

Study of cables used in Japanese NPP

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Background

- Assessment of Cable Aging for Nuclear Power Plant (ACA) project in Japan
 - ACA project finished (FY2002-FY2008).
 - Life time of cables are evaluated. The result shows that the lifetime of three cables are very short.
 - Proposed tentative value of the activation energy at in temperature of actual plant is 62.8kJ/mol(15kcal/mol).



Purpose

- The NISA issued the regulatory instruction in 2007
 - Perform operability evaluation of these cables that is determined to have short life time in ACA project.
- Study of used cables in NPP are done by Japanese utilities and NPP venders.
 - DBE test
 - Evaluation of activation energy
- Following cables that have short life (result of ACA) are tested.
 - XLPE cable (A manufacture)
 - XLPE cable (B manufacture)
 - FR-EP cable (A manufacture)

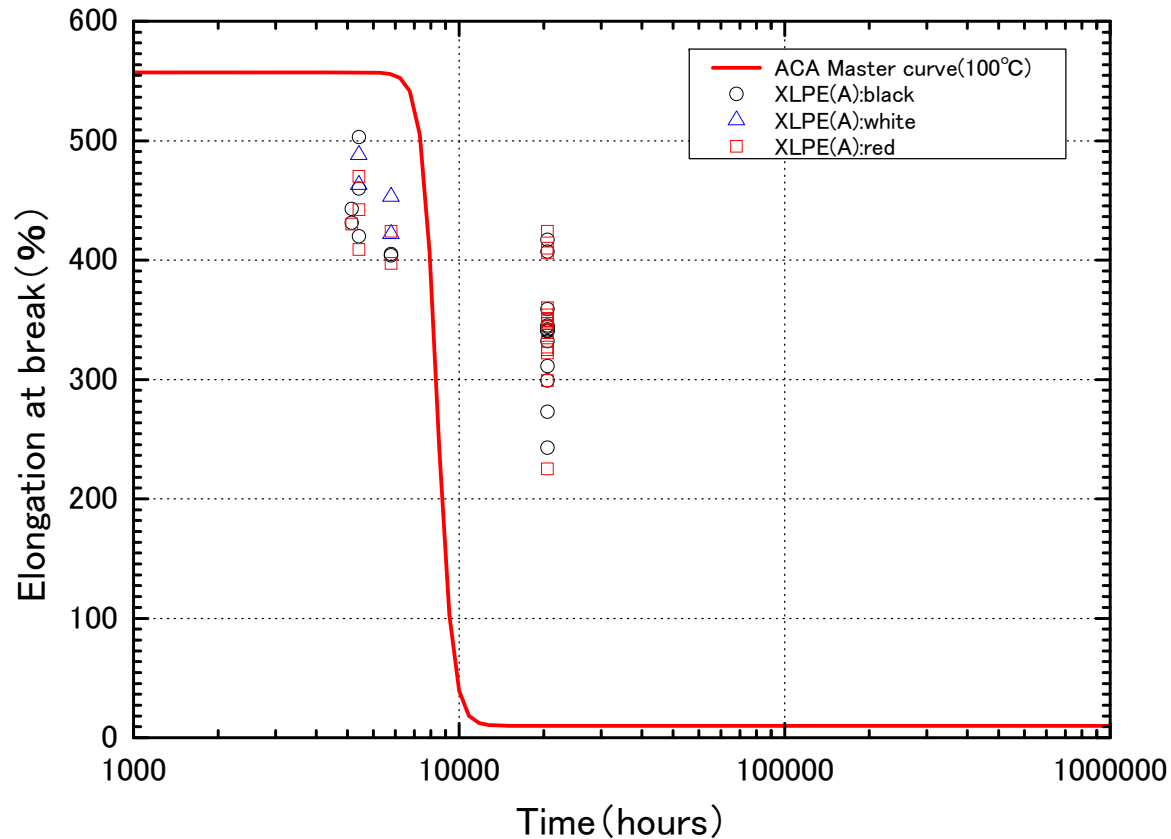


Evaluations of activation Energy

- Evaluate the activation energy of cable used in NPP
 - Measure the elongation at break of cable
 - Compare the EAB of used cable with that of ACA project
 - Evaluate the activation energy

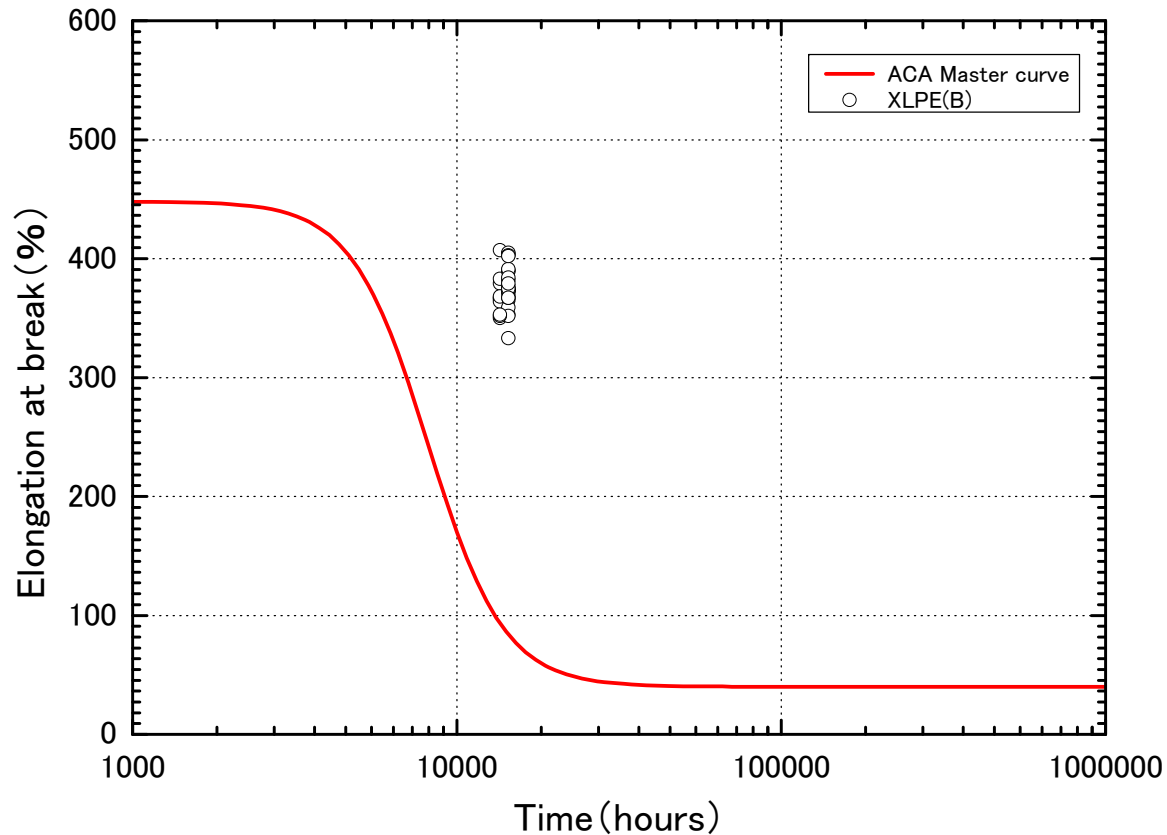
Evaluations of activation Energy (Cont.)

- Activation energy of XLPE cable (A manufacture) : 22.6-22.8kcal/mol



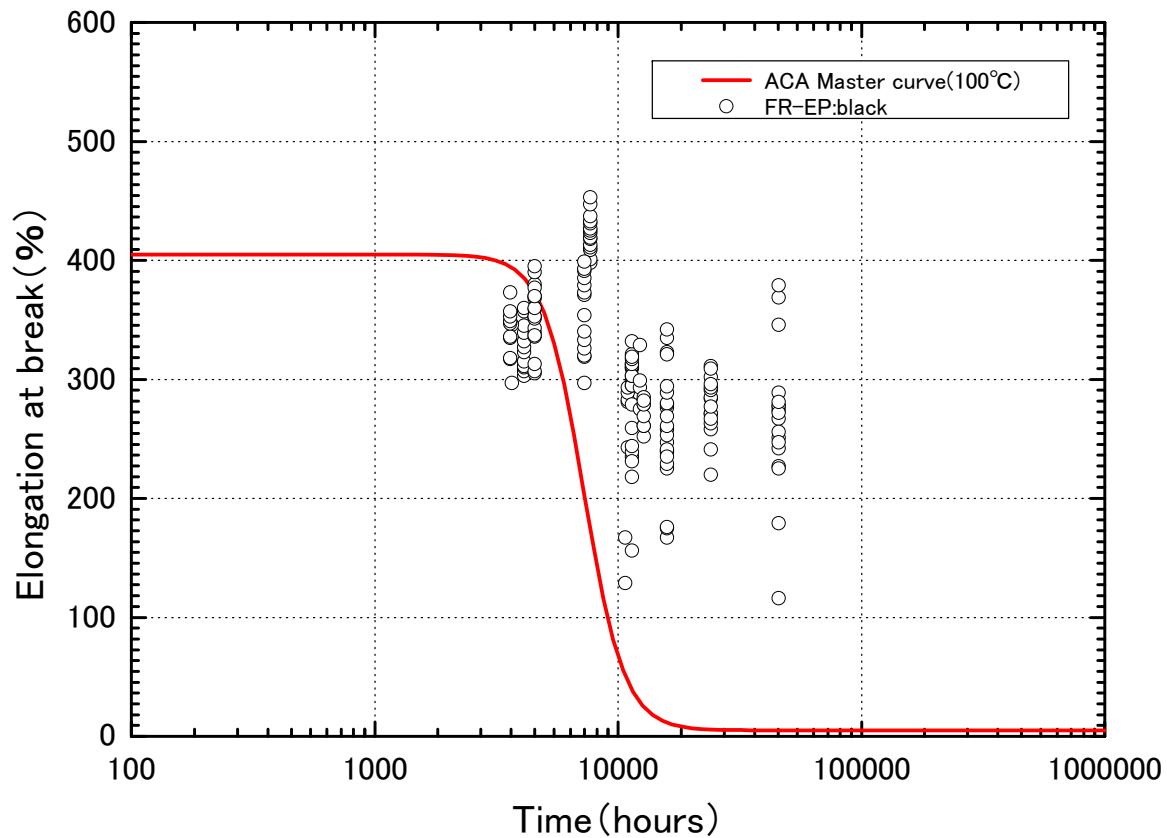
Evaluations of activation Energy (Cont.)

- Activation energy of XLPE cable (B manufacture): 17.4-18.7kcal/mol



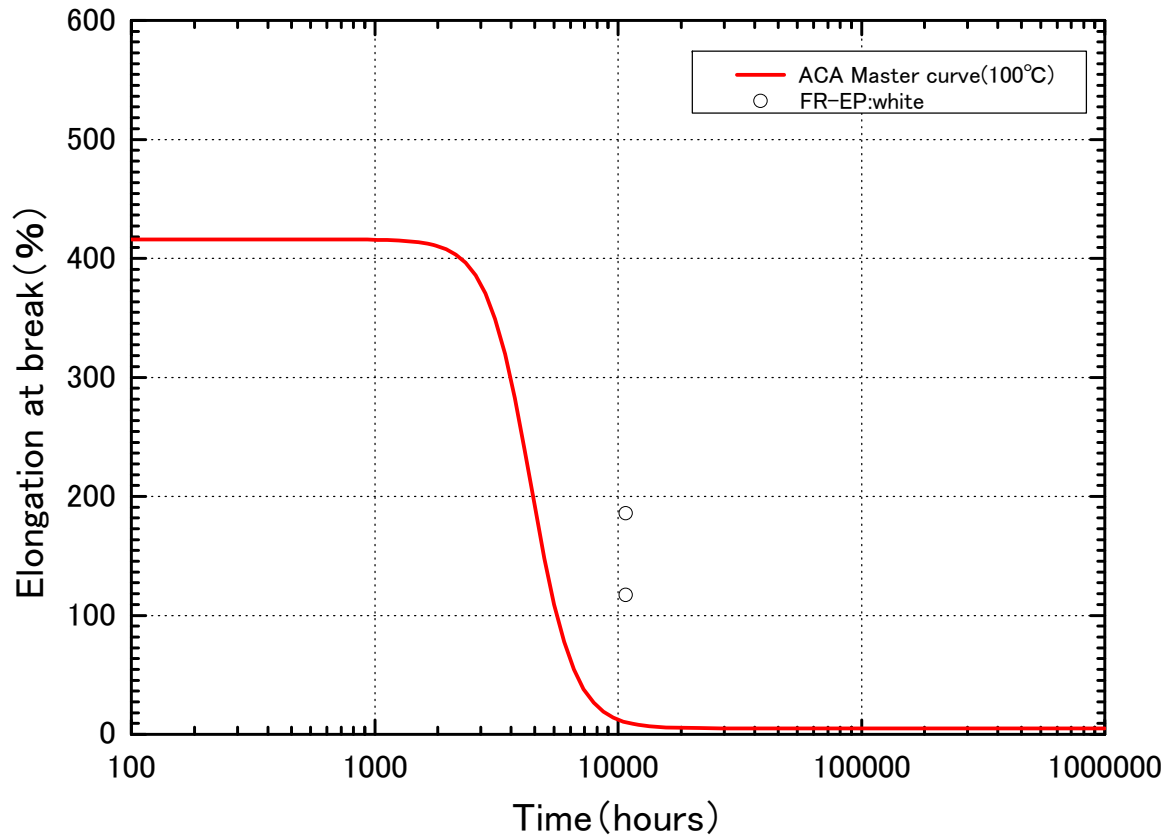
Evaluations of activation Energy (Cont.)

- Activation energy of FR-EP cable (Black wire) : 16.2-34.4kcal/mol



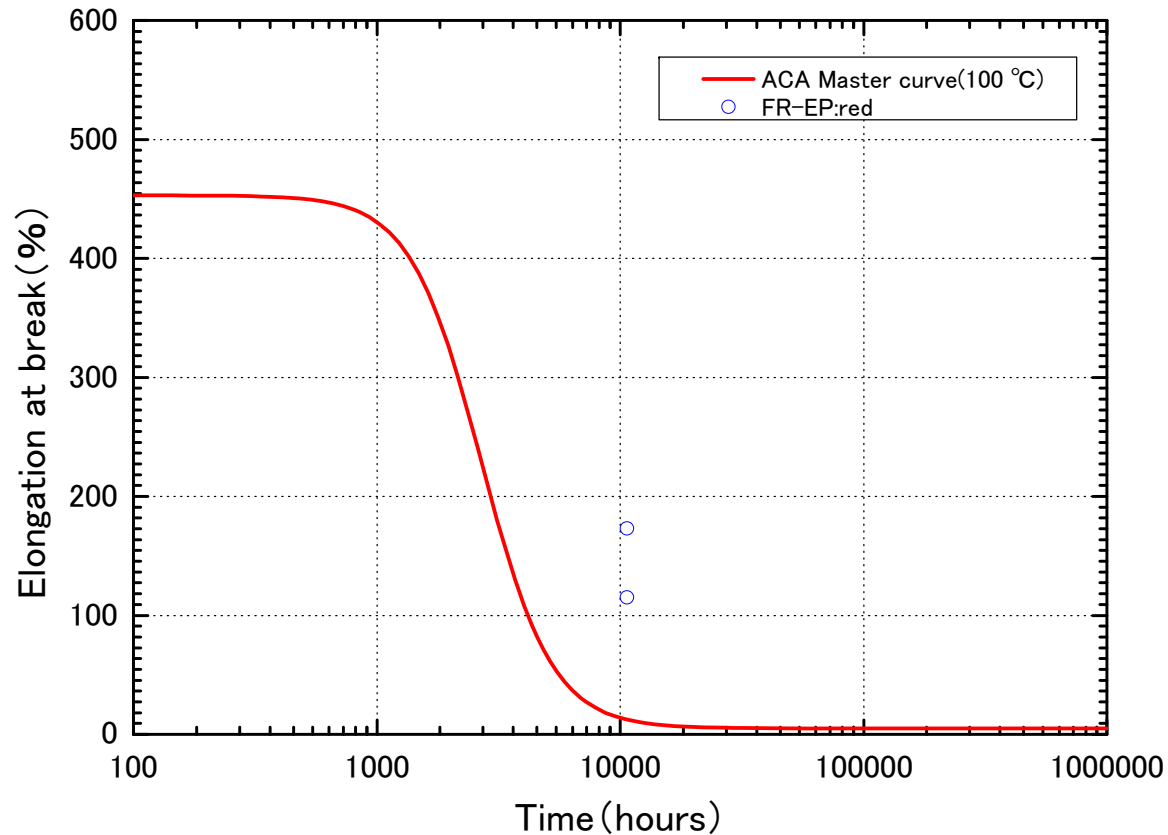
Evaluations of activation Energy (Cont.)

- Activation energy of FR-EP cable (White wire) : 20.5-21.5kcal/mol



Evaluations of activation Energy (Cont.)

- Activation energy of FR-EP cable (Red wire) : 18.7-19.5kcal/mol





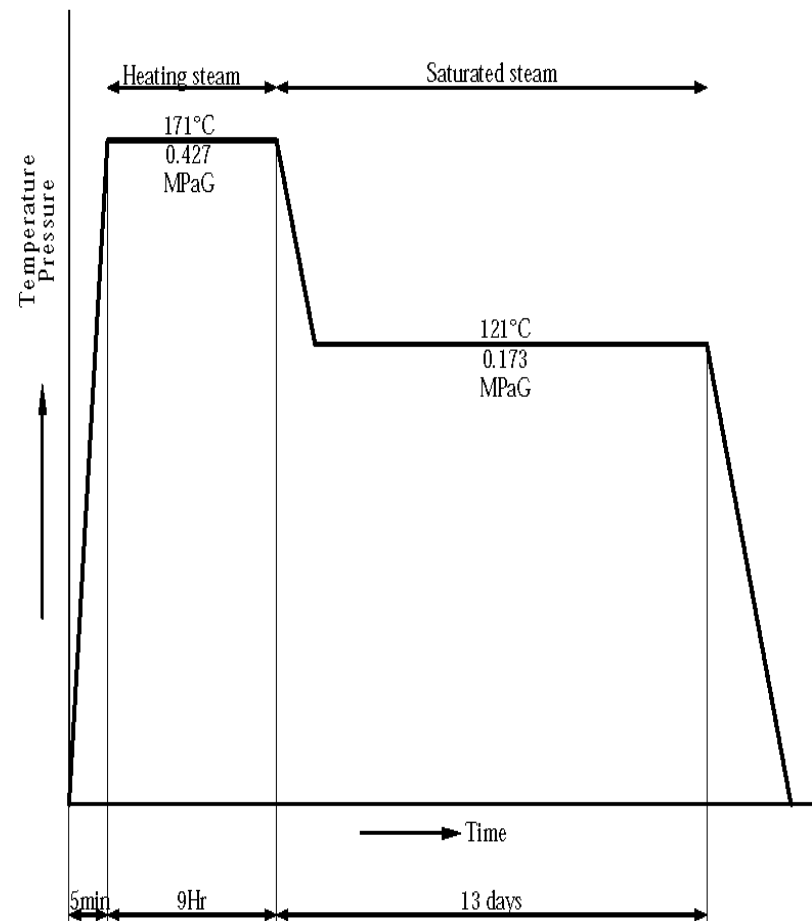
DBE test results

- Number and age of the cables used for DBE test
 - XLPE cable (A manufacture): 10, 31-35 years
 - XLPE cable (B manufacture): 18, 27-29 years
 - FR-EP cable (A manufacture): 33, 19-30 years

DBE test results (Cont.)

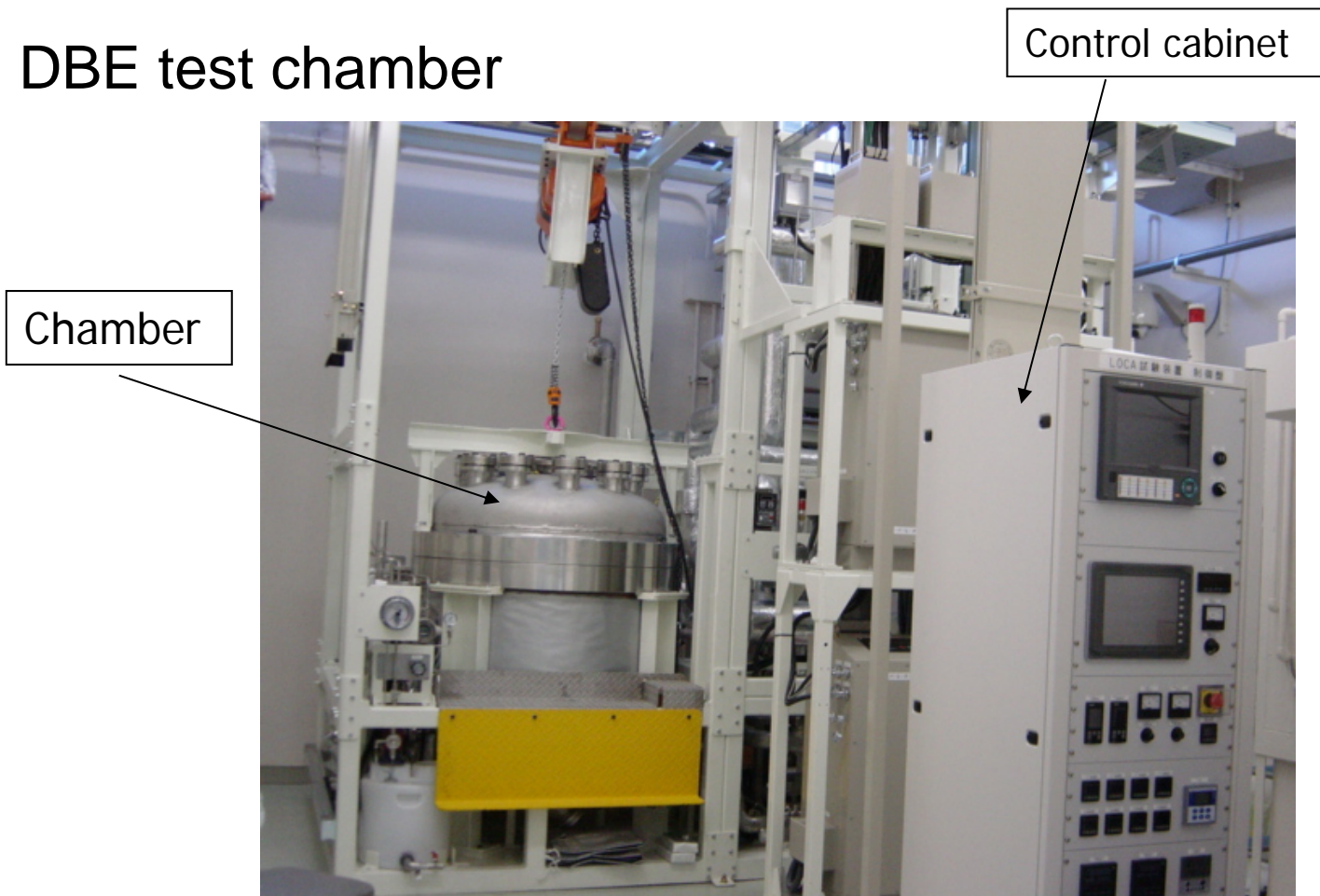
■ DBE test condition (BWR)

- Total dose of DBE:
 - 500kGy (FR-EP cable)
 - 260kGy (XLPE cable)
- Profile of DBE temperature and pressure (Right figure)
- Acceptance criteria:
 - Withstand voltage test in accordance with Japanese industrial standard (JIS)
 - 1500V 1min. for 2.0-5.5mm² (14-10AWG)



DBE test results (Cont.)

- DBE test chamber





DBE test results (Cont.)

■ DBE test Results

- All cables passed LOCA test
- XLPE cable (A manufacture):
 - Worst condition : 66.1°C-0.0539Gy/h, 31years [actual 21.3years]
 - Assumed life time in ACA project is 9.13years at 66.1°C-0.0539Gy/h
- XLPE cable (B manufacture):
 - Worst condition : 54.7°C-0.0149Gy/h, 29years [actual 20.4years]
 - Assumed life time in ACA project is 16.2 years at 54.7°C-0.0149Gy/h
- FR-EPcable (A manufacture):
 - Worst condition : 76.2°C-0.0498Gy/h, 27years [actual 20.6years]
 - Assumed life time in ACA project is 4.48 years at 76.2°C-0.0498Gy/h

DBE test results (Cont.)

List of DBE test results (XLPE A manufacture)

No.	Cable No.	Insulation	Size and Conductor no.	Age of use	Enviroment		EAB	Withstand test
					Temperature(°C)	Radiation(Gy/h)		
1	C2439B	XLPE	2mm ² *7C	35	48.9	0.0124	426%,430% (Red) 431%,443% (Black)	Pass
2	C21028	XLPE	5.5mm ² *3C	35	50.3	0.0050	409% (Red) 455% (White) 420% (Black)	Pass
3				35	50.8	0.0341	397%,424% (Red) 422%,453% (White) 404%,405% (Black)	Pass
4	RR457P01	XLPE	38mm ² *3C	35	50.3	0.0050	442%,470% (Red) 463%,488% (White) 460%,503% (Black)	Pass
5	RE55Y05	XLPE	2mm ² *3C	31	66.1	0.0539	225~360% (Red) 101~344% (Black)	Pass
6	RE55Y06	XLPE	2mm ² *5C	31	66.1	0.0539	325~354% (Red) 273~342% (Black)	Pass
7	RE55Y03	XLPE	2mm ² *3C	31	66.1	0.0539	349% (Red) 341% (Black)	Pass
8				31	66.1	0.0539	299%,322% (Red) 243%,311% (Black)	Pass
9	RE65Y02	XLPE	2mm ² *3C	31	66.1	0.0539	327~351% (Red) 311~345% (Black)	Pass
10	RH50P01	XLPE	5.5mm ² *3C	31	66.1	0.0539	406~424% (Red) 359~417% (Black)	Pass

DBE test results (Cont.)

List of DBE test results (XLPE A manufacture)

No.	Cable No.	Insulation	Size and Conductor no.	Age of use	Enviroment		EAB	Withstand test
					Temperature(°C)	Radiation(Gy/h)		
1	4RS76D06	XLPE	2mm ² *2C	27	54.7	0.0149	350%,407% (Black)	Pass
2	4RS76D07	XLPE	2mm ² *2C	27	54.7	0.0149	379%,383% (Black)	Pass
3	4RS78D07	XLPE	2mm ² *2C	27	54.7	0.0149	366%,367% (Black)	Pass
4	4RS78D03	XLPE	2mm ² *2C	28	54.7	0.0149	365%,404% (Black)	Pass
5	4RS79D04	XLPE	2mm ² *2C	28	54.7	0.0149	333%,390% (Black)	Pass
6	4RS79D05	XLPE	2mm ² *2C	28	54.7	0.0149	353%,368% (Black)	Pass
7	4RS79D06	XLPE	2mm ² *2C	27	54.7	0.0149	364%,368% (Black)	Pass
8	4RS80D03	XLPE	2mm ² *2C	28	54.7	0.0149	373%,374% (Black)	Pass
9	4RS80D04	XLPE	2mm ² *2C	28	54.7	0.0149	371%,405% (Black)	Pass
10	4RS80D05	XLPE	2mm ² *2C	28	54.7	0.0149	377%,389% (Black)	Pass
11	4RS80D06	XLPE	2mm ² *2C	28	54.7	0.0149	359%,403% (Black)	Pass
12	4RS80D07	XLPE	2mm ² *2C	28	54.7	0.0149	391%,402% (Black)	Pass
13	4RS81D03	XLPE	2mm ² *2C	28	54.7	0.0149	367%,375% (Black)	Pass
14	4RS81D04	XLPE	2mm ² *2C	28	54.7	0.0149	352%,382% (Black)	Pass
15	4RS81D05	XLPE	2mm ² *2C	28	54.7	0.0149	373%,384% (Black)	Pass
16	4RS83D03	XLPE	2mm ² *2C	28	54.7	0.0149	373%,375% (Black)	Pass
17	4RS84D05	XLPE	2mm ² *2C	27	54.7	0.0149	352%,353% (Black)	Pass
18	4RS86D03	XLPE	2mm ² *2C	28	54.7	0.0149	367%,379% (Black)	Pass

DBE test results (Cont.)

List of DBE test results (FR-EP A manufacture) (1/2)

No.	Cable No.	Insulation	Size and Conductor no.	Age of use	Environment		EAB	Withstand test
					Temperature(°C)	Radiation(Gy/h)		
1	RR59Y04	FR-EP	2mm ² *9C	19	55.4	0.0160	398~453% (Black)	Pass
2	C61356D	FR-EP	2mm ² *7C	29	40.7	0.0107	303~360% (Black)	Pass
3	RB14D04	FR-EP	2mm ² *2C	25	55.8	0.0262	287%,297% (Black)	Pass
4				25	60.7	0.0183	225~323% (Black)	Pass
5	RB14D06	FR-EP	2mm ² *2C	25	55.8	0.0262	156%,259% (Black)	Pass
6				25	60.7	0.0183	81~176% (Black)	Pass
7	RB14D08	FR-EP	2mm ² *3C	25	55.8	0.0262	299~321% (Black)	Pass
8				25	60.7	0.0183	239~342% (Black)	Pass
9	RB16D04	FR-EP	2mm ² *3C	25	55.3	0.0144	281~289% (Black)	Pass
10				25	66.9	0.0356	220~285% (Black)	Pass
11	RB16D06	FR-EP	2mm ² *3C	25	55.3	0.0144	243%,293% (Black)	Pass
12				25	66.9	0.0356	271~311% (Black)	Pass
13	RB16D08	FR-EP	2mm ² *3C	25	66.9	0.0356	258~309% (Black)	Pass
14	RB18D04	FR-EP	2mm ² *3C	25	55.8	0.0262	218~310% (Black)	Pass
15	RB18D06	FR-EP	2mm ² *3C	25	55.8	0.0262	231~311% (Black)	Pass
16	RB18D08	FR-EP	2mm ² *3C	25	55.8	0.0262	303~332% (Black)	Pass
17	RB30D04	FR-EP	2mm ² *2C	25	60.7	0.0183	229~279% (Black)	Pass
18	RB30D06	FR-EP	2mm ² *3C	25	60.7	0.0183	253~294% (Black)	Pass

DBE test results (Cont.)

List of DBE test results (FR-EP A manufacture) (2/2)

No.	Cable No.	Insulation	Size and Conductor no.	Age of use	Environment		EAB	Withstand test
					Temperature(°C)	Radiation(Gy/h)		
19	RG56P02	FR-EP	5.5mm ² *3C	25	55.0	0.0071	129%,167% (Black) 117%,186% (White) 115%,173% (red)	Pass
20	RH77A02	FR-EP	2mm ² *7C	27	48.7	0.0192	297~399% (Black)	Pass
21	RB25D05	FR-EP	2mm ² *3C	27	76.2	0.0498	251~379% (Black)	Pass
22	RB27D03	FR-EP	2mm ² *2C	27	76.2	0.0498	66~274% (Black)	Pass
23	RB33D03	FR-EP	2mm ² *2C	27	76.2	0.0498	227~289% (Black)	Pass
24	RB33D05	FR-EP	2mm ² *3C	27	76.2	0.0498	179~281% (Black)	Pass
25	RB035D02	FR-EP	2mm ² *2C	23	43.3	0.0146	297%,346% (Black)	Pass
26				23	46.1	0.0221	336~353% (Black)	Pass
27	RB035D04	FR-EP	2mm ² *3C	23	46.1	0.0221	305~380% (Black)	Pass
28	RB038D02	FR-EP	2mm ² *2C	23	46.1	0.0221	370~395% (Black)	Pass
29	RB038D04	FR-EP	2mm ² *3C	23	46.1	0.0221	337~370% (Black)	Pass
30	RG091A02	FR-EP	2mm ² *5C	23	43.1	0.0122	317~373% (Black)	Pass
31	RB017D06	FR-EP	2mm ² *2C	24	60	0.006	275~329% (Black)	Pass
32	RB017D03	FR-EP	2mm ² *2C	24	60	0.098	252~285% (Black)	Pass
33	RB018D04	FR-EP	2mm ² *2C	24	60	0.098	261~282% (Black)	Pass



Conclusions

- Activation energy of these cables used in NPP are slightly higher than 15kcal/mol(62.8kJ/mol), tentative value proposed in ACA project.
- These Cables, which used for longer time than the life time evaluated in ACA project, are passed DBE test.

Evaluate operability of other cable

- Convert/shift the condition, temperature and radiation to the worst condition of cable passed DBE test, used shift parameter, provided in ACA project.
- In case of the used age are shorter than the used age of the worst condition, the cable is evaluated 'operable'.

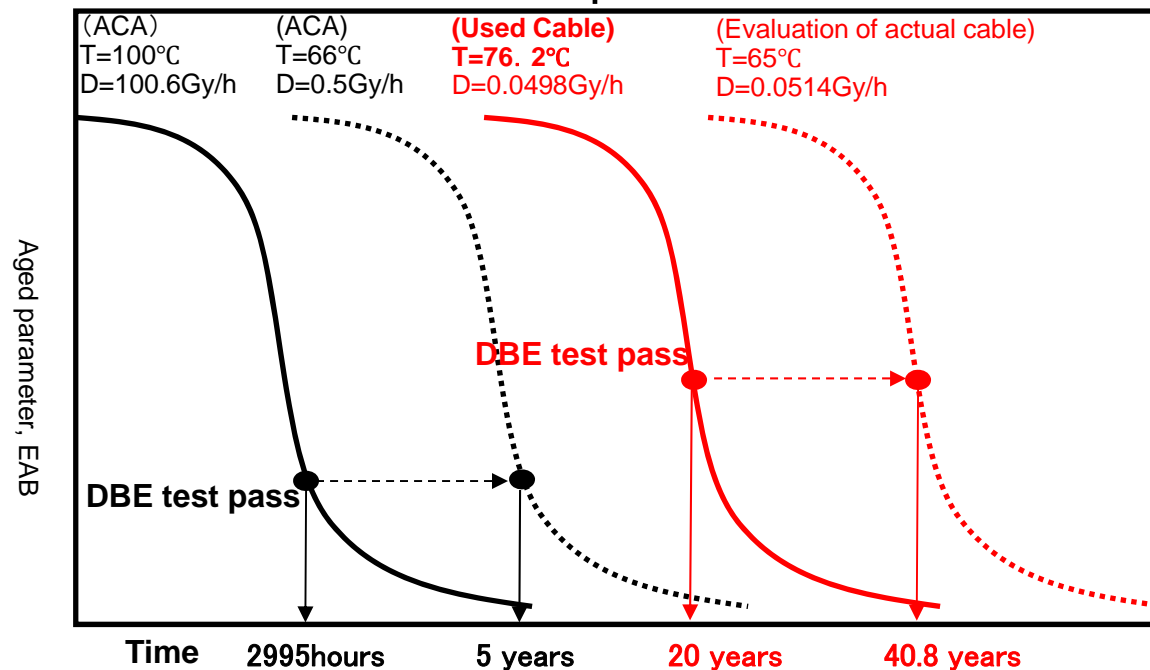


Image of operability evaluation