"Operation Surveillance of Nuclear Power Plant Components by Vibration and Noise Analysis"

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III.C.1.

ABSTRACT

Damage occurred to coolant recirculating pumps and to reactor internals in pressurized-water reactor plants which led to long shutdown periods and enormously complicated and costly repairs to activated components.

Nineteen instances of damage to turbines in Community nuclear power plants have been reported since 1963 which likewise involved long outages.

Continuous surveillance of these components could probably have facilitated the early detection of changes likely to cause damage, provided that suitable techniques had been available, thus cutting down outages and repairs.

It is in the plant operators' interest to develop methods and instruments for the continuous operational surveillance of the vibration characteristics of important nuclear power plant components and to demonstrate their effectiveness.

By initiative of the Commission of the European Communities, the experts working in this field in the Member States have been brought together for cooperation under a study contract with the title :

"Critical comparison of operational surveillance techniques for components of nuclear power plants by vibration and noise analysis for the early detection of damage and theoretical studies for their further development".

RESUME

Des pompes de recirculation de réfrigérant et des structures internes de réacteur ont subi, dans certaines centrales à réacteur à eau pressurisée, des avaries qui ont entraîné de longs arrêts et des réparations extrêmement compliquées et coûteuses sur des composants activés.

Depuis 1963, on a enregistré dans les centrales nucléaires de la Communauté dix-neuf cas d'avaries qui ont ainsi entraîné de longues mises hors service.

Une surveillance continue de ces composants aurait probablement facilité la détection précoce des modifications susceptibles de provoquer des avaries si l'on avait disposé de techniques appropriées, ce qui aurait permis de réduire les arrêts et les réparations.

Les exploitants de centrales ont intérêt à ce que l'on mette au point des méthodes et des instruments de surveillance opérationnelle continue des caractéristiques vibratoires d'importants composants des centrales nucléaires et à ce qu'on en démontre l'efficacité.

A l'initiative de la Commission des Communautés Européennes, les experts travaillant dans ce domaine dans les Etats membres coopèrent dans le cadre d'un contrat d'étude intitulé:

"Comparaison critique des techniques de surveillance opérationnelle des composants des centrales nucléaires par analyse des vibrations et du bruit en vue de la détection précoce d'avaries et étude théorique en vue de leur développement".

It will be recalled that damage occurred to coolant recirculating pumps and, more seriously, to the reactor internals in the Trino Vercellese and Chooz pressurized-water reactor plants which led to long shutdown periods and enormously complicated and costly repairs to activated components. Operation of the Trino Vercellese plant was interrupted from March 1967 to June 1970 and of the Chooz plant from January 1968 to May 1970. A large number of connecting bolts were broken on the core barrel of the two reactors owing to vibrational stress due to insufficiently understood hydrodynamic forces.

Nineteen instances of damage to turbines in Community nuclear power plants have been reported since 1963 which likewise involved long outages. The damage mainly consisted of broken turbine blades and the effects of same.

Continuous surveillance of these components by, for example, acoustic or neutron flux noise analysis could probably have facilitated the early detection of changes likely to cause damage, provided that suitable techniques had been available, thus cutting down outages and repairs. In some cases it was the consequential malfunctions (jamming of control rods, presence of fragments in the boxes of the steam generators, damage to the turbine condenser and to rupture discs) which first indicated the breakage of the connecting bolts in both belts of the core barrel in one case and failure of some of the turbine blades in another.

In view of the difficulties and damage encountered in the Trino Vercellese and Chooz plants, special attention was paid to the behaviour of the reactor internals during the startup of the Obrigheim plant, a comprehensive series of measurements being carried out. This enabled suitable measures to be taken (i.e., rigid mounting of the thermal shield) as a result of which a repetition of similar damage in this reactor was avoided.

Detecting and rectifying the causes of damage is without question the job of the manufacturers. There can, however, be no doubt that unforeseen stresses, due in particular to vibration, are still to be expected. It is in the plant operators' interest, therefore to develop methods and instruments for the continuous operational surveillance of the vibration characteristics of important nuclear power plant components and to demonstrate their effectiveness.

As much as three years ago, on the occasion of a meeting held in Brussels in October 1966 under the programme for the exchange of experience between the nuclear power plant operators and the Commission, we drew attention to the need for joint action in this field.

Comprehensive monitoring measurements, especially on the reactor internals, were performed during the renewed startup of these installations after repair and on the Obrigheim plant; this enabled those concerned to gain experience and to develop special methods for carrying out and evaluating such vibration and noise measurements. Mr. Cioli (of ENEL) will explain details of these measurements and the conclusions drawn from them in his report.

On 17 December 1970 we held a conference on the subject of "Vibration Phenomena Inside Light Water Reactor Vessels", which was attended by experts on noise analysis from Member States and delegates from some of the departments of the Commission. This included reports and discussions on theoretical research and experiments concerning mechanical vibrations in pressure vessel internals, particular attention being given to measurements made on operational pressurized water plants (Trino Vercellese, Cnooz, Obrigheim).

At the meeting it was agreed to set up a working party of all specialists active in this field and to expand the scope of future meetings to include noise analysis and vibration monitoring in other reactor types (notably fast breeders).

We have contacted various groups of experts within the Community in an attempt to induce them to cooperate in this field. We wanted to involve at least one organization from each Community country which represents the circle of national experts and already possesses practical experience in such measuremats on light water reactors or turbines.

The Allianz-Zentrum für Technik GmbH (Germany), the Laboratorium für Reaktorreglung und Anlagensicherung Garching (Germany), the EDF (France), the ENEL (Italy) and the Laborelec (Belgium), with the assistance of the TNO (Netherlands) are at present beginning work on a study - limited for the time being to one year - on the subject of :

"Critical comparison of operational surveillance techniques for components of nuclear power plants by vibration and noise analysis for the early detection of damage and theoretical studies for their further development".

First of all a report is being drafted on the present state of the art. This is intended to provide a rundown of the measuring devices, techniques and evaluation procedures currently in use in all fields involving the use of noise analysis for the early detection of damage, namely :

1. Crack formation and propagation (stress wave emission)
2. Vibrational phenomena in reactor pressure vessel internals
3. Vibrational phenomena in turbines.

A summary will also be given of measurements made to date.

An attempt will then be made to carry out a comparative analysis of the results of measurements performed hitherto on light-water reactors and turbines in order to arrive at a uniform interpretation of the peaks observed in the spectra.

This task forms the main section of the study in view of its major importance for the practical application later on of noise measurements in nuclear power stations for the early detection of damage.

The study should conclude by giving draft recommendations and proposals for further research and development work and by stimulating the continuation of this cooperation in future years (e.g., work on improving methods and measuring devices, developing new equipment or performing further experiments).