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CERNAVODA NUCLEAR POWER PLANT: MODIFICATIONS IN THE FIRE PROTECTION MEASURES OF THE CANDU 6 STANDARD DESIGN

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Abstract

Having as purpose the improvement of fire safety at the Cernavoda NPP - both in the prevention and the protection aspects in the case of fire - we implemented some modifications in the CANDU 6 standard design. These improvements are inspired, mainly, from two sources:

- the world-wide achievements in the field of fire protection techniques, introduced in nuclear power plants since the middle of 70's, when the CANDU 6 design was completed;
- the national practice and experience in fire protection, usually applied in industrial objectives (conventional power plants, in particular).

The absence of any incident may be considered as a proof of the efficiency of the implemented fire preventing and protection measures.

1. INTRODUCTION

In 1979, Romania, an Eastern European developing country, has embarked on a very ambitious nuclear power project with the aim to build at Cernavoda, on the Danube bank, the first nuclear plant, supposed to have, finally, 5 units of CANDU 6 type.

Romania's choice of the CANDU was based on this technology's outstanding international record for safety, environmental protection and reactor reliability. Until 1989, the normal development of the project suffered from the disadvantages of the highly centralised economy, from the decisions taken by the political leaders, sometimes, against technical or economical reasons.These aspects caused large delays in completion of the project.

After the Romanian revolution of 1989, the circumstances affecting the completion of the Cernavoda project have changed. A new development of the project has begun in December of 1990, when a Consortium made up of the Atomic Energy of Canada Limited and the Italian Company ANSALDO working closely with RENEL has established an effective new project management team.

The unit 1 construction started based on AECL standard design. Since the design had been prepared, some major incidents occurred: the incident of Browns Ferry NPP, in 1975, Three Miles Island, in 1979, Vandellos 1, in 1989 and Chernobyl accident in 1986. Fire protection has received serious attention all over the world.

2. RELEVANT SUBJECTS OF THE DESIGN UPGRADING

Having as purpose the improvement of fire safety at the Cernavoda NPP - both in the prevention and protection aspects in case of fire - we implemented some modifications in the CANDU 6 standard design. These improvements are inspired, mainly, from 2 sources:

A. The world-wide achievements in the field of fire protection techniques, introduced in nuclear power plants since the middle of 70's, when the CANDU 6 design was completed:

- The development and use of Fire Risk Analysis for the assessment of the protection measures;
- The use of modern addressable fire detection system;
- The use in civil works of new materials, which can be easily installed and provide highly efficient fire protection.

B. The national practice and Romanian expertise in fire protection, usually applied to industrial objectives (conventional power plants, in particular). The traditional approach in the fire protection design, used in the construction of industrial objectives in Romania, induced design changes at the Cernavoda NPP, too. This approach has its roots in the lack of confidence in the action of the active measures (due to the low reliability of the detection and fire suppression systems previously available in Romania), as well as in the relatively low level of the "safety culture" of the operational and maintenance personnel whose preventive attitude and skills for fire extinction were not enough developed.

The Romanian program for upgrading fire protection became substantial due to the mission organized by IAEA, at the request of the Romanian Commission for the Nuclear Activities Control, our national regulatory board.

The IAEA experts pointed out the importance of fire preventing for nuclear safety of a nuclear power plant. In fact, the fire protection system was considered as a safety system.

Based on the recommendation of the experts, as well as on the provisions of the IAEA Safety Guide 50 - D2 and the Romanian rules for fire preventing and prevention, we reviewed the CANDU 6 standard design.

Our concept is intended to implement the phylosophy of "defence in depth" protection against the hazards of a fire and its associated effects on safety related equipment, with its three main objectives:

- preventing fire from starting;
- quickly detecting and extinguishing the fire which does start, thus limiting the damage;
- preventing the spread of the fire which has not been extinguished, thus minimizing its effect on the essential plant functions.

The design of the Cernavoda NPP recognizes fire as a design basis event. The fire protection design is based on one random fire at a time, which may occur at any location in the plant.

More conservative than the Canadian philosophy which states that combustible materials are subject to ignition only whenever a source of ignition is present, our philosophy is base on the assumption that an ignition may occur even when an important thermal load only is present. Therefore, we proceeded to find adequate fire preventing and protection measures wherever the thermal load exceeds 200 MJ/mp. Thus, the first step in preparing fire preventing program was to determine thermal load for each area or room in the nuclear power plant. This was done in a Fire Risk Analysis. The Fire Risk Analysis performed before the initial loading of the reactor fuel consists of:

- identifying the areas (zone or room) with high thermal load
- analyzing of the consequences of fire in such areas, taking into account the presence of the items important to safety
- determining the required fire resistance of fire barriers
- identifying cases where aditional fire separation is required
- determining of the type of fire detection and protection means to be provided.

Based on this analysis, we establish the following aditional measures:

2.1. Fire Protection of Structural Steel in the Nuclear Service Building

The stipulations of the Romanian technical, related to fire resistance require the rating of compartment boundary to be the same with the resistance rating of the structural steel assemblies upholded. The AECL design did not observed this requirements. The structural steel being unprotected, under fire they would resist only 15 minutes, although uphold walls have a fire resistance rating of an hour for the top level and two hours for the current levels. Therefore it became necessary to use a fire protection coating on the structural steel in order to upgrade the level of fire resistance. Depending on the stage of works on site, defferent protection solutions were used: asbestos spray, glass fiber reinforced gypsum plaster, intumescent paint.

2.2. Upgrading of Fire Resistance of Fire Barriers

Some tests were carried out in order to verify that the openings in each fire barrier are protected by elements and material designed and tested to provide an appropriate fire resistance rating apropriate (fire rated doors, fire rated dampers, fire rated sealings around all the electrical and mechanical penetrations).

The fire doors as well as the fire dampers did not meet all criteria required by the Romanian norms. Since the standard design requires that a fire resistant door or damper would guarantee tightness and mechanical stability in case of fire, our approach, more conservative, asks, in addition, to provide a high thermal insulation of such doors or dampers, in case of fire. Therefore, we proceeded to substitute the fire dampers on the ventilation ducts at the penetration of the fire compartment boundary by fire resistant dampers being adequately qualified. The doors which did not assure the adequate thermical insulation were verified one by one. Some of them, for the rooms containing an important inventory of combustible materials, were coated by intumescent paint.

2.3. New Fire Compartments

Based on the Fire Risk Analysis, we defined some new fire comparments in the Service Building, smaller than those considered in the standard design, round the rooms with a large thermal load: new fuel storage area, cable spreading room. A carefully analysis was performed for these areas, as well as for the area with ventilation system filters. Also, we improved the physical separation between some redundant components, as electrical panels, Diesel generator, by erecting separation fire resistant walls.

2.4. The Upgrading of the Detection and Extinguishing Systems

A hydraulic calculation for the water piping in the spreading cables room proved that the extinguishing system did not assure an efficient fire suppressing. Therefore, the system was re-designed. Some cables in this room are fire retardant, but this does not apply to all of them. The room is protected by a deluge system which has its control valves located in the corridor in the proximity of the room. The water system is sectorized in seven inlets covering all the area of cables in the room. A modern and performant system of detection CERBERUS type was provided. As a passive protection we provided protection of the structural steel of this room. An additional measure, which is applied to all Romanian power plants, was established for the spreading room, but because of the Canadian partner's reticence it was not yet applied. This refers to fire stops from incombustible materials installed on cable trays, at a distance of 25 meters.

The fuel route in the station begins in the new fuel storage area, which is adjacent to the main air lock of the reactor building. New fuel arrives at Cernavoda packed in expanded polystyrene containers in wooden cases. The standard design provided no protection measure for the fresh fuel room. Based on the Fire Risk Analysis, some improvements were done: the structural steel have been protected by asbestos spray and the access doors have been protected by intumescent paint, a smoke detection system and a water spray extinguishing installation were provided. The personnel access to the room is carefully controlled.

In the areas containing air filters of the ventilation systems, CO2 extinguishind system was substituted by a water spray extinguishing system of the sprinkler type. Later on, taking into account the disadvantages of CO2, all over the plant, this system was replaced by the water spray system

Above the false ceilings, where a thermal load from cables was present, we provided smoke detectors.

2.5. The Upgrading Measures in the Balance of the Plant

In the turbine building, the risk rests with the lubrication oil, generator seal oil and the hydrogen cooling systems, particularly with the piping. Now, the turbine and generator bearings are protected by a manually operated water system of the deluge type. The system is actuated from two different sides. The spurious actuating is prevented. In the original ANSALDO design, the automatic operation of the same system type was specified. This current arrangements do meet the local Romanian technical standards.

Smoke detectors are installed over each bearing. Operating and training procedures are in place to minimize the delay between fire detection and the application of the suppression system.

In the standard design, turbine clean / dirty lube oil storage tank was located in a room under the main lube oil tank, without any protection against fire. Based on our norms, this tank of 92 tones capacity is separated from all other areas of the turbine building by three hour rated enclosure. A water spinkler system is installed. An oil containment system is provided as part of the protection scheme. The system is capable of containing all the oil in the tank plus the sprynkler system discharge. The oil tank is also protected also by a dedicated foam system. Some smoke detectors are provided. To remove any source of ignition, the electrical equipments are capsulated.

2.6. Fire Fighting Capabilities

Human fire fighting action represents an important part of the defence in depth strategy. For some area of the plant, human fire fighting action is the second line of defence (the first line being the automatic extinguishing system), while for other areas with lower fires load, human fire fighting represents the only method of fire extinguishing.

Based on a fire fighting approach different to that of the Canadian nuclear stations, the Cernavoda NPP has in its organizational chart a dedicated civil fire brigade composed of 44 full-time professional fire fighters. They operate in five shifts, covering 24 hour/day. This fire brigade is reporting to the Health Physics Department and is responsible for the performance of such activities as: supervision and control for fire prevention, training of the staff for fire protection maintaining the readiness of the fire fighting equipment and supplies, liaison with external military fire brigade.

Although the dedicated fire brigade exist, the operating personnel is familiar with the fire extinguishing procedures for all possible hazards, being regularly trained and examined on their knowledge of the relevant procedures.
The operational personnel is, also, trained for the evacuation in case of fire.
In the proximity of the nuclear power plant a military fire brigade operates, responsible for fire intervention and rescue in the town, villages and industrial objects of the area.
Combined drills are conducted regularly so that the off-site brigade and plant fire brigade can learn to act as a single team.

CONCLUSIONS

A comparison of the requirements related to fire protection reveals an evident flexibility which exist in Canada in the determination of the fire protection measures. The corresponding Romanian requirements appear more rigid, which proves a very conservative approach. Our main direction was the enhancement of the passive methods for fire protection. This approach has its roots in the lack of confidence in the action of the active measures, as well as in the relatively low level of the "safety culture" of the operational and maintenance personnel, whose preventive attitude was not enough developed. Despite of procuring a modern, reliable equipment for fire detection and suppression and providing an adequate training for operational personnel, the Romanian authorities and designers still emphasize the use of passive methods.
Our experience in the operation of a nuclear power plant is very limited (about one year), but the absence of any incident may be considered as a proof of the efficiency of the implemented fire preventing and protection measures.