deflector was marked "ZSTZ-15 68°C SSU 2010," which suggested a model designation of ZSTZ-15, a temperature rating of 68°C (155°F) and 2010 as the year of manufacturer. Each sprinkler had a chrome finish and utilized a non-certified 5 mm Job F5 bulb with a nominal temperature rating of 68°C (155°F). In addition, the wrench boss of both the pendent and upright constructions were marked with "P A" on one side.

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. **Performance Test Results** – Limited testing conducted in general accordance with ANSI/UL 199 yielded several non-compliant results such as (1) elevated inlet pressures to release the water seal and discharge water, (2) lodgment of operating parts during activation which adversely impacted the sprinkler discharge characteristics, (3) inferior water distribution characteristics and (4) inferior fire control capabilities. A summary of the results is included in the following table:

Test Description (ANSI/UL 199)	ZSTX-15 Pendent	ZSTZ-15 Upright
X-Ray Florescence (XRF) – Metallic Material Identification	**No match to XRF library for sprinkler frame**	**No match to XRF library for sprinkler frame and cap**
Strength of Frame (Sec 19)	Not tested	Acceptable result
Rough Usage (Sec 22)	Not tested	**Non-compliant**
Flow Endurance (Se 23)	Acceptable result	Acceptable result
Leakage & Hydrostatic (Sec 24 & 25)	Acceptable result	Acceptable result
Sensitivity Oven Heat (Sec 31)	**Non-compliant**	**Non-compliant**
Operation - Lodgment in Upright Orientation (Sec 32)	**Non-compliant**	**Non-compliant**
Heat Resistance (Sec 36A)	Acceptable result	Acceptable result
10 Day Salt Spray (Sec 41)	Not tested	**Non-compliant**
Calibration (Sec 49)	Acceptable result	Acceptable result
10 Pan Distribution (Sec 50)	Acceptable result	Acceptable result
16 Pan Distribution (Sec 51)	**Non-compliant**	Acceptable result
159 Kg (350 lb) Wood Crib Fire (Sec 58)	**Non-compliant**	Not tested

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 considered to have the ability to cause failure of the sprinkler system to control a fire.

Table of Contents

Table of Figures

List of Tables

1 INTRODUCTION

This report describes the results of UL's testing of standard spray pendent (SSP) and standard spray upright (SSU) sprinkler samples that were reported to be removed from a parking garage in Brazil, South America. The sprinklers were not marked as being certified by UL or any other certification organization.

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NOTE

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 the non-certified upright and pendent 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.

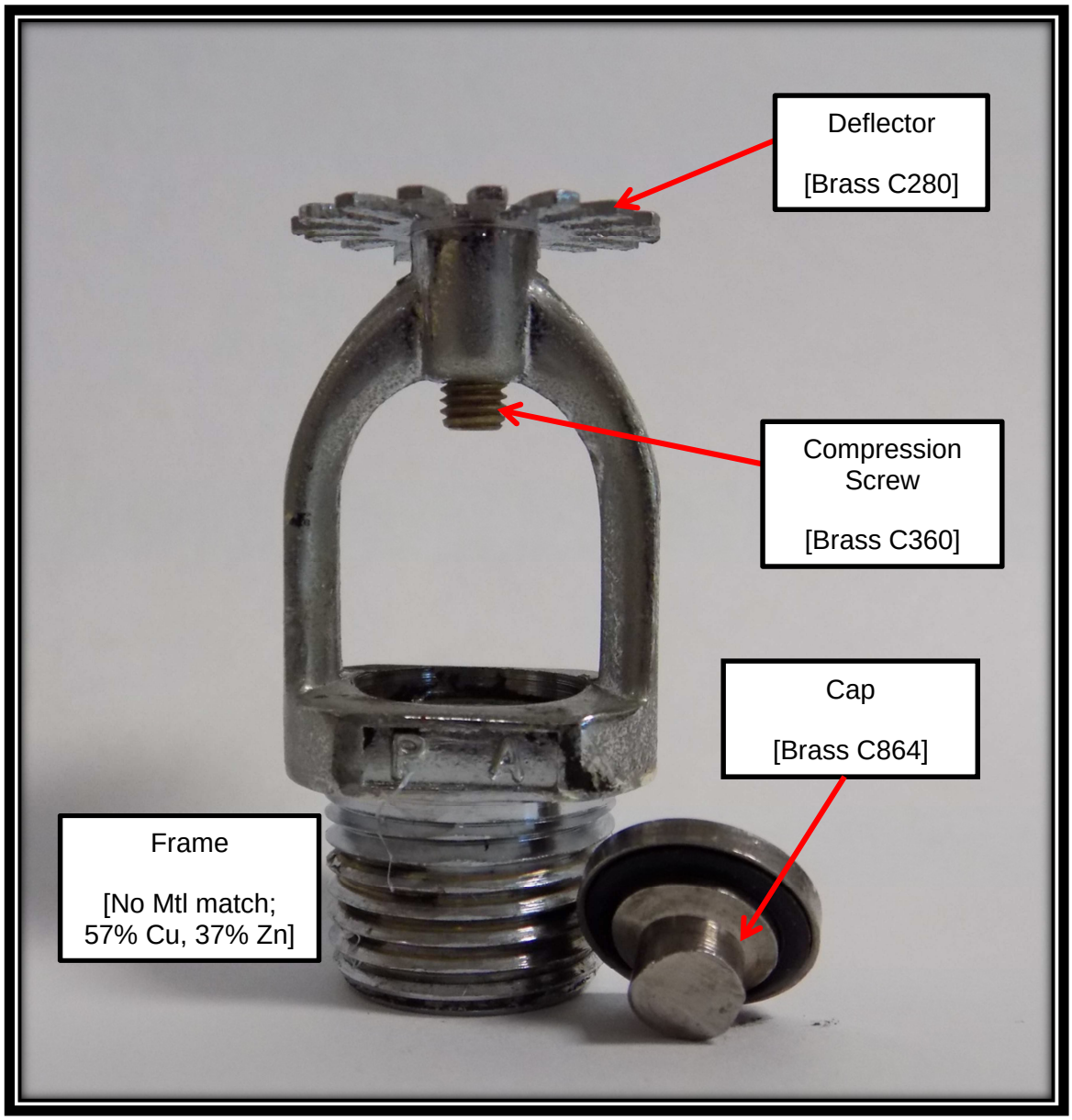

Figure 1 Non-certified Pendent, Material Analysis

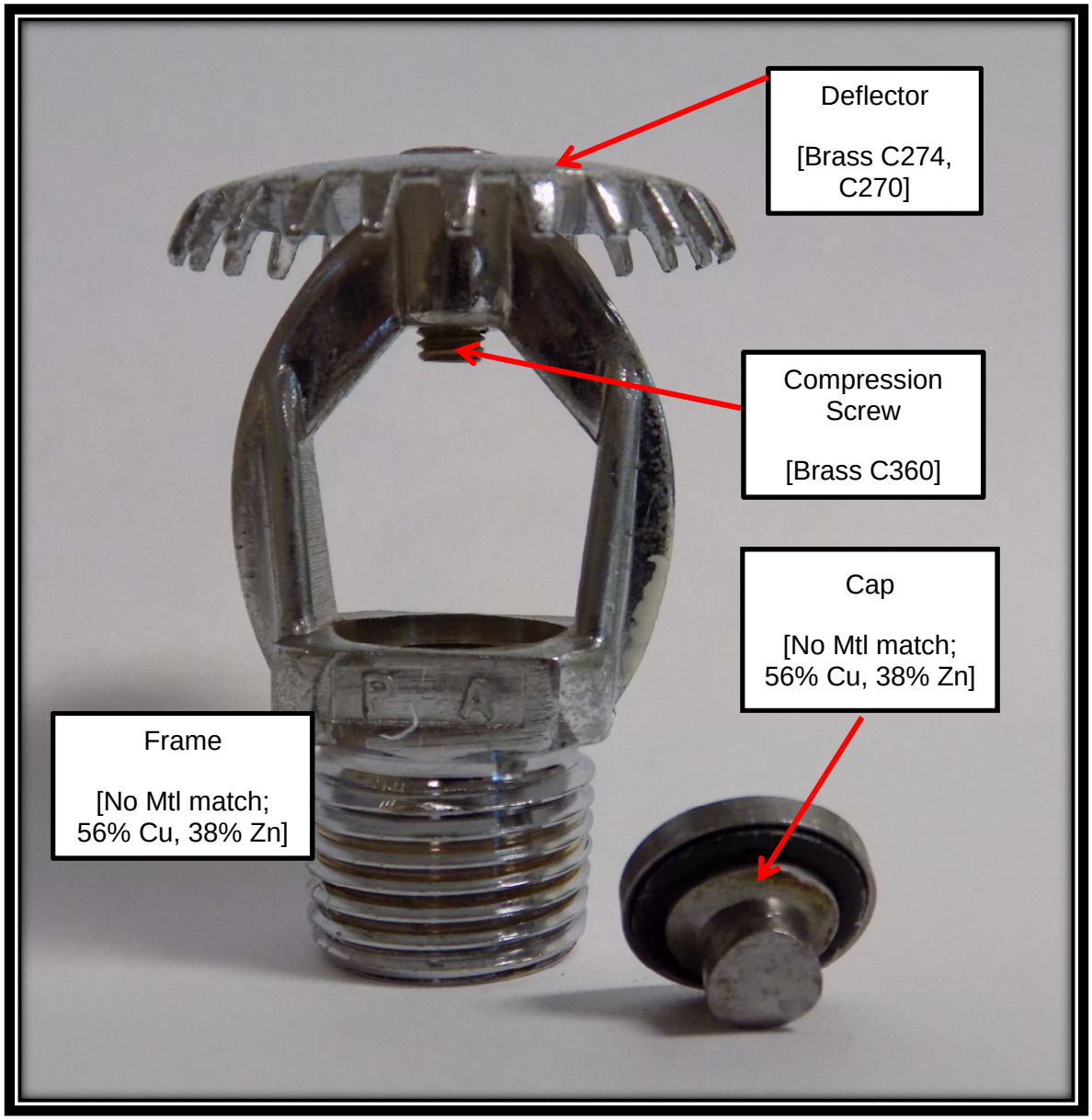

Figure 2 Non-certified Upright, Material Analysis

3 PERFORMANCE TESTING

3.1 EXAMINATION OF SAMPLES:

METHOD

Representative samples of both the Model ZSTX-15 pendent and ZSTZ-15 upright sprinklers were examined.

RESULTS

Both the Models ZSTX-15 pendent and ZSTZ-15 sprinklers utilized a dynamic O-ring type water seal, as shown in Figure 3, which has not been permitted in ANSI/UL 199 since January 9, 2003.

Figure 3 O-ring Seal

Both the Models ZSTX-15 pendent and ZSTZ-15 sprinklers utilize a non-certified 5 mm Job F5 bulb with a nominal temperature rating of 68°C (155°F) as shown in Figure 4.

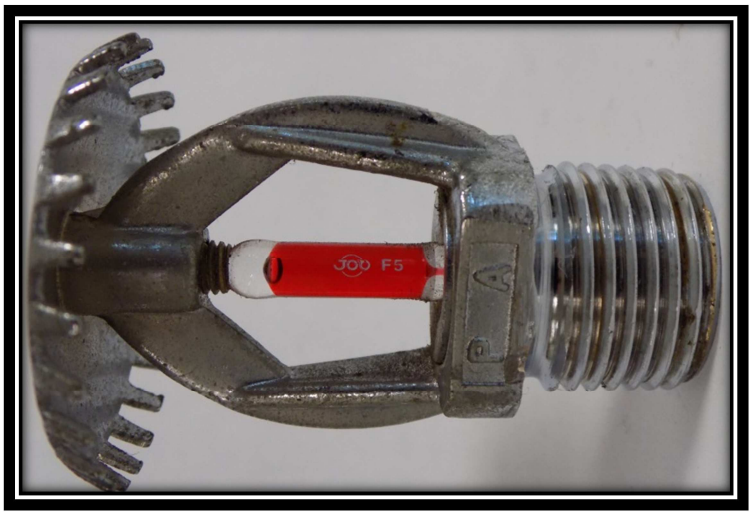

Figure 4 Job F5 5mm Bulb

Both the Models ZSTX-15 pendent and ZSTZ-15 sprinklers were provided with external pipe threads at the inlet end as specified in TABLE 1. Inlet-end pipe threads complied with the Standard for Pipe Threads, General Purpose (Inch), ANSI/ASME B1.20.1.

TABLE 1 PIPE THREADS

Nominal K-Factor, gpm/(psi)$^{1/2}$(L/min/ (bar)$^{1/2}$)	Discharge coefficient "K"		External Thread-type
	gpm/(psi)$^{1/2}$	(L^3/min/ (bar)$^{1/2}$)	Inch NPT
5.6 (80)	5.3 - 5.8	(76-84)	1/2

The pendent sprinkler construction was marked “ZSTX-15 68°C SSP 2010,” suggesting the sprinkler. The upright sprinkler construction was marked “ZSTZ-15 68°C SSU 2010”. In addition, the wrench boss of both the pendent and upright constructions were marked with “P A” on one side. See Figure 5 and Figure 6 for all markings.

Figure 5 Deflector Markings

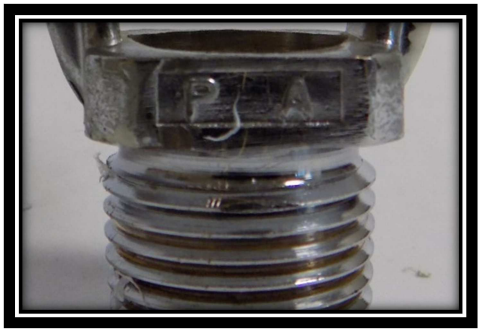

Figure 6 Wrench Boss Marking

3.2 SPRINKLER ASSEMBLY LOAD/STRENGTH OF FRAME TEST:

METHOD

Ten representative samples of the Model ZSTZ-15 upright sprinkler were used for this test.

The load impressed on the sprinkler frame due to the assembly of the operating parts into the frame was determined. Sample sprinklers were individually measured at the top of the sprinkler frame using an instrument to indicate frame deflection. The heat responsive element of the test sample was removed in a manner that did not damage the frame. The negative deflection, due to the release of the assembly, was recorded. A load was then applied to re-deflect the sprinkler frame at a rate of 0.5 mm/min (0.02 in./min) until the deflection returned to zero. This load plus the hydraulic load at rated pressure was recorded as the assembly load for each test sample.

For sprinklers using glass bulb heat responsive elements, the upper tolerance limit was then calculated in accordance with ANSI/UL 199.

The five sample sprinkler frames were then subjected to a load of twice the assembly load at rated pressure.

Each sprinkler was individually installed in a tensile testing machine and a load was uniformly applied at the base of the frame and at the apex of the frame arms, until a load of twice the assembly load at rated pressure was reached. A dial indicator was placed on a set position on the top surface of the boss of the frame and a measurement was taken before and after the load had been impressed. The amount of permanent distortion was calculated.

RESULTS

The results are presented in TABLE 2.

TABLE 2 STRENGTH OF FRAME/ASSEMBLY LOAD TEST

		Assembly Load, Kgf (lbf)				Strength of Frame Permanent Set, mm (in)	
Model	Nominal K-Factor	Min.	Max.	Upper Tolerance Limit	Results	Max.	Allowable
ZSTZ-15	5.6 (80)	20(44)	28.6(63)	39.1 (86.2)	A	0.0051 (0.0002)	0.038 (0.0015)

A – Acceptable
B - Unacceptable

3.3 ROUGH USAGE TEST:

METHOD

Five representative samples of the Model ZSTZ-15 upright sprinkler were individually placed into a vinyl-lined right hexagonal prism-shaped drum designed to provide a tumbling action. For each test, one sample sprinkler and five nominal 33.8 mm (1-1/2) in. hardwood cubes were placed in the drum. The drum was rotated at 1 r/s for 3 min.

After the Rough Usage Test, the sprinklers were visually examined for damage and subjected to the Leakage and Sensitivity-Oven Heat Tests.

RESULTS

No damage or leakage at 34 bar (500 psig) when subjected to Leakage Test after Rough Usage Exposure. Four of the five samples tested operated below the minimum time limit for standard response sprinklers when subjected to Sensitivity-Oven Heat Test.

3.4 FLOW ENDURANCE TEST:

METHOD

Two representative samples of each the ZSTX-15 and the ZSTZ-15 upright sprinkler samples were 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

None of the sprinkler samples showed signs of cracking, deformation or separation of sprinkler body or components.

3.5 LEAKAGE AND HYDROSTATIC STRENGTH TEST:

METHOD

Twenty samples of each the Model ZSTX-15 pendent and ZSTZ-15 upright sprinkler were 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.

3.6 SENSITIVITY TEST:

METHOD

Twenty samples of each the Model ZSTX-15 pendent and ZSTZ-15 upright sprinkler 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).

The time required for each sprinkler to operate was electronically recorded.

RESULTS

Six out of the ten Model ZSTX-15 pendent sprinklers operated as intended within the required operating time range of 25.6-111.9 seconds; and three sprinklers had an operating time less than the minimum allowed.

Five out of the ten Model ZSTZ-15 upright sprinklers operated as intended within the operating time range of 25.6-111.9 seconds; and three sprinklers had an operating time less than the minimum allowed. While the bulb operated on sample U109, the water seal did not release.

The results are presented in TABLE 3.

TABLE 3 SENSITIVITY OVEN HEAT TEST

Sample No.	Sprinkler Identification	Temperature Rating, °C (°F)	Element Orientation to Air Flow	Operating Time, s	Results
P75	ZSTX-15	68 (155)	Centered	27.77	A
P76				26.82	A
P77				28.65	A
P78				24.82	B
P79				41.62*	B
P80				26.33	A
P81				24.38	B
P82				28.09	A
P83				25.33	B
P84				26.46	A
U101	ZSTZ-15	68 (155)	Centered	31.10	A
U102				25.62	A
U103				25.20	B
U104				26.62	A
U105				24.71	B
U106				25.70	A
U107				63.19*	B
U108				24.25	B
U109				DNO	B
U110				28.72	A

* Bulb operated in less than 30 seconds, but the water seal did not release until the times referenced in TABLE 3.

DNO – Glass bulb operated, but the water seal did not release with the applied air pressure of 0.28 ± 0.07 bar (4 ± 1 psig). Subsequently, the sprinkler was subjected to a gradually increasing water inlet pressure to determine the pressure required to release the water seal. For sample U109, this pressure was 1.24 bar (18 psig).

A – Acceptable test results.
B – Unacceptable test results.

3.7 OPERATION - LODGMENT TEST:

METHOD

Sample sprinklers of each of the Model ZSTX-15 pendent and ZSTZ-15 upright sprinklers were used in this test. The sprinklers were individually installed in their intended operating position and supplied with water at pressures of 0.5, 1.7, 3.4, 5.2, 6.9 8.6, 10.3 and 12.1 bar (7, 25, 50, 75, 100 125 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 4 and TABLE 5.

TABLE 4 OPERATION LODGEMENT TEST – SINGLE FEED

Sample Nos.	Sprinkler Identification	Inlet Pressure, bar (psig)	Comments
P1- P5	ZSTX-15	1.7 (25)	Operated as intended
P6-P7	ZSTX-15	3.4 (50)	Operated as intended
P8			The O-ring lodged on the frame arm, adversely impacting the water discharge pattern
P9-P10			Operated as intended
P12-P15	ZSTX-15	5.2 (75)	Operated as intended
P16			The cap lodged on the frame arm, adversely impacting the water discharge pattern
P20-P21	ZSTX-15	6.9 (100)	Operated as intended
P22			The cap lodged on the frame arm, adversely impacting the water discharge pattern
P23-P24			Operated as intended
P25-P29	ZSTX-15	8.6 (125)	Operated as intended
P30-P33	ZSTX-15	10.3 (150)	Operated as intended
P34			The cap lodged on the frame arm, adversely impacting the water discharge pattern
P35-P39	ZSTX-15	12.1 (175)	Operated as intended
U21	ZSTZ-15	0.5 (7)	Operated as intended
U22		0.5 (7)	DNO [See Figure 7]
U23-U25		0.5 (7)	Operated as intended
U26-U30	ZSTZ-15	1.7 (25)	Operated as intended
U31-U35	ZSTZ-15	3.4 (50)	Operated as intended

Sample Nos.	Sprinkler Identification	Inlet Pressure, bar (psig)	Comments
U36-U40	ZSTZ-15	5.2 (75)	Operated as intended
U41-U45	ZSTZ-15	6.9 (100)	Operated as intended
U46-U50	ZSTZ-15	8.6(125)	Operated as intended
U51	ZSTZ-15	10.3 (150)	The cap lodged on the frame arm, adversely impacting the water discharge pattern
U52			Operated as intended
U53			The O-ring lodged on the set screw, adversely impacting the water discharge pattern [See Figure 8]
U54-U55			Operated as intended
U56-U57	ZSTZ-15	12.1 (175)	Operated as intended
U58		12.1 (175)	The cap lodged on the frame arms, adversely impacting the water discharge patter n[See Figure 9]
U59-U60		12.1 (175)	Operated as intended

DNO – Glass bulb operated, but the water seal did not release with the applied water pressure of 0.5 bar (7 psig). Subsequently, the sprinkler was subjected to a gradually increasing water inlet pressure to determine the pressure required to release the water seal. For sample U22, this pressure was 2.34 bar (34 psig).

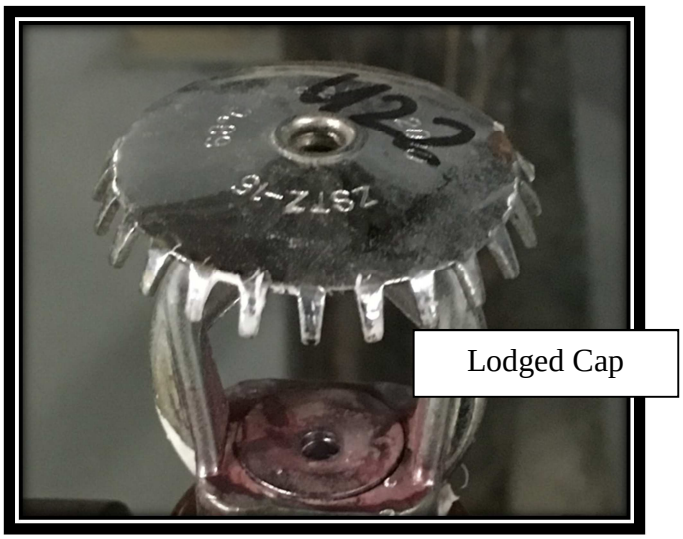

Figure 7 Sample U22 – Single Feed Upright, Non-compliant Lodgment Test

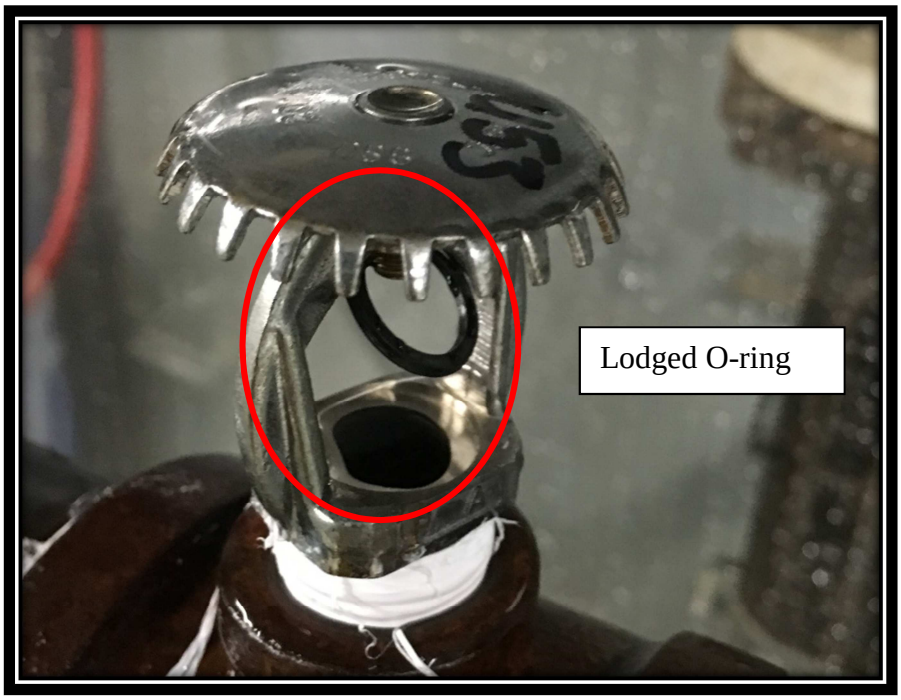

Figure 8 Sample U53 – Single Feed Upright, Non-compliant Lodgment Test

Figure 9 Sample U58 – Single Feed Upright, Non-compliant Lodgment Test

TABLE 5 OPERATION LODGEMENT TEST – DOUBLE FEED

Sample Nos.	Sprinkler Identification	Inlet Pressure, bar (psig)	Comments
P40-P44	ZSTX-15	1.7 (25)	Operated as intended
P45-P49	ZSTX-15	3.4 (50)	Operated as intended
P50-P54	ZSTX-15	5.2 (75)	Operated as intended
P55-P59	ZSTX-15	6.9 (100)	Operated as intended
P60-P61	ZSTX-15	8.6 (125)	Operated as intended
P62			The cap lodged on the frame arm, adversely impacting the water discharge pattern
P63			The cap lodged on the set screw, adversely impacting the water discharge pattern [See Figure 10]
P64			Operated as intended
P65-P69	ZSTX-15	10.3 (150)	Operated as intended
P70	ZSTX-15	12.1 (175)	The cap lodged on the set screw, adversely impacting the water discharge pattern
P71			Operated as intended
P72			The cap lodged on the set screw, adversely impacting the water discharge pattern
P73			Operated as intended
P74			Operated as intended
U61	ZSTX-15	0.5 (7)	Operated as intended
U62			DNO [See Figure 11]
U63-U65			Operated as intended
U66-U70	ZSTX-15	1.7 (25)	Operated as intended
U71-U73	ZSTX-15	3.4 (50)	Operated as intended
U74			The O-ring separated from the cap and lodged on the frame arm, adversely impacting the water discharge pattern [See Figure 12]
U75			Operated as intended
U76-U80	ZSTX-15	5.2 (75)	Operated as intended
U81-U83	ZSTX-15	6.9 (100)	Operated as intended
U84			The cap lodged on the set screw, adversely impacting the water discharge pattern
U85			Operated as intended
U86-U88	ZSTX-15	8.6 (125)	Operated as intended
U89			The cap lodged on the set screw, adversely impacting the water discharge pattern [See Figure 13 for post-test image of cap and O-ring after water exposure ended]
U90			Operated as intended
U91-U95	ZSTX-15	10.3 (150)	Operated as intended
U96-U97	ZSTX-15	12.1 (175)	Operated as intended
U98	ZSTX-15	12.1 (175)	The cap lodged on the set screw, negatively impacting the water discharge pattern [See Figure 14 for post-test image of cap and O-ring after water exposure ended]

Sample Nos.	Sprinkler Identification	Inlet Pressure, bar (psig)	Comments
U99-U100	ZSTX-15	12.1 (175)	Operated as intended

DNO – Glass bulb operated, but the water seal did not release with the applied water pressure of 0.5 bar (7 psig). Subsequently, the sprinkler was subjected to a gradually increasing water inlet pressure to determine the pressure required to release the water seal. For sample U62, this pressure was 2.14 bar (31 psig).

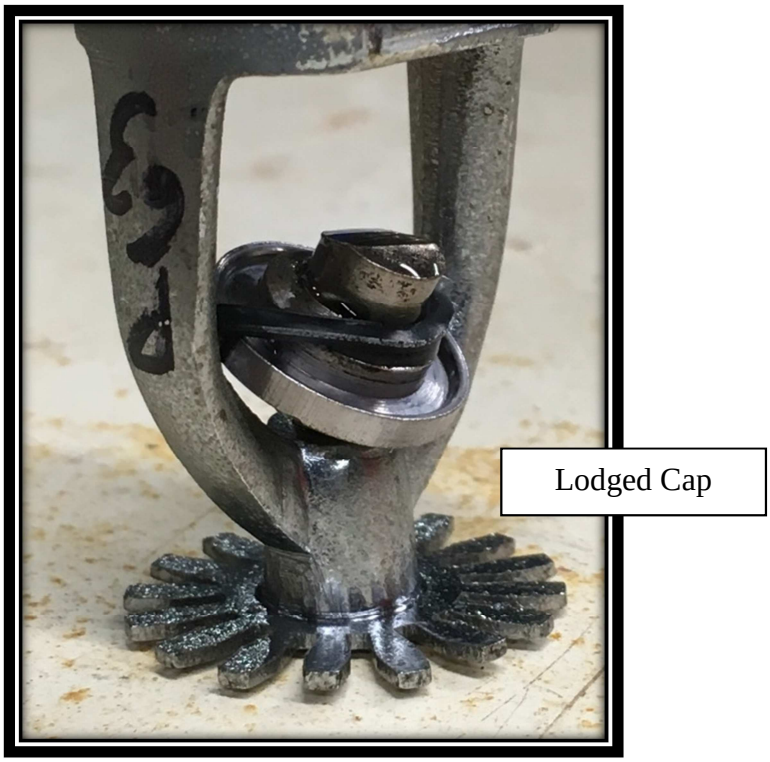

Figure 10 Sample P63 – Double Feed Pendent, Non-compliant Lodgment Test

Figure 11 Sample U62 – Double Feed Upright, Non-compliant Lodgment Test

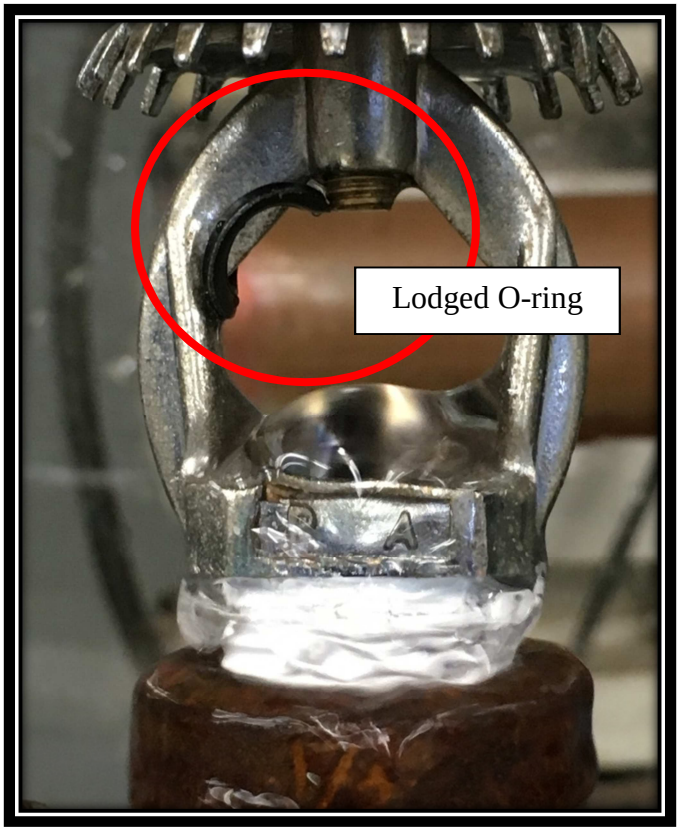

Figure 12 Sample U74 – Double Feed Upright, Non-compliant Lodgment Test

Figure 13 Sample U89 – Double Feed Upright, Non-compliant Lodgment Test

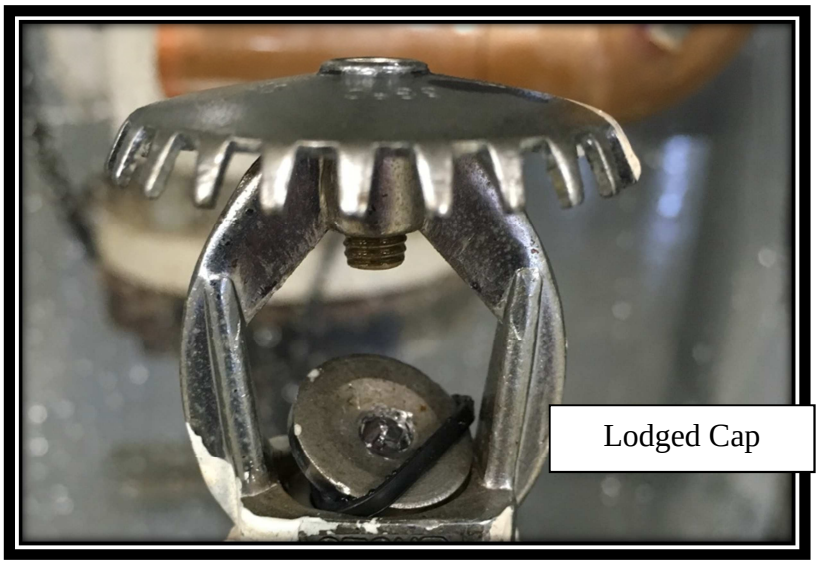

Figure 14 Sample U98 – Double Feed Upright, Non-compliant Lodgment Test

3.8 HEAT RESISTANCE TEST:

METHOD

Two samples of each of the Model ZSTX-15 pendent and ZSTZ-15 upright sprinklers, without operating parts, were placed vertically on their inlet in an oven heated to 650 ±10°C (1200 ±20°F) for 15 minutes, as shown in Figure 15. 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 199.

Figure 15 Heat Resistance Samples – Test Set Up

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.

3.9 10-DAY CORROSION (SALT SPRAY) TEST:

METHOD

Ten samples of the Model ZSTZ-15 upright sprinkler 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 199. Following the ten day exposure to the salt spray environment, the samples were subjected to the Sensitivity-Oven Heat Test.

RESULTS

The Salt Spray Corrosion Test results are unacceptable. Eight of the ten samples tested operated below the minimum time limit for standard response sprinklers when subjected to Sensitivity-Oven Heat Test, as presented in TABLE 6.

TABLE 6 RESPONSE TIME INDEX FOLLOWING 10-DAY SALT SPRAY EXPOSURE

Exposure	Sample No.	Temperature Rating, °C (°F)	Element Position	Operating Time, s
NaCl	U111	68 (155)	Most Favorable	23.13
	U112			26.94
	U113			23.82
	U114			26.89
	U115			23.69
	U116			24.72
	U117			23.66
	U118			24 *
	U119			23 *
	U120			24 *

*Slight delay between time bulb operated and the water seal released.

3.10 CALIBRATION TEST FOR 175 PSIG RATED SPRINKLERS:

METHOD

Two samples of each of the Model ZSTX-15 pendent and ZSTZ-15 upright sprinklers were installed in a hydraulic system and water was discharged through each sprinkler at predetermined pressures. The discharge capacity of each sprinkler was measured using a flowmeter in the water supply line. Flow measurements were recorded at various pressures from 0.5 to 6.9 bar (7 to 100 psig) and repeated at the same pressures from 6.9 to 0.5 bar (100 to 7 psig). The discharge coefficient "K" was then calculated.

RESULTS

The average K-factor for both the Model ZSTX-15 pendent and Model ZSTZ-15 upright sprinkler fell within the required range of 5.3-5.8 gpm/$(psi)^{1/2}$ (76-84 L/min/ $(bar)^{1/2}$)

3.11 10 PAN DISTRIBTUION TEST:

METHOD

An open Model ZSTX-15 pendent and ZSTZ-15 upright sprinkler were individually installed in its intended concealed pendent position in 1 in. tee, supplied with water by nominal 1 in. piping, flowing from one direction. The sprinkler deflector was located 17.78 cm (7 in) below a 3.66 by 3.66 m (12 by 12 ft.) ceiling. The frame arms of the sprinkler were parallel to the piping on which it was installed and the deflector was 1.22 m (4 ft.) above a row of ten 0.3 m^2 (1 ft^2) test pans.

The test pans were mounted on a motor operated rotating table. The center of the first pan was directly below the center of the sprinkler. With the pans rotating at 1 rpm water was discharged at a rate of 56.8 lpm (15 gpm).

The water was discharged for 10 min and the water collected in each pan was measured and the density was calculated

RESULTS

The results are presented in TABLE 7 and TABLE 8.

TABLE 7 MODEL ZSTX-15 PENDENT

Pan No.	0	1	2	3	4	5	6	7	8	9
Test No. 1										
mm/min	3.26	7.33	4.07	7.33	6.11	4.07	2.44	0.82	+	+
gpm/ft^2	0.08	0.18	0.10	0.18	0.15	0.10	0.06	0.02	+	+
Test No. 2										
mm/min	3.67	7.33	4.48	8.15	6.52	4.48	2.44	0.82	+	+
gpm/ft^2	0.09	0.18	0.11	0.20	0.16	0.11	0.06	0.02	+	+

+ Trace amount of water, less than 0.41 mm/min (0.01 gpm/ft2).

TABLE 8 MODEL ZSTZ-15 UPRIGHT

Pan No.	0	1	2	3	4	5	6	7	8	9
Test No. 1										
mm/min	7.33	11.00	11.00	5.70	3.26	2.04	1.63	0.82	0.41	+
Gpm/ft^2	0.18	0.27	0.27	0.14	0.08	0.05	0.04	0.02	0.01	+
Test No. 2										
mm/min	6.52	10.59	12.22	6.52	3.67	2.04	1.63	0.82	0.41	+
gpm/ft^2	0.16	0.26	0.30	0.16	0.09	0.05	0.04	0.02	0.01	+

+ Trace amount of water, less than 0.41 mm/min (0.01 gpm/ft2).

3.12 16-PAN DISTRIBUTION TEST:

METHOD

Four open Model ZSTX-15 pendent and ZSTZ-15 upright sprinklers were installed on a nominal 1 in. pipe grid in nominal 1 in. tees in their intended position with the deflectors 30.48 cm (12 in) below a 3.66 by 3.66 m (12 by 12 ft.) smooth flat horizontal ceiling. The sprinklers were placed at the corners of a 3.05 by 3.05 m (10 by 10 ft.) square area and installed with frame arms parallel to the piping. Sixteen 0.3 m^2 (1 ft^2) collection pans, located 2.29 m (7.5 ft) below the sprinkler deflectors and centered between the sprinklers were used to collect the sprinkler discharge which was at a rate of 56.8 lpm (15 gpm) per sprinkler.

Water was discharged for 10 min and the amount collected in each collection pan was measured. The discharge in gallons per minute per square foot was calculated. The test was repeated after transposing two sprinklers in the opposite corners.

RESULTS

The 16-Pan Distribution Test results for the Model ZSTX-15 pendent sprinklers were unacceptable due to measured average water collection that was less than 6.11 mm/min (0.15 gpm/ft$^{2)}$ as presented in TABLE 9.

TABLE 9 MODEL ZSTX-15 PENDENT

Test No. 1 mm/min (gpm/ft^2)			
5.30 (0.13)	4.89 (0.12)	5.70 (0.14)	8.15 (0.20)
5.30 (0.13)	4.89 (0.12)	5.30 (0.13)	6.52 (0.16)
6.11 (0.15)	4.89 (0.12)	4.48 (0.11)	5.30 (0.13)
6.11 (0.15)	5.30 (0.13)	4.48 (0.11)	4.89 (0.12)
		Mean = 5.30 (0.13)	
Test No. 2 mm/min (gpm/ft^2)			
6.11 (0.15)	5.70 (0.14)	6.93 (0.17)	8.96 (0.22)
5.30 (0.13)	5.30 (0.13)	6.11 (0.15)	8.15 (0.20)
4.89 (0.12)	4.48 (0.11)	5.30 (0.13)	6.11 (0.15)
5.30 (0.13)	4.48 (0.11)	4.48 (0.11)	5.30 (0.13)
		Mean = 5.70 (0.14)	

The 16-Pan Distribution Test results for the Model ZSTZ-15 upright sprinklers were acceptable as presented in TABLE 10.

TABLE 10 MODEL ZSTZ-15 UPRIGHT

Test No. 1 mm/min (gpm/ft^2)			
9.78 (0.24)	10.59 (0.26)	10.18 (0.25)	8.15 (0.20)
9.78 (0.24)	9.78 (0.24)	9.78 (0.24)	8.96 (0.22)
8.15 (0.20)	8.96 (0.22)	9.37 (0.23)	9.37 (0.23)
6.93 (0.17)	8.15 (0.20)	8.56 (0.21)	8.96 (0.22)
		Mean = 8.96 (0.22)	
Test No. 2 mm/min (gpm/ft^2)			
9.78 (0.24)	10.18 (0.25)	10.18 (0.25)	8.56 (0.21)
9.37 (0.23)	8.96 (0.22)	8.96 (0.22)	8.96 (0.22)
8.15 (0.20)	8.15 (0.20)	8.96 (0.22)	9.37 (0.23)
6.93 (0.17)	8.15 (0.20)	9.37 (0.23)	9.37 (0.23)
		Mean = 8.96 (0.22)	

159 KG (350 LB) WOOD CRIB FIRE TEST:

METHOD

The test fire was conducted in a room having a 4.8 m (15.75 ft) ceiling. Four open Model ZSTX-15 pendent sprinklers were installed on a 3.05 x 3.05 m (10 by 10 ft) spacing above the fire test crib with the water discharge started manually after a 1 min free burn or after the ceiling temperature reached 760°C (1400°F), whichever occurred last. In individual tests, total flows of 227 lpm (60 gpm) equivalent to 57 lpm (15 gpm) per sprinkler were established through sprinklers in their normal intended position. The deflector to ceiling distance was 31 cm (12 in). Water discharge was continued in each test for 30 min.

The standard fire test combines the use of a heptane torch with a crib of wood weighing approximately 159kg (350 lb).

The heptane torch, supplied with heptane at a rate of 3.4 lpm (0.9 gpm), was directed vertically upward from under the center of the wood crib, which is 1.2 m (4 ft) square and 55 cm (21-1/2 in) high, with its top area 2.3 m (7-1/2 ft) above the floor and 2.3 m (7-1/2) ft below the deflectors of the test sprinklers.

At the end of the 30 min test period, the flow of heptane to the torch and water flow to the sprinklers was stopped.

The wood test crib, which was weighed prior to the test, was weighed again after seven days to determine the weight loss caused during the fire exposure.

The temperature at the ceiling level was continuously recorded using a thermocouple centrally located above the test crib. The recorded temperature was reviewed for determination of the maximum temperature and the time of maximum pre-burn after the start of the fire exposure and before water discharge, 5 min after the start of water discharge and for the controlled ceiling temperature during water discharge.

RESULTS

The non-compliant results are presented in TABLE 11.

TABLE 11 159 KG (350 LB) CRIB – MODEL ZSTX-15 PENDENT

Sprinkler K-Factor	80 (5.6)
Spacing, m (ft)	3.05 x 3.05 (10 by 10)
Density, mm (gpm/ft²)	6.1 (0.15)
Flow, lpm (gpm) – total	227 (60)
Pre-Test Crib Weight, kg (lb)	162.4 (358)
Post Test Crib Weight, kg (lb)	132.4 (292)
Total Crib Weight Loss – Weight, kg (lb)	30 (66)
Total Crib Weight Loss, %	18
Time to Water Discharge, sec	72
Ambient Temperature, °C (°F)	32 (89)
Required Control Temperature, °C (°F)	326 (619)
Time to Control Temperature, min:Sec	Not achieved
Measured Temperature – Average, °C (°F)	408 (767)
Results	Non-Compliant due to high temperatures

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 considered to have the ability to cause failure of the sprinkler system to 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. **Performance Test Results** – Limited testing conducted in general accordance with ANSI/UL 199 yielded several non-compliant results such as (1) elevated inlet pressures to release the water seal and discharge water, (2) lodgment of operating parts during activation which adversely impacted the sprinkler discharge characteristics, (3) inferior water distribution characteristics and (4) inferior fire control capabilities. A summary of the results is included in the following table:

Test Description (ANSI/UL 199)	ZSTX-15 Pendent	ZSTZ-15 Upright
X-Ray Florescence (XRF) – Metallic Material Identification	**No match to XRF library for sprinkler frame**	**No match to XRF library for sprinkler frame and cap**
Strength of Frame (Sec 19)	Not tested	Acceptable result
Rough Usage (Sec 22)	Not tested	**Non-compliant**
Flow Endurance (Se 23)	Acceptable result	Acceptable result
Leakage & Hydrostatic (Sec 24 & 25)	Acceptable result	Acceptable result
Sensitivity Oven Heat (Sec 31)	**Non-compliant**	**Non-compliant**
Operation - Lodgment in Upright Orientation (Sec 32)	**Non-compliant**	**Non-compliant**
Heat Resistance (Sec 36A)	Acceptable result	Acceptable result
10 Day Salt Spray (Sec 41)	Not tested	**Non-compliant**
Calibration (Sec 49)	Acceptable result	Acceptable result
10 Pan Distribution (Sec 50)	Acceptable result	Acceptable result
16 Pan Distribution (Sec 51)	**Non-compliant**	Acceptable result
159 Kg (350 lb) Wood Crib Fire (Sec 58)	**Non-compliant**	Not tested

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