Education on nuclear fundamentals with iPWR Basic Principle Simulator

60 Years providing Solutions to our Clients
Company Milestones

- **1957**: Company Foundation
- **1962**: Zorita NPP Program Starts
- **70’s**: Development of Spanish NPP Program
- **80’s**: Technological Independence Achieved
- **2010’s**: Tecnatom as International Group

<table>
<thead>
<tr>
<th>Decade</th>
<th>Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-1979</td>
<td>Automated Inspection Systems, Full Scope Simulators</td>
</tr>
<tr>
<td>90’s</td>
<td>Internationalization in Nuclear Markets, Consolidation of Strategic Alliances</td>
</tr>
<tr>
<td>2000’s</td>
<td>Diversification to Synergic Markets</td>
</tr>
</tbody>
</table>

**Shareholders**
- Endesa: 45%
- Iberdrola: 30%
- GasNatural Fenosa: 15%
- Tecnatom: 10%
International Footprint

Subsidiaries & Shared Companies
Representatives
Projects
Value proposition

Develop and implement integrated and innovative solutions that promote the safety, efficiency and reliability of your assets, processes and the performance of people
Digital Operation and Asset Management

Operation support

Monitoring

Asset management
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Integral Pressurized Water Reactor (iPWR) Simulator

Scope:
Basic Principle Simulator – Generic behavior
Small Modular Reactor, iPWR type
Part of IAEA’s collection of Basic Principle Simulators for Education
Fully developed with Tecnatom’s simulation technology

https://www.iaea.org/NuclearPower/Simulators/
Integral Pressurized Water Reactor (iPWR) Simulator

Main thermal-hydraulic parameters:

- Reactor thermal power ~ 150 MW
- Electrical power ~ 45 Mwe
- PZR pressure ~ 15.5 Mpa
- Feedwater flow ~ 79 Kg/s

Passive safety:

- Automatic Depressurisation system (ADS)
- Pressure Injection system (PIS)
- Gravity Injection system (GIS)
- Passive decaay heat removal (PDHR)
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Integral Pressurized Water Reactor (iPWR) Simulator
**Configuration capabilities**

### Operating modes

- Reactor Leading Mode
- Turbine Leading Mode

### Core cooling

- Natural circulation
- Forced circulation

### Circulating water cooling

- Open loop
- Closed loop

### Setpoints

- **Low-low level vessel**
  - Current: 99.99 %
  - Target: 100.00 %
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Technological approach

SIMULATION TECHNOLOGY
TEAM_SUITE

- MODELLING
  - THERMAL-HYDRAULIC
    - NEUTRONICS
      - NEMO_CODE
    - THERMAL-HYDRAULIC
      - TRAC_RT
  - ELECTRICAL
    - TEAM_LOGIC
    - TEAM_ELECTRIC
  - LOGIC & CONTROL
    - TEAM_LOGIC
- BOP + AUXILIARIES
- NSSS CODES
- HMI BUILDER
- INSTRUCTOR STATION
- INPUT / OUTPUT
- TUTOR SYSTEM
- CONFIGURATION MANAGEMENT SYSTEM
- MODELING TOOLS
- TEAM_SUITE
- TEAM_AIDES
- TEAM_STATION
- TEAM_SKETCH
- TEAM_TUTOR

TEAM_SUITE

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Technological approach

**SIMULATION TECHNOLOGY TEAM_SUITE**

- **NEUTRONICS**
  - Neutronic model
- **THERMAL-HYDRAULIC**
  - Reactor Coolant System
    - Main Steam
    - Feedwater
    - Turbine
    - Containment building & pools
  - Condenser cooling
  - Emergency core cooling
  - Containment cooling
- **LOGIC & CONTROL**
  - Reactor and Protection System
    - Valves / pumps logics
- **ELECTRICAL**
  - Generator system

**NSSS CODES**

**BOP + AUXILIARIES**

**INPUT / OUTPUT**

**INSTRUCTOR STATION**

**HMI BUILDER**

**MODELING TOOLS**

**CONFIGURATION MANAGEMENT SYSTEM**

**SICOSIS**
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Graphical User Interface

HMI BUILDER

Human Factors Engineering principles & methods

NUREG-0700

Human-System Interface Design Review Guidelines
Overview of the plant systems
Overview of the plant systems
Control loops

TURBINE BYPASS CONTROL

Turbine load

Reference temperature

Load-lagged temperature

Temperature error

Valve position demand 1

Valve position demand 2

Steam pressure

Set steam pressure

Average temperature

Load-lagged temperature

Valve position demand

Steam header pressure

Turbine bypass valve

Off-psr

Control loops

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Simulator control and supervision
Malfunctions activation

- Number: 1
- System: CBS
- Description: Loss of containment Vacuum
- Status: ACTIVATED
- Final severity: 80
- Current severity: 27.3925
- Ramp time: 25

ACTIVATE

DEACTIVATE
Exercises for standard operations:

- Load maneuvering in turbine leading mode
- Reactor power decrease from 100% to 0%
- Reactor trip and restart
- ...

Exercises for malfunction transient Events

- Loss of feedwater Flow
- Turbine runback
- Large steam generator tube rupture
- ...

<table>
<thead>
<tr>
<th>TABLE 11: STATION BLACKOUT (cont.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STATION BLACKOUT</strong></td>
<td><strong>DESCRIPTION</strong></td>
</tr>
<tr>
<td>5</td>
<td>Verify turbine trip:</td>
</tr>
<tr>
<td>6</td>
<td>Verify power supply:</td>
</tr>
<tr>
<td>7</td>
<td>Verify main steam safety valves are clamping steam to main steam.</td>
</tr>
<tr>
<td>8</td>
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</tr>
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**NOTE**

ADS valves are full close valves. On a station blackout event, ADS valves close to avoid an unnecessary breach on the reactor coolant pressure boundary. These valves should be pressured up its associated hoses before they are fully discharged.
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Different operating systems and platforms

- Windows 7 or higher
- 32-bit / 64-bit
- Chinese, Japanese, Korean, Arabic,...
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Conclusions

✓ iPWR Basic Principle Simulator is a useful tool to support the education on the fundamentals of this technology

✓ Simulator compliant with IAEA’s requirements for their suite of Basic Principle Simulator

✓ The development and supply of the simulator has been a success, in terms of quality, cost and timescale