

### A comparative study on the fire resistance of cables used in nuclear power plant for the fire safe shutdown capability

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가 69-1

103-16

2

3 . , USNRC KINS 2 ,

10CFR50, Appendix R 가

(NFR-8) 가

1 30 가 IEEE 383( ) IEC 60331( ) 가 가 , UL 910

2

#### Abstract

The safety systems of nuclear power plant are consisted of same two systems in terms of multiplicity which is one of the defense-in-depth strategy. Especially, the regulatory authority as USNRC, KINS requires two systems for the fire safe shutdown should be separated by the 3-hour fire resistance ratings fire barrier. But our country's nuclear power plants constructed in the early stage can not fulfill the current regulatory requirement because that nuclear power plants were constructed before the establishment of the regulatory code, 10 CFR 50, App R, .G. In this circumstances, we investigated the possibility of adoption fire resistant cable (NFR-8) to operating domestic nuclear power plant to fulfill the regulatory requirement. Test results show that the selected and reviewed fire resistant cables are met the minimum 1½ hour fire separation requirement. Therefore, we propose that the approval requirement of cable associated safe components should be strengthened by the inclusion of IEC 60331 in addition to the current IEEE 383 test standard to enhance the safety of nuclear power plant. Also, we know that proper separation distance between the two systems can be calculated using UL 910 test results.

1.

Analysis Fire Protection of Safe Shutdown Capability , 10CFR50 Fire Hazard , Appendix R, . General

Requirements, A

3가

,  
,  
,

가

( )

가

가

가

(Defense-in-Depth)  
(Redundancy)

2-Way System

가

가

.G

, A, B

10CFR50, App R,

2

3  
79.1.1

가 가

81.

가

TMI,

2-Way

system

2.

10CFR50, App R, .G

가.

( , )

(1)

3

(2)

가

20ft (6.1m)

가

(3)

1

(Fire Barrier)

(Enclosed)

- (1) 가 , 20ft
- (2) .
- (3) ,

3.

. , , 가 , .  
 1 가 , 2 , 裸 .  
 2 가 .

가.

- (1) 가 , 20ft (6.1m)  
 ( , A, B ) , 가 20ft (6.1m) ,  
 가 .

(2)

(3)

(Non-Combustible radiant shields) BTP CMEB 9.5-1  
 90 .

(1)

, 3  
 ( , ) 3  
 , , 3  
 3 (Sealant, Fire Stop )  
 3 Fire Damper .

(2)

, 20 ft 가  
 가 ( , A, B ) 20ft ,  
 가 ( , 가 )

가 가

(3) Barrier) (Enclosed) 1 (Fire

, A, B

1 가

4.

USNRC IEEE 383

USNRC IEEE 383 (integrity) IEC 60331 , 가

UL 910

가 ( NFR-8 가 CV ) EPR/CSP(Q )

가 가

(Remote Shutdown Panel, RSP)

1

1.

			(V)		AWG No.
가	'A'	EPR/CSP	600	2 C	12
		EPR/CSP	600	1 P	14
		EPR/CSP	600	9 C	14
		EPR/CSP	600	5 C	14
	'B'	EPR/CSP	600	1 P	16
		EPR/CSP	600	1 C	14
	'C'	NFR-8	600	3 C	2 mm

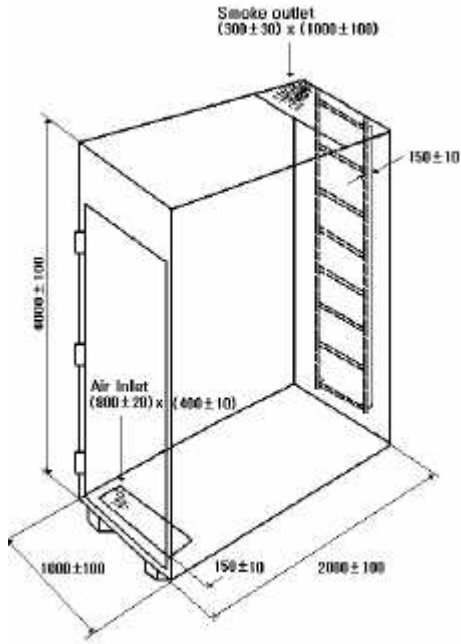
(1) IEEE 383 ( )

Class IE

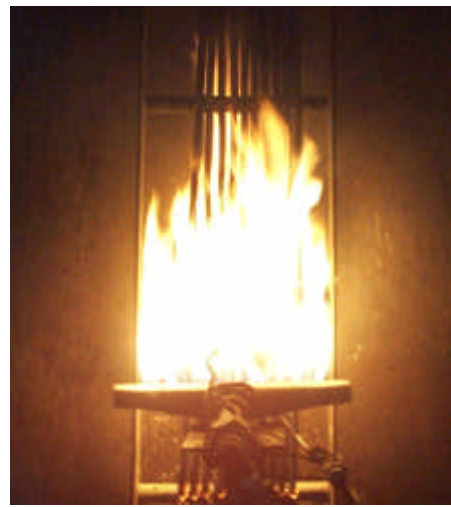
20  
가

가

. IEEE 383



1 IEEE383



2 IEEE383

(2) IEC 60331 ( )

(Integrity)

- Part 11 : 750
- Part 21 : 0.6/1 kV
- Part 22 : 1 kV
- Part 23 : DATA
- Part 25 :

가

가

가

가

가  
15 가  
가 Burner  
Lamp가 )

90 가 Burner

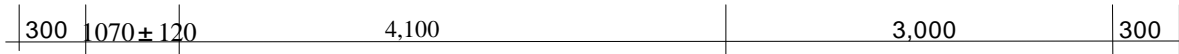
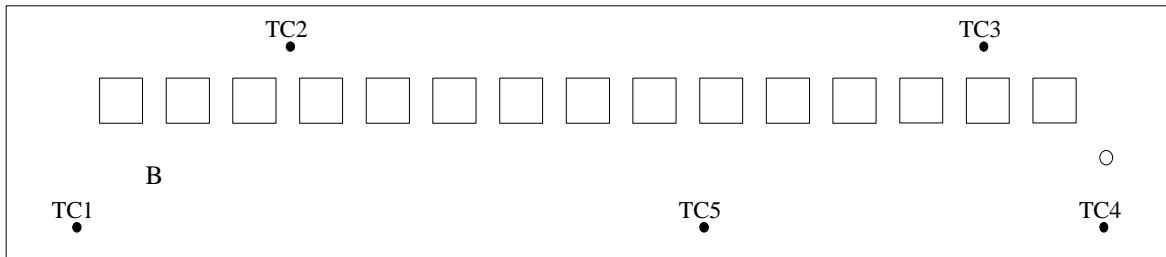
. 3 IEC 60331 . (



3 IEC 60331

(3) UL 910 ( )

가  
 가 20  
 137cm )  
 Cable-Tray,  
 152 cm( Grouped Cable  
 2.89 m = UL 910  
 가 Burner 1.37m +  
 4 UL 910 Test Test Chamber,  
 5



TC : Thermocouple, B : Burner, O : Chamber

4 UL 910 Test chamber



( )

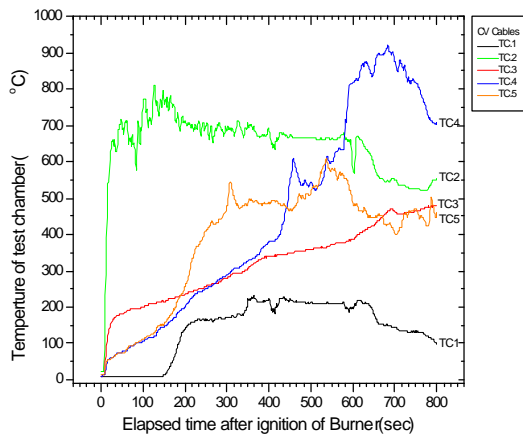
5



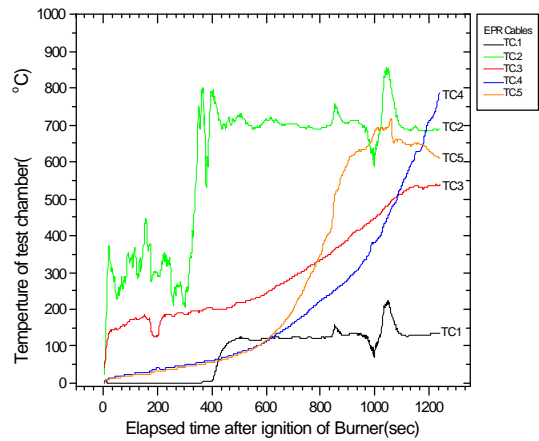
( )

6 CV type, EPR/CSP, NFR-8

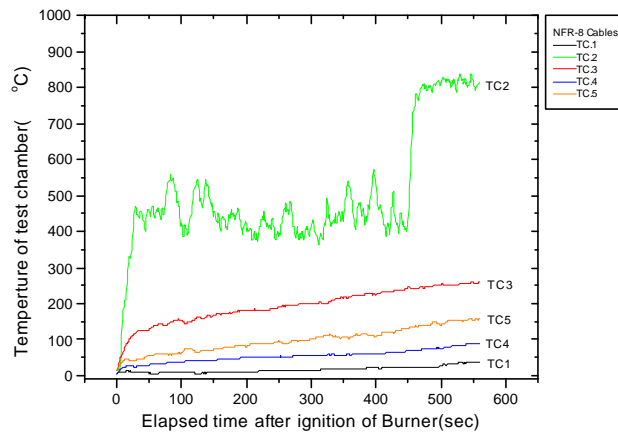
Test Chamber



(CV type)



EPR



NFR-8

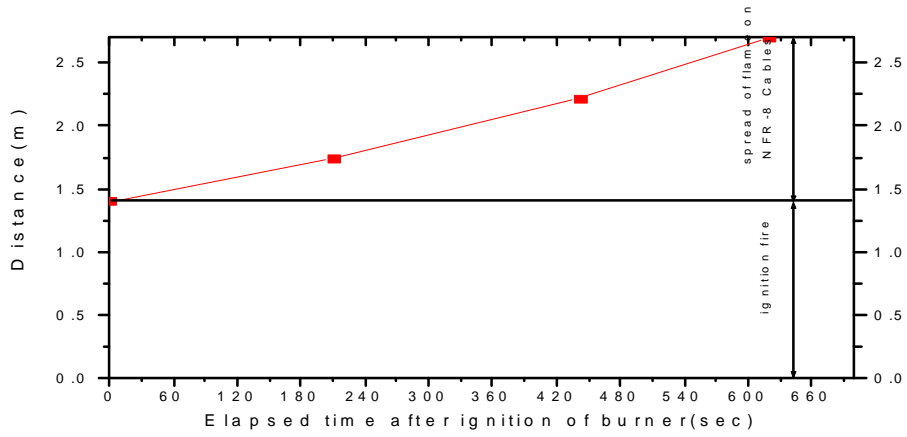
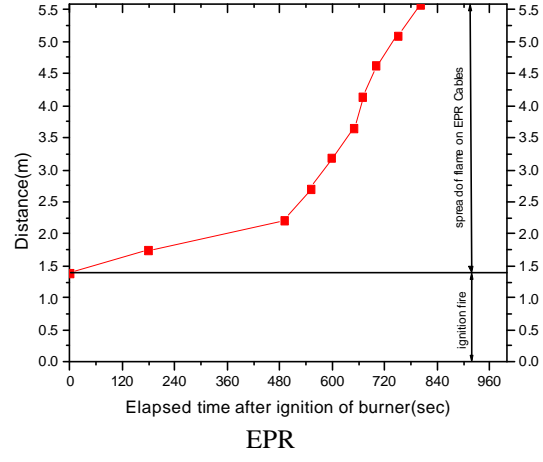
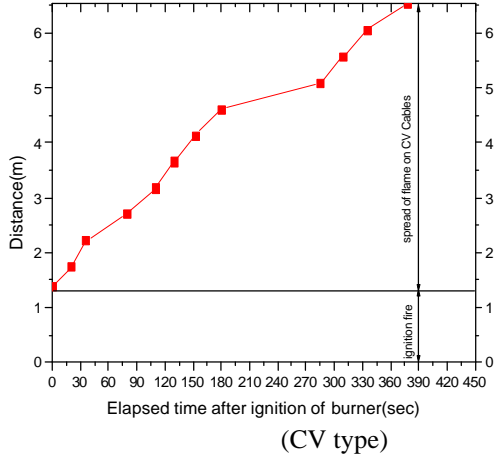
6

Burner

, Burner

1.37 m

7



NFR-8

7

2, 3, 4



2. IEEE 383 ( )

			AWG No.		(mm)	( : )	
'A'	EPR/CSP 600 V	2	12	10	480	1:40	有
	EPR/CSP 600 V	1 P	14	10	480	1:16	有
	EPR/CSP 600 V	9 C	14	8	670	2:36	有
	EPR/CSP 600 V	5 C	14	10	730	3:10	有
'B'	EPR/CSP 600 V	1 P	16	11	820	0:00	有
	EPR/CSP 600 V	1 C	14	16	810	0:00	有
'C'	NFR-8 600 V	3 C	2 mm	9	530	0:14	有

3. IEC 60331 ( )

			AWG No.		가 (V)	( : )
'A'	EPR/CSP 600 V	2	12	10	600	2:56
	EPR/CSP 600 V	1 P	14	10	600	2:47
	EPR/CSP 600 V	9 C	14	8	600	3:38
	EPR/CSP 600 V	5 C	14	10	600	2:30
'B'	EPR/CSP 600 V	1 P	16	11	600	3:8
	EPR/CSP 600 V	1 C	14	16	600	1:25
'C'	NFR-8 600 V	3 C	2 mm	9	600	

4. UL 910 ( )

			Chamber ( 10 )				(m/min)	20		
			TC.2 ( )	TC.5 ( )	TC.3 ( )	TC.4 ( )				가
EPR ( 'A' )	EPR/CSP (600 V)	Cable Core	713	117	245	114	: 0.11 490 : 0.65	( 2.89 m + 1.52m)	8.6 m	No Good
( 'C' )	NFR-8 (600 V)	Cable Core	814	158	258	90	0.13		2.6 m	O.K.
( )	CV, CVV VCT(600 V)	Cable Core	575	485	384	819	0.82		16.4 m	Bad

5.

가.

RSP

NFR-8  
 가  
 2 3  
 (1 45 ) NFR-8

(1)

- NFR-8 EPR/CSP CV type
- CV type EPR/CSP 가 (core)  
short
- NFR-8 (core)  
short

(2)

- 0.11 0.65 m/min 0.82 m/min NFR-8 0.13 m/min CV type EPR/CSP
  - CV type, EPR/CSP, NFR-8 (2.89 m) NFR-8  
20
  - 가
- (A, B )

6.

가. IEEE 383, IEC 60331, UL 910

( , NFR-8 )  
 EPR type IEC 60331 1 45 ) 가  
 90 ( 가  
 ,  
 UL 910 가  
 , A, B 가  
 , UL 910  
 ,  
 ,  
 IEEE 383( ) IEC 60331 ( 가  
 ) 가  
 가 , Q ( , EPR )  
 IEC 60331 Q 가 가 가  
 90  
 ,  
 가 2

- 1) 10CFR50, Appendix A, Criterion 3, Fire Protection
- 2) USNRC Standard Review Plan(Branch Technical Position) 9.5-1, Fire Protection Program
- 3) 10CFR50.48, Fire Protection
- 4) 10CFR50, Appendix R, Fire Protection Program for Nuclear Power Facilities Operating Prior to Jan 1, 1979
- 5) Appendix A to BTP APCS 9.5-1, Guidelines for Fire Protection for Nuclear Power Plants Docketed Prior to January 1,1979
- 6) USNRC BTP CMEB 9.5-1, Guidelines for Fire Protection for Nuclear Power Plants
- 7) IEEE Standard 383-1974, Type Test of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations
- 8) IEC Standard 60331, Tests for Electric Cables under Fire Conditions – Circuit Integrity, 1999
  - Part 11, Apparatus-Fire Alone at a Flame Temperature of at least 750
  - Part 21, Procedures and Requirements- Cables of Rated Voltage up to and Including 0.6/1.0 kV
- 9) UL Standard 910, Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air, 1998
- 10) USDOE/NE-0113(REV.1),Energy Reactor Core Protection Evaluation Methodology for Fires at RBMK and VVER Nuclear Power Plants, 1997
- 11) USNRC, Appendix R to Fire Protection Audit Report for Cooper Nuclear Station, 1989