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Fire Protection Upgrading of four russian 440/230 VVER Units

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Abstract

The main goal of TACIS 3.6, a project funded by the Commission of the European Communities (CEC), was the front-end engineering for upgrading the Fire Protection System (FPS) of the safety-related equipment of Novovoronezh, Units 3 and 4, and Kola, Units 1 and 2, VVER 440/230 nuclear power plants. As a first step, all the safety-related equipment had to be identified, evaluation criteria had to be established and the existing FPS reviewed against the criteria. In the second step, the selection of the upgrading measures, depending on feasibility and cost estimate, has been accomplished, room by room. The third step, carried out on schedule and completed end July '95, has been essentially the preparation of the Technical Specifications for procurement of the needed equipment including remaining detail engineering. The Russian sub-contractor AtomEnergoProekt (AEP), who have been the designers of these older NPP's, have done the work with the Italian Ansaldo as the consultants of their Russian colleagues.

Practical aspects of the engineering work are discussed and examples of improvements selected for retrofitting described.

1. INTRODUCTION

The Fire Protection System installed in old VVER nuclear power plants, in particular the older type VVER-230, is a major source of concern because lacking the required technology and, perhaps, because in the past Soviet designers did underestimate the fire risks. It is therefore understandable that the Commission of the European Communities (CEC) has set up a project, TACIS 3.6 Fire Protection Technology, and provides funding for the fire protection upgrading of two VVER 440/230 NPP's, i.e. Novovoronezh Units 3 and 4, and Kola Units 1 and 2, aimed at improving their nuclear safety against fire. Though these Units are subject of extensive Russian and TACIS programmes for safety upgrading and therefore TACIS 3.6 originally was not intended by the CEC as an isolated project, difficulties arisen in the co-ordination with the other projects suggest that TACIS 3.6 be extended to cover the analysis, by a deterministic approach, of the consequences of fire on the nuclear safety.

Note: This article reflects the progress of the TACIS 3.6 project and updates the relevant information already provided at the Fire&Safety '94 Barcelona conference.

2. THE TACIS 3.6 PROJECT

In the frame of the TACIS 3.6 project, the Italian engineering company Finmeccanica/Ansaldo-Nuclear Division had the responsibility of the overall engineering and management. In turn, Ansaldo has chosen the Russian engineering company Atomenergoproekt (AEP), assisted by the Russian Utility Rosenergatom, as the Sub-Contractor for doing the work with Ansaldo as a consultant. With this structure and staffing, three major conditions for an effective performance of the project have been met:

- assurance of identification of all safety-related equipment to be protected, because AEP have engineered the relevant Units,

- comments-in-time by Rosenergatom on the project documents and hence reasonable expectation of prospective rapid approval by Russian regulatory institutions of the proposed implementations,

- information on modern fire protection rules and on available state-of-the-art fire protection technology, provided by the western Consultant.

The project has started mid '93 and been completed mid '95 on schedule. The issued documentation provides the front end engineering, carried out room-by-room, of the fire protection system upgrading, but does not include any system analysis of the consequences of fire on the nuclear safety nor a budget cost estimate of the successive steps, which are to be funded and therefore are outside the scope of the project, i.e. remaining detail engineering, procurement of equipment, erection and commissioning.

3. THE PROJECT RULES

The selected evaluation criteria for the background information (i.e. the actual plant FPS configuration) and design rules have been issued by the Consultant as Design Guides, that, after having been examined for possible conflicts with Russian rules, have been accepted as the binding Project Design Guides (PDG).

The PDGs cover, but are not limited to, the following fire protection topics:

1 FIRE LOAD ASSESSMENT
2 FIRE RESISTANCE OF THE ROOM BOUNDARY
3 FIRE SUPPRESSION SYSTEM
4 FIRE DETECTION SYSTEM
5 FLOOR DRAINAGE SYSTEM
6 VENTILATION SYSTEM
7 ESCAPE ROUTES
8 FIRE PUMPING STATION
9 FIRE WATER SUPPLY
10 OUTSIDE HYDRANTS
11 FIRE DOORS

The PDGs are based mainly on the US Code of Federal Regulations, Part 50, Appendix R, Fire protection program for NPP's operating prior to Jan.1979, and, to a lesser extent, on the recent IAEA Safety Guide nr 50-SG-D2, Rev. 1, Fire protection in nuclear power plants. The adoption of the IAEA Guide as the only project rule would have not be practical, because this Guide is intended for new NPP's and does not allow alternative solutions, as Appendix R does, which are needed to cope with the existing plant configurations, and with considerations of residual life time of the Units and budget constraints.

Russian design practices have been accepted to a limited extent on a case by case basis, whenever they have been judged equivalent to the correspondent western practices.

4. GATHERING BACKGROUND INFORMATION

A programme has been established, entailing Quality Assurance, and a PC relational electronic database used to process, as far as practicable, the predicted huge amount of information on all topics of the FPS.

The relational database (MS ACCESS) has been tailored to the project needs and those data entered, that could be retrieved from the AEP files. Information shortfalls have been cleared or superseded by means of information gathered at each site (Novovoronezh and Kola) from interviews with the plant operators and from visual inspection.

The main information has been as follows:

- Location of each safety-related equipment and its redundant counterpart. The list of the safety-related systems (i.e. the systems performing at least one of the three safety functions of hot and cold shutdown and activity confinement after Design Basis Accidents) has been therefore the first background information provided by AEP,

- Information related to each room enclosure of interest (rooms containing safety equipment and adjacent rooms) such as boundary fire resistance, fire load, existing fire protection system,

- plant fire water system,

- internal and external fire brigades.

The information relevant to the Novovoronezh NPP has been collected first and is in general valid also for the Kola NPP, because the two NPPs are similar. Noticeable differences have been found out in the Diesel Bldg (no partitions between the diesel-gen sets of Kola) and the active fire protection of the cable trays (foam water for NVV and halon gas for Kola).

5. MAIN NON-COMPLIANCES AND UPGRADES

The required fire resistance of each room boundary has been determined using an internationally recognized specific-fire-load vs time curve, as a practical means to avoid to carry out engineering calculations. By comparison of the required with the actual fire resistance of the room boundary, non-compliances of this major issue have been highlighted.

Similarily, other non-compliances have been discovered by comparison of the existing fire protection system with the criteria of the project rules, that rest largely on the defence-in-depth principle.

A written report of any findings on each topic accompanied by the mention of possible corresponding upgrading measures has been prepared and the upgrading measures examined for feasibility and cost. Eventually, measures have been selected and engineered to the extent needed for preparation of the preliminary Technical Specifications (TS). Because of budget constraints, some TS are limited to the general description of the upgrade, the scope of which involves therefore the detail engineering still to be done to specify equipment items or packages.In several cases, however, the TS may be directly used for the preparation of the procurement documentation for enquiry of equipment (Material Requisitions).

A basic aspect of quality of the Material Requisitions is the identification of the standards the equipment or package must comply with. It has been agreed to define applicable only internationally recognized western standards. Russian standards (or any other relevant national standard) will be accepted as well, but they have to be proven equivalent to the relevant applicable standard. This practical decision has freed the designers from the heavy burden of a preventive comprehensive comparison between western and Russian standards and avoids the risk of limiting procurement to western equipment.

5.1 FIRE RESISTANCE OF THE ROOM BOUNDARY

Comparison of the actual fire resistance of the room boundaries with the required fire resistance, with consideration of the fire load in adjacent room enclosures, has provided evidence that the actual fire resistance of many room enclosures was not adequate The actual fire resistance has been defined as the resistance of the weakest component part of the barrier, mostly fire doors, cable penetrations and ventilation dampers.

5.2 FIRE SUPPRESSION SYSTEM

The applicable fire protection design guide requiring that:

a. Manual fire suppression be installed everywhere there is fire hazard to safety-related components

b. fire detectors and automatic fire suppression be provided everywhere no adequate prevention equipment protects safety-related components against fire herd.

Evidence of deficiencies of both manual and automatic fire suppression has been discovered. Whereas the deficiency of manual fire suppression has been consistently eliminated, the case of automatic fire suppression has required consideration of the involved fire load. In case of low distributed fire load in the examined room enclosure and adjacent rooms, the automatic fire suppression system has been dispensed of. In any case the installation of the fire detectors has been provided.

5.3 FIRE DETECTION SYSTEM

Fire detectors have been provided in each room enclosure with safety related components. See also the conclusion of para 5.2.

5.4 FLOOR DRAINAGE SYSTEM

The collected background information has given evidence of generalized not adequate drainage capability that would bring about accumulation of fire water or its spreading around and falling into the lower stores.

In most room enclosures and the whole upper stores of the turbine building there is no water drainage at all, so that provisions have been recommended to drain the water, whenever required by the potential risks of failure of safety-related components.

5.5 VENTILATION SYSTEM

Fire dampers have been provided at the ventilation duct penetrations to avoid the risk of fire spreading into adjacent room enclosures.

5.6 ESCAPE ROUTES

The analysis of the background information on the escape routes has been limited to the turbine building and to the room enclosures not belonging to the Accident Limitation Compartment (ALC). For the rooms belonging to ALC less stringent rules apply, being ALC a restricted access area.

In general, the basic requirements of distance to exit, exit number and dimensions are met.

A spot check during the visits to NVV and Kola NPP's has given evidence of generalized poor marking and lighting of the existing escape routes.

5.7 MISCELLANEOUS

The following non-compliances relevant to each of the following fire protection topics are based on the examination of the background information and/or on the visual inspection at the NW NPP and answers of the plant operators.

5.7.1 Pumping station

Only one high-pressure fire pump (a jockey pump) is fed by the diesel generator sets.

All fire pumps are of normal industrial construction. The flat characteristic curve required over the flow rate range is approximated, however, by means of the sequencial operation of several pumps installed in parallel.

5.7.2 Foam-water system

-All foam-water pumps are located underground and are subjected to the risk of water flooding.

-The foam-water main loop is normally under hydrostatic pressure only.

The pumps start on fire signal instead of on low fire water pressure.

-The foam/water inventory will last over about 1 hour, instead of the required 2 hours.

-The re-filling time of the foam/water inventory is 24 hours instead of the required 8 hours.

5.7.3 Fire detection system

-The electric power supply of the fire detection system is not backed up by batteries.
-The fire detectors located inside the ALC are not suited to radiactive ambient conditions.

5.7.4 Outside Hydrants

- Outside hydrants are generally not provided with isolation valve.

5.7.5 Emergency lighting

- In most cases emergency lighting is supplied over less than 8 hours.

5.7.6 Fire doors

- The fire doors maintained normally open appear, once closed, not to provide the required smoke- tightness .

- Many fire doors appear degradated with time.

5.7.7 Lube oil tanks in the Turbine Building

- The lube oil tanks under the turbine, and those near the feed pumps are not provided with oil containment basin. In case of fire, hot oil could spread around beyond the reach of the manual suppression system with consequent fire risk of even far-located safety components.

5.7.8 Fire suppression system of the lube oil tanks.

- The available local manual fixed water fire suppression system, though capable of keeping cool the turbine oil tanks in case of fire exposure, is not adequate to suppress fire, because the installed sprinkler nozzles would not produce oil-water emulsion (required are spray nozzles).

- The manual valve of the above mentioned fire suppression system would be exposed to fire of the nearby lube oil tanks and could become soon inaccessible to operators.

5.7.9 Internal and external fire brigades.

Manual fire fighting is generally adequate at both plants, owing to the good organization and training of the fire brigades. Their fire fighting equipment is well maintained, but suffers of some identified shortfalls, that could not be eliminated because of funding shortage.

5.8 Technical Specifications

The technical specifications have been assembled into three main documents with generic common headings as follows:

1- Passive fire protection materials and components

This document includes the specifications for fire doors; cable penetrations; ventilation dampers; fire barriers; fire-retardant cable coating; floor finishing; fire-resistant painting for the structural steel of the turbine hall; a containment basin around the lube oil tanks in the turbine hall; fire resistant coating of the ventilation ducts.

2- Active fire protection materials and components

This document includes the specifications for isolation valves for the external high-pressure fire water main; fire hose stations and piping; fire extinguishers (portable and wheeled); a fixed spray-water system for the turbine lube-oil tanks; automatic sprinkler systems for the cable trays in the turbine hall; automatic fire detection systems; emergency batteries for the existing fire detection system; fire detectors; escape routes marking- and emergency lighting; portable drain pumps; the emergency electrical power supply for the high-pressure fire pumps; a foam water system.

3- Plant fire brigade equipment

This document includes specifications for miscellaneous equipment such as fire engines; breathing apparatuses complete of radio sets; fire hoses and branchpipes; portable smoke removal fans; fire clothing; portable diesel gensets; personal computers.

7. CONCLUSION

The Technical Specifications available since the end of TACIS 3.6 would allow the start of the procurement of equipment and packages for upgrading the Fire Protection System of both Novovoronezh, Units 3 and 4, and Kola, Units 1 and 2, NPP's.

There is no doubt that the implementation of the fire protection system upgrades identified with TACIS 3.6 would also significantly improve the nuclear safety against fire of both NVV and Kola NPP's.

The ultimate goal of achieving nuclear safety against fire would require, however, as additional step in the frame of a contract extension, the deterministic analysis of the consequences of fire on safety-related systems and facilities. This would involve the interaction and co-ordination with other on-going projects on the same NPP's, in order to ensure that upgrades other than those proper to the FPS, such as e.g. equipment relocation or cable re-routing, are identified and implemented.

Once this additional step accomplished, the methodology adopted, the findings and upgrades of TACIS 3.6 would become a useful tool and guide also for the fire protection upgrading of the remaining VVER 440/230 NPP's.