

EDS NUCLEAR INC.

Test Procedure

for

Electrical Cable Penetration Fire Stops

DUANE ARNOLD ENERGY CENTER
IOWA ELECTRIC LIGHT AND POWER COMPANY

Job Number 0460-023

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Figure 1 - Standard Time-Temperature Curve for Control of Fire Tests

I. Introduction

Several different designs of electrical cable penetration fire stops have been installed at the Iowa Electric Light and Power Company's Duane Arnold Energy Center. In conjunction with the DAFC Fire Hazards Analysis Report and in response to an SER question, Iowa Electric is undertaking an electrical cable penetration testing program to establish fire resistance ratings for typical electrical cable penetration fire stop designs located throughout the plant. The resultant fire resistance test data will be used to demonstrate the adequacy of the existing cable penetration fire stops in relation to the fire loadings of areas immediately adjacent to each side of the fire stop as described in the DAFC Fire Hazards Analysis Report.

II. Purpose

This test procedure describes the methods which will be used to evaluate the duration for which different electrical cable penetration fire stop designs will contain a fire and retain their structural integrity during a standard fire test exposure. The performance of the test procedure described herein is intended to constitute a standard fire test as defined in NFPA-251 (ASTM E 119-78) and to provide fire resistance ratings for the electrical cable penetration fire stops tested.

III. Fire Test

1.0 Temperature Control

The fire tests shall be controlled by the standard time temperature curve shown in Figure 1.

1.1 Temperature of Exposed Surface

The temperature fixed by the standard time-temperature curve shall be deemed to be the average temperature obtained from the readings of not less than nine thermocouples symmetrically disposed and distributed to show the temperature near all parts of the test samples. The thermocouples shall be enclosed in sealed porcelain tubes 3/4 in. (19 mm.) in outside diameter and 1/8 in. (3 mm) in wall thickness, or, as an alternative in the case of base metal thermocouples, enclosed in sealed, standard-weight, 1/2 in. (13 mm), black

wrought steel or black wrought iron pipe. The exposed length of the pyrometer tube and thermocouple in the furnace chamber shall be not less than 12 in. (305 mm). For floors, the junction of the thermocouples shall be placed 12 inches away from the exposed face of the sample at the beginning of the test while for walls, the thermocouples shall be placed six inches away from the exposed face of the sample.

The temperatures shall be read and recorded at intervals not exceeding 5 minutes during the first 2 hours and thereafter the intervals may be increased to not more than 10 minutes.

The accuracy of the furnace control shall be such that the area under the time-temperature curve, obtained by averaging the results of the pyrometer readings, is within 10 percent of the corresponding area under the standard time-temperature curve shown in Figure 1 for fire tests of 1 hour or less duration, within 7.5 percent for those over 1 hour and not more than 2 hours, and within 5 percent for tests exceeding 2 hours in duration.

1.2 Temperature of Unexposed Surface

Temperatures of the unexposed surfaces shall be measured by thermocouples placed under flexible, dry, felted asbestos pads. The wire leads of the thermocouple or the stem of the thermometer shall have an immersion under the pad and be in contact with the unexposed surface for not less than $3\frac{1}{2}$ inches. Temperature readings shall be taken at not less than nine points on the surface of the test fixture. These points shall be on the exterior surface material, near the cable jacket/cable penetration fire stop interface and near the interface between the fire stop and through metallic components other than the insulated cable jacket for each fire stop design under test.

Temperature readings shall be taken at intervals not exceeding 15 minutes until a reading exceeding 212°F has been obtained at any one point. Thereafter the readings may be taken more frequently at the discretion of the testing body, but the intervals need not be less than 5 minutes.

The temperature end point of the fire endurance period shall be determined by the average of the measurements taken at the individual points on each respective fire stop design; except that if a temperature rise 30 percent in excess of the specified limit (cable jacket ignition temperature) occurs at any one of these points, the remainder shall be ignored and the fire endurance period judged as ended.

2. Test Samples

The samples selected for testing shall be representative of the installed configuration of cable loading and penetration fire stop size and design. The electrical cables used in the tests shall be comprised of the cable sizes and insulation materials used at the facility. All cable penetrating the fire stop should extend at least three feet on the unexposed side and at least one foot on the unexposed side of the fire stop.

3. Conduct of Fire Tests

Both wall and floor test fixtures will be available for conducting fire tests. Test samples of penetration fire stop designs installed in floors shall be tested in a floor test configuration. Test samples of penetrations fire stop designs installed in walls shall be qualified by testing in either a wall or floor test configuration.

Test samples tested in a wall test configuration shall be subjected to a hose stream test for all cases where the resistance period of the test sample is equal to or greater than one hour. The hose stream test shall be made on the specimen subjected to the fire endurance test immediately following the expiration of the fire endurance test as defined in NFPA-251 (ASTM E 119-78) and as modified by NFPA-803-78.

If a cable penetration fire stop construction is unsymmetrical (has different details on each face), a fire test exposing each side of the fire stop construction shall be required.

When several test samples are concurrently tested in the same test fixture and individual test samples fail prior to the expiration of the fire test, the openings created by the failed test samples shall be plugged and the test continued until all test samples have failed or the test is completed. Records of time of failure for each test sample shall be measured to the nearest 5 minutes and recorded.

4. Conditions of Acceptance

The fire test shall be considered successful if it meets the criteria of NFPA-803 as follows:

- a. "Fire does not propagate to the unexposed side of the test assembly nor shall there be any visible flaming on the unexposed side."
- b. "Temperature readings on the unexposed side shall not be high enough to ignite combustible material as evaluated in the fire hazard analysis."
- c. "Penetration seal does not permit projection of water from hose stream test."

IV. Format of the Fire Test Report

- 1. Title Page
- 2. Table of Contents
- 3. Description of Fire Test Facility and Tests Conducted
 - 3.1 Description of test Furnace
 - 3.2 Description of all Materials

Type, size, class, strength, densities, trade name, and any additional data necessary to define materials. The testing laboratory should indicate whether materials meet ASTM Standards by markings, or by statement of sponsor, or by physical or chemical test by the testing laboratory.

3.3 Description of Test Assembly:

- 3.3.1 Give details of structural design.
- 3.3.2 Include plan, elevation, principal cross section, plus other sections as needed for clarity.
- 3.3.3 Location of thermocouples and other items for test.

3.3.4 Describe general ambient conditions at:

- a. Time of construction,
- b. During curing (time from construction to test), and
- c. Time of Test.

3.4 Description of Test

3.4.1 Report temperature at beginning and every 5 minutes. If charts are included in report, clearly indicate time and temperature:

- a. In furnace space,
- b. On unexposed surface.

3.4.2 Report appearance of exposed face:

- a. Every 15 minutes,
- b. At any noticable development give time and details, that is, cracks, buckling, flaming, smoke, loss of material, etc.
- c. At end of the test include the amount of drop out, condition of fasteners, sag, etc.

3.4.3 Report appearance of unexposed face:

- a. Every 15 minutes,
- b. At any noticeable development including cracking, smoking, buckling, give details and time, and at the end of test.

3.4.4 Report time of failure by:

- a. Temperature rise
- b. Passage of flame-heat-smoke.

3.4.5 If a hose stream test is required describe the test apparatus and procedure. If failure occurs in hose stream test - describe the nature of the failure.

3.4.6 Provide a statement to the effect that the test construction represents facility construction. If the construction does not represent typical facility construction, then the deviations shall be noted.

3.4.7 If construction is unsymmetrical (has different details on each face) indicate the face exposed to fire.

4.0 Summary of Results, include:

4.1 Endurance time

- 4.2 Nature of failure, and
- 4.3 Hose stream test results (if required).
- 5.0 List Official Observers - Signatures of responsible persons.
- 6.0 Drawings and Photographs
 - 6.1 Drawings required for the test report
 - a. Detailed drawings of the test assembly
 - 6.2 Photographs required for the test report
 - a. Assembly in construction.
 - b. Unexposed face at end of fire endurance test.
 - c. Exposed face after hose stream test.
 - d. Unexposed face after hose stream test.
 - 6.3 Photographs taken to show what cannot be covered in the report or to add clarification
 - a. Exposed face prior to fire test.
 - b. Unexposed face at start of endurance test; include recording equipment when possible.
 - c. Exposed face at end of fire endurance test.
 - d. Unexposed face at end of fire exposure before hose test.
 - e. Exposed face at end of fire exposure before hose test.
- 7.0 Appendix - Include all data not specifically required by test standard, but useful to better understanding of test results.

STANDARD TIME-TEMPERATURE CURVE FOR CONTROL OF FIRE TESTS

Time h:min	Temperature, deg F	Area Above 68 F Base		Temperature, deg C	Area Above 20 C Base	
		deg F-min	deg F-h		deg C-min	deg C-h
0:00	68	00	0	20	00	0
0:05	1 000	2 330	39	538	1 290	22
0:10	1 300	7 740	129	704	4 300	72
0:15	1 399	14 150	236	760	7 860	131
0:20	1 462	20 970	350	795	11 650	194
0:25	1 510	28 050	468	821	15 590	260
0:30	1 550	35 360	589	843	19 650	328
0:35	1 584	42 860	714	862	23 810	397
0:40	1 613	50 510	842	878	28 060	468
0:45	1 638	58 300	971	892	32 390	540
0:50	1 661	66 200	1 103	905	36 780	613
0:55	1 681	74 220	1 237	916	41 230	687
1:00	1 700	82 330	1 372	927	45 740	762
1:05	1 718	90 540	1 509	937	50 300	838
1:10	1 735	98 830	1 647	946	54 910	915
1:15	1 750	107 200	1 787	955	59 560	993
1:20	1 765	115 650	1 928	963	64 250	1 071
1:25	1 779	124 180	2 070	971	68 990	1 150
1:30	1 792	132 760	2 213	978	73 760	1 229
1:35	1 804	141 420	2 357	985	78 560	1 309
1:40	1 815	150 120	2 502	991	83 400	1 390
1:45	1 826	158 890	2 648	996	88 280	1 471
1:50	1 835	167 700	2 795	1 001	93 170	1 553
1:55	1 843	176 550	2 942	1 006	98 080	1 635
2:00	1 850	185 440	3 091	1 010	103 020	1 717
2:10	1 862	203 330	3 389	1 017	112 960	1 882
2:20	1 875	221 330	3 689	1 024	122 960	2 049
2:30	1 888	239 470	3 991	1 031	133 040	2 217
2:40	1 900	257 720	4 295	1 038	143 180	2 386
2:50	1 912	276 110	4 602	1 045	153 390	2 556
3:00	1 925	294 610	4 910	1 052	163 670	2 728
3:10	1 938	313 250	5 221	1 059	174 030	2 900
3:20	1 950	332 000	5 533	1 066	184 450	3 074
3:30	1 962	350 890	5 848	1 072	194 940	3 249
3:40	1 975	369 890	6 165	1 079	205 500	3 425
3:50	1 988	389 030	6 484	1 086	216 130	3 602
4:00	2 000	408 280	6 805	1 093	226 820	3 780
4:10	2 012	427 670	7 128	1 100	237 590	3 960
4:20	2 025	447 180	7 453	1 107	248 430	4 140
4:30	2 038	466 810	7 780	1 114	259 340	4 322
4:40	2 050	486 560	8 110	1 121	270 310	4 505
4:50	2 062	506 450	8 441	1 128	281 360	4 689
5:00	2 075	526 450	8 774	1 135	292 470	4 874
5:10	2 088	546 580	9 110	1 142	303 660	5 061
5:20	2 100	566 840	9 447	1 149	314 910	5 248
5:30	2 112	587 220	9 787	1 156	326 240	5 437
5:40	2 125	607 730	10 129	1 163	337 630	5 627
5:50	2 138	628 360	10 473	1 170	349 090	5 818
6:00	2 150	649 120	10 819	1 177	360 620	6 010
6:10	2 162	670 000	11 167	1 184	372 230	6 204
6:20	2 175	691 010	11 517	1 191	383 900	6 398
6:30	2 188	712 140	11 869	1 198	395 640	6 594

Figure 1