TEMELÍN NPP - I&C REPLACEMENT

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Ivan Spálenka
ČEZ, a. s., JE Temelín
Temelín-elektrárna
373 05
Czech Republic

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INTRODUCTION

The Temelín Nuclear Power Plant (NPP) consists of two Russian VVER 1000 type units. Original Instrumentation and Control (I&C) system is replacing and upgrading by a modern Westinghouse supplied I&C system which meets requirements imposed to current NPP designs. Following is information related to I&C replacement in Temelín NPP mainly history and ČEZ intention with very brief new I&C system description.

1. HISTORY AND PURPOSE OF THE I&C SYSTEM REPLACEMENT

At the end of 1970 years Czech party initiated discussions with Soviet general designer of Temelín NPP about I&C equipment for VVER 1000. It was apparent that similar design from VVER 440 would probably not satisfy the up-to date requirements for I&C systems at that time. Based on a good experience with Czech provenance I&C systems used in fossil power plants within the frame of Eastern Europe market situation Czech party was forcing Soviet general designer to introduce this field-proof I&C systems to the VVER 1000 design. Later some compromise solution was accepted by Soviet general designer which meant that in 1984 Soviet technical design of the Temelín NPP I&C system was based for plant primary part on former Soviet design and partially Soviet and Czech supply of I&C systems and for secondary part on Czech design and supply. Former Soviet design and supply also included unit information and special computer systems. Control room boards were based on Soviet design considering Czech supply.

Because of society change in 1989 the opportunity to replace certain equipment was enhanced. The first inquiry was dedicated for computer information system in 1990.

Following the IAEA position based on the design audit performed in the middle of 1990 ČEZ ordered expertise from two independent companies Colenco and TUV Bayern. Expertise has focused in original I&C system design assessment from the overall NPP design and from the international standard requirements points of view. The both expertise results have shown certain design and quality assurance inconsistencies. On the base of above mentioned results ČEZ decided to enhance the required scope of replacement for the unit I&C system directly related to nuclear safety and electricity production at the end of January 1991.

Expected contribution of such replacement was:

- to reach compliance with international standard requirements in areas of nuclear safety, operation availability, reliability of I&C system itself, etc.;
- to add special systems not included in the original design (e.g. Post accident monitoring system, Safety parameter display system, Technical support centre);
- to solve the control room design from international standard

requirements point of view;
- to perform hardware and software for I&C which will be licensable during the start-up of the Temelín NPP;
- to ensure maintenancability and reparability during designed life.

The contract for I&C system replacement with Westinghouse company was signed in May 1993.

2. I&C SYSTEM DESIGN

Similarly to other NPPs we can divided Temelín NPP I&C to two main parts. One which is important for nuclear safety and the other one which is not but is important from the point of view of plant operational availability, technological equipment protection or monitoring of plant status. Common practise for both parts in case of I&C system replacement is to maintain the functional design of the NPP as close as possible to the original philosophy. Sometimes it is necessary to make certain changes in order to meet required licensing criteria or to increase reliability.

Both parts of I&C system is planned to be implemented as a distributed digital system.

2.1 I&C systems important for nuclear safety

Architecture of systems important for nuclear safety consists of three redundant and independent divisions (not only I&C system but also electrical and technological parts). Every division is able to perform all safety functions necessary for remedies of design events.

Temelín I&C systems which are important for nuclear safety are:

- Primary Reactor Protection System (PRPS)
- Diverse Protection System (DPS)
- Post Accident Monitoring System (PAMS)

2.1.1 Primary Reactor Protection System (PRPS)

PRPS has three redundant and independent divisions consistent with related electrical and technological systems. PRPS as a whole is 1E qualified system and is implemented on the base of Eagle 21 system. Eagle 21 for Temelín NPP is distributed Intel 486 microprocessor system, programmed in Assembler and PLM 86 languages.

PRPS basically consists of following parts performing automatic actions:

- part performs Reactor Trip (RT)
- part performs Engineering Safeguard Features (ESF)

PRPS also offers manual actions from Main and Emergency control boards.

2.1.2 Diverse Protection System (DPS)

DPS is designed to decrease the potential for common mode failure (CMF) within the execution part of PRPS . DPS is also implemented in three redundant and independent divisions. This system is required to meet relax safety requirements for events occurred with probability less 10^{-3} per year. This is similar approach as for Secondary Protection System in Sizewell B NPP.

DPS is also 1E qualified system. In order to ensure diversity from PRPS, DPS is specially developed Motorola microprocessor based system and is programmed in ADA language.

DPS shares the same sensors used for PRPS. There is no manual actions designed through DPS.

2.1.3 Post Accident Monitoring System (PAMS)

PAMS is 1E qualified system which provides information to the operator in Main and Emergency Control Rooms. PAMS is implemented in two redundant and independent divisions.

2.2 I&C systems not important for nuclear safety

Temelín NPP I&C systems not important for nuclear safety are basically:

- Reactor Control and Limitation System (RCLS)
- Plant Control System (PCS)
- Unit Information System (UIS)

All above mentioned systems are classified as non-1E.

2.2.1 Reactor Control and Limitation System (RCLS)

RCLS importance related to primary part control and subsequent plant operational availability led to implement it with high reliable Eagle hardware using the same cabinet and software design approach like for PRPS.

Functionally RCLS performs the important control and monitoring functions mainly on the primary side of unit including reactor power control, pressurizer level and pressure control, feedwater control, steam generator level control and steam dump control. RCLS has two basic sets of inputs:

- its own sensors;
- information directly received from PRPS through a digital communication and separation devices.

RCLS also offers manual control in the same way like PRPS.

2.2.2 Plant Control System (PCS)

PCS performs control and monitoring functions including Turbine Control System (TCS) or related to auxiliary systems of Temelín NPP. Similarly to RCLS inputs to PCS are also possible to split in two sets:

- its own sensors;
- information received from DPS through a digital communication and separation devices.

PCS is implemented by using Westinghouse Distributed Process Family (WDPF) microprocessor based system.

PCS manual actions are accessible either on control board or through Unit Information Systems displays.

2.2.3 Unit Information System (UIS)

UIS is information system which collects and work with data from all other systems. Its function is to perform suitable function supported the operator in Control Rooms to monitor and control the plant functions. Also its certain applications support plant core engineers or maintenance staff. UIS performs important calculations and archive functions.

UIS is distributed microprocessor system consists of individual workstations (special PC). The redundant high speed fibre distributed data interfaces as a part of UIS are connected to all other above mentioned systems.

3. CONTROL ROOMS DESIGN

Temelín NPP is designed with two control centres, Main Control Room (MCR) and Emergency Control Room (ECR).

3.1 Main Control Room (MCR)

MCR is operational control centre where all information and control necessary for plant operation, start-up, shutdown, maintaining in shutdown conditions or necessary for remedy actions following an accident are available. MCR consists of control board panels and consoles. Panels are designed with system mimics including related control switches and monitors. Sitdown consoles are equipped by UIS equipment with appropriate control and monitoring functions. The staff placed in MCR consists of Primary side operator, Secondary side operator, Control room supervisor and potentially Shift supervisor.

3.2 Emergency Control Room (ECR)

ECR is control centre which is used in case of unavailability of the plant

control from MCR. ECR board panels included only necessary selected set of controls necessary for plant shutdown and maintaining in safe shutdown state. Also UIS functions are available in ECR consoles.

Special case of manual controls is Diverse Manual (DMC) and Fix Wired Controls (FWC). DMC is placed in MCR and FWC in ECR only. These controls are expected to be used only in very low probable situation:

- CMF either in PRPS or DPS together with concurrent UIS unavailability.

DMC and FWC are connected directly to individual components specified for plant shutdown and maintaining plant safe shutdown state. DMC and FWC are independent from microprocessor based systems.

CONCLUSION

The incorporation of the new I&C system into Temelín NPP is very complex and exacting process which gives experience for all involved parties and its successful finish will be considered as proven way for future upgrades of the I&C systems.