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Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development **16-Jan-2004**

English text only

NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

NEA/CSNI/R(2004)3
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CONCLUSIONS DRAWN FROM RECENT (2002-2003) EVENTS IN NUCLEAR POWER PLANTS

TECHNICAL NOTE

English text only

JT00156786

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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CONCLUSIONS DRAWN FROM RECENT (2002-2003) EVENTS IN NUCLEAR POWER PLANTS

Technical note

Introduction

This document is the second in a series of CSNI Working Group on Operating Experience (WGOE) technical notes on recent events in nuclear power plants (NPPs). The purpose is to transmit WGOE views to both the NEA Committee on Safety of Nuclear Installations (CSNI) and Committee on Nuclear Regulatory Activities (CNRA) and through them to NEA member countries. The identified safety issues are generic in nature. Consequently, national bodies and nuclear licensees must use their judgment about how to take these issues into account in their own programs of action.

The Incident Reporting System (IRS), jointly operated by the NEA and IAEA, has contributed to the promotion of the feedback of lessons learned from operating experiences of NPPs. The IRS has enabled the 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 IAEA have held joint meetings for this purpose. The most recent meeting was held in Paris in September-October 2003.

The significant events and other operating experience used as material of this note were presented at the joint IRS meeting and / or collected in the tasks supervised by WGOE.

Recent Significant Events

Fuel Failure at PAKS

Unit 2, of the four-unit VVER station PAKS, in Hungary, experienced a failure of thirty fuel elements during a fuel cleaning procedure in April 2003. A cleaning device had been placed in the fuel pool and a number of assemblies inserted for the cleaning operation. After the cleaning process, the assemblies over-heated due to lack of sufficient cooling. The delayed opening of the device resulted in thermal shock and severe fuel damage followed by a limited release of fission products. There were detectable elevated radiation readings off-site for a very short period of time. Slight contamination resulted in the reactor hall. Among the given causes were: i) decrease in station safety culture; ii) excessive trust in the contractor supplying the cleaning device; iii) underestimation of safety consequences in the design of the cleaning cask; iv) lack of regulatory oversight in licensing and inspection; v) lack of competence and procedures for the cleaning operation itself; and, vi) stress of time and overemphasis of production versus safety.

Reactor Vessel Penetration Degradation at South Texas

The WGOE technical note for 2002, NEA/CSNI/R(2002)24, mentioned the reactor upper head corrosion event at the Davis Besse PWR in the USA. A related, but much less significant, event involved the discovery of a minor amount of boric acid deposits around the lower vessel instrument penetrations at the

South Texas PWR station. Two penetrations exhibited cracks during the non-destructive examination. The risk of the event, as discovered, was thought to be very low. The plant has concluded that there were some lack of fusion zones in the initial welding, and that this allowed primary water to intrude. Thus, there was a high-temperature, high-purity water environment, a susceptible material, and high local stresses. All of these factors are known to promote primary water stress corrosion cracking. The regulator also concludes that this explanation is the most likely, and is consistent with the available information. Further details may become available later. The plant has returned to service.

Circulator Failure at Torness

Two separate cases of destructive failure of gas coolant circulators at the UK Torness reactor were reported. The first instance involved the complete disintegration of the impeller on a 1.6-meter diameter circulator. The initiator is supposed to be fatigue. A few months later a second failure occurred but the operators detected the vibrations and tripped the circulator before it fully disintegrated. The vibration alarms had been discredited by unreliability and poor presentation, and were thought by some to be superfluous until the second failure occurred. More comprehensive circulator vibration monitoring equipment has been or is being installed at Torness and its sister station Heysham 2.

Safety Injection at Dampierre-3

A spurious case of safety injection occurred at the Dampierre-3 reactor. The plant was in an intermediate start-up state. The steam generators were removing decay heat, and there was a bubble in the pressurizer. A key-lock inhibited safety injection during the plant startup. At this point in the startup sequence, the operator mistakenly removed the inhibition, and the high-pressure injection began. Another error was made during resetting the signal. In consequence of those two errors, the pilot-operated relief valve first cycled 21 operations and then 54 operations more at high reactor pressure. The lessons learned indicated a need for more training and better procedures on interlocks. This is still under consideration as of the writing of this note.

Spurious valve functions at Two Facilities

Two events illustrated long-standing errors in actuation set points or settings. There was an event at the Angra-2 unit in Brazil; this unit was commissioned in the year 2000. While at shutdown, and at pressure of 31 bars and temperature of 75 ° C, there was an inadvertent opening of the safety valves in the RHR system. The RHR rooms were flooded; the pressurizer emptied, and there was a high level alarm in the containment sump. The actual cause of the incorrect set point was not found. The consequences in other situations, especially if this primary leak could not be isolated, could be more severe. There also was a failure on demand of an injection valve of the reactor core isolation cooling (RCIC) system at the Laguna Verde station. This valve had been removed during the last maintenance period and it had been reported as tested. A maintenance contractor had then re-installed the valve with errors in the motor wiring. As a result, when the valve reached the full-open position, it automatically closed. This prevented injection during a transient that occurred at the plant and would have called the RCIC function. The high pressure coolant injection system provided vessel makeup during the event.

Thermal Sleeve Failures at Barseback-2

At Barseback-2 boiling water reactor, there was a material failure of thermal sleeves in a tie-joint between the normal feed-water system and the RHR system. The sleeves got loose and went to the feed water divider header, with some tiny parts going into the reactor vessel. The direct cause was attributed to flow-induced vibration, the root cause being an unproven design and lack of supervision/analysis. Of more concern to SKI was that the plant did not provide enough guidance and support for the project work, and did not shut down on a timely basis. SKI has taken strong action in a court proceeding, according to the Swedish Nuclear law.

Electrical Problems at Koeberg

The two-unit PWR in South Africa, the Koeberg station near Cape Town, experienced electrical difficulties with degraded breakers on a 6.6 kV safety bus. During the replacement campaign, the two diesel generators were found to be inoperable due to some independent failures. This two-unit station has two diesels per unit, and a swing unit for either unit. During this event, the train A was without back-up AC power source for 15 hours.

Small LOCA at Kozloduy

Unit 3 of the Kozloduy NPP, in Bulgaria, had an event involving primary coolant leak through a make-up system pipe into the confinement area. The event was characterized as a small LOCA. High pressure safety injection took place, for slightly more than an hour, until isolation could be effected. The failure was attributed to wear-out thinning due to mechanical friction from a nearby support. There was an initial error in design and construction in this zone. A total of about 30 cubic meters escaped from the primary system. Core cooling remained adequate, and sub-cooling margin was maintained. The NDE program did not include this portion of the pipe. Also, there were some deficiencies in the operating procedures, training program and evaluation.

ICDE Project findings

To complete the picture of operating experience with messages from lower level data collection, the NEA ICDE (International Common-Cause Data Exchange) special project has analyzed events dealing with common cause failures (CCFs) for about 10 years now. The results point at the same direction for all the analyzed components: causes of complete CCFs seem to be mostly human actions as a part of operation or design rather than manufacturing deficiencies. The contribution of human actions gets more and more dominating when the degree of redundancy increases.

Identified Safety Issues

In the technical note prepared by WGOE in 2002, recurring events were discussed. The WGOE received a new report on the current state of recurring events. It was observed that this remains as a significant safety issue. The WGOE intends to pursue this topic and investigate the nature of corrective actions among the represented countries to prevent recurrence of loss of RHR in shutdown. One objective is to determine which corrective actions seem to be the most effective.

A variety of human-related safety issues were revealed in recent events. These included:

a. Deficient operator knowledge;
b. Loss of memory of prior events;
c. Problems with procedures;
d. Complacency.

An additional factor that appeared several times was organizational matters such as clear definitions of responsibility and authority. The national bodies, CSNI and CNRA may want to consider this kind of repeated findings in their forthcoming action programs.

Several events reviewed in 2003 involved problems with control and assessment of contractor work. These include the severe fuel damage at PAKS; the mis-wired valve at Laguna Verde; the electrical components at Koeberg; and, the thermal sleeve at Barseback. The CNRA, its WGIP and the suggested Regulator-Industry Forum to be organized in June 2004 seem to focus upon this issue and WGOE is ready to support CNRA by its own actions.

On the basis of the recent events WGOE sees reasonable:

- That CNRA considers the continuation of the licensing and regulatory aspects of the use of contractors in performing work on safety related structures, systems, and components, and
- That CSNI/CNRA may wish to study topics related to electrical grid stability in light of recent developments in the opening of electricity markets to competition and in conjunction with diesel generator operability issues.

Generally, poor communications between utilities and grid operators have played a major role in the recent blackout events. A recent report on the Canadian-USA blackout mentions this aspect. The WGOE will study this report during 2004, as well as potentially the features of other recent large power failures e.g. in Italy.