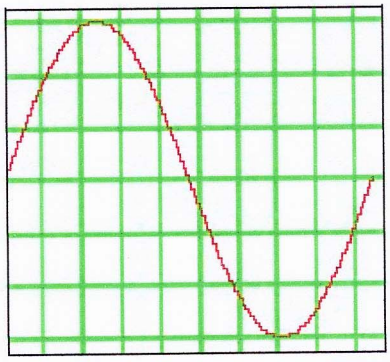
Energy Report



EDR-5348

Flammability Testing Report According to IEEE-1202 (IEEE-383)

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REF	REV	PAGE	PARA	DESCRIPTION
1	1	3	N/A	Changed Table of Contents page numbers
2	1	4	3&4	Added 2001 Sb2O3 Change
3	1	4&5	8,9,&1	Added 2011 results summary statements
4	1	5	2	Added 2011 performance statement
5	1	5	3	Corrected wire size
6	1	5	5	Added 2011 sample preparation
7	1	6	2	Added 2011 70,000 BTU/hr procedure
8	1	6	3	Added 2011 210,000 BTU/hr procedure
9	1	7	1	Added 2011 sample damage procedure
10	1	8	3	Added 2011 results table “4”.
11	1	9	1	Added 2011 test observations
12	1	9	3	Added 2011 Conclusion
13	1	10	1&3	Added 2011 Cable & WCSF ID.
14	1	17&18	N/A	Added 2011 Test Pictures

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1. INTRODUCTION

This report documents a program of vertical tray flame testing. The program constitutes a Type Test for qualification of a heat shrinkable field splicing system WCSF made of the new formulation for Class 1E electric cables for nuclear power generating stations.

Testing was conducted in the flame chamber of the Northbrook Testing Facility of the Underwriters Laboratories Inc. (UL) in accordance with IEEE Standard 1202-1991, "IEEE Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies", called for in the IEEE Standard 383-1980 "IEEE Standard for Qualification of Class 1E Electrical Cables and Field Splices for Nuclear Power Generating Stations.

In 2011, the antimony trioxide (Sb2O3) used in the WCSF compound formulation at less than 10 weight percent, was discontinued by its supplier. The antimony trioxide works synergistically with the major flame retardant. A comparable grade of antimony trioxide was identified and qualified.

The vertical flame testing was repeated on January 27, 2011 in the flame chamber at Rockbestos Surprenant Cable Corporation in accordance with IEEE 1202-2006 "Standard for Flame-Propagation of Wire and Cable" (70,000 BTU/hr), called for in the IEEE 383-2003 "Standard for Qualifying Class IE Electrical Cables and Field Splices for Nuclear Power Generating Stations". An additional vertical flame test was carried out in accordance with ICEA T-29-520 1986 "Vertical Cable Tray Flame Tests" (210,000 BTU/hr). The ICEA T-29-520, although not required for IEEE-383, is sometimes required by end users of WCSF product.

2. SUMMARY

Both spliced and un-spliced cable samples were self-extinguishing when subjected to the vertical tray flame test with a 70,000 BTU/hour propane burner heat source. The specimens did not exhibit jacket damage higher than 150 cm as required in IEEE-1202-1991, Section 7.2.

In addition, all samples were self-extinguishing when tested in accordance with IEEE 1202-1991 procedures and a 210,000 BTU/hour propane burner heat source and the specimens did not exhibit jacket damage higher than 150 cm as required in Section 7.2.

On the basis of the test results, heat shrinkable WCSF components made out of the new compound are flame test qualified as a field splicing system for Class 1E electric cables in accordance with IEEE Standard 383-1980.

Flame testing repeated in 2011 passed IEEE 1202-2006 performance criteria. The length of the cable damage for all spliced and un-spliced cable test specimens, tested using a 70,000 BTU/hour flame source, did not exceed 4.9 ft (150 cm) when measured in accordance with IEEE-1202-2006.

Additionally, the vertical flame tray test carried out at 210,000 BTU/hour in 2011 passed the ICEA T-29-520 1986 performance criteria. The length of the cable damage did not exceed the 8

ft (244 cm) requirement when measured in accordance with ICEA T-29-520 nor did the damaged length exceed 4.9 ft (150 cm).

Test results confirm the antimony oxide replacement has not adversely affected the flammability performance of WCSF product. On the basis of these test results, heat shrinkable WCSF products are flame test qualified as a field splicing system for Class 1E electric cables in accordance with IEEE Standard 383-2003.

3. SAMPLE DESCRIPTION

Field splices were installed on eight-foot lengths of seven conductor, 14 AWG insulated and jacketed control cable utilizing appropriate WCSF heat shrinkable splicing sleeves. A detailed sample description is given in Appendix I. The splices were installed in accordance with Raychem Installation Guide for WCSF Type In-Line Multi-conductor Field Splices. Each test run consisted of three spliced cables and four identical un-spliced cables to produce the tray fill required by the specification. A 12-inch cable tray with 6 inch rung spacing was used to support the samples. The spliced cables for a given test were alternated with un-spliced cables across the tray. In all cases an un-spliced cable was placed at each side of the group of samples.

For cables 13 mm (0.51”) and larger in diameter, each specimen was individually attached to the cable tray with a separation of one-half diameter between specimens. The number of cables was sufficient to fill at least the center 250 mm (9.8”) of the cable tray.

WCSF field splice samples used in the 2011 vertical flame test were installed on 8' lengths of seven conductors, 14 AWG insulated and jacketed control cable. The splices were installed per TE Connectivity Installation Guide for WCSF Type In-line Multi-conductor Field Splices. To prepare the spliced cables, each of the 7 conductors making up the cable were spliced in-line using WCSF-070-6/2-N (splice OD ~0.26", bundled OD ~0.78"). WCSF-500-38/13-N and WCSF-500-38/13-U was used over the seven spliced conductors. The governing standard specifies that the minimum conductor size construction for each cable design is to be tested to qualify all larger construction sizes. The largest wall thickness was at the seal length or overlap onto the cable. This dimension was below the application use range to maximize the material thickness. Testing this wall thickness ensures compliance to the standard and introduces some safety margin. A 12-inch cable tray with 9 inch rung spacing was used to support the samples. Each cable tray consisted of three spliced cables and four un-spliced cables to produce the tray fill requirement. The spliced and un-spliced cables were alternated across the tray. Four cable trays were prepared incorporating coated WCSF-070-6/2-N & WCSF-500-38/13-N and two cable trays were prepared incorporating coated WCSF-070-6/2-N and uncoated WCSF-500-38/13-U with S1119 adhesive used to seal the ends. See Appendix I. for a more detailed sample description. Reference Laboratory Notebook 20171-(06-08).

4. TEST PROCEDURE

A propane burner, as described in the Standard was utilized as the heat source. Flow meters calibrated by weight and the gas consumed were utilized to achieve either 70,000 or 210,000 BTU/hour gas consumption. The burner was positioned approximately two feet above the bottom of the vertical tray with the splices located so that the point of flame impingement was located at the lower end of the splice area. The burner-on time for all tests was 20 minutes. Four separate tests were run at 70,000 BTU/hour and two at 210,000 BTU/hour, utilizing different samples of cable and splicing components (Appendix I) to demonstrate reproducibility. In the first test (Sample A-1 – 70,000 BTU/hour) the splices were positioned 24 inches above the burner. For all the other tests, the splices were positions so that the point of burner flame impingement was located at the lower end of the splice.

The 2011 vertical flame test performed in accordance with IEEE-1202-2006 standard used a 70,000 BTU/hr flame. Four cable trays were tested. Two cable trays in which the spliced cables were prepared using WCSF-070-6/2-N, and WCSF-500-38/13-N and two cable trays in which the spliced cables were prepared using WCSF-070-6/2-N, WCSF-500-38/13-U, and S1119 adhesive. Spliced and un-spliced cables were positioned in the center 10 inches of a vertical 8 ft high 1 ft wide rack. The rack was placed in the flame enclosure. A 10 inch ribbon burner with a controlled air-propane mixture ignited the cables with a 70,000 BTU/hr flame. The burner was mounted on a stand a placed at 20 degrees from the horizontal with the burner ports up. The top of the burner was positioned 12 inches above the base of the cable tray and parallel to the cable tray rungs. A burner stand guide was used to place the leading edge of the burner face 3 inches from the surface of the cables. The burner flames impinged on the test specimens for 20 minutes. Following the 20 minute flame application, the flame was extinguished and the cable fire, if any, was allowed to self extinguish.

The 2011 vertical flame test performed in accordance with ICEA T-29-520 1986 standard used a 210,000 BTU/hr flame. Two cable trays in which the spliced cables were prepared using WCSF-070-6/2-N, and WCSF-500-38/13-N were tested. Spliced and un-spliced cables were positioned in the center 6 inches of a vertical 8 ft high 1 ft wide rack. The rack was placed in the flame enclosure. A 10 inch ribbon burner with a controlled air-propane mixture ignited the cables with a 210,000 BTU/hr flame. The burner was mounted on a stand and placed at 0 degrees from the horizontal. The top of the burner was positioned 12 inches above the base of the cable tray and parallel to the cable tray rungs. A burner stand guide was used to place the leading edge of the burner face 8 inches from the surface of the cables. The burner flames impinged on the test specimens for 20 minutes. Following the 20 minute flame application, the flame was extinguished and the cable fire, if any, was allowed to self extinguish.

5. RESULTS AND DISCUSSION

The maximum flame propagation height along the 2.3 m (8’) lengths of cable specimens, as measured from the lower edge of the burner face, was determined by visual observation. After each test, the maximum damage heights of the splice, cable jacket and conductor insulation were obtained. The flame height versus time was recorded and tabulated (Table 2). A summary of the test results is shown in Table 3.

The maximum flame propagation height requirement did not change as a result of the IEEE-1202 -2006 update. After each 2011 flame test, the limit of charring was determined by pressing against the cable surface with a sharp object. The limit of charring was identified when the surface of the cable changed from resilient surface to a brittle and crumbling surface. The length of cable damage was determined by measuring the distance of the charred height on the most centrally located specimens from the lower edge of the burner face. See Table 4 for 2011 flame test results. Damaged cable length was determined by this same method for test specimens tested in accordance with ICEA T-29-520 1986.

Time (min.)	Flame Height (cm)					
	Test A-1	Test A-2	Test A-3	Test A-4	Test A-5	Test A-6
1	40	40	40	40	60	75
2	50	50	50	50	75	75
3	50	50	50	50	75	75
4	50	50	50	50	75	75
5	50	50	50	50	75	75
6	50	50	50	50	100	75
7	50	40	50	50	100	100
8	50	50	50	50	125	100
9	50	50	50	50	125	100
10	50	50	50	50	125	100
11	50	50	50	50	150	150
12	50	50	50	50	150	150
13	50	50	50	50	150	150
14	50	50	50	50	125	150
15	50	50	50	50	125	150
16	50	50	50	50	100	150
17	50	50	40	50	75	150
18	50	40	40	40	75	100
19	50	40	40	40	75	100
20	50	40	40	40	60	60
Afterburn out (min:sec)	23:20	20:27	21:04	20:06	N/A	20:10

Table 2: Flame height during test

Cable specimens exhibiting jacket damage of not more than 150 cm (4’ 11”) are considered to be in compliance with requirements of the IEEE – 1202 Standard.

Cable damage is determined by measuring the distance of charring or the affected portion above the horizontal line form the lower edge of the burner face. On cable constructions that do not have charring, the limit for the affected portion is defined as the point where the overall diameter is visibly reduced or increased.

Sample – Test No.	Burner power (BTU/h)	Maximum flame height (cm)	Maximum damage height (cm)			
			Jacket			Conductor
			Melt	Char	Ash	
A-1	70,000	50	59	49	40	46
A-2	70,000	50	59	44	35	37
A-3	70,000	50	58	44	38	40
A-4	70,000	50	59	48	41	45
A-5	210,000	150	160	140	112	128
A-6	210,000	150	166	137	113	122

Table 3: Test Results

The following observations can be made with reference to the above test data and typical test sequence photographs (Appendix II):

All samples self-extinguished and were classified as non-propagating.

The WCSF splices had no effect on either jacket char or insulation damage lengths.

Portions of splicing sleeves remained intact on the cable above the flame impingement point

The 210,000 BTU/hour burner setting caused greater jacket char and insulation damage length due to the greater quantity of burning gases surrounding the cables.

Bundle ID	**Specification/Burner Output**	**Maximum Cable Damage Allowed (inches)**	**Jacket Burned Length (inches)**	**Dripping**	**Pass/Fail**
B-1	**IEEE 1202/70,000 BTU**	**59**	**21**	**None**	**Pass**
B-2	**IEEE 1202/70,000 BTU**	**59**	**26**	**None**	**Pass**
B-3	**ICEA T-29-520/210,000 BTU**	**96**	**59**	**Yes**	**Pass**
B-4	**ICEA T-29-520/210,000 BTU**	**96**	**58**	**Yes**	**Pass**
B-5	**IEEE 1202/70,000 BTU**	**59**	**27**	**None**	**Pass**
B-6	**IEEE 1202/70,000 BTU**	**59**	**19**	**None**	**Pass**

Table 4: 2011 Vertical Flame Test Results

The following 2011 vertical flame test observations were made:

All test specimens self extinguished.
All cable test specimens ceased to burn 12-15 minutes into the test.
Cables spliced with WCSF had less cable damage than un-spliced cables.

6. CONCLUSION

Both spliced and un-spliced cable samples were self-extinguishing when subjected to the vertical tray flame test with a 70,000 BTU/hour propane burner heat source as required in IEEE 1202-1991. In addition, all samples were self-extinguishing when tested in accordance with IEEE 1202-1991 procedures and a 210,000 BTU/hour propane burner heat source. On the basis of the test results, heat shrinkable WCSF components are flame test qualified in accordance with IEEE Standard 383-1980.

Flame testing repeated in 2011 passed IEEE 1202-2006 performance criteria. The length of the cable damage for all spliced and un-spliced cable test specimens, tested using a 70,000 BTU/hour flame source, did not exceed 4.9 ft (150 cm) as required in IEEE-1202-2006. Additionally, the vertical flame tray test carried out at 210,000 BTU/hour in 2011 passed the ICEA T-29-520 1986 performance criteria. The length of the cable damage did not exceed 8 ft (244 cm) as required in ICEA T-29-520. All of the spliced and un-spliced cables self-extinguished prior to the burner flame being extinguished. Test results confirm the antimony trioxide replacement has not adversely affected the flammability performance of WCSF product. On the basis of these test results, heat shrinkable WCSF products are flame test qualified as a field splicing system for Class 1E electric cables in accordance with IEEE Standard 383-2003.

APPENDIX 1. TEST SAMPLES

Cable Specifications:		**2011 Cable Specifications:**	
Manufacturer:	Rockbestos	Manufacturer:	Rockbestos Firewall III
Reel Number:	93A1418G	PCN Number:	C53-0070
Insulation Material:	XLPE	Insulation Material:	XLPE
Jacket Material:	Hypalon	Jacket Material:	Hypalon (CSPE)
Insulation Diameter:	0.14"	Insulation Diameter:	0.14"
Insulation Thickness:	0.03"	Insulation Thickness:	0.03"
Jacket Diameter:	0.5"	Jacket Thickness: Nominal Cable OD	0.045" 0.50"
Wire gauge:	14 AWG	Wire gauge:	14 AWG
Number of Conductors:	7	Number of Conductors:	7

WCSF Specifications:

Tubing	**Lot Number**
WCSF-500 (38/13)S	PT 00003 / EC20051-16 & EC20051-17
WCSF-070 (6/2)S	MSE9558-1-2-3-9-99
WCSF-500 (38/13)U	MSE95441-0-2-1-2
S1119/144 Adhesive	NA16077

2011 WCSF Specifications:

Tubing	**Lot Number**
WCSF-500 -38/13-N	Lot EP20631A
WCSF-070 (6/2)S	Lot EP 20641A
WCSF-500 (38/13)U	Lot EP20651A
S1119/144 Adhesive	446-P17232-40-2

2011 Wire Connector: Solistrand Pressure Type Wire Connectors Butt 16-14, PN 31819, Date Code 10473.

APPENDIX 2. TEST PICTURES

Before test	During the test	After the test
		

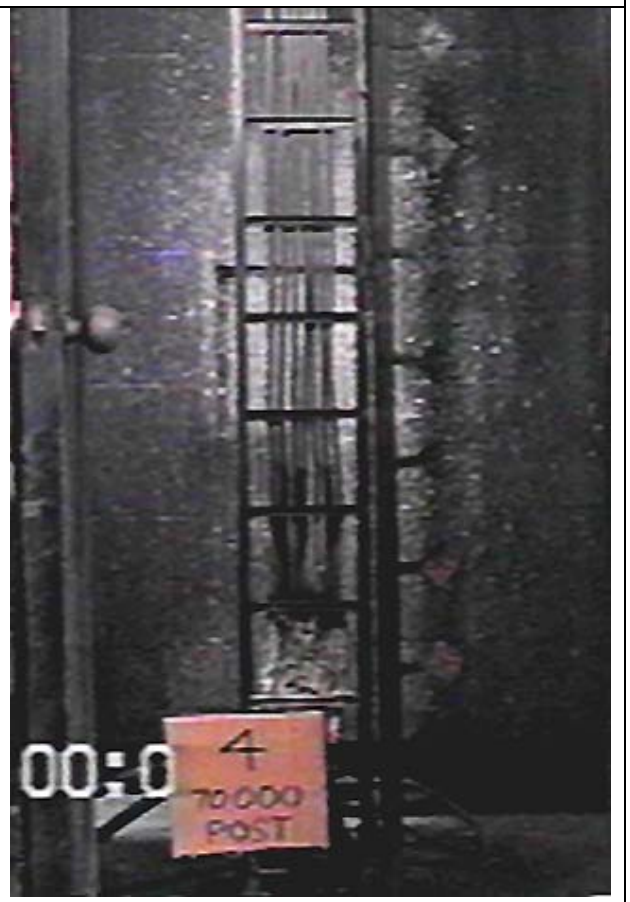
Test #A-1

Before the test	During the test	After the test
		

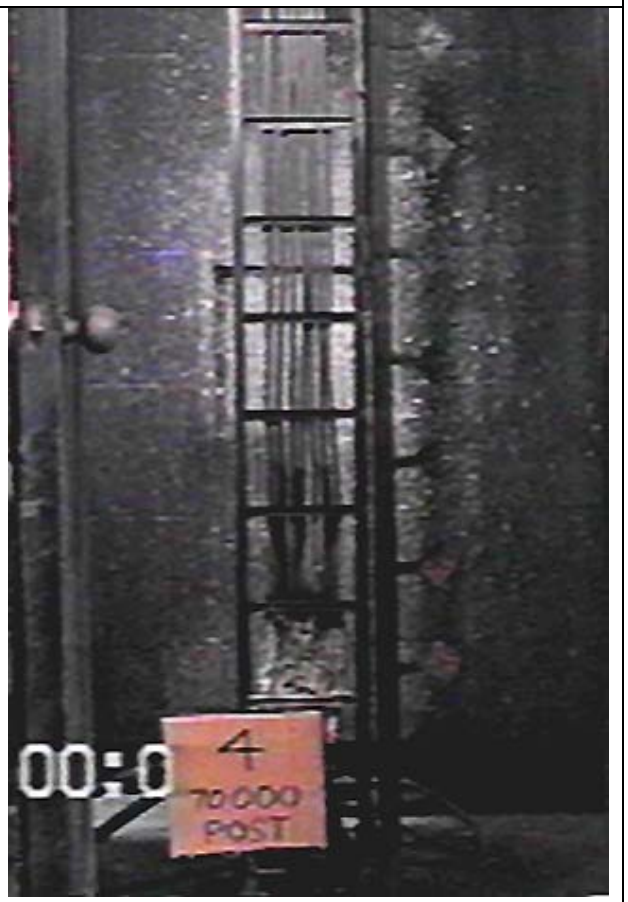
Test #A-2

Before the test	During the test	After the test
		

Test #A-3

Before the test	During the test	After the test
		

Test #A-4

Before the test	During the test	After the test
		

Test #A-5

Before the test	During the test	After the test
		

Test #A-6

2011 70,000 BTU Test

Before Test

During Test

After Test

After Test

2011 210,000 BTU Test

Before Test

During Test

During Test

After Test