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 OECD Nuclear Energy Agency (NEA) member countries joined the SCAP (Project) in 2006 to share knowledge and 16 countries have joined the project as of April 2009. 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 has been defining and refining the database performance requirements, data format and coding guidelines and the project is currently focusing on populating the database and will start the assessment of the data. It is envisaged that the project's outcomes will be used by the 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.*

I. INTRODUCTION

The number of ageing nuclear power plants is increasing in 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.

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. There are currently 16 countries participating in SCAP: Belgium, Canada, the Czech Republic, Finland, France, Germany, Japan, Mexico, Norway, the Republic of Korea, Spain, Sweden, Switzerland, the Slovak Republic, the United States and Ukraine. The International Atomic Energy Agency (IAEA) and the European Commission are also participating as observers.

II. 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 will help regulators and operators to enhance ageing management.

The project is scheduled to last four years and is currently focusing on populating the database and has started the assessment of the data. The commendable practices report is expected to be published at the end of the project in mid 2010.

III. 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.

As of April 2009, the SCC working group has met seven times and the Cable working group has met six times. The SCC and Cable database scope and the structures have been defined. The SCC and Cable database formats have also been finalized and the working groups have been collecting data and assessing the data. This paper will concentrate on the work and results of the SCC working group.

IV. SCC EVENT DATABASE

IV.A. Scope of the SCAP SCC event database

The SCAP SCC event 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[*1], 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, irradiation-assisted SCC, primary water SCC, external chloride SCC and transgranular SCC.

IV.B. SCC database structure

The SCC event database structure was defined based on the participating experts' experience, NEA experience in handling different international databases, such as the OECD Piping Failure Data Exchange Project (OPDE Project) and the R&D information provided by the member countries (Ref.1).

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.

IV.B.1. Failure data input

This form defines the minimum data requirements. All data entry starts from here. It contains 35 fields, including the plant's name and the plant's operational state at the time of the 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.

IV.B.2. Flaw characterization

This form contains 11 fields with information that characterizes the flaw (description, information about size and further details according to the type of flaw).

[*1] 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.

IV.B.3. ISI history

This form consists of 4 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 the most recent inspection.

IV.B.4. Root-cause information

This form consists of 52 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.

The SCC working group has been populating event data and there are 267 events in the online database as of April 2009. The Access version contains 1450 records as of April 2009, including SCC events transferred from OPDE for countries participating in both projects. Figure 1 shows the content of the event database by mechanism.

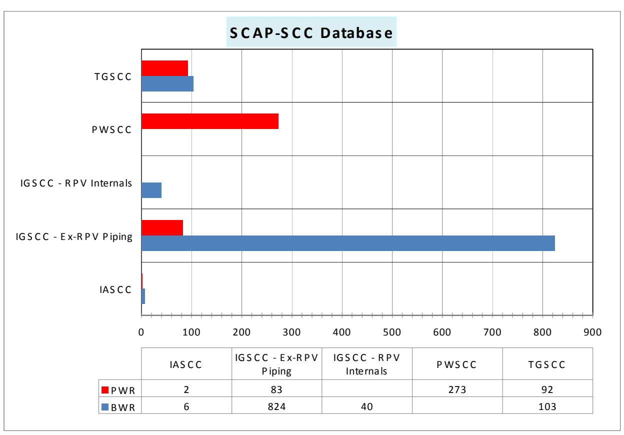

Figure1. SCAP-SCC Database by SCC Mechanism

V. THE SCAP SCC KNOWLEDGE BASE

The aim of the SCC 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 SCC knowledge base complements the SCC event database and cross-references will be implemented between event data and the Knowledge base data to enhance the usability of the information.

The SCC working group has identified the element of the each knowledge base and is collecting relevant information. The SCC knowledge base platform tools have been developed and the web interfaces are being set up. The structure of the knowledge base is illustrated in Figure 2. Basic background information such as the different regulatory practice in the participating countries, ISI qualification requirements as well as mechanism related mitigation and evaluation approaches is being collected. It is the intention of the project that the knowledge base will be available to a wider range of organizations and countries than those participating in SCAP.

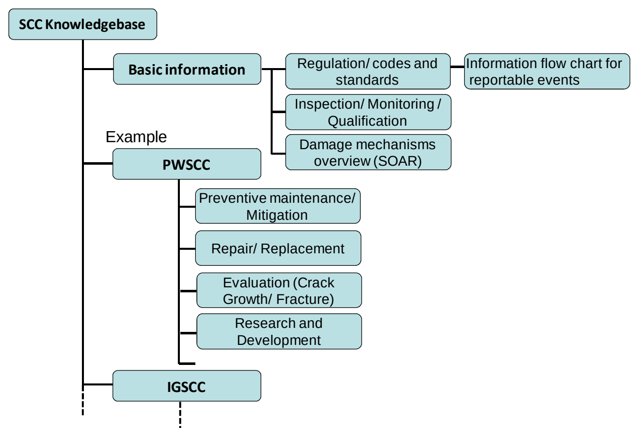

Figure 2. SCC knowledge base structure

VI. FUTURE STEPS AND INTENDED OUTCOMES

The project has been defining and refining the database performance requirements, data format and coding guidelines and is currently focusing on populating the database and assessing of the data. Population of databases such as the SCC event database is a continuous process.

The SCC working group agreed to identify representative events for which all the input forms should be completed. For statistical purposes only the first form (failure input data) needs to be completed for events identical or very similar to a representative event.

The database, together with the knowledge base and the commendable practices which will be developed from them, will provide a tool for assisting the member countries. The final report will be published at the end of the project and will 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. The linkage between the different sources of information and the process leading to the final report are illustrated for the SCC working group input in Figure 3.

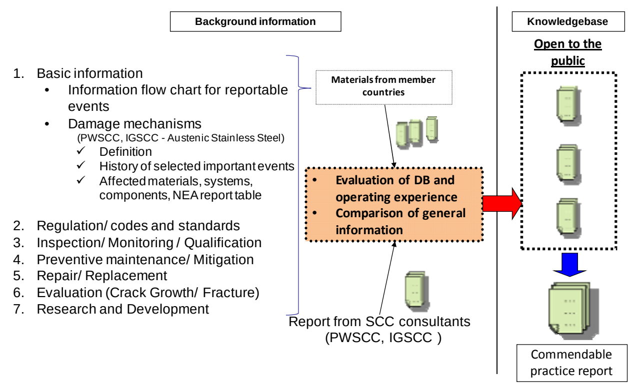

Figure3. SCC working group approach to identify commendable practices

It is expected that SCC commendable practices can be divided into several major groups according to the underlying mechanisms:

- Events for which sufficient research and development work has been done so that prediction, reliable inspection and mitigation methods are available
- Events for which there is insufficient understanding of the mechanism but for which there are repair methods developed and/or disposition of cracks is possible and for which further research and development work is necessary
- Events which occur for the first time

It is envisaged that the project's outcomes will be used by the 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.

VII. INSIGHT INTO ESTABLISHING AN INTERNATIONAL DATABASE

It is a complicated task to establish a forum for the exchange of international event data. Complications arise because of the different regulatory regimes and the proprietary nature of much of information relating to engineering activities that involve structural evaluation of flawed parts, root cause evaluation, and ISI technology. Another basic problem is that reporting levels vary from country to country and even over time in a given country. Experience has shown that this has resulted in considerable difficulties to provide detailed or complete information about very early events. There is now an awareness of the value of compiling such information and thus for more recent events extensive information can often be collected. These difficulties are of course reflected in the quality of the data and can reflect the usefulness of the database for some applications in which specific information is required but not available to the extent necessary.

To try and overcome these difficulties, the project has brought together SCC experts from regulatory bodies, industry, research institutions and academia. However a period of four years is very short to establish and populate a database of the complexity of the SCC event database. Without the experience from the OPDE project the establishment of the SCC event database would not have been practical within the timeframe of the SCAP project.

The usefulness of the database obviously grows as member countries continue to enlarge and update it. Consideration is therefore being given to maintaining the database beyond the timeframe of the project.

It is expected that the expert network will facilitate the sharing of knowledge as well as increase co-operation among experts outside the project.

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