MANAGEMENT OF I&C AGEING

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Abstract

This report presents a brief perspective on the management of I&C ageing in UK NPPs. It does not address the issues of refurbishment strategies, the use of digital I&C or the technical details of advanced monitoring techniques. These items are discussed in other country reports and elsewhere in this TECDOC.

1. INTRODUCTION

The UK has 35 Nuclear Reactors connected to the National Grid. Twenty of these reactors are Gas Cooled reactors with Magnox fuel, 14 are Advanced Gas Cooled Reactors (AGRs) and there is one PWR - the most recent station Sizewell B. A whole range of I&C equipment is installed on these reactors; from electromechanical devices such as cam-timer circuits, through analogue electronic and relay equipment to the latest generation of computer based SCADA systems.

2. AGEING MANAGEMENT OF I&C SYSTEMS

The UK nuclear industry, and its regulator the Nuclear Installations Inspectorate, have always recognized that ageing presents a threat to plant systems of all types, including I&C. Until recently no specific measures have been taken for I&C systems although the practices of equipment selection, qualification and regular maintenance have always included features to guard against the effects of ageing. These areas are now considered in more detail.

3. EQUIPMENT CLASSIFICATION AND TYPE APPROVAL

All UK NPP I&C equipment is classified according to its safety significance and business impact and this classification is also applied to other activities carried out on the equipment such as maintenance, modification and storage of spare parts. All equipment important to nuclear safety is Type Approved before entering service. For established items specific Quality Assurance requirements are imposed on the manufacturing process which will include procedures for testing and component traceability, etc. New items are type-tested which includes a full range of environmental testing at extremes of temperature, humidity and vibration for extended periods to identify design failures which would render the safety function vulnerable to ageing mechanisms. Safety equipment is also tested to ensure it can withstand the environment or hazard which it is designed to protect against. Equipment Qualification for the UK's most recent plant, Sizewell B, included qualification of aged components against design basis hazards. For example a system which is intended to shut down the plant after an earthquake will be aged and seismically tested to ensure it can survive the earthquake.

In addition to type-testing, new equipment is also analyzed to predict its in-service reliability, and the reliability figures are then used to allow a maintenance regime to be derived which ensures the equipment continues to meet the safety claims based upon it. This analysis will include an allowance for ageing. A conservative system design philosophy is also used to ensure that a single random failure, such as could be caused by the onset of ageing, will be tolerated without detriment to safety.

4. MAINTENANCE PRACTICES

Traditionally I&C equipment has been maintained by a combination of scheduled and breakdown maintenance. Surveillance requirements for all systems relevant to nuclear safety are formally included in station documentation and in some cases are subject to approval by the regulator. On gas cooled reactors there is a maintenance schedule which covers all such items and specifies the type and frequency of maintenance. At Sizewell 'B' (PWR) the technical specifications for each system include the surveillance requirements.

The frequency for all scheduled maintenance is mainly determined from consideration of aspects such as calibration drift and an assessment of the probability (either numerical or qualitative) of an unrevealed failure during normal operation. The latter aspect is determined from a combination of operational history of the system or similar equipment but also includes an allowance for early detection of ageing effects to allow remedial action before the effects become more widespread. At Sizewell 'B' equipment performing a safety function is replaced at the end of the qualified life determined in the qualification process.

In recent years the established approach to maintenance has been examined to ensure it best serves the nuclear safety and business needs of the operators. This has led to the introduction of reliability centred maintenance (RCM) and review of effective maintenance (REM) techniques, whilst ensuring that there is adequate defense against low probability/high consequence events and this evaluation is continuing. A more extensive program of condition monitoring of I&C equipment is being investigated at Sizewell B.

5. CALIBRATION FREQUENCIES

Calibration frequencies are specified according to the duty and technical performance of the equipment concerned. In multiple channel redundant systems routine calibration of individual channels is usually staggered to ensure that under normal conditions only one channel is unavailable due to maintenance and each channel is always at a different stage of its maintenance cycle to minimize peak system unreliability. However staggered maintenance is often not possible on in-core/containment devices as access may be restricted to outages. Historically gas cooled reactor safety circuit equipment was calibrated every three months, but in several instances a re-evaluation of the process and equipment history has allowed the intervals to be extended, although in some cases extension has not been justifiable. For most routine calibration activities the entire channel is tested including the primary sensor and all items downstream. Primary in-core/containment sensors are specifically checked during major overhauls although continual plant surveillance causes anomalous readings to be checked as soon as they are detected and techniques are being developed to perform on-load checks of some primary sensors. On-line condition monitoring techniques such as noise analysis and channel checks are being investigated at Sizewell 'B' and moves are in hand to consider the application of these techniques to the gas cooled reactors. Excessive calibration drift of safety circuit I&C equipment may be classified as a dangerous failure mode which would then be formally investigated.

6. REGULATORY REQUIREMENTS

A triennial safety system review is carried out on all systems with an identified safety duty which includes a substantiation that the equipment continues to meet the safety claims placed upon it.

Site license conditions also require a periodic review of plant safety every 10 years. The aim of the periodic safety review is to assess the whole plant to ensure the safety case remains valid and supportable for the period of operation until the next review. For plant systems, including I&C equipment, this includes an assessment of ageing and degradation effects. The assessment includes a review of operating environment, maintenance processes, operational history and wider consideration

of the implications of information available on ageing and degradation from other plants. It is beyond the scope of this report to describe the other important aspects of periodic safety review and how it applies to I&C equipment although it is discussed in other IAEA documentation.

Periodic safety reviews have recently been completed for all of the AGR plant. The assessment of ageing effects has included a comprehensive review of operational experience and a review of information available in the public domain and to date no significant generic effects have been identified other than those already mentioned in this TECDOC.

7. OPERATIONAL FEEDBACK (OEF)

Whilst UK nuclear power generators are legally obliged to inform the regulator of abnormal events which may impact safety they have also established an operational feedback (OEF) system to ensure that the lessons from all significant events are learned wherever applicable.

The objective of OEF "is to effect improvements in the design, operation and maintenance of UK nuclear power plants in order to minimize the risk of events, to enhance safety and improve availability". Five key activities support this objective:

1. Collection, recording and analysis of nuclear safety related events at UK nuclear stations such that information is available in a readily retrievable and usable manner.
2. Review of event information for generic issues and make recommendations for implementation on station to minimize the risk of events.
3. Collection, analysis and recording of information on good practices.
4. To facilitate the effective dissemination of event and good practice information to relevant staff.
5. To interface with other reporting organizations to both transmit and receive OEF information.

Site events are reported in accordance with a formal procedure which provides guidance on reporting, recording and notification of events. It defines the types of events to be reported, and to what extent they should be reported. The types of events that are included are incidents, abnormal occurrences, minor events and near misses.

The central feedback unit (CFU) are a central, co-ordinating team for OEF activities for all UK nuclear stations, and the interface between international organizations and corresponding databases. It receives event reports (where the event classification requires it to be reported off-site) from all UK Nuclear stations and screens them on a weekly basis for clarity and adequacy, and takes the decision on the most appropriate action to implement a solution. Human Factors and Engineering Departments also provide technical assessment of the reports. Only events that are required to be reported off-site, or where the OEF engineer deems the report to be beneficial to other stations are reported to the CFU. The event report is then made available to all NUPER users. The CFU also routinely screen information from international sources, with any significant events being made available on the NUPER database via an International Event Report. They will also screen UK reports for reporting to either World Association of Nuclear Operators (WANO) or the Incident Reporting System (IRS).

When an event has significant implications for safety, a mandatory assessment (MA) can be issued. The MA details are put onto NUPER, and will require a response from those stations and HQ department to which it is applicable. The purpose of a mandatory assessment is to determine the action taken at stations in response to an event or issue, and to consolidate good practices that are of benefit to the stations. In addition, any plant event that has been subject to an external panel of inquiry will result in an MA being issued to other stations. Stations may also respond to an event even if they are not required to by an MA, if they feel that other stations would benefit. This is known as 'deferred assessment'.

8. AGEING RESEARCH

The wide diversity of I&C equipment employed on UK NPPs has meant it has been difficult to justify research into the ageing of specific items unless there is actual operational experience of ageing phenomena. However electrical cables have been acknowledged as an area worthy of generic research due to their key role in almost all aspects of I&C and the potential effect of ageing on system integrity. Conclusions reached by UK sponsored research are generally consistent with those worldwide: the dominant mechanisms are heat and radiation which affect the physical and electrical properties of cable insulation.

There has been research and investigation into specific components where ageing related failures have been encountered but these have not revealed any general ageing trends or failure modes.

The UK nuclear industry also funds a comprehensive research programme for all aspects of nuclear power and the issue of ageing and obsolescence of I&C systems has recently been acknowledged as an area deserving attention.

9. MANAGEMENT OF AGEING

With the exception of SZB, the UK's most modern nuclear station, all UK NPPs have experienced an on-going program of replacement or refurbishment of I&C systems. Some of this work has arisen to combat the threat of ageing equipment although a greater amount has been due to obsolescence or a need for improved performance, including meeting more onerous nuclear safety requirements. The ageing mechanisms include all those mentioned in the main body of this TECDOC and are not dominated by any single cause. On all power stations, including the older magnox stations, much of the original I&C equipment remains. To date no large scale replacement of cables has been found necessary although it has been found necessary to replace some Vulcanised Rubber Insulated cables on a particular site.

The recent acceleration of I&C equipment development and the consequent shortening of product life-cycles has brought the combined problems of ageing and obsolescence into sharp focus. Whilst the management strategies of the past were essentially reactive, it is now recognized that a more forward-looking approach is required. The periodic safety reviews discussed above have considered the problems from a nuclear safety perspective and work has begun using I&C life-cycle management methodologies developed by EPRI to manage the commercial threat to businesses. At present this work has mainly involved the production of system maintenance plans for key systems, which address the issues of reliability, maintainability and obsolescence. Long term management plans for on-line data processing systems are also seen as a key activity. This work is being carried out with a regular review and a rolling horizon of several years (10 years is often chosen).