Japanese Electric Utilities' Action to Meet Environmental Qualification (EQ) Requirements for Electric and I&C Equipment Including Cables according to Latest Knowledge

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Nuclear Power Division

THE KANSAI ELECTRIC POWER CO., INC.

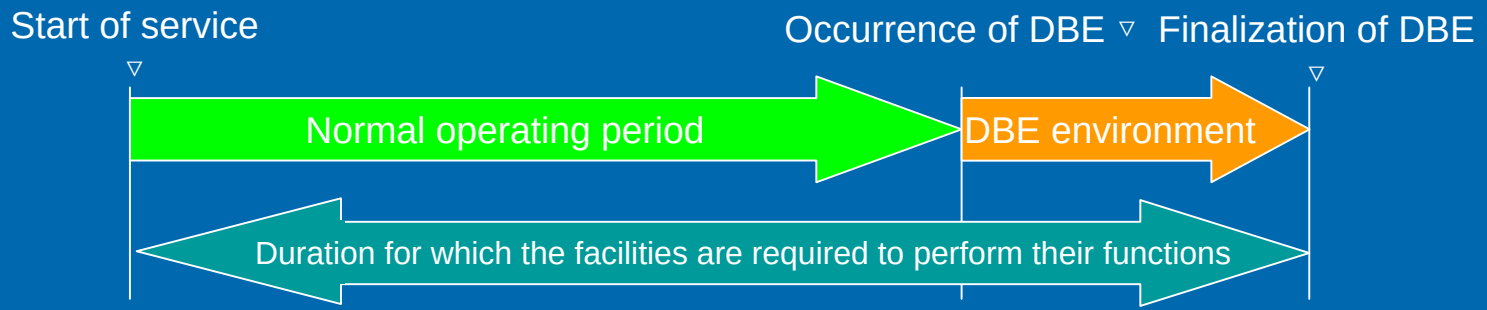
Contents

1. Regulatory Requirements for EQ during and after an Accident

Ministerial Order No. 62 Article 8-2.2

The safety-important facilities shall be installed so that they can achieve their safety functions under any applicable environmental conditions.

Safety-important facilities which are required to function during and after Design Basis Event (DBE, ex: Loss-Of-Coolant Accident (LOCA), Main Steam Line Break (MSLB)) : Their safety functions shall be performed while the facilities are exposed to the DBE environment at the end of service life.



Before the installation, the electric equipment is subject to the EQ Test according to IEEE323.
It is planned to publish the Japanese industrial standard "Japan Electric Association Guide (JEAG) 4623" regarding EQ by the end of 2008 (Organizer: Kansai Electric).

Example of safety system of the electric and I&C equipment

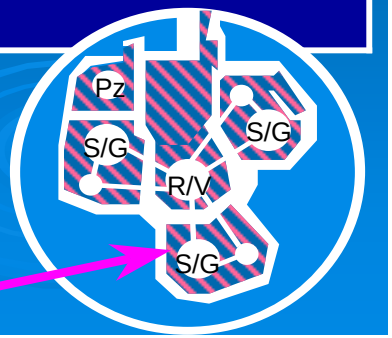
Cables	Insulation : Cross-linked Polyethylene (XLPE), Ethylene Propylene Rubber (EPR), Flame-retardant (FR) -EPR, Silicone Rubber (SiR) etc…
Others	Electric Penetration, Connection Assemblies, Motor, Actuator for Motor Operated Valve (MOV) etc…

2.1. Latest Knowledge about Cable Lifetime Evaluation

The latest knowledge obtained from" **the Assessment of Cable Aging for Nuclear Power Plants (ACA)**" Project, which have been conducted by Japan Nuclear Energy Safety Organization (JNES) under the sponsorship of Nuclear and Industrial Safety Agency (NISA), suggests that the conventional cable lifetime needs to be re-evaluated.

	1981 ~ Present	Evaluation methods adopted by ACA	
Aging Method of thermal/radiation	Sequential aging based on IEEE323 and other codes	Simultaneous & Revised accelerated aging with an upper limit of acceleration (<10kGy/h)	
Activation Energy **→Reference 1/2**	Data （or values obtained from literatures） above 120℃ can be extrapolated to actual conditions. →The present maintenance programs can assure the safety of all equipment	The activation energy used for the extrapolation to the cases below 100℃ is obtained from actual data or latest knowledge：**15kcal/mol**	
		PWR	The lifetime of EPR insulated cables and FR-EPR insulated cables, which are installed inside the Containment Vessel (CV) at locations with Severe environmental conditions※ were provisionally determined to be about ***25 years***.
		BWR	The lifetime of XLPE insulated cables, which are installed inside the CV at locations with severe environmental conditions were provisionally determined to be about ***3.5 to 5.5 years***.

A NISA document was published in October 2007→ 5



※Locations inside PWR Containment Vessel (CV) with Severe environmental conditions = "Loop room", "Pressurizer room" (higher temperature and radiation doses, the shaded portion of PWR CV cross section)

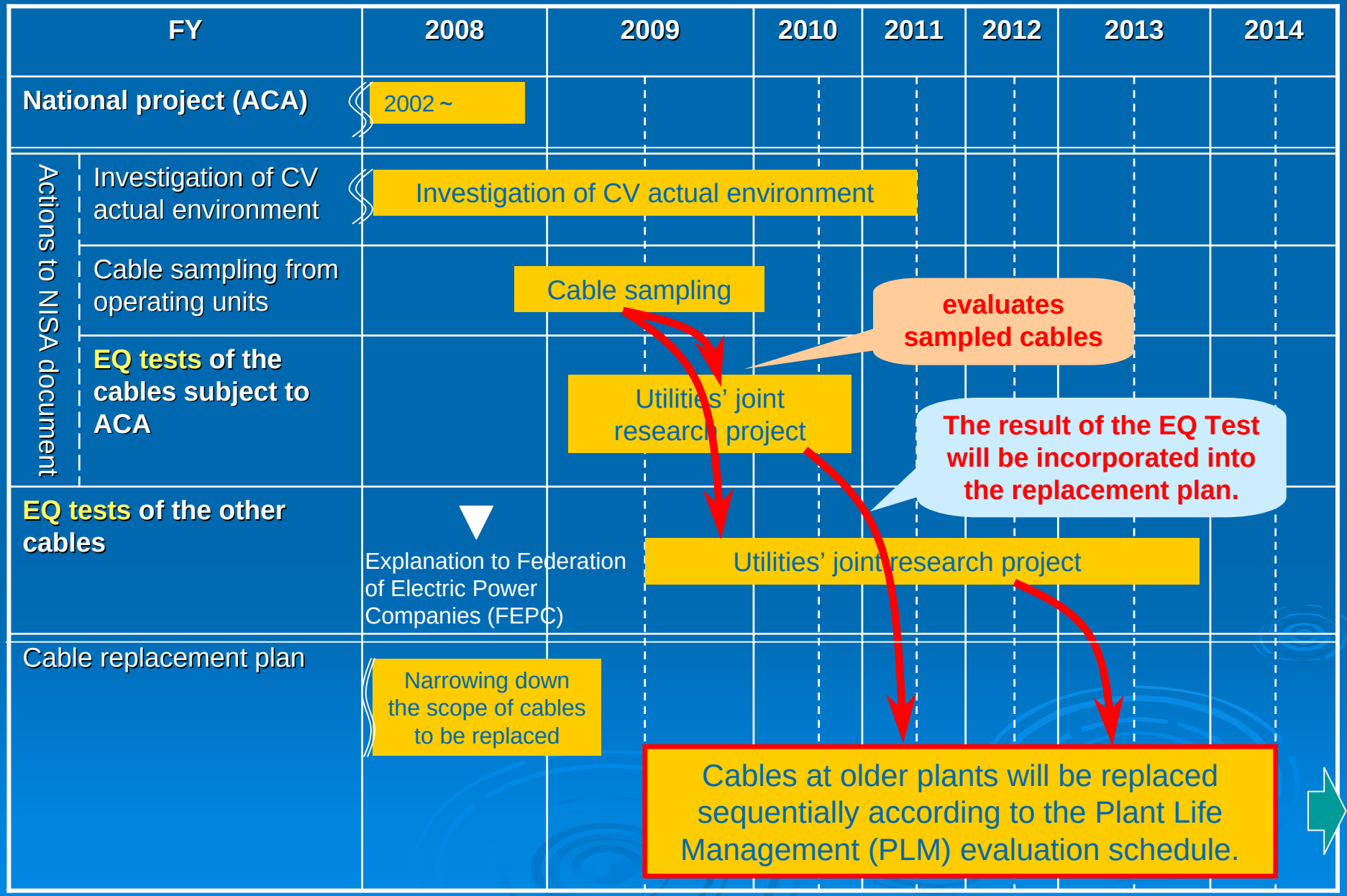
2.2 Actions to NISA Document Regarding Cables

The utilities are taking following actions in response to October 2007 NISA document:

	Instructions in NISA document	Utilities actions
I	The utilities should perform the investigation of actual environment (temperature, dose rate) inside CV in which cables are installed.	Each utility is preparing the budget for the investigation of the CV environment of each unit, implementing the investigation and reporting the result sequentially.
II	The utilities should perform sampling tests by taking out actual cables from the representative plants of the same manufacturer, environment and type as those evaluated by ACA Project, and take necessary actions (replacement planning) based on the test results as necessary. （This requirement applies only to the BWR cables which were evaluated to have 3 to 3.5 lifetime in FY2006. However, PWR utilities are voluntarily taking actions like BWR utilities to address the result that some cables were evaluated to have about 25 years lifetime.）	Each utility is preparing the budget for the identification and sampling of cables subject to the investigation, and implementing the investigation. The utilities' joint research project performs the EQ tests for sampling cables in FY2008 ~ FY2010. The joint research project will verify the validity of the ACA method and each utility will establish a replacement plan.

The time schedule for the environmental investigation, sampling and EQ tests of the cables that were subject to the ACA project, and the planned actions to address other cables that were not subject to the national project will be shown next:→ 6

2.3 Cable Evaluation and Replacement Schedule



3. Evaluation of Electric and I&C Equipment except Cables

○ Knowledge obtained from ACA about Cables

- The progress of simultaneous aging at a low temperature and radiation is significantly rapid.
- Activation energy values for polymer should be lower than those adopted by the past verifications.

○ Applying the knowledge to the other equipments

- Applying the knowledge obtained from ACA to the other equipments, JNES started the "**Assessment of Equipment Aging for Nuclear Power Plants (AEA)**" Project from FY2008.
- In FY2008, the project will select the electric and I&C equipment subject to the evaluation and identify the concerned parts and their degradation modes.

- Utilities will perform EQ tests during FY2009 to 2012 to verify the validity of the AEA results.
- The lifetime of the components, which have been evaluated assuming high activation energy (ex: more than 30kcal/mol), are likely to be determined to be extremely shorter.→**Reference 3**

○ Time schedule

	2008	2009	2010	2011	2012	2013	2014
National project AEA	Selection of equipments, EQ tests (simultaneous aging at lower temperature and lower radiation rate)						
Utilities' joint research (for equipment subject to AEA)	Selection of equipments	EQ tests using specimens taken out of operating plants					

Reference 1: Lifetime Evaluation by The Current Methods

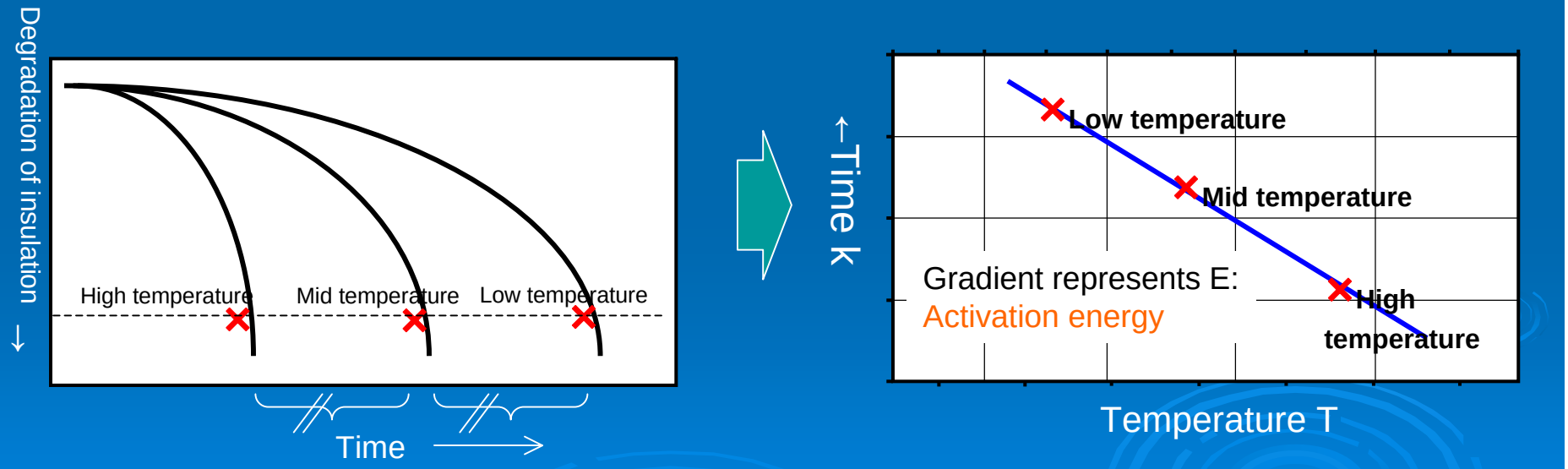
Accelerated test conditions for organic materials are set according to the Arrhenius rule

$$\ln(k) = \frac{-E}{R}\frac{1}{T} + C$$

E : **activation energy (kcal/mol)**
(Degradation parameter set according to each organic material)

R : gas constant

k : time ***T*** : temperature (K) ***C*** : constant



Current evaluation method: assuming a linear activation energy (independent of temperature)

Reference 2: Lifetime Evaluation by the ACA Method

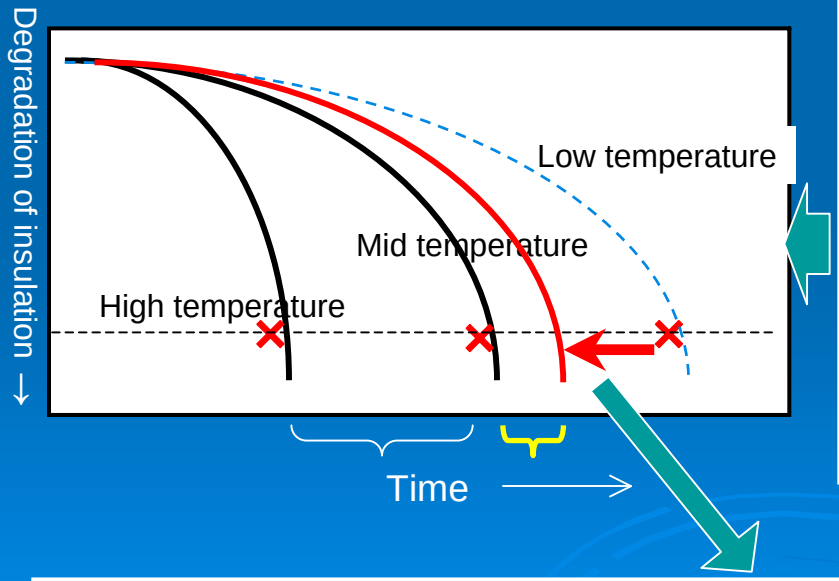
Knowledge obtained from ACA Project suggests that the activation energy used in the evaluation according to the Arrhenius rule differ between low and high temperature regions.

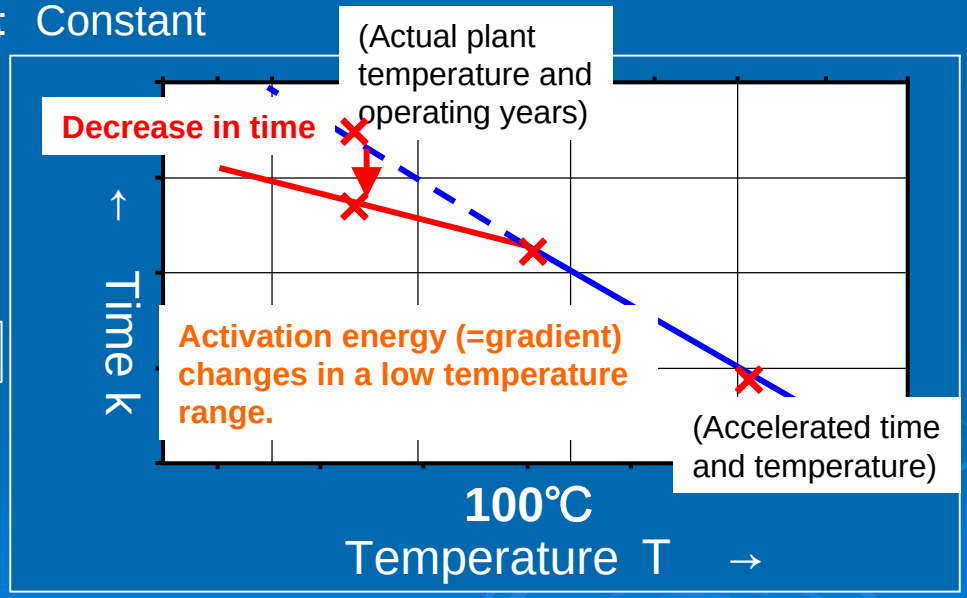
$$\ln(k) = \frac{-E(t)}{R}\frac{1}{T} + C$$

***E* (t)** : **activation energy (Degradation parameter set according to each organic material, temperature-dependent)**

R : gas constant

k : time ***T*** : temperature (K) ***C*** : Constant





The originally estimated lifetime was reduced (60 years →25 years).

Reference 3: Risks for Equipment Subject to Evaluation Assuming a High Activation Energy

(The following Arrhenius plot combines those in Reference 1 and 2.)