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NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

LESSONS DRAWN FROM RECENT (2003-2004) NUCLEAR POWER PLANT OPERATING EXPERIENCE

TECHNICAL NOTE

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), Korea (12th December 1996) and the Slovak Republic (14 December 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of 28 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The Committee on the Safety of Nuclear Installations (CSNI) of the OECD Nuclear Energy Agency (NEA) is an international committee made up of senior scientists and engineers. It was set up in 1973 to develop, and co-ordinate the activities of the Nuclear Energy Agency concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations. The Committee's purpose is to foster international co-operation in nuclear safety among the OECD Member countries.

The CSNI constitutes a forum for the exchange of technical information and for collaboration between organisations, which can contribute, from their respective backgrounds in research, development, engineering or regulation, to these activities and to the definition of the programme of work. It also reviews the state of knowledge on selected topics on nuclear safety technology and safety assessment, including operating experience. It initiates and conducts programmes identified by these reviews and assessments in order to overcome discrepancies, develop improvements and reach international consensus on technical issues of common interest. It promotes the co-ordination of work in different Member countries including the establishment of co-operative research projects and assists in the feedback of the results to participating organisations. Full use is also made of traditional methods of co-operation, such as information exchanges, establishment of working groups, and organisation of conferences and specialist meetings.

The greater part of the CSNI's current programme is concerned with the technology of water reactors. The principal areas covered are operating experience and the human factor, reactor coolant system behaviour, various aspects of reactor component integrity, the phenomenology of radioactive releases in reactor accidents and their confinement, containment performance, risk assessment, and severe accidents. The Committee also studies the safety of the nuclear fuel cycle, conducts periodic surveys of the reactor safety research programmes and operates an international mechanism for exchanging reports on safety related nuclear power plant accidents.

In implementing its programme, the CSNI establishes co-operative mechanisms with NEA's Committee on Nuclear Regulatory Activities (CNRA), responsible for the activities of the Agency concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also co-operates with NEA's Committee on Radiation Protection and Public Health and NEA's Radioactive Waste Management Committee on matters of common interest.

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LESSONS DRAWN FROM RECENT (2003-2004) NUCLEAR POWER PLANT OPERATING EXPERIENCE

Technical Note

Introduction

This document is the third in a series of CSNI Working Group on Operating Experience (WGOE) technical notes on nuclear power plant (NPP) recent operating experience. The purpose is to provide lessons to the NEA Committee on Safety of Nuclear Installations (CSNI) and Committee on Nuclear regulatory Activities (CNRA) as instructed in the WGOE mandate. The identified safety issues are generic in nature. Consequently, national regulatory bodies, technical support organisations and nuclear operators should analyse them in order to see if they are relevant to safety of the NPPs in their countries.

The Incident Reporting System (IRS), jointly operated by the NEA and the IAEA, has contributed to the promotion of the feedback of lessons learned from operating experiences of NPPs. The IRS has enabled these agencies to perform studies on operating experiences, as well as to engage in other activities such as workshops, specialists meetings, and joint research projects. There are many advantages to sharing of operating experiences worldwide, and thus the NEA and the IAEA have held joint meetings for this purpose. The most recent meeting was held in Vienna in September 2004. The WGOE had its annual meeting on the same occasion. These meetings and the tasks supervised by WGOE produced material for this technical note.

Recent Significant Events

Recent events of safety significance include: erosion-corrosion of piping, electrical disturbances and foreign material intrusion into the primary system. These areas of concern are summarised in the following sections.

Electrical Disturbances. Several electrical events, both plant-centered and in the off-site grid, have been reported in recent international operating experience. The previous (2003) WGOE technical note NEA/CSNI/R(2004)3 mentioned the August 2003 massive grid disturbance in the United States, which propagated into parts of Canada. More information was presented at the IRS TM meeting in 2004. The Pickering station (8 units) experienced a total loss of off-site power. Plant cooling was by natural circulation for a number of hours. The event revealed deficiencies in a number of safety systems, including emergency service water, firewater, and standby generators, as well as high-lighting opportunities for improvements in the licensing basis. Corrective actions including changes in plant design and operation are currently being instituted.

Also, in June 2004 there was a loss of off-site power at the Palo Verde NPP in the USA involving a complete loss of 5,500 Mwe generating capacity on the grid, including more than 3,700 from the three units at Palo Verde. The cause was traced to a single failure of protective circuitry at an off-site substation. In general, the station responded according to design, although one emergency diesel generator failed to start. It was observed that the transmission company operators had not analyzed a situation of a simultaneous loss of all three units. The event was considered as highly risk-significant. Corrective actions included improvements in the off-site grid components.

These events had common messages: 1) The operating utility had not adequately analyzed these scenarios and, in the case of Palo Verde, there was a weakness in the ability to supply offsite power from two independent sources; 2) The deficiencies at Pickering indicated the need to make significant changes in operating procedures and equipment in order to enhance the licensing basis and 3) Both events indicated the frailties of the interconnected grids when large concurrent trips of generating capabilities occur.

Foreign material intrusion into the primary system. There have been two recent significant events involving foreign material intrusion. At the Tihange-1 plant in Belgium, a severely damaged spiral-wound metallic gasket was found in a safety injection system check valve. A fuel failure was observed some months later. The fuel anti-debris devices were unable to catch some portions of the gasket, and the mechanical damage of the fuel cladding was likely caused by the pieces of the gasket that went through these anti-debris devices. Another significant foreign intrusion event was experienced at the Fessenheim facility in France. A human error in valve alignment in the letdown and makeup system (or CVCS), combined with a design modification that was possibly not fully analyzed, resulted in intrusion of demineralizer resins into the primary system. The consequences included: contamination and exposure of workers, obstruction of the sampling system, and a six-month outage of the facility for cleanup and repair. The systems affected included operation of the control rods (20 of 48 rods failed to insert on command); blockage of injection to reactor coolant pump seals; and potential failure of high-pressure injection pumps due to bearing failure. Although foreign material intrusion is a recurring concern, these two events were particularly significant. The first one led to a fuel failure and the second one to safety system impairments and a long outage.

Erosion-corrosion of piping. A significant event occurred that involved failure of a condensate water pipe at the Mihama 3 (Japan) on August 9, 2004. The event resulted in severe injuries to plant personnel, including 5 fatalities. Although the accident is still under investigation, some features of the event are known at this time including that: 1) the ruptured portion of the piping should have been inspected according to plant guidelines - however, it had not been inspected since the plant start-up in 1976; 2) there was an unauthorized residual life evaluation rule, like the ones used at thermal power plants, applied by the plant operating organization; 3) quality management system of the operating organization was not sufficient to check the contracted work; and 4) the secondary piping inspection had been within the scope of utilities' self-imposed inspections. There was a precursor event at a similar plant in the USA (Surry-2) in 1986. Furthermore, a number of other erosion-corrosion events may be found in the IRS database, including pipe ruptures. As a corrective action, improvements in inspection practices of both the operator and the regulator are being considered and/or already applied. For instance, from 1 October 2003 the self-imposed inspection is legally required, and the regulatory agency now reviews secondary wall thickness inspection by the utilities. Also, the Japanese Society of Mechanical Engineers is preparing a piping thickness management standard, and the regulatory body (NISA) is considering the endorsement of the standard by regulation.

All these three areas represent recurring events and illustrate the continuing need of responding to operating experience and instituting an appropriate and timely corrective action program. They also may indicate the need for more prompt and prescriptive actions by the regulatory bodies.

Generic Safety Issues identified by WGOE

The identified generic safety issues include recurring events, events involving the use of and performance of contractors, and origins of common cause failures (CCFs).

Recurring Events. As approved by the CSNI, the WGOE has continued its study of recurring events. In the WGOE 2004 annual meeting, the draft report of corrective actions for Loss of Decay Heat Removal in a PWR While in a Reduced Inventory Situation was discussed. More than 50 such events have occurred

over the past 25 years. Several types of corrective action approaches have been used, ranging from information notices, to advisories and suggestions, to formal and binding directions by the regulatory authorities. It was seen that the peak in this scenario frequency was in 1988. The US NRC issued a generic letter at that time with non-binding suggestions on means for reducing the number of occurrences. Some notable effect was seen, but events have continued to occur even in 2004. By contrast, for instance, France and Korea issued some binding[1] requirements that seemed to stop the recurrence there. The CNRA may want to consider the contrast between advisory responses and firm and prescriptive issuances by the regulatory body.

Moreover, the WGOE proposes to continue the recurrence theme next year in a similar study on the risk-significant issue of loss of service water to safety-related equipment. This study may require a kick-off WGOE working meeting to gather more information than is usually contained in the IRS reports, and to obtain the benefit of further events which have not heretofore been reported.

Events Involving Contractors. The WGOE in-depth discussion theme at the 2004 annual meeting was the influence of contractor (and sub-contractor) work on the evolution of events. Member states gave several presentations about events involving contracted work including, e.g. a brief interruption in decay heat removal due to maintenance during an outage, and a plant start-up before some scheduled contracted work could be completed; and manufacturing deficiencies in the component cooling water system heat exchangers. Also, ideas for avoiding problems and correcting the situation were discussed.

There is an increasing use of contractors and sub-contractors in the nuclear industry, although outsourcing is in fact nothing new. Concerns about the use of contractors have increased lately due to the fact that both the licensee and the contractor organisations may experience lack/loss of competence via outsourcing. Small utilities and regulatory bodies dealing with large and sometimes multinational contractor organisations seem to be most vulnerable to this. The licensee must be able to exercise contractor supervision in all circumstances. However, some events indicate a growing problem of detecting sub-standard performance. In addition, the licensees need to qualify the contractors, but the procedures for this may not be adequate or not even exist in the light of recent experience. Also, matters such as training on nuclear specific requirements always belong to the operator organisation. Contracting and subcontracting may, if not handled adequately, lead to losing a long-term safety focus. Core competencies must always be kept in-house in order to remain an intelligent customer. This includes, among other things, the ability to qualify contractors; oversight on training of contracted personnel; supervision and approval of contracted work; and, most importantly, continuing involvement in the maintenance of safety focused thinking.

Based on the presentations and discussion, the WGOE is ready to carry out more work in the area if agreed by the Committees.

ICDE project findings - batteries

The most recent ICDE project report was issued in late 2003 about batteries (http://www.nea.fr/html/nsd/docs/2003/csni-r2003-19.pdf). Deficiencies in design were involved in 50% of events. Of them, 92% occurred during battery manufacture (e.g. inadequate selection of component materials for the plates, in the electrolyte, in separators, in cells, or in terminal connections) and 8% occurred during the plant specification or modification process (e.g. calculation errors in the capacity definition). Deficiencies in maintenance / testing were involved in 42% of events. Of these, approximately half were due to physical failures in the battery subcomponents, nearly 30% were due to electrical failures, nearly 20% due to direct

[1] Some examples of these binding requirements are: in France, an automatic makeup function was provided; a detailed work schedule and required conditions was required prior to mid-loop entry, and, a vortex detection device was installed. In Korea, there were requirements for better training of staff; better level instruments; revision of RHR pump procedures; review of critical level calculations; and, revised technical specifications.

human actions, and one event was due to premature ageing caused by lack of maintenance. The data suggests that the majority of maintenance / test events could be prevented with adequate test / maintenance practices and surveillance of the circuit continuity.

More generally, the main areas for improvement against common cause failures at NPPs, according to the findings of the ICDE project, are: 1) scrutinizing existing operation, maintenance and testing procedures for deficiencies creating the potential for CCF of redundant systems, 2) ensuring comprehensive work control, 3) comprehensively prescribing the steps of testing required in the re-qualification of components or systems after maintenance, repair or backfitting work and 4) intensifying training, introducing ergonomically better designs and introducing more key locks. These findings apply to all analyzed component types.

Concluding Remarks

Almost all the recent significant events reported at the international meetings have occurred earlier in one form or another. Counteractions are usually well known, but information does not always seem to reach end users and/or corrective action programmes are not always rigorously applied. Due to these concerns, the WGOE has developed in 2003 new IRS guidance to report recurring events so that more information would be available in IRS reports.

Another possible issue of concern deals with gaps in the operating experience loop at NPPs. The WGOE is aware of several instances where reports indicate gaps in the utility groups responsible for analysis and evaluation of operating experience.[2] Recurring failures and events are often either directly or indirectly attributed to shortcomings of these groups. The topic deserves intensified oversight.

The main lessons both from the ICDE project, telling that operation & maintenance dominate as causes for CCFs, and a number of recent events dealing with the increased role of contractors and subcontractors, show that the regulators may need to enhance oversight on the organizational arrangements, competence and safety culture of the licensees to ensure a safe operation and maintenance of the NPPs.

[2] This refers to, at least, IRS reports 7330, 7573, and 7604, as well as the Davis Besse Lessons Learned Task Force.