Richard Hascik, Mochovce 3&4 Project, Slovenske Elektrarne - ENEL Inc., Slovakia

Preparation of Two Units of Mochovce NPP for Completion

Abstract

This paper presents activity performed over the last 16 months on preparatory works and future plans for completion of two NPP units at Mochovce, Slovakia. Four NPP VVER-440 units are located at Mochovce. Two of them are in operation and the other two are in a "postponed construction" stage. In 2006, 66% of the shares of Slovenske Elektrarne Inc. (the Slovak national electricity production company) were acquired by ENEL Produzione S.P.A. After the Slovenske Elektrarne acquisition contract became effective, ENEL started a feasibility study on the completion of the two postponed units. The two areas of focus of the feasibility study were the safety improvements to be performed to the plant's basic design and the condition assessment of the existing assets. The main results of these studies are given below.

Slovenske Elektrarne (SE)

The joint-stock company SE, a.s., was founded on 21 January 2002 as a new entity, from which SEPS (Slovak Electricity Transmission System plc) was separated as of the above date. Currently, SE, a.s., is a commercial and production company with a dominant position in the electricity market in the Slovak Republic, securing the generation of and trade in electricity and heat, including the provision of supporting services for the power system of the Slovak Republic, handling spent nuclear fuel and radioactive wastes.

Generation resources of the company are composed of nuclear power plants, thermal power plants and hydro power plants, forming a properly diversified resource base. Since 2006, the ownership structure of SE, a.s. is as follows:

The National Property Fund owns 34%
Italian company ENEL SpA owns 66%.

The MO34 Plant

The Mochovce NPP is situated in the southwestern region of the Slovak Republic at the western border of Levice district in Nitra region. The area lies in the southwestern part of the Kozmálovské hills, mainly in the Hron highlands. These hills are situated in the northern part of Pohronská highlands called Mochovecká highlands in front of the southern foothill of Pohronský Inovec. The terrain in the area reaches 200 to 250 m above sea level.

Construction of Mochovce NPP Units 3 & 4 started in 1986 with the laying of the foundations of the main buildings (reactor building, longitudinal electrical building, basement of transformers, cooling towers, vent stack) and continued up to 1992. In 1992, construction works were suspended. From 1992 to 2000, maintenance and conservation of the suspended equipment and components and of the civil structures were performed by the original main suppliers and constructors on behalf of the Slovenské Elektrárne, a.s. (SE), while from 2000 until now, the preservation and protection works on buildings, structures and on selected safety and non safety-related equipment were performed by SE on the basis of programs approved by the Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR) and in accordance with IAEA-TECDOC-1110.

The current state of the NPP Mochovce 3 & 4 construction is:

Civil part is complete up to 70%;

Mechanical equipment supply is complete up to 30%;

Electrical and I&C equipment supply is negligible.

According to a Risk Audit carried out by the International Atomic Energy Agency (IAEA), the safety level of the Mochovce NPP Units 1 & 2 was evaluated as being comparable with Western European standards. Therefore it has been selected as the "reference" for the completion of Units 3 & 4.

Permitting

The original construction permit for MO34 was issued by the District National Committee in Levice on the basis of the Land Planning Decisions in November 1986. This Permit was renewed firstly in May 1997 by letter of the Regional Authority in Nitra, and further by Decision of the Regional Construction Authority in Nitra in July 2004 (the current construction permit for completion of MO34).

Safety improvements

The safety improvements of MO34 have been conceived mainly on the basis of the IAEA document IAEA-EBP-WWER-03, *Safety Issues and Their Ranking for VVER-440 Model 213 Nuclear Power Plants*, and taking EMO12 as the starting point for their further improvement.

Nonetheless, two important aspects need to be pointed out when considering the MO34 safety improvements:

- the main purpose of the IAEA document was to provide "a reference for the development of plant specific safety improvements and for the evaluation of measures proposed and/or implemented". Hence, the document was mainly intended to be used as a support in the safety upgrade of operating plants;
- EMO12 is already 100% compliant with the IAEA recommendations.

For these reasons, within the framework of MO34 project, all the IAEA recommendations will be followed and exceeded, as specific design changes have been implemented for the completion of the construction works.

In particular, the most important modifications concerning nuclear safety can be summed up as follows:

Design measures for Severe Accident Management: Within the MO34 project, not only have the IAEA recommendations been fully met, but additional measures have also been considered, as severe accidents are dealt with at the design level. In fact, specific design modifications have been identified on the basis of a large number of analyses, in order to:

- ensure the integrity of the RPV through external cooling;
- avoid high-pressure core melt scenarios;
- ensure containment integrity, through long-term cooling and management of the burnable gases in the containment atmosphere;
- improve the Post-Accident Monitoring System.

Improvements of I&C and electrical equipment: State-of-the-art I&C will be installed in MO34. In particular, an advanced digital control system will be used, with an increase of control and monitoring capacity of the NPP. The human-machine interface will also be improved, for more efficient monitoring and control of the plant safety status. In relation to electrical equipment, the use of solid-state technology for electric systems will improve the overall reliability of the plant; in addition, electrical interconnections between the different units and improved connections to the HV grid will reduce the impact on safety of the loss of offsite power.

Seismic upgrade: In accordance with the requirements of the Slovak NRA, the MO34 design will be improved in order to achieve a higher seismic resistance of the plant. Seismic design Zero Period Acceleration (ZPA) is 0.15 g.

Design measures for the reduction of internal hazards: The MO34 design will address all the IAEA issues concerning internal hazards, including those deriving from:

- fires;
- internal flooding;
- turbine missiles;
- high-energy pipe break.

Improved design of safety systems and safety-related equipment: Several design improvements have been considered for some safety systems (e.g. ECCS, EFWS) and for components of primary relevance for safety (e.g. Steam Generators, pressurizer safety valves, etc.) as a result of the operational feedback of EMO12 and on the basis of the IAEA recommendations, in order to:

- increase the reliability and separation of safety systems;
- increase the lifetime of components important for safety.

Measures dedicated to Severe Accident Management

The design of this plant includes systems for Severe Accident Management: these systems, such as the hydrogen catalytic recombiners and igniters and the reactor cavity flooding system described above, ensure that accidents involving significant core damage, even if very unlikely, are safely managed, preventing significant radioactive releases to the environment.

Containment system

MO34 is equipped with a containment system of pressure-suppression type, which relies on a large amount of cold water to condense steam released from the reactor coolant system as a consequence of an accident. A similar technology is widely used by other reactors, such as General Electric, Siemens and ASEA Atom (now ABB) BWR's.

The VVER-440 model 213 containment system is intended to prevent the escape of steam and fission products and to facilitate steam condensation, thereby reducing the pressure after the break of any single primary system pipeline, including the double-ended rupture of 500 mm inner diameter pipes.

The containment system is composed of:

- reinforced concrete structure, providing the containment function;
- bubbler condenser, providing passive pressure-suppression function;
- water spray system, providing active pressure-suppression function and radioactivity removal function.

The containment includes a sealed set of interconnected compartments surrounding selected primary system

components (steam generators, inlet and outlet piping, pumps, isolation valves and the major portion of the reactor vessel) and additional compartments containing the bubbler condenser.

The reinforced concrete walls of the VVER-440/213 are approximately 1.5m thick. All walls and roofs of the localization compartments have internal steel lining. Reinforced concrete structures, the airtight entrance doors and penetrations are designed for the 0.15 MPa overpressure.

The bubbler condenser comprises twelve levels of borated water-filled trays. The reactor spray system (RBS) provides a water spray to the reactor compartment following a LOCA or steam line break, to limit containment pressure and to minimize the release of radioactive iodine and particulates to the environment. The RBS is composed of three identical and completely independent trains, each of them with a capacity of approximately 600 m^3/h. The efficiency of the Mochovce containment in rapidly reducing the accident pressure by combination of pressure suppression system and containment spray allows termination of radioactive leakages in a very short time, as fully demonstrated by research programs sponsored by the IAEA, OECD and European Commission through Phare programs. In addition to the previously described safety systems, which ensure that the integrity of the containment is preserved during and after an accident, the MO34 design includes several improvements, in compliance with the most recent international safety requirements, which are specifically aimed at preserving the structural integrity of the containment even for extremely-unlikely accident scenarios ("severe accidents").

In particular, the design measures defined for MO34 will:

- avoid the uncontrolled burning of the hydrogen which is generated during a severe accident (by using hydrogen recombiners/igniters);
- avoid high-pressure core-melt scenarios (through a dedicated line for fast depressurization of the primary circuit);
- avoid reactor pressure vessel failure (through the in-vessel retention of the molten core by reactor-cavity flooding and external core cooling), thus practically eliminating the accident sequences which could jeopardize the containment structural integrity.

Appendix

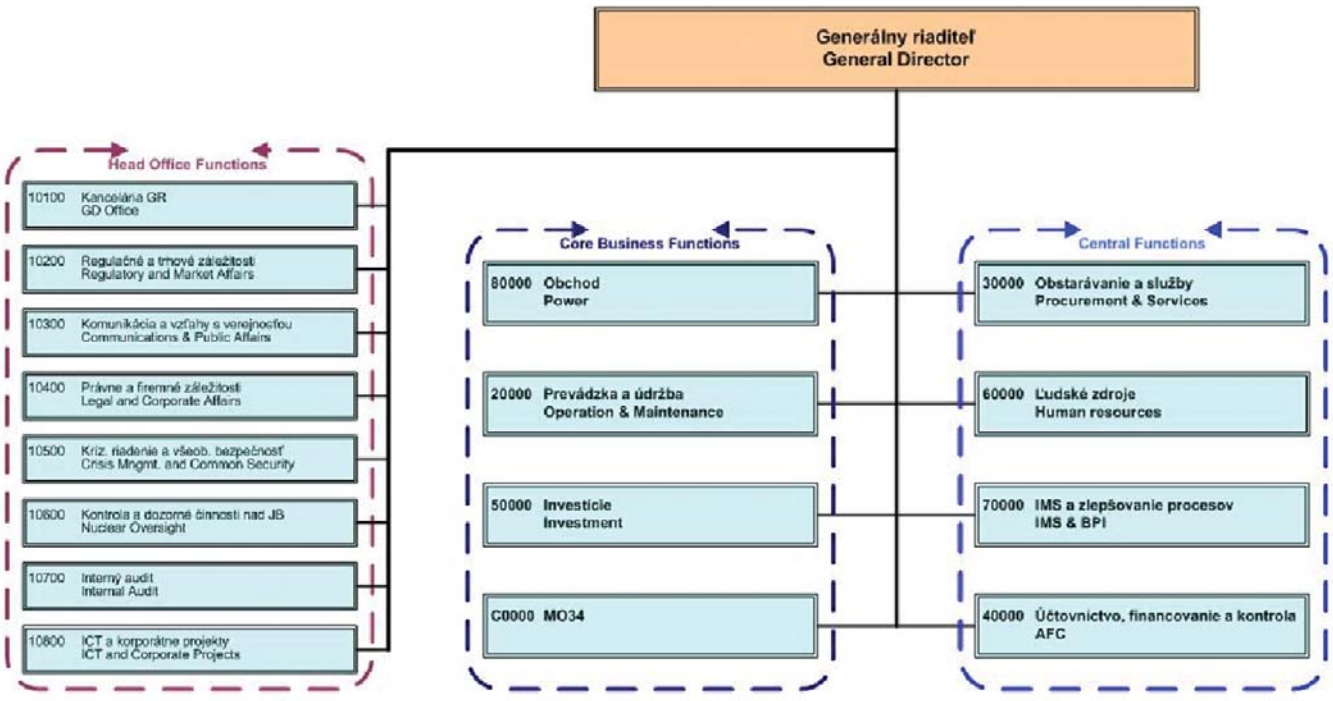

Figure 1. Slovenske Elektrane organizational scheme

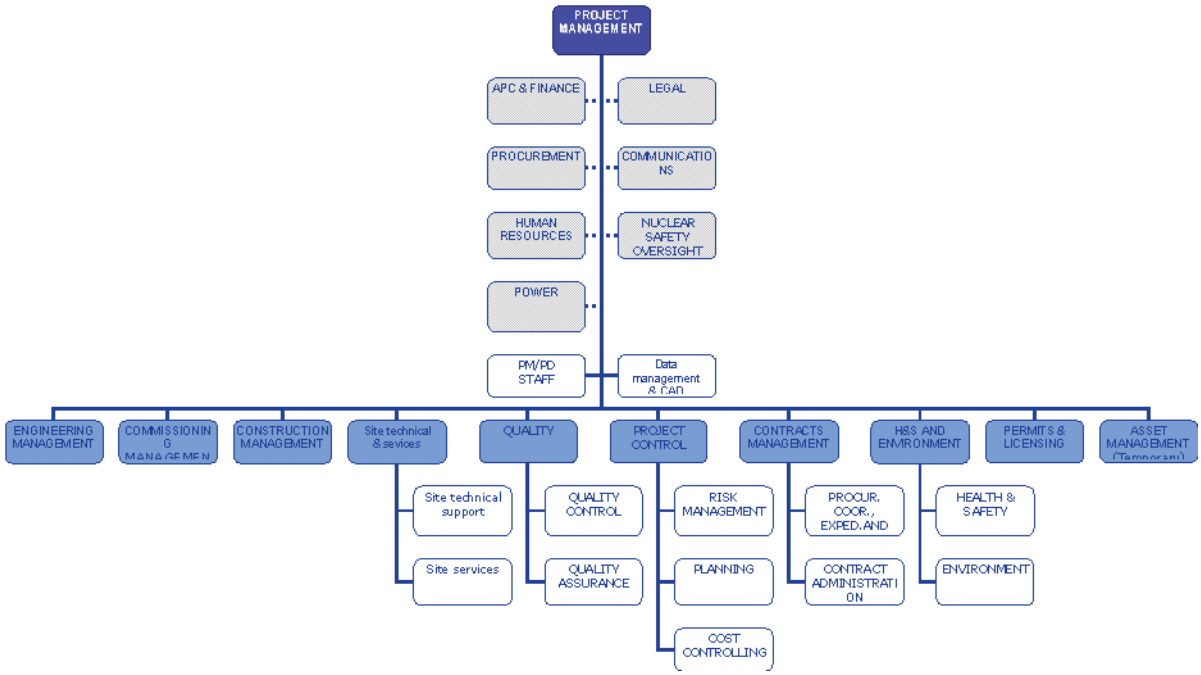

Figure 2. MO34 Plant organization scheme