23rd Technical Working Group on Nuclear Power Plant Instrumentation and Control (TWG-NPPIC)

I&C Modernization in Brazil

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Brazil has actually two NPPs in operation and one under construction in the southeast region.
- Angra 1 and Angra 2 in operation
- Angra 3 under construction
Four more planned, two in the northeast and two in southeast of Brazil.
Brazil

Area: 8,502,728 km²
Capital: Brasilia
Language: Portuguese
Population: 190,000,000
GDP: $1,571 x 10^9
Per Capita GDP: $8,114
Electrical Generation: 104,815 MW
Nuclear: 2,007 MW (1.9%)

GDP (Gross Domestic Product)
2009 year data
Angra 1 NPP

- Westinghouse PWR type, two loops, 657 MWe
- Commercial operation in 1985
- Instrumentation and Control:
  - Analog I&C predominant
  - Digital, hardwired Reactor Protection System
  - Digital Electric-Hydraulic turbine control
  - Digital Rod Position Indication System
  - Conventional Human-Machine Interface
  - Few automatic control systems
  - SPDS and plant computer using distributed PC-based system
Angra 2 NPP

- Areva, former KWU, PWR type, four loops, 1350 MWe
- Commercial operation in 2001
- Instrumentation and Control:
  - Analog and digital hardwired I&C predominant
  - Digital, hardwired Reactor Protection System
  - Conventional Human-Machine Interface
  - Several automatic control systems
  - SPDS and plant computer using distributed PC-based system
Angra 3 NPP (under construction)

- Areva PWR type, four loops, 1350 MWe
- Commercial operation prevision for 2015
- Instrumentation and Control:
  - Digital I&C
  - Software and network based digital system
  - Advanced Human-Machine Interface
  - Fully automatic control systems

The I&C configuration for Angra 3 is actually being discussed with Areva
Why modernize I&C?

Obsolescence of installed equipment
Manufacturers do not supply replacement parts.

Reliability
Ageing related failures of critical instruments cause the increase of plant events.

Benefits of new technology
License renewal for life extension of the plant

Economic factors
Reduced maintenance costs and increased plant availability and output
Evaluating the obsolescence of the I&C systems

Items to be considered

Spare parts availability from the original manufacturer
Spare parts from alternative suppliers
Commercial grade substitution (dedication)
Technical support
Inventory and shelf life
Design limitations
Trends in failure/maintenance
Operator man-machine interface
Upgrade to Digital I&C

Analog I&C of the plants designed in the 1970/80s

I&C in the market today is digital

Operating experience of digital I&C in industry (non-nuclear safety)

Multiple channels/functions

Increase the accuracy and optimization of setpoints

Improved diagnostics

Ensure continued operation for life extension
Benefits of modern technology

Use of digital computer:
- enhanced displays
- fault tolerant and redundant control
- improved diagnostics and maintenance tools
- greater reliability

Use of smart transmitters: reduced maintenance, calibration and drift

Use of communication networks: reduced number of cables

Open system architecture: allows replacement of hardware/software as they become obsolete

Use of fiber optic cables: better noise immunity and isolation

Increase use of self-testing for on-line system surveillance

Enhanced man-machine interface
Problems related to modernization

Man-machine interface and human factors

How will be the Control Room layout after modernization?

Few nuclear qualified equipment manufacturers

Rapidly changing technology

Modification of plant procedures

Plant licensing

Training of Operation personnel

Training of I&C maintenance personnel

Configuration and design change control
Angra 1 modernization

Systems to be modernized:

- Reactor Protection System
- Diesel Generator Sequencer
- Radiation Monitoring System
- Digital Rod Position System
- Control Rod Drive Mechanism
- Steam Dump Control
- Chemical Volume Control System
- Nuclear Instrumentation Systems (ex-core, in-core)
- Alarm Display System
Angra 1 modernization

Systems already modernized or recently installed:

- Plant computer and SPDS
- Turbine control computer
- Turbine vibration monitoring system
- Vent stack computer
- Sub-cooling margin monitor
- Reactor vessel level instrument system
- Recorders
Angra 1 modernization

Systems already modernized or recently installed (cont.):

- Reheaters (pneumatic to digital I&C)
- Containment H₂ monitoring system
- Seismic monitoring system
- Leakage monitoring system
- Loose parts monitoring system
- Chlorination system
- Water demineralization system
Angra 1 modernization

Systems being modernized:

Feedwater control system

Fire detection system

Meteorological system (site system)
Angra 2 modernization

Systems to be modernized:

- Reactor Protection System
- Reactor Control and Limitation System
- In-core Instrumentation
- Ex-core Instrumentation
- Radiation Monitoring
- Leakage Monitoring System
Angra 2 modernization

Systems already modernized or being modernized

Plant computer and SPDS
Chlorination system
Reactor control system
Angra 2 modernization

Cooperation with the European Commission

Eletronuclear recently started cooperation with the EC to upgrade Safety Related I&C of Angra 2.

The project goal is to transfer the best EU and international “know-how” on operational safety culture to Angra 2, in order to define a strategy for the replacement of the existing analogue I&C equipment currently used in Angra 2 systems important to safety.

The project duration is 2 years and Eletronuclear will use the results of this project to modernize Angra 2 safety related I&C.
Angra 3 instrumentation and control

The following design criteria will be applied to the I&C architecture

Defense-in-depth concept

Diversity of I&C systems and equipment

Single failure criterion and redundancy

Separation

Independence
Angra 3 instrumentation and control

Human-Machine Interface

Main Control Room
- Terminals for reactor, turbine and auxiliary systems
- Large screen displays
- Safety panel
- Indicators for accident and post accident instrumentation
- Reactor protection panel

Emergency Control Room
- Terminals for supervision (operation) of I&C systems
- Conventional emergency control station
- Indicators for accident and post accident instrumentation

Local Control Stations
- Terminals for system control or conventional panels
Angra 3 instrumentation and control

Architecture levels
Angra 3 instrumentation and control

Network architecture
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General view
Muito obrigado!
Thank you very much!