IMPROVING REGULATORY PRACTICES THROUGH THE OECD – NEA STRESS CORROSION CRACKING AND CABLE AGEING PROJECT (SCAP)

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Abstract

For regulatory authorities, it is important to verify the adequacy of ageing management methods applied by the licensees, based on reliable technical evidence. In order to achieve that goal, 14 NEA member countries joined the SCAP (Project) in 2006 to share knowledge. The project focuses on two important safety issues: stress corrosion cracking and degradation of cable insulation, due to their relevance for plant ageing assessments and their implications on inspection practices. The project goal is to establish a complete database and a knowledge base in these fields and to perform an assessment of the data, and to identify the basis for commendable practices which would help regulators and operators enhance ageing management. The project is scheduled to last four years and is currently in the development phase, defining and refining the database performance requirements, data format and coding guidelines. It is envisaged that the project's outcomes will be used by the NEA member countries to evaluate how operating experience and state-of-the-art technology are incorporated into plant operating practices, and to support regulatory authorities' reviews of ageing management programmes.

1. Introduction

The number of ageing nuclear power plants is increasing in OECD/NEA member countries. Accordingly, maintenance programmes, in-service inspection and testing of structures, systems and components important to safety have been implemented to ensure that levels of reliability and effectiveness remain in accordance with the design assumptions. This is often being done using an integrated ageing management strategy based on state-of-the-art technology.

Ageing effects, especially material degradation, have been experienced worldwide and progressively since the start of nuclear power plant operation. Material degradation is expected to continue as plants age and operating licenses are extended. It is clear that unanticipated and unmanaged structural degradation could result in significant loss of safety margins, undermining public confidence and straining the resources of both regulatory authorities and the operators. For regulatory authorities, it is also important to verify the adequacy of the ageing management methods applied by the licensees, based on reliable technical evidence.

Two subjects – stress corrosion cracking (SCC) and degradation of cable insulation – were selected as the focus of the SCC and Cable Ageing Project (SCAP) due to their relevance for plant ageing assessments and their implication on inspection practices. Fourteen NEA member countries[1] agreed to contribute to the project. The International Atomic Energy Agency (IAEA) and the European Commission are also participating as observers.

The project is being financed through a Japanese voluntary contribution to the NEA. Japanese technical institutions are also actively co-operating in the project under the co-ordination of the Nuclear and Industrial Safety Agency (NISA) of Japan.

2. Objectives of the SCAP

The main SCAP objectives are to:

- Establish a complete database with regard to major ageing phenomena for SCC and degradation of cable insulation through collective efforts by OECD/NEA members;
- Establish a knowledge base in these areas by compiling and evaluating the collected data and information systematically;
- Perform an assessment of the data and identify the basis for commendable practices which would help regulators and operators to enhance ageing management.

The project is scheduled to last four years. It is anticipated that the database definition and the collection of data from member countries will take approximately two years. The subsequent assessment and the commendable practices report are expected to take one year each.

3. Project organization

SCAP participants are experts in the fields of SCC and cable ageing and come from regulatory bodies, industry, research institutions and academia. They provide the relevant information and perform the assessments needed for the proper execution of the programme.

The SCAP Management Board (MB) runs the project with assistance from the NEA Project Secretariat. The MB responsibilities include, but are not limited to: approving the programme of work to be carried out by the working groups on SCC and cable; monitoring the project's progress in terms of results and timeliness; and supervising reporting within and outside the project.

There are two working groups, one dealing with SCC and the other with cable insulation degradation. The working groups are responsible for carrying out the programme of work and ensuring the quality and timeliness of the reporting within and outside the project.

The Clearinghouses work to ensure the consistency of the data contributed by the participating countries. They verify whether the information provided complies with the SCAP Coding Guidelines. They also verify the completeness and accuracy of the data, and maintain and distribute copies of the database. There is one Clearinghouse for the SCC database and one for the cable insulation database.

[1] There are currently 14 participating countries in the SCAP: Belgium, Canada, the Czech Republic, Finland, France, Germany, Japan, Mexico, Norway, the Republic of Korea, Spain, Sweden, the Slovak Republic and the United States.

The MB held its first meeting in June 2006 and Prof. Sekimura from Japan was elected chairman. During that meeting, the Terms of Reference of the project were approved as was the reporting and data access policy proposed by NEA. The MB held its second meeting in May 2007 and approved the programme of work for 2007 and 2008 as proposed by the two working groups on SCC and cables.

As of July 2007, The SCC working group has met three times. The scope of the SCC event database and the SCC event database structure has been defined. The SCC event database format has also been finalised.

The Cable working group has met twice as of July 2007. The scope of the cable database and the cable database structure has been defined.

4. Scope of the SCAP database

Based on differences in the fundamental knowledge concerning the SCC and cable insulation degradation mechanisms, as well as the operating experience associated with SCC and cable insulation degradation events, it is expected that the scope and focus of the databases will be different. The SCC database will be mainly based on event occurrences, including piping and component failures. On the other hand, since cable failure or event occurrences are rare, the cable database will focus on cable material and condition monitoring methodology and validation.

The SCAP SCC database addresses passive components degradation or failure attributed to SCC occurring at nuclear power plants in participating countries. The scope of the database includes class 1 and 2 pressure boundary components[2] reactor pressure vessel internals and other components with significant operational impact, excluding steam generator tubing. The following mechanisms are considered in the database: inter-granular SCC in austenitic stainless steel and nickel-based material, irradiated-assisted SCC, primary water SCC, external chloride SCC and transgranular SCC.

The cable database covers safety-related cables (including those supporting emergency core cooling), cables important to safety (cables that are needed to prevent and mitigate design basis events) and cables important to plant operation (cables whose failure could cause a plant trip or reduction in plant power). The scope of the database includes cables with voltage levels up to 15kV AC and 500 V DC, including instrumentation and control (I&C) cables.

5. SCAP database structures

The SCC and cable database structures were defined based on the participating experts' experience, NEA experience in handling different international databases, such as the OECD Piping Failure Data Exchange Project (OPDE) and the OECD Computer-based Systems Important to Safety (COMPSIS), and the R&D information provided by the member countries.

[2] Class 1 and 2 pressure boundary components are defined by the American Society of Mechanical Engineers (ASME) as follows: class 1 includes all reactor coolant pressure boundary (RCPB) components; class 2 generally includes systems or portions of systems important to safety that are designed for post-accident containment and removal of heat and fission products.

5.1 SCC database structure

The SCAP SCC database is a relational database using Microsoft® Access software. The data entry is managed via input forms, tables, roll-down menus and database relationships. Database searches and applications are performed through user-defined queries that utilize the tables and built-in data relationships. The data entry forms are organized to capture essential passive component failure information together with supporting information. The four data entry forms are described below.

5.1.1 Failure data input

This form defines the minimum data requirements. All data entry starts from here. It contains 39 fields, including the plant's name and the plant's operational state at the time of discovery of the event.

This allows differentiation between events with an operational impact, e.g. forced shutdown, and those events discovered through scheduled or augmented inspections. It also contains information regarding the event type, with a roll-down menu offering options such as a through-wall crack without active leakage, a partial through-wall crack and different types of leaks.

Information regarding collateral damage related to operational events involving active through-wall leakage is included. A menu defines the different corrective actions taken at the plant. A detailed description of plant conditions prior to the event and plant response during the event, the method of detection, and the corrective action plan are included in the event narrative field.

All the relevant information that characterizes the degraded component is also included such as code class, dimensions, base metal and weld metal material designation, mechanical properties, for example yield strength and hardness, and the type of process medium at the time of detection.

5.1.2 Flaw characterization

This form contains 28 fields with information that characterizes the flaw (description, information about size and further details according to the type of flaw).

5.1.3 ISI history

This form consists of 3 fields. While primarily intended for recording in-service inspection (ISI) programme weaknesses, the free-format field may be used to document any information pertaining to the ISI of the affected component, or ISI history such as the time of most recent inspection.

5.1.4 Root-cause information

This form consists of 25 fields and includes information regarding the estimated age of the component, i.e. the in-service life at the time of failure. If the affected component has a known repair or replacement history this is to be taken into consideration.

A free-format field is provided to describe the location of failure, i.e. line or weld number or using a piping and instrumentation (P&I) reference. Roll-down menus present different options for choosing the method of detection, the apparent cause and contributing factors. Finally, a free-format field is included to provide information relevant to the root-cause analysis and cause-consequence relationship.

5.2 Cable database structure

Data entry in the SCAP cable database is managed via tables and roll-down menus. Database searches and applications will be performed through user defined queries that will be defined at the next meeting of the working group. The data entry tables are organized to capture essential cable insulation failure events along with information regarding environmental qualification and condition monitoring. The nine data entry forms are described below.

5.2.1 Technical data of cables

This table describes the technical data of the cables. There are fields to describe the cable specifications in terms of insulation material, conductor size and rated voltage, amongst others. Information related to cable type and manufacturer is also included.

There is a detailed description of the operating environmental conditions including information such as location, design pressure, temperature, humidity and dose rate. This table also considers the information related to the environmental qualification and the code or standard used for such purposes.

5.2.2 Cable maintenance data

This table is organized in different sub tables covering aspects such as cable inspection and in-service condition monitoring methods, cable sampling and cable repairing.
The cable inspection information considers the description of the monitoring techniques, the assumed ageing mechanisms and the frequency of inspections.

5.2.3 Data for the cable failure events

This table collects information regarding the real cable failures. There is a free-format field for the narrative description of the event. This is followed by fields for collecting data such as the date of occurrence of the event and the age of the cable. A detailed description of the countermeasures taken at the plant is also included.

5.2.4 Cable environmental qualification data

This table presents information regarding the environmental qualification of the cables. Fields are provided to describe the main results of the qualification test report including the environmental conditions and the test and measurements sequence.

5.2.5 Plant and cable environmental condition

This table describes the environmental condition of the cables. There are fields to describe the environment investigated, the temperature history of the environment and the dose rate history of the environment.

5.2.6 Mitigation of cable- installed environment

This table presents information regarding mitigation methods to reduce the severity of the cable environment.

5.2.7 Cable replacement
This table describes the reasons for cable replacement such as degradation, failure, modification, end of qualified life and so on. It also includes the description of the abandoned cable and the installed cable which was replaced as a new one.

5.2.8 Regulatory information for cables
This table presents information regarding regulatory requirements for cable ageing management, regulatory guides and results of previous safety evaluations. It also includes the industry standards implemented according to the regulatory requirements.

5.2.9 Cable condition monitoring
This table describes the condition monitoring of cables. A field is used for describing the condition monitoring method used, the principle of monitoring, a description of the monitoring device, and a description of any correlation between ageing indicators, such as elongation at break and the monitoring data, along with the acceptance criteria used and its basis.

6. The SCAP knowledge base

The aim of the knowledge base is to provide a state-of-the-art description of the degradation mechanisms, the main influencing factors, the most susceptible materials and locations, and common strategies available for mitigation and repair. The knowledge base would complement the SCC and cable databases, and cross-references will be implemented between event data and knowledge base data to enhance the usability of the information. The working groups will soon discuss the steps to follow in order to develop the knowledge base performance requirements, as well as to define the range of applications and the platform tools to be used once the database are populated.

7. Future steps and intended outcomes

The SCAP is currently in the development phase, defining and refining the database performance requirements, data format and coding guidelines. The SCC working group has finalised the SCC event database format they and is now focusing on populating the event database. The cable working group will finalise the cable database format and the coding guideline at its next meeting in September 2007. Some preliminary data have already been provided by the member countries and used to test the adequacy of the database format and structure. The working group's members will soon develop a pilot set of data to verify the applicability of the format and the coding.

An assessment report will be published at the end of the SCAP project and provide the technical basis for commendable practices in support of regulatory activities in the fields of SCC and cable insulation. However, the exact scope of the assessment will depend on the amount and quality of the information gathered, and will be defined though participants' discussions.

It is envisaged that the project's outcomes will be used by the NEA member countries to evaluate how operating experience and state-of-the-art technology are incorporated into plant operating practices, and to support regulatory authorities' reviews of ageing management programmes.

The usefulness of the database obviously grows as member countries continue to enlarge and update it. Consideration will therefore be given to maintaining the database beyond the time frame of the project.

The project has brought together SCC and cable experts from regulatory bodies, industry, research institutions and academia. It is expected that this expert network will facilitate the sharing of knowledge as well as increase co-operation among experts outside the project.