STRATEGY PROPOSED BY ELECTRICITÉ DE FRANCE IN THE DEVELOPMENT OF AUTOMATIC TOOLS

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The strategy proposed by EDF in the development of a means to limit personal and collective dosimetry is recent. It follows in the steps of a policy that consisted of developing remote operation means for those activities of inspection and maintenance on the reactor, pools bottom, steam generators (SGs), also reactor building valves; target activities because of their high dosimetric cost.

One of the main duties of the UTO (Technical Support Department), within the EDF, is the maintenance of Pressurized Water Reactors in French Nuclear Power Plant Operations (consisting of 54 units) and the development and monitoring of specialized tools. To achieve this, the UTO has started a national think-tank on the implementation of the ALARA process in its field of activity and created an ALARA Committee responsible for running and monitoring it, as well as a policy for developing tools. This point will be illustrated in the second section on reactor vessel heads.

EDFs CURRENT ALARA STRATEGY

The objective of EDF's ALARA strategy is the adequacy between the reduction in collective dosimetry and its cost, with the priority of reducing exposure of personnel with the highest personal dosimetry.

The ALARA strategy breaks down into two distinct cases, depending on the type of maintenance operation.

FIRST CASE

In the case of a maintenance operation of a repetitive nature, therefore that could be contracted out, EDF draws up the Technical Specifications of the operation and a compulsory dosimetric results clause. The contractor(s) develop(s) the equipment and procedures required to accomplish this objective. the main aim of this process is to make the contractor responsible for achieving the best personal and collective dosimetric results possible, and a financial encouragement would be quite feasible on achieving certain objectives. The main obstacle for EDF remains the most precise evaluation of forecasted dosimetry that needs on-site mapping of irradiation rates in the various worksites, and analysis of forecasted operator dosimetry. To do this, experience feedback and worksite monitoring are necessary. Processes of this type are underway for Vessel head opening/closing operations, fuel pit decontamination, cleaning of the secondary side of SGs and primary valve maintenance.

SECOND CASE

In case of an exceptional maintenance operation, the investment required to develop the adapted means may be beyond the contractor's financial means. The UTO assumes the costs of developing the tool and makes it available to the contractor, who shall ensure that it is used correctly. The ALARA attitude of the UTO is the

same as in the first case and a partnership with the user enterprise optimizes the tool as regards dosimetry reduction.

Examples of several developments underway:

- Tool for inspecting and aiding transfer device alignment
- Removal of foreign bodies from the SG secondary side
- New generation SG nozzle dams
- Decontamination by soft chemistry.

APPLICATION TO OPERATIONS ON VESSEL HEADS

After the discovery of a penetration defect in the vessel head of Bugey 3 in 1991, EDF, backed by nuclear industrialists, investigated to find the origin and extent of the problem throughout all nuclear plants in France.

Approved processes were employed for the inspections and repairs performed in 1992. They were in part implemented with semi-automatic means developed beforehand for exceptional operations of an assurance nature (dismounting CRDM), but also and often with means requiring the presence of operators under the vessel head, consequently, exposed to high doserates (approximately 50 man Sv/h).

As a result of means generally ill-adapted to operating conditions, a lot of time was spent in 1992 on vessel head worksites that accounted for about 4% of non-availability in the EPN, and substantial collective dosimetry (9 man Sv) during these worksites.

The vessel head phenomenon proved to be a generic affair in 1992. A specific ALARA organization was created for this affair as a result of the massive collective doses in the first few months:

September 91 to December 91: 2 man Sv

An inspection program requested by the Safety Authorities was made possible by the development of technically adapted and robotized means to reasonably reduce operator doserates.

This would explain why EDF, the constructor FRAMATOME and French (ACB, COMEX, INTERCONTROLE, etc.) and foreign (ABB, etc.) contractors made substantial efforts in 1992 to rapidly and urgently develop and research the best means and procedures to perform both inspections and repairs in theoretically subcritical time as regards unit outage, with minimum dosimetry (automated or robotized means keeping human intervention under the vessel head to a minimum).

Robotized means were implemented in 1993 throughout all sites in a major inspection program. The intention is to establish a zero point status in all units affected by this problem during 1993 and 1994.

DESCRIPTION OF THE PHENOMENON

Vessel heads in pressurized water reactors have 65 to 78 penetrations for the passage of the CRDM drive shaft tubes and mounting of the motor drive mechanism (Figure 1). In French reactors, this penetration is a tube with an internal diameter of 70 mm, 16 mm thick. The lower section ends in a cylindrical or conical flaring depending on the reactor (Figure 2). Inside, there is a thermal sleeve made of austenitic steel ending in a

guide in the shape of a trumpet. The space between the sleeve and the adapter is approximately 2 mm. It is locally reduced in certain penetrations by the adapter oval shape. In most reactors throughout the world, this adapter is made of a nickel alloy, known as Inconel 600, which has proved to be vulnerable to stress corrosion cracking in primary water. The cracks develop in proportion to rising temperature under the dome. Initiating stress, result from deformation of the adapter under the effect of welding on the vessel head. This deformation is increased and asymmetric for the adapters on the edge of the head because they are at an incline compared to the surface.

It has been proved today after numerous inspections, that the predominant influence of residual stress has caused longitudinal cracks concentrated along two opposing lines of the tube.

CHANGES IN MEANS AND DOSIMETRY

Given that there is a 2 mm space between the thermal sleeve and the adapter, the control rod mechanism and the sleeve have to be dismounted and cut open.

These long and costly operations, using first generation, often manual tools resulted in high doserates : 0.44 man Sv in the inspection of one 900 MW vessel head.

Cracks are detected by ultrasonic means (depth - position in relation to the weld) and sometimes, repairs by excavation of the cracked zone and then build-up welding. These entirely manual repairs on the first operations required the physical presence of an operator under the head, resulting in high doserates.

These tools and techniques have been used to inspect and repair several heads, it is quite inconceivable, because of the high doserate generated, to use them throughout the EPN plants.

Detection Test Using an Eddy Current Detector

Development of inspection robots by industrial groups like ABB and FRAMATOME, has enabled an eddy current detector to be inserted between the adapter and the thermal sleeve to detect any cracks. This has considerably helped reduce dosimetry by robotizing manual tasks (no personnel under the head) and by getting rid of costly operations, in terms of doserate, on the rod mechanism and thermal sleeves (dismounting and remounting).

In fact, all vessel head adapters are inspected by eddy current and only 3% approximately require ultrasonic testing and eventually repairs.

The dosimetry count for eddy current detection of a vessel head has now been improved from 0.44 man Sv to 0.04 man Sv.

Adapter Repair

Adapters were first repaired by excavation and manual welding, performed under the vessel head inside biological protection. FRAMATOME has since developed a series of automatic machines that are manually positioned by an operator under the vessel head, simply to connect the machine to the adapter.

The average dosimetry count for such an operation was improved by 0.2 man Sv or so for the first manual operations to 0.08 man Sv for automatic operations.

Characterization of Adapters with Sabre Ultrasonic Detector

On all adapters controlled by eddy current detectors, about 3% had cracks that needed to be determined (depth of the crack) by ultrasonic means. In 1993, this operation required dismounting and remounting of control rod mechanisms and thermal sleeves. To avoid these high doserate operations, COMEX, ABB and FRAMATOME suggested defining cracks using a sabre type tool carried by a robot or tank capable of inserting an ultrasonic detector into the 2 mm space between the thermal sleeve and the adapter. This operation, totally remote controlled, allows an economy of 80 man mSv for first-of-a-kind mechanism dismounting and 15 man mSv thereafter.

Dismantling and Remounting of the Thermal Sleeve

Dismantling of control rod mechanisms is only justified when removing a thermal sleeve. If non destructive testing does not any more require this operation, repairs do require it, in fact, it would be difficult to design excavation and welding tools that fit into the 2 mm space available.

FRAMATOME and COMEX are currently developing tools that will remove, from under the vessel head, the lower section of the thermal sleeve thereby giving access to the adapter and also reweld this part of the sleeve onto the section that remained in place. This entire operation is remote controlled and no human intervention is required under the vessel head.

This service will be operational by the middle of 1994, it will be the last in a series of developments that aim at reducing operator dosimetry to a minimum by means of automated operations adapted to the environment and extent of the problem to be handled.

SERVICE CONTRACTS AND DOSIMETRY

Reducing dosimetry is a matter of making contractors in charge of the operation aware of the problem. In addition to the legitimate tendency of industrial groups to avoid exposing their personnel, EDF is determined to go even further, by including obligations or incentives to reduce doserates in the service contracts.

Dosimetry Planning

Each contractor with a service contract concerning reactor vessel heads is obliged to propose a detailed exposure forecast prior to the operation.

The "DOSIANA" software enables operations to be broken down into elementary tasks, each task is attributed a theoretical dose. During the operation, the task is monitored. This enables highly penalizing operations to be indicated, where it is necessary to make efforts to reduce doserate, and to detect the differences between real and theoretical doserates so the undefined part of the operation can be quantified and analyzed.

Financial Incentives to Reduce Doserate

Solving the problem of reactor vessel heads sometimes means replacing the head. Such an operation requires dismounting of the entire control rod mechanism and remounting it on the new head. An initial operation with existing tools, developed to dismount and remount several units, therefore not totally adapted to the replacement of a complete vessel head, generated 600 man mSv.

On the assumption of more heads needing to be replaced, EDF negotiated a financial package with the industrial contracting group in exchange for a substantial reduction in recorded doserate. The target doserate, that is now in the contract, is 260 man mSv, if this quantity is overshot, there will be no financial penalty, but it will be considered as nonobservance of a contractual commitment on behalf of the industrial group, and therefore, a reason for EDF to possibly break the contract.