Symulatory reaktorów jądrowych – przykłady rozwiązań

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Symulatory reaktorów jądrowych – przykłady rozwiązań

- Symulatory mają szerokie zastosowanie w elektrowniach jądrowych
- Istnieją różne ich typy, zależnie od przeznaczenia i zastosowanych rozwiązań
- Opowiem o wybranych przykładach symulatorów analitycznych i doświadczeniu z ich opracowywania.

Simulator types – example

- Compact simulators
  the scope of simulation is often limited only to the most crucial systems
- Plant analyzers
  combine advanced thermal-hydraulic and core modeling so as to permit an extensive modelling of the plant systems
- Full-scope (training simulators)
  full range of plant operating conditions and for training EOPs. These simulators normally include the full replica of the CR. The software development has been fast, and in many cases the simulators are even fully capable of simulating most of the postulated accident domain
- Multifunctional simulators
  the quality of the physical models is at least the same as for the full-scope simulators, but there is little control panel hardware
- Severe Accident simulators
  the capability of simulating plant conditions beyond initial core degradation up to the full severe accident phenomenology may be referred to as severe accident or SAM simulators
- Accident management support tools
  Computerized tools for supporting accident management during an accident can function both as tracking and predictive simulators.

Purpose

The accident analysis simulation is expected, but not limited to, to be used in the following areas of application:

- Accident analysis training – visual and interactive method of learning of possible actions and strategies in response to a spectrum of postulated accident conditions
- Development, refinement and validation of general procedures for accident response (emergency operating procedures, accident management guidelines)
- Accident analysis evaluation tool for Technical Support Centers
- Design basis, beyond design basis and severe accident analysis – fast, convenient and user friendly environment providing on-line access to a large number of parameters presented in graphical or digital form.

Purpose - AMP

Accident Management Programme - AMP decisions typically concern such issues as:

- off-site and on-site emergency preparedness recommendations,
- effectiveness of in-plant mitigation measures, and
- prioritization of actions to recover inoperable equipment and systems.

- adding water to a degraded core,
- depressurization of the reactor coolant system,
- preventing steam generator tube creep rupture, and
- containment related decisions, e.g. use of sprays, flooding, filtered venting and hydrogen management.

Działanie w oparciu o…

- Charakterystyki
- Równania bilansu dla poszczególnych komponentów
- Symulacje kodami typu ‘best estimate’
- Sieci neuronowe…

Simulation system features of a plant analyzer

Among the most important are:

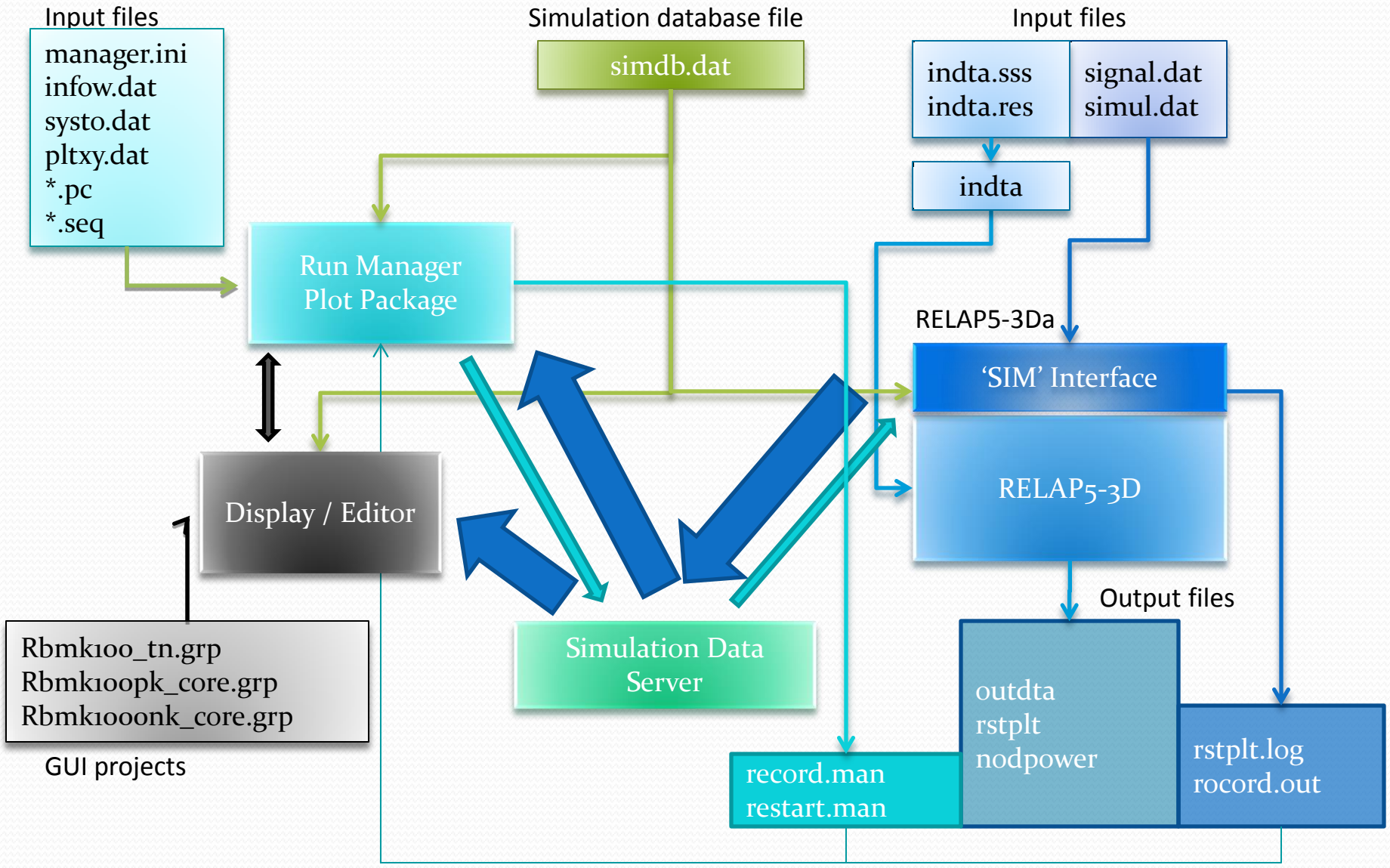
- Real-time simulation for most of the severe accident scenarios
- Plant animation screens and control panels (optional)
- On-line interactions capabilities
- Systems and components malfunctions
- Real-time plots
- Restart capabilities and simulation replay
- On line database
- Indexed code(s) manuals

Modular Model Generation Process

In general, the modular model generation processes include:

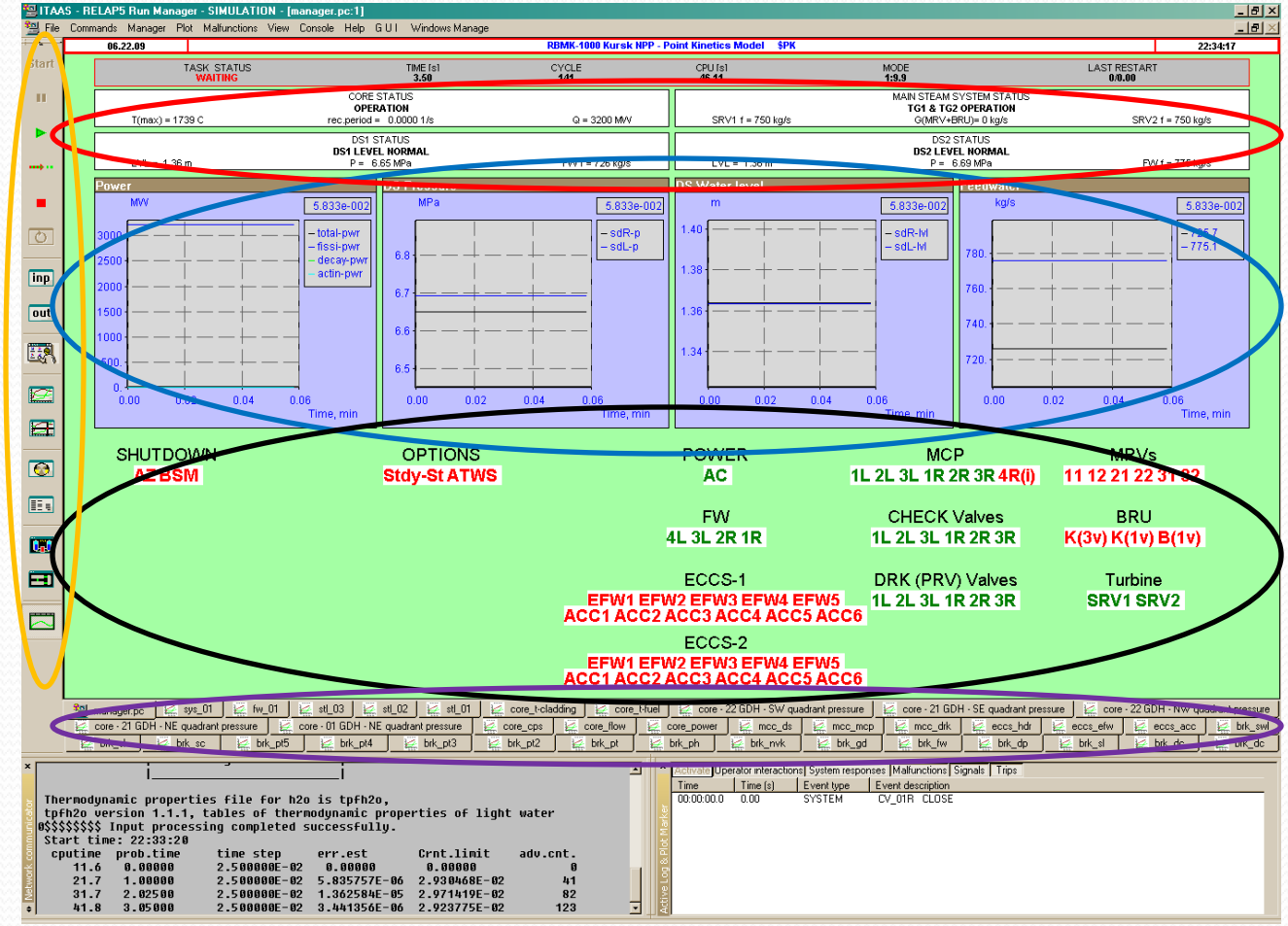
- basic units of component
  - individual mathematical model for each of these components
- Modularization
  - Subsystem modules — reactor, heat transport system, boiler, feedwater system etc. Each subsystem model is further broken down to process model, electrical power distribution model and control logic model.
- develop specialized algorithms specific to the requirements of the particular modules
- build subsystem models using basic blocks of generic algorithms, as well as the specialized algorithms
- testing to ensure that the subsystem model satisfies the modeling requirements specification
- integrated to form a large size system model, followed by testing and model tuning etc.

Programs, files, data flow



Run Manager, its windows and files

Toolbar



Safety status windows (infow.in)

Plots (pltxy.in)

System status window (systo.in)

Tabs: RM & Plots

Console window

Active Events Log window

RBMK 1000 Kursk 1 NPP Purpose

- The Accident Analysis and Associated Training Programme for the RBMK 1000 Kursk 1 NPP - IAEA
- Designed to contribute towards enhancing the RBMK accident analysis capability in Russia
- Qualification of various analytical methods and computer codes for use in RBMK-1000 transient and accident analysis
- Vehicle for technology transfer,
- Independent analytical capabilities at the plant
- Training tool for NPP staff

Simulation system for RBMK 1000 Kursk 1 NPP

- W oparciu o medel w RELAP5-3D®
- Kinetyka reaktora
  - Nodalna – 3D
  - Punktowa
- Stan ustalony dla kilku poziomów mocy
  - 100 %, 50%, 5%
- Analizy awarii, szkolenie operatorów

ITAAS for RBMK - presentation

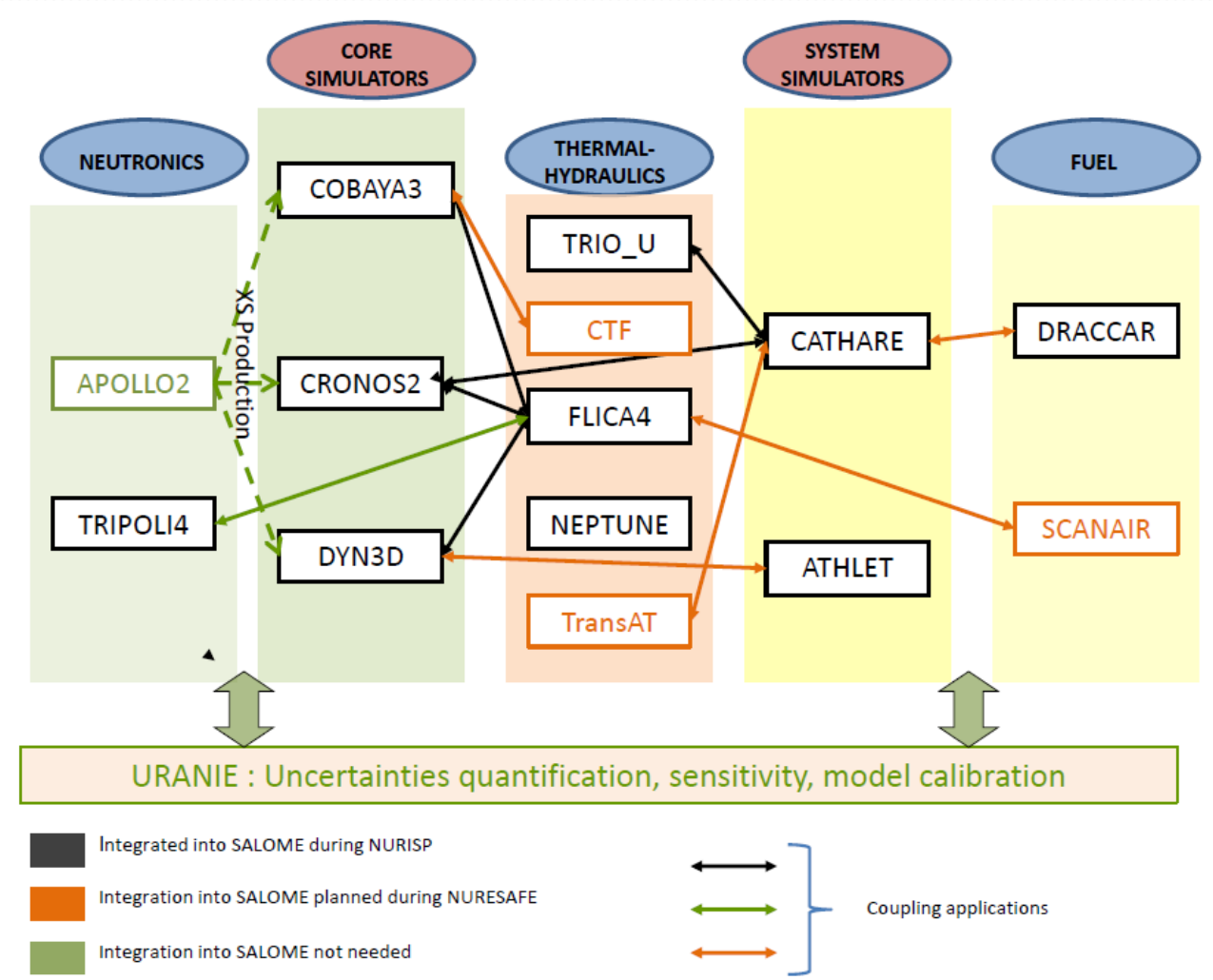
- Przykłady ekranów na końcu prezentacji

Other of the same type:

- WWER440/213 – Bohunice NPP, Dukovany NPP,
  - RELAP5 , MELCOR
- WWER440/230 - Armenia 1
  - MELCOR
- WWER 1000 – Kozloduj NPP
  - RELAP5
- PWR300 MWe – Chasma 1 NPP, Qinshan 1 NPP
  - RELAP5 i MELCOR
- Under construction – AP1000, BWR „Fukushima-like”
  - MELCOR

Selected demonstration

Analityczne systemy symulacji Platforma NURESIM

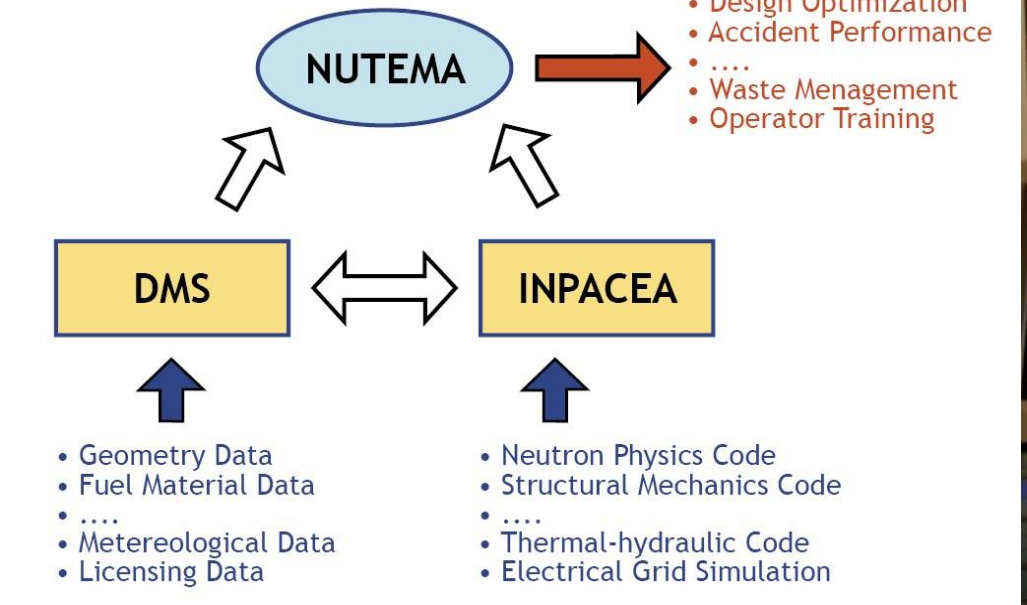


Analityczne systemy symulacji Platforma NUTEMA

- San Piero a Grado Nuclear Research Group – Pisa

NUTEMA

Nuclear Power Plant Technology
Knowledge Management System
or
Nuclear Technology Master



Tendencje

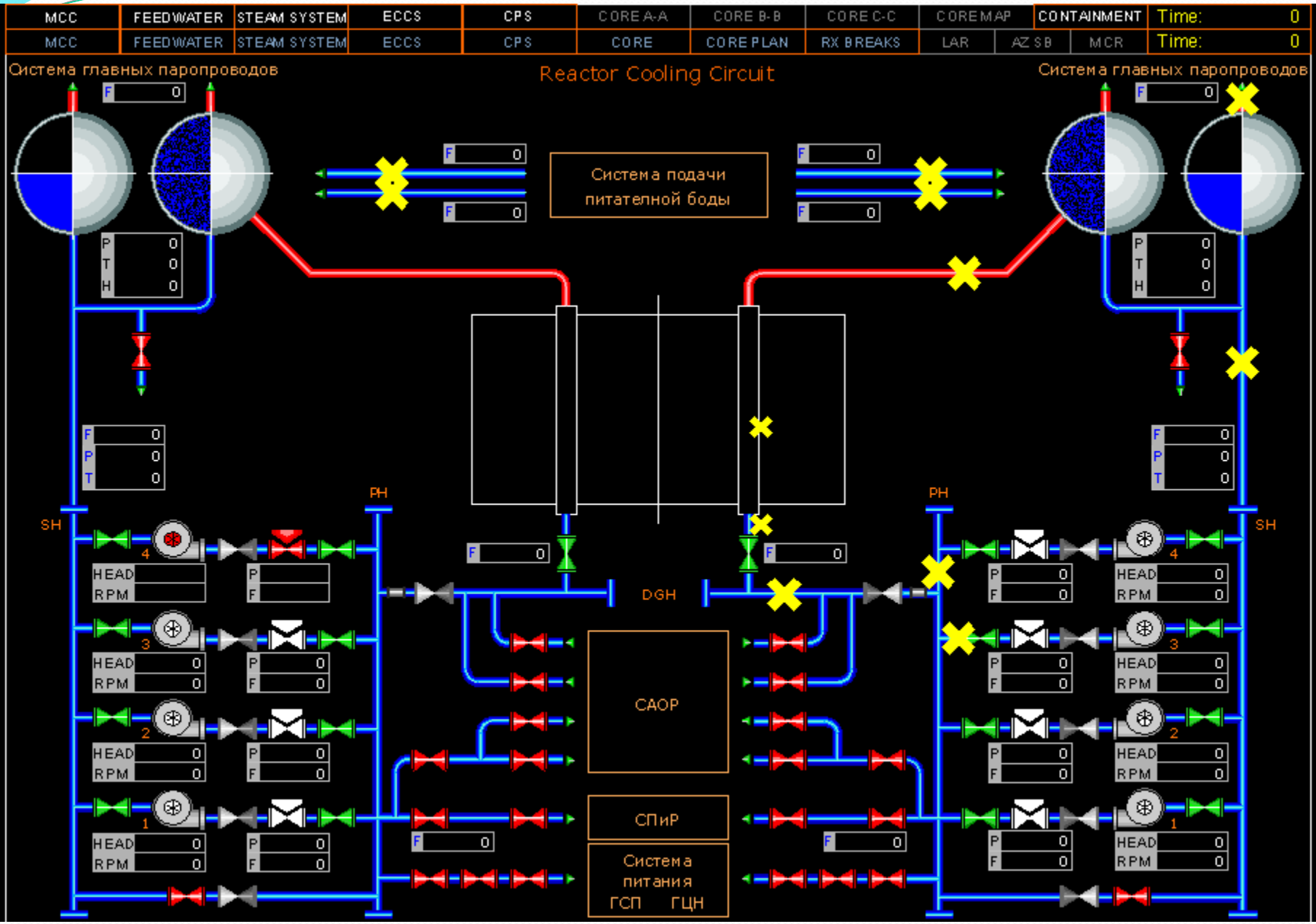
- Zacieranie się różnic w wierności symulacji pomiędzy różnymi wspomnianymi typami symulatorów
  - Rosnąca wydajność obliczeniowa
- Twórcy kodów opracowują własne interfejsy graficzne
  - Np. SNAP (for R5, MELCOR), ATLAS (for ATHLET)
- Platformy symulacyjne
  - Multiscale – multiphisics
  - Sprzęganie kodów
    - TH – neutronics
  - Stosowanie uniwersalnych bibliotek
- Nacisk na rozwój szybkich narzędzi wspomagających decyzje do liczenia awarii ciężkich i ich skutków radiologicznych

Referencje

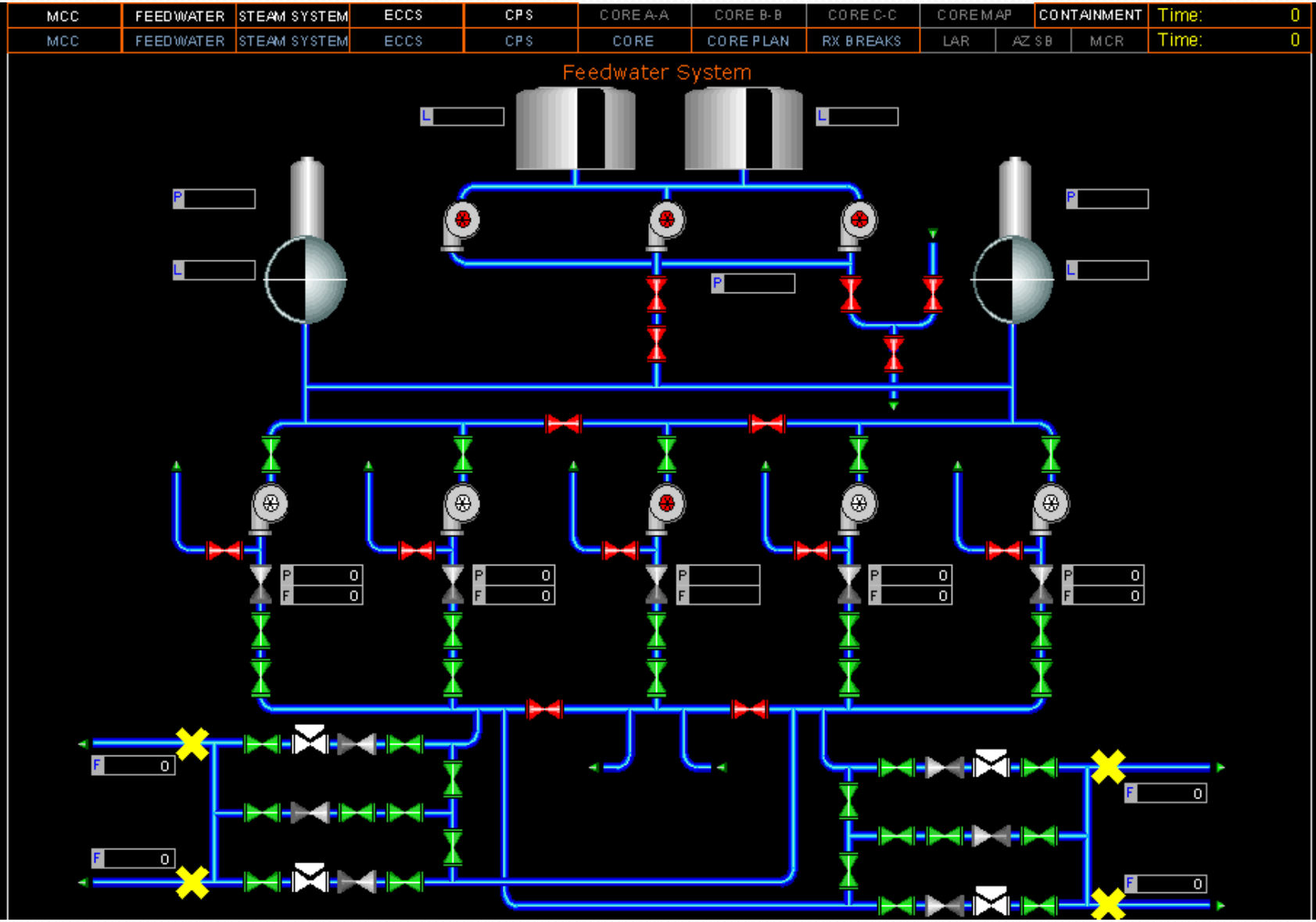
- IAEA-TECDOC-1352 Application of simulation techniques for accident management training in nuclear power plants
- IAEA-TECDOC-995 Selection, specification, design and use of various nuclear power plant training simulators
- IAEA – Reactor simulator development – workshop material
- IAEA-TECDOC-1500 Guidelines for upgrade and modernization of nuclear power plant training simulators
- http://www.grnspg.ing.unipi.it/nutema/components.html
- NURESAFE FP7 Project documents

Dziękuję !

RBMK 1000 Kursk NPP
Example Technological Display



RBMK 1000 Kursk NPP
Example of Technological Display



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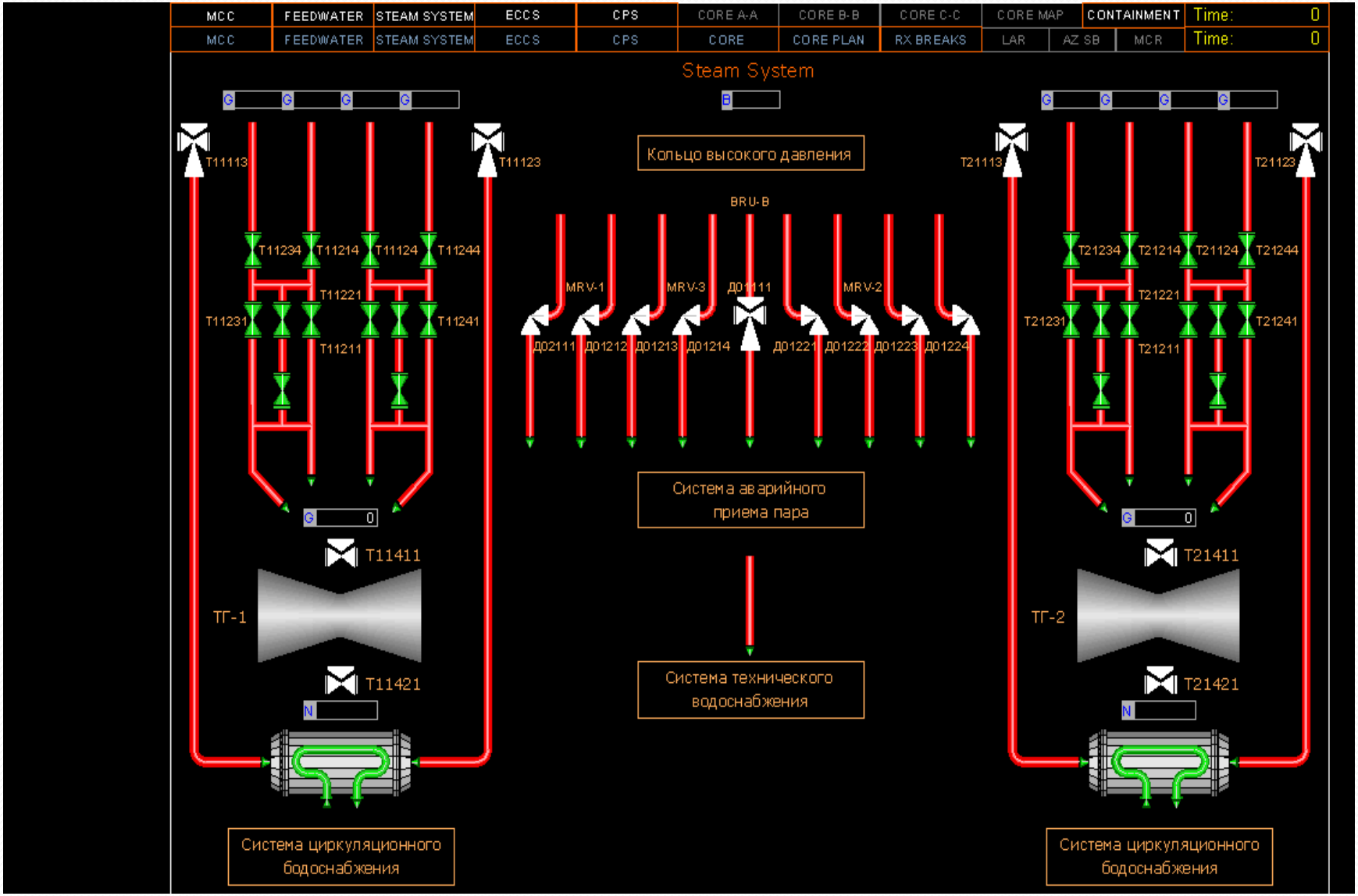

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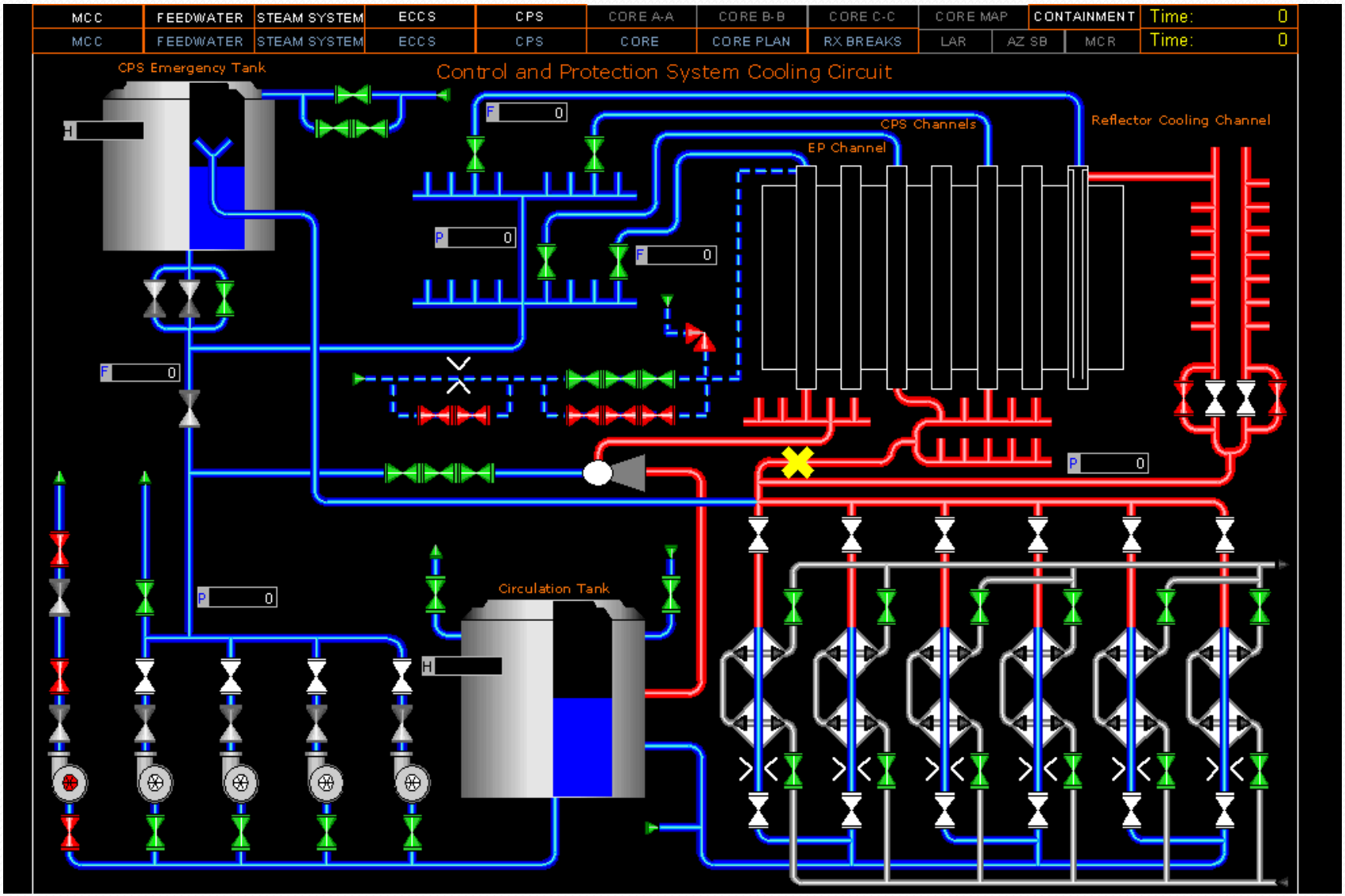
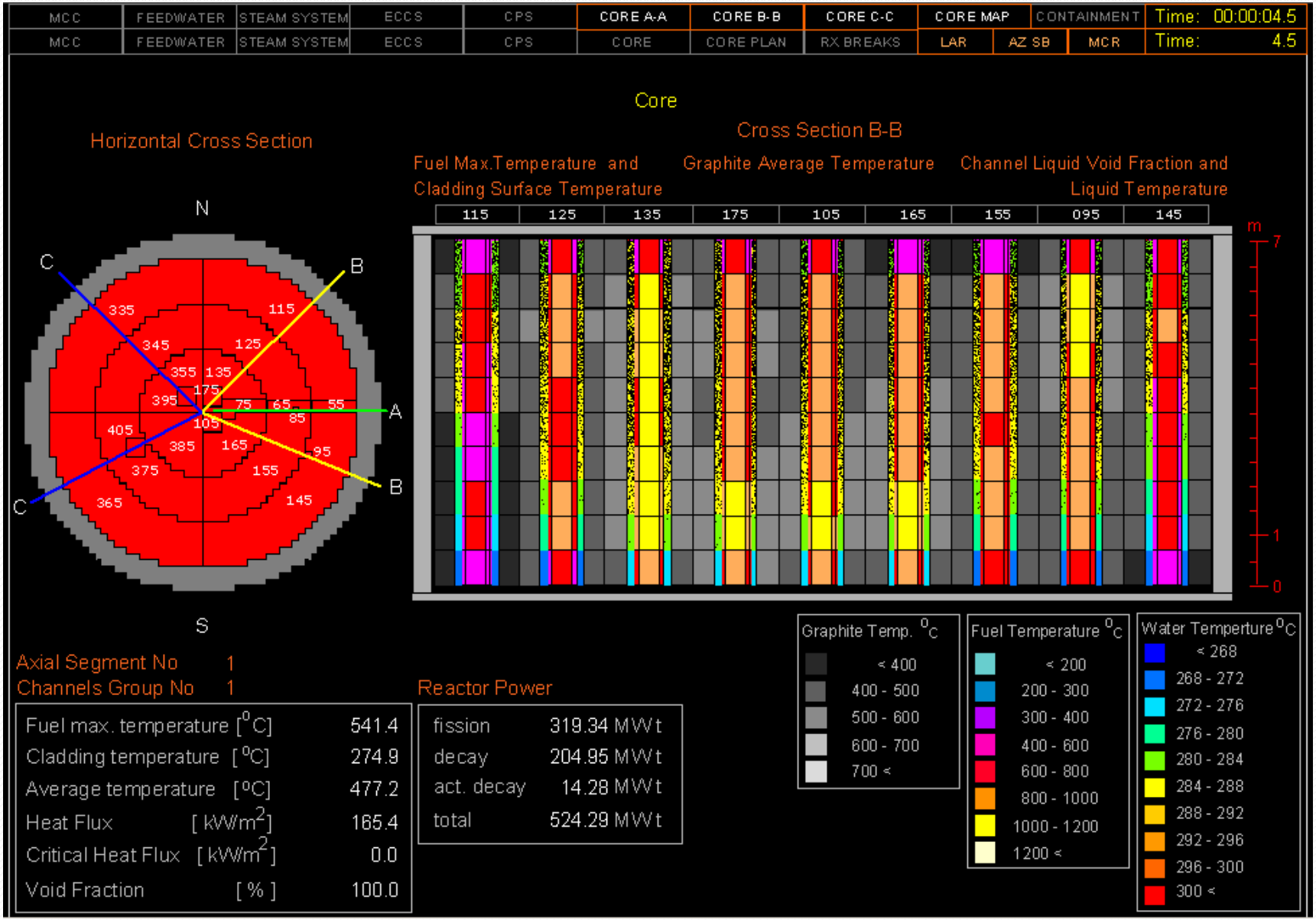
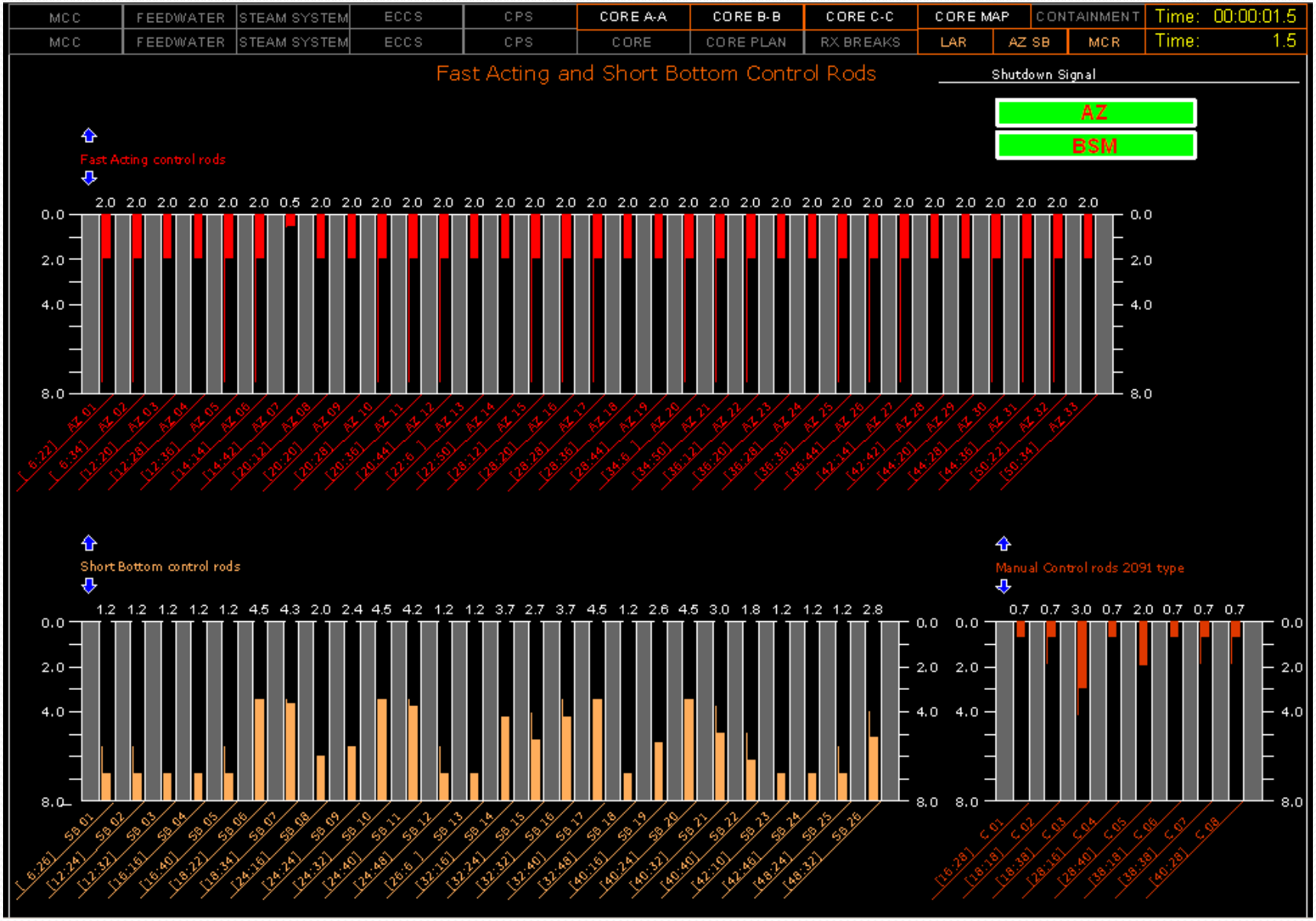


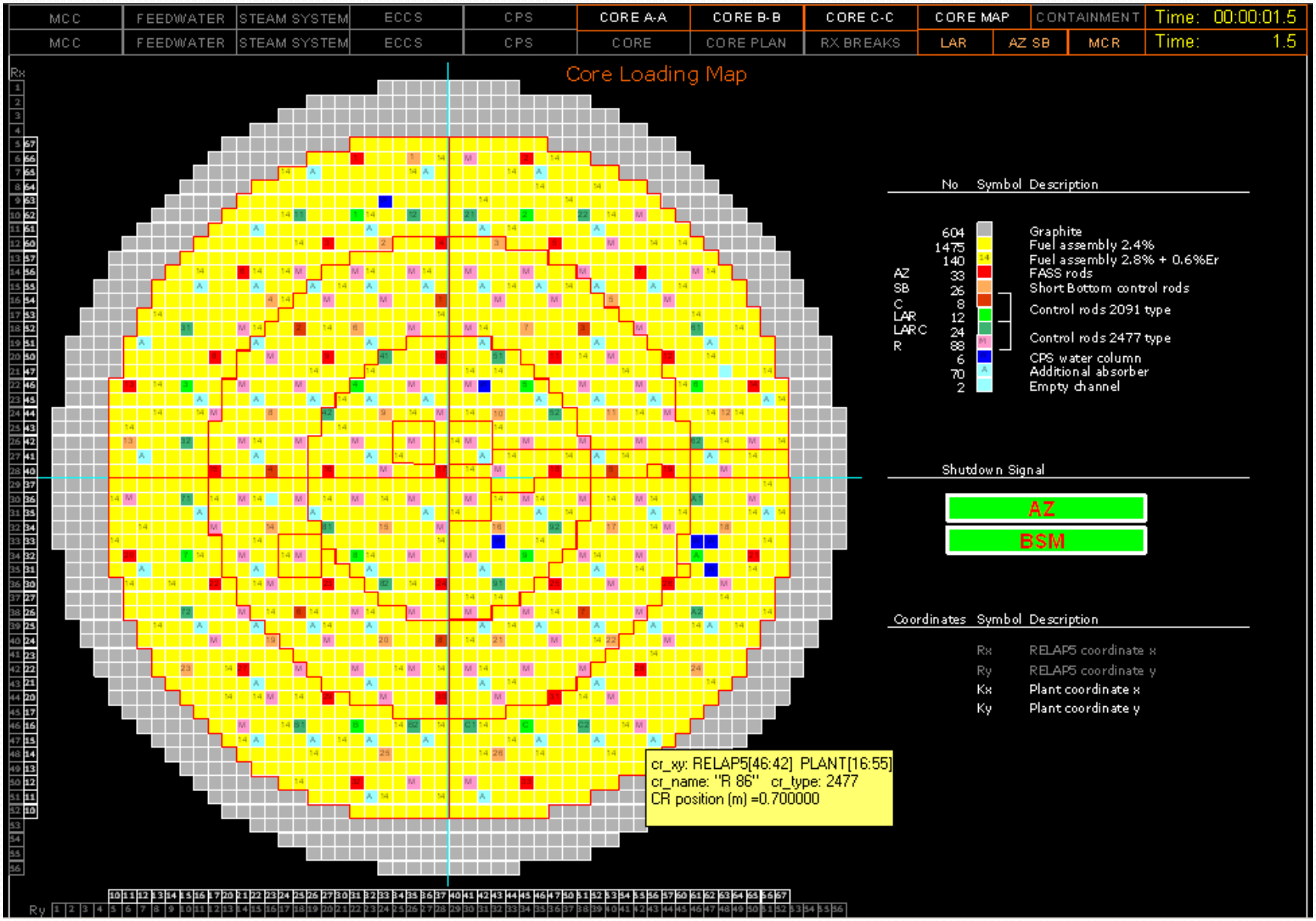
RBMK 1000 Kursk NPP
Example of Core Display



RBMK 1000 Kursk NPP
Example of Control Rods Display

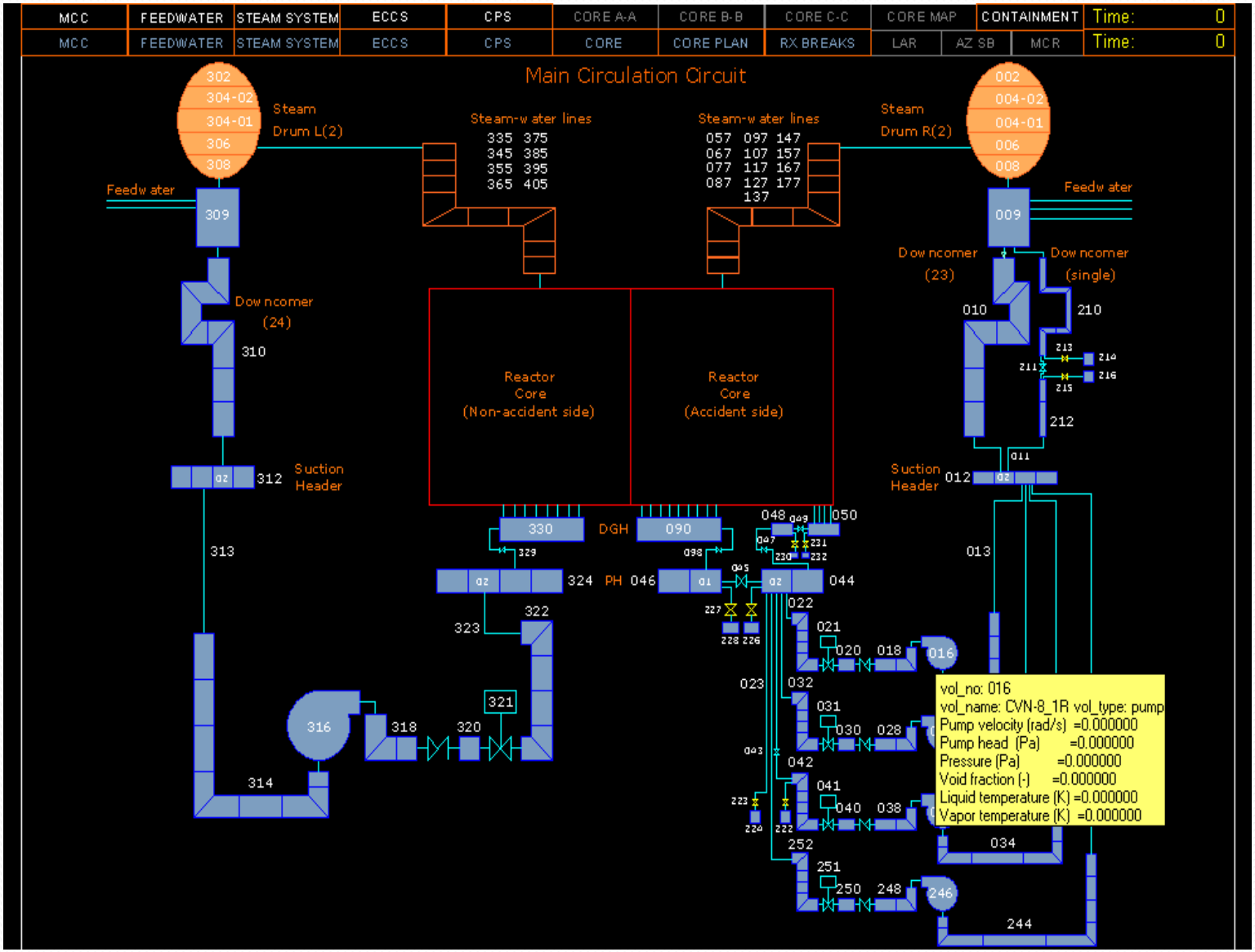


RBMK 1000 Kursk NPP
Example of Core Loading Map Display



RBMK 1000 Kursk NPP

Example of RELAP5-3D Nodalization Display



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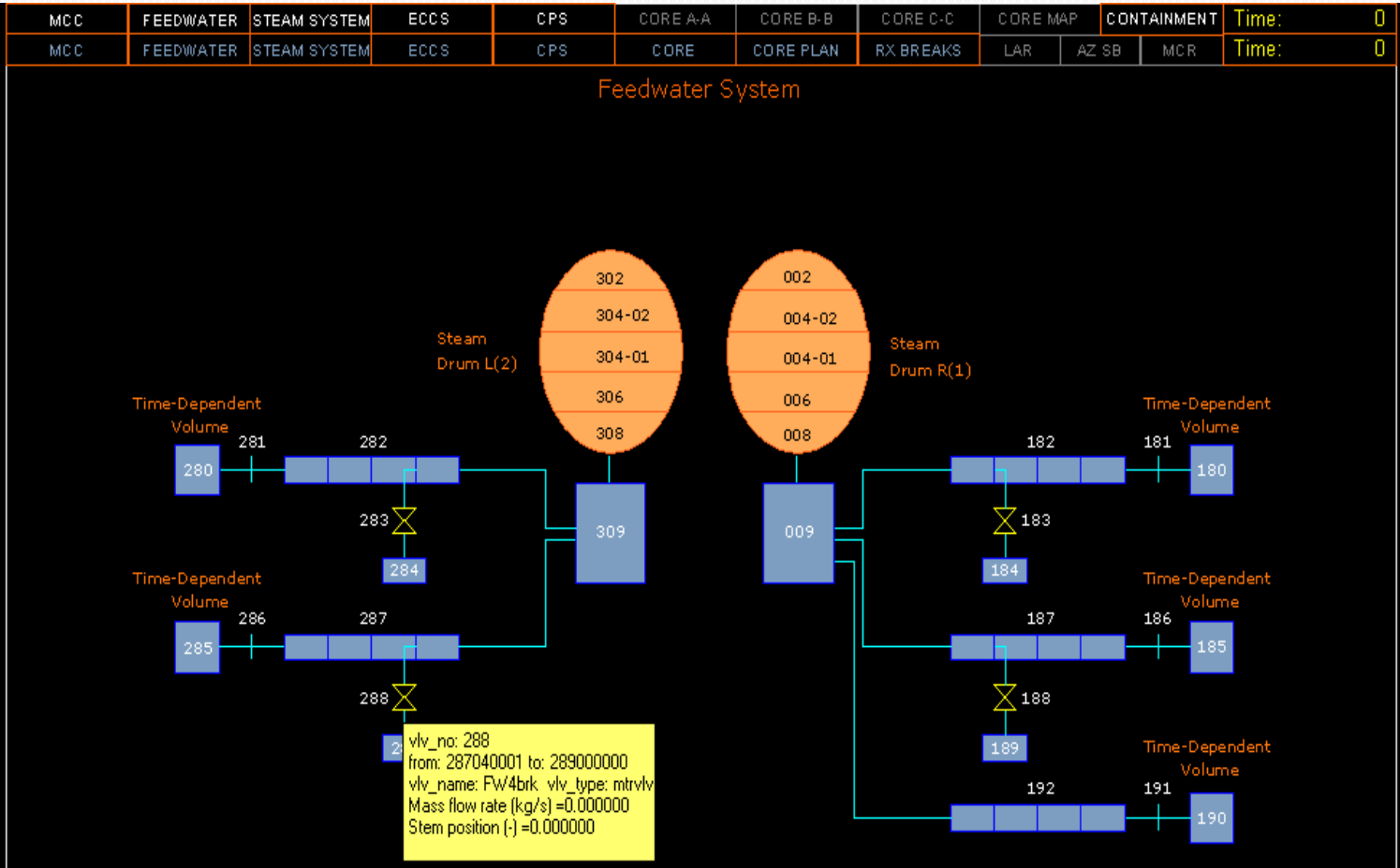

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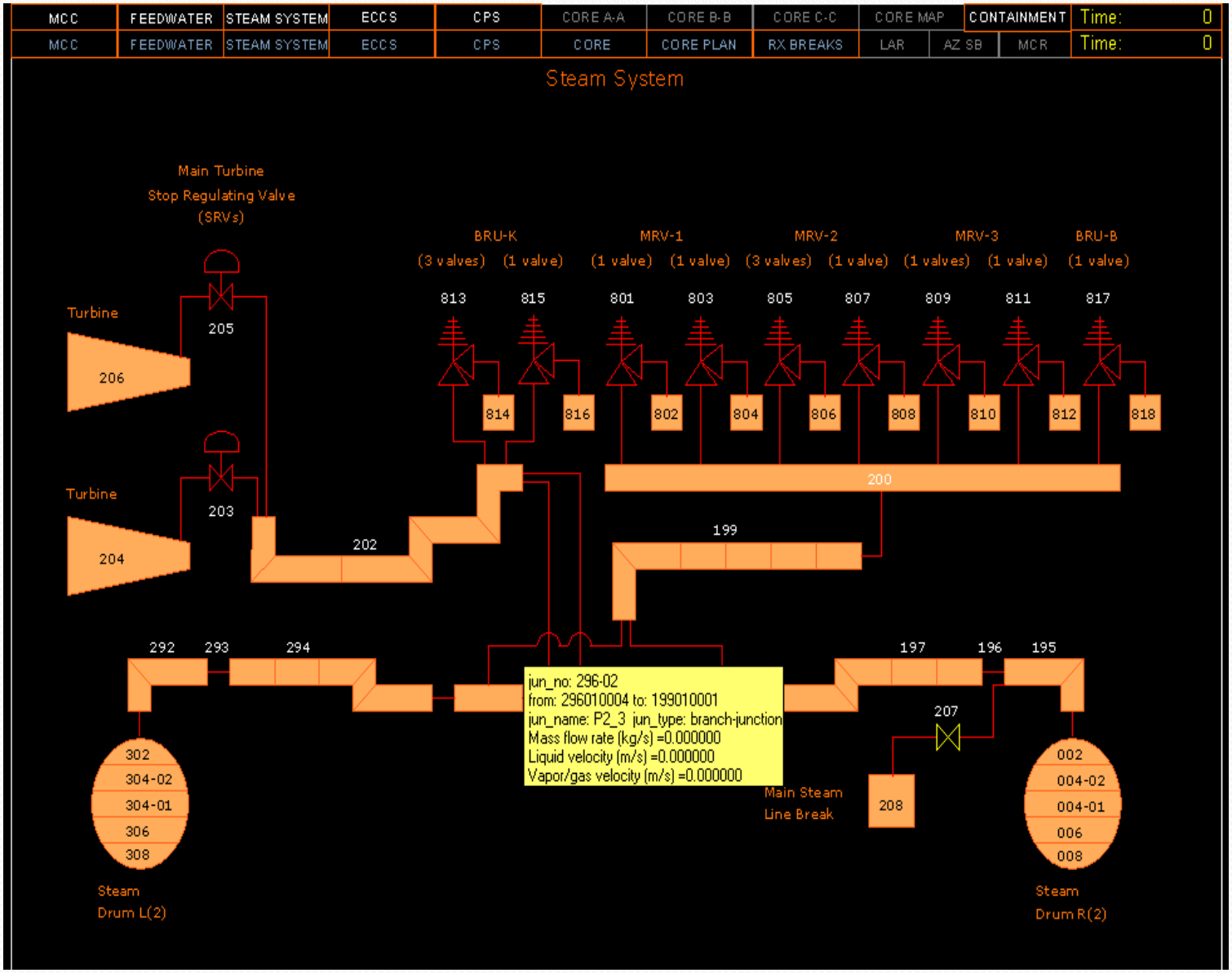

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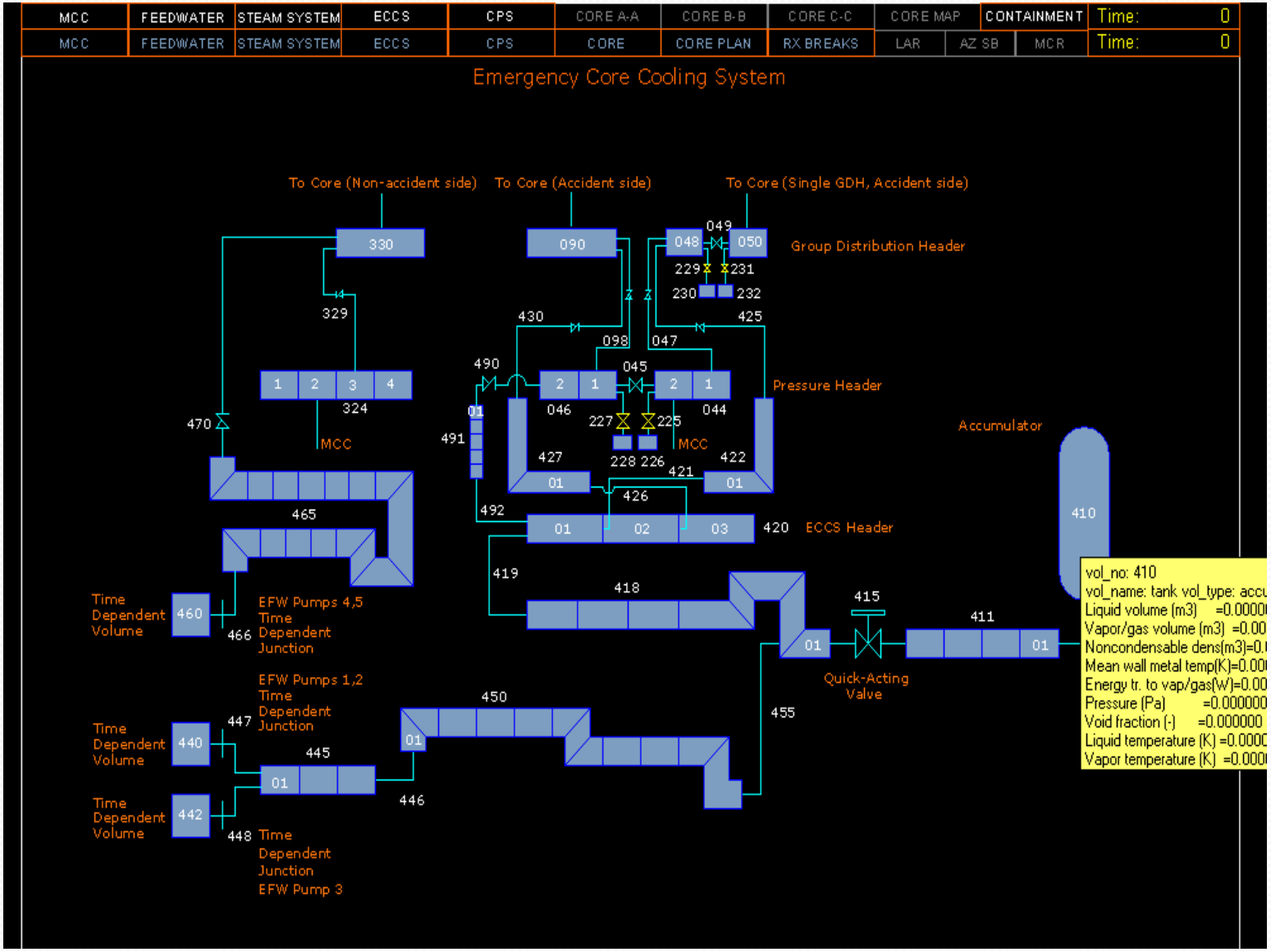

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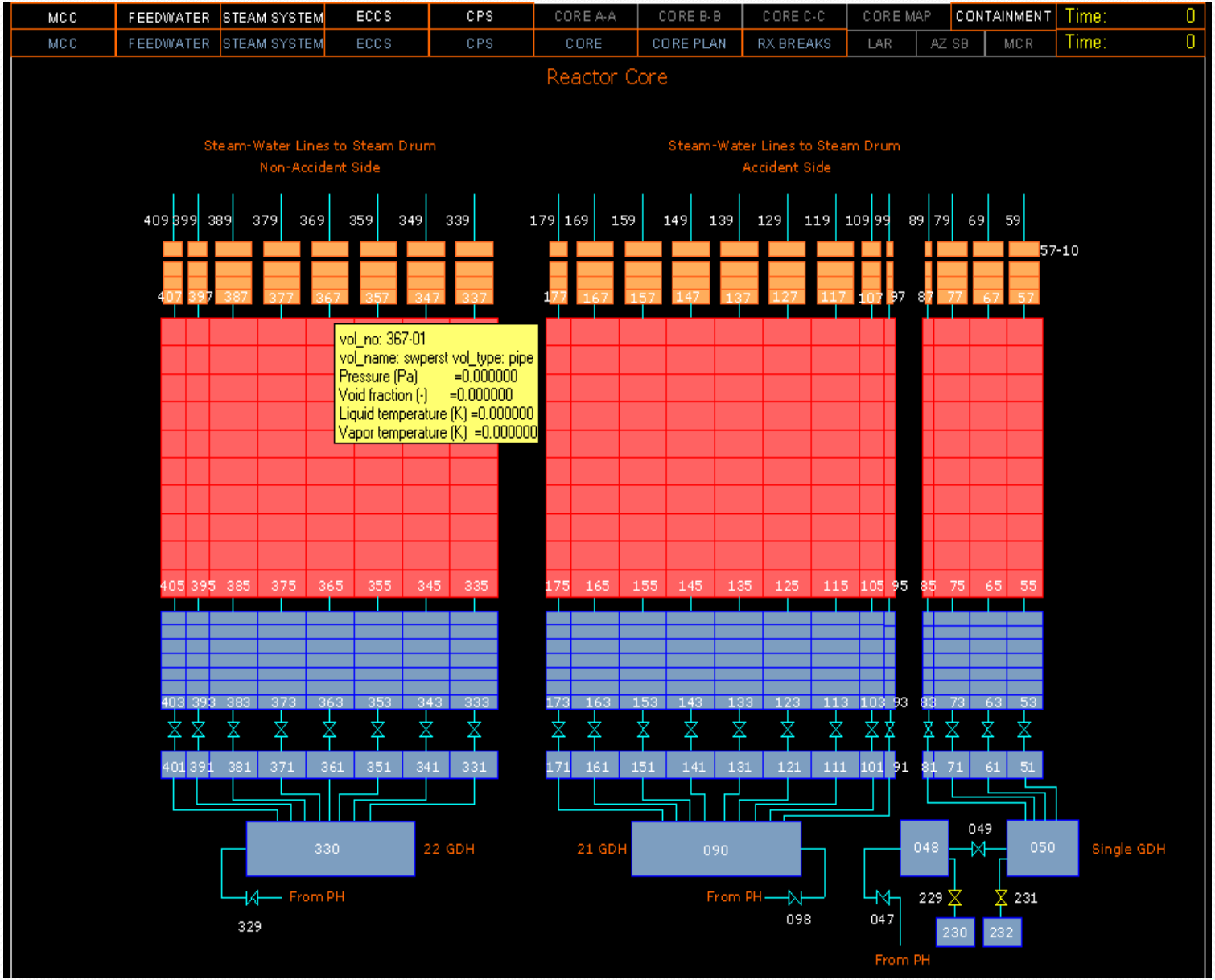

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