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Support to the Nuclear Safety Regulator of Brazil (CNEN) through an INSC Project

INSC = Instrument for Nuclear Safety Cooperation

INTRODUCTION

- The presentation introduces the European Union funded cooperation between the Brazilian nuclear regulatory body (CNEN) and a consortium of several European organizations through an INSC Project.
- The cooperation is dedicated to the enhancement and strengthening of the nuclear safety regulatory framework in Brazil in compliance with international criteria and practices.
- Topics of the project:
  - Probabilistic Safety Analysis (PSA)
  - Deterministic Safety Assessment
  - Ageing Management and Long Term Operation
  - Emergency Preparedness
  - Severe Accident Management (SAM)
  - Safety of digital instrumentation and control (I&C) systems

PART 1: SUPPORT OF CNEN ON SAFETY ASSESSMENT OF DIGITAL I&C SYSTEMS

- Main objectives:
  - Advise and support for CNEN in setting up an adequate regulatory process
  - Support CNEN on issues related to classification and qualification of I&C systems
  - Peer-Review the CNEN Safety Evaluation Reports
- Methodology
  - EU experts provide guidance to CNEN regarding selected issues based on the state-of-the-art safety requirements on digital I&C important to safety, on international practices.
  - Training and review workshops, guidance documentation.

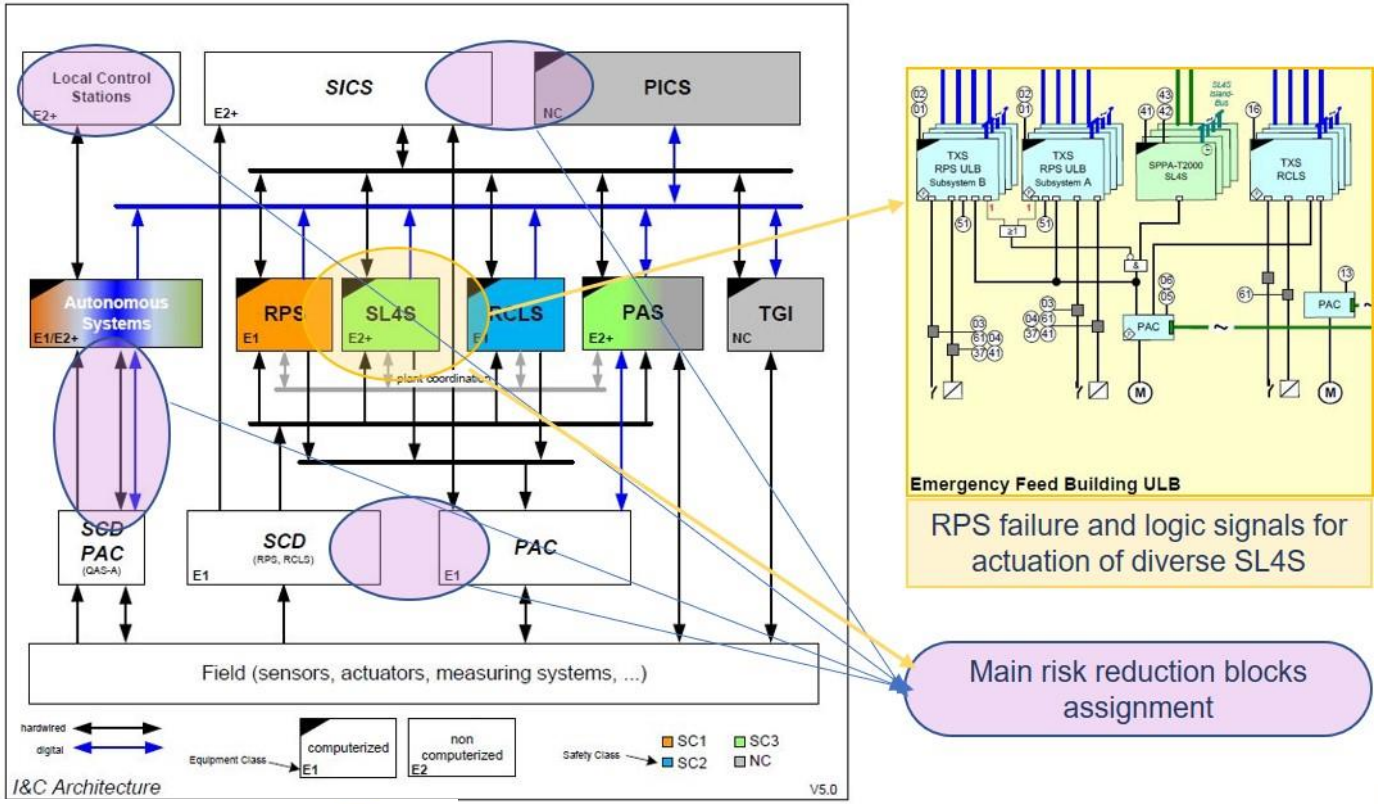
SUPPORT CNEN ON SAFETY ASSESSMENT OF DIGITAL I&C SYSTEM

- Digital I&C of the Angra 3 NPP:
  - AREVA, PWR, 4 loops, 1330 MWe
  - Based on safety criteria of the reference plant Angra 2, and on concept of Siemens/KWU PWR-1300 (Konvoi type) plants.
  - Digital I&C platforms, designed and arranged according to the diverse and defence-in-depth concepts (D3) to comply with the three lines of defence: preventive, main and risk reduction lines.

I&C Systems Comp. Platform	I&C Functions (Levels 1 and 2)	Classification (F. Class)(S. Categ)	Location (Building)	Defense Line Assignment
SPPA-T2000	Process automations	(SC3,NC) (E2+,NC)		
SPPA-T2000	PICS (monitoring, manual HMI)	(NC) (NC)	MCR / ECR	PREVENTIVE
TELEPERM XS	RCLS, PAMS	(SC2,SC3) (E1, E2+)	UBA / ULB	
TELEPERM XS	Autonomous automations	(SC1,2,3) (E1, E2+)		
Hardwired Panel	SICS (conventional HMI)	(-) (E2+)	MCR / ECR / LCS	MAIN
TELEPERM XS	RPS	(SC1) (E1)	UBA/ULB/UJA/UJB	
SPPA-T2000	SL4S (diverse actuation system for CCF of RPS)	(SC3) (E2+)	ULB	RISK REDUCTION

SUPPORT CNEN ON SAFETY ASSESSMENT OF DIGITAL I&C SYSTEM

- Simplified diagram of Angra 3 DI&C architecture exemplifies and highlights main functions and systems of risk reduction defence level
- This issue involves important aspects of ongoing licensing evaluations on architecture, D3 analysis and cooperation support discussions



SUPPORT CNEN ON SAFETY ASSESSMENT OF DIGITAL I&C SYSTEM

- Approach
  - Regular communication through e-meetings
  - Yearly workshops
  - Joint visits of CNEN and EU experts to meet experts of other organizations with relevant knowledge on similar challenges as CNEN
  - Sharing good practices, visit to installations and operational experiences discussions
  - Commenting documents and reports
  - Preparing presentations and reports on specific topics

SUPPORT CNEN ON SAFETY ASSESSMENT OF DIGITAL I&C SYSTEM

- Preliminary results
  - Support and opinion making on issues related to safety evaluations and licensee responses to Construction License I&C Conditions
  - Opinion making on the usage of FPGA or computer-based technologies and different solutions for digital I&C similar to Angra 3
  - Workshop together with the Brazilian licensee (ETN), licensing of Angra 3, Angra 2 upgrade (TXS, reactor control system)
  - Commenting CNEN‘s evaluation reports
  - Workshop in Finland and discussions on licensing experiences of digital I&C (also EPR) with STUK

PART 2: ASSESSMENT OF SAM PROGRAM AND SEVERE ACCIDENT ANALYSES FOR ANGRA 2 NPP

- Main objectives of the support task
  - Support CNEN on the safety evaluation of Angra 2 SAMP
  - Assist CNEN on the development of the Angra 2 simulation model using MELCOR severe accident code
- Methodology
  - EU experts provide guidance to CNEN regarding selected issues based on the state-of-the-art safety requirements for the assessment process for Angra 2 SAMP
  - Training and review workshops, guidance documentation.

ASSESSMENT OF SAM PROGRAM AND SEVERE ACCIDENT ANALYSES FOR ANGRA 2 NPP

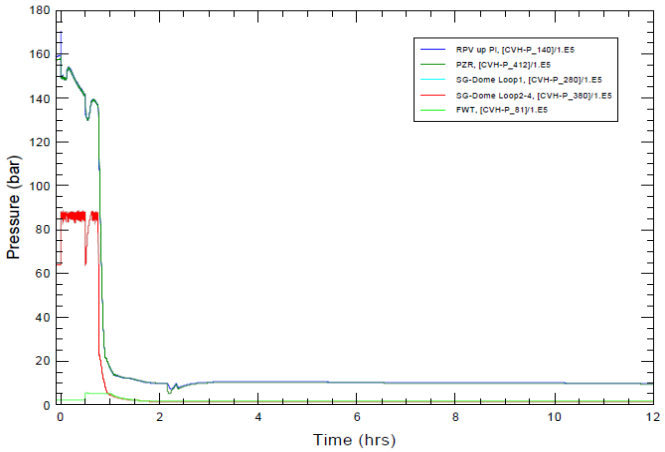
- Preliminary results – concerning SAMP
  - The European counterparts presented the practices observed on their respective countries and associated guides and standards concerning SAMP.
  - The main recommendations of the experts concerning SAMP review: Regarding SAMG; upgrade pressurizer valve station to allow PBF through Relief and Safety valves; Passive autocatalytic recombiners; Filtered Containment Venting.
  - The most of recommendations of the experts were considered in the evaluation process of the SAMP and presented to the operator of Angra 2 as CNEN requirements.

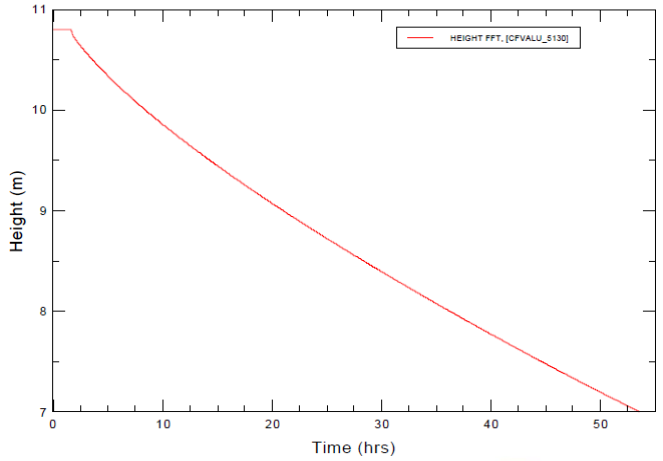
ASSESSMENT OF SAM PROGRAM AND SEVERE ACCIDENT ANALYSES FOR ANGRA 2 NPP

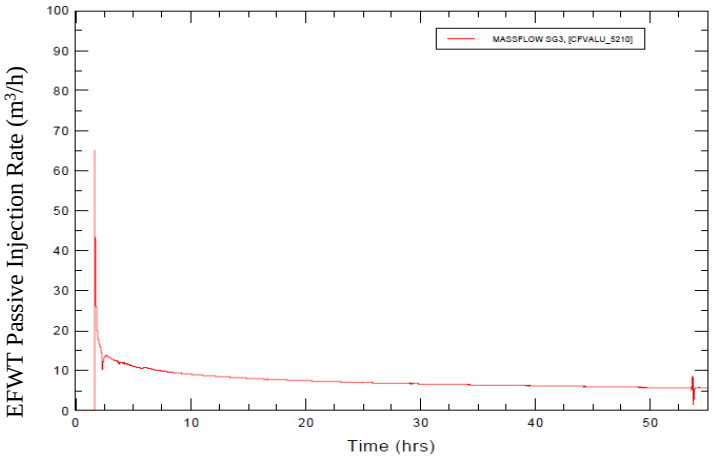
- Preliminary results – concerning MELCOR simulation
  - Significant contribution to core damage states or release categories of PSA Level 2 for Angra 2, among the most probable, are SBO and SB LOCA (20 cm^2).
  - Assumptions were defined to simulate:
    - SBO - considering that no Reactor Coolant System depressurization was available: Loss of all AC power; All accumulators available; No PBF available; SBF available.
    - SB LOCA - a leak of 20cm2 in a cold leg of a RCL: Turbine bypass not available; Condenser not available; ECCS injection from the RWST by SIPs and RHR pumps are available; all accumulators are available; loss of suction from the sump and of secondary side 100 K/h cooldown; EFWS is available; no SBF and no PBF.

ASSESSMENT OF SAM PROGRAM AND SEVERE ACCIDENT ANALYSES FOR ANGRA 2 NPP

- Preliminary results – concerning MELCOR simulation
  - SBO results



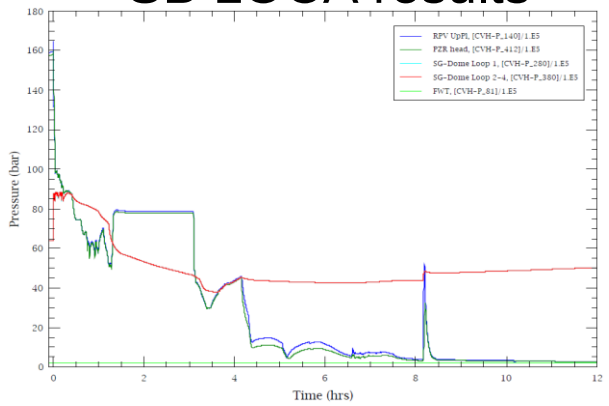


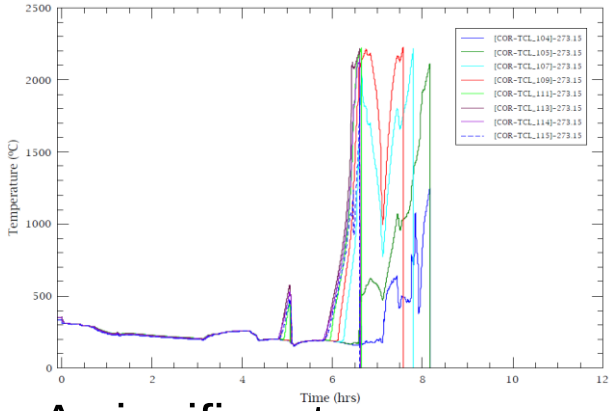


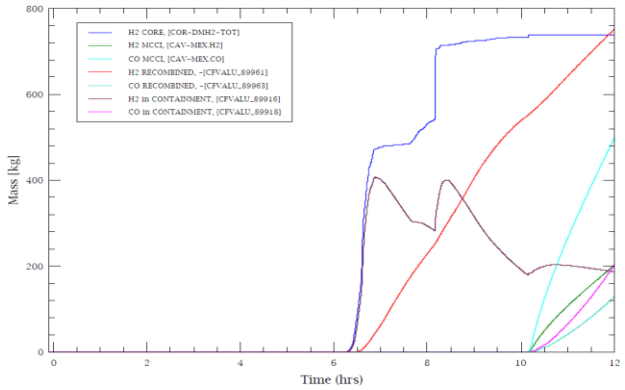
- Due to the extensive time during which the reactor core is protect by the secondary bleed and feed (50 h), no core damage can be observed

ASSESSMENT OF SAM PROGRAM AND SEVERE ACCIDENT ANALYSES FOR ANGRA 2 NPP

- Preliminary results – concerning MELCOR simulation
  - SB LOCA results







- A significant pressure spike due to melt relocation into the residual water appears at about 8h 13 m
- Core meltdown begins at 6*h* 30*m* and it ends at 8*h* 17*m*.
- The calculated hydrogen and carbon monoxide mass generated in the core and by MCCI and the masses recombined

SUMMARY

- The experience gained in the frame of this INSC Project evidenced that the transfer of important nuclear safety know-how can be achieved in an effective and fruitful way through this kind of project.
- The examples presented showed that CNEN is improving the assessment of Angra 2 SAMP, as well as the use of the severe accident code MELCOR to simulate the main significant severe accident scenarios for this NPP. This project will also favor a more efficient assessment of SAMP for the other Brazilian NPP constructed or under construction (respectively Angra 1 and Angra 3).

SUMMARY

- The project has also supported CNEN to consolidate its internal guideline for review and assessment of digital I&C based on modern safety and technical standards and current practices.
- Furthermore, the EU experts have provided valuable contributions regarding I&C modernization with TXS platform and also encompassing review methodologies and specific guidance on assessment of the quality and reliability of software and programmable electronics.