



Real-Time MELCOR 1.8.6 Desktop Simulator of the PWR

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Background



- **Contract:** Ministry of VROM (Housing, Spatial Planning and the Environment) of the Netherlands
 - **Product:** A software package that provides a simulation of the Dutch nuclear power plant Borssele (KCB)
 - Training tool for the Dutch regulatory body (KFD)
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- Understanding advanced plant characteristics
 - Safety features
 - Plant response
 - Insight in accident progression



<http://www.nrg-nl.com/product/ppt/tenyear/index.html>
Borssele nuclear power plant

PWR Desktop Simulator

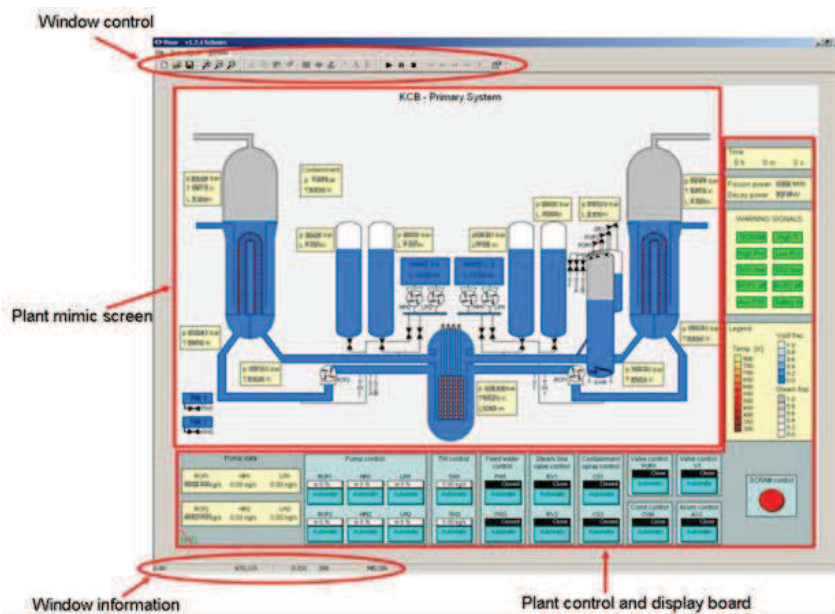


- Realistic model of the plant: two-loop PWR
- Model based on technical information about the plant's design and operation
- Validated against the results of the safety evaluations from the KCB safety report
- Steady-state run and a variety of accident conditions
- User friendly graphical user interface
- Coloured mimic of the primary system, containment and the secondary system
- Animated:
 - Liquids and atmosphere: water level, void fraction, steam fraction
 - Pumps
 - Valves, locks and sprays
 - Control rod movement
 - Temperature changes

Simulator Windows

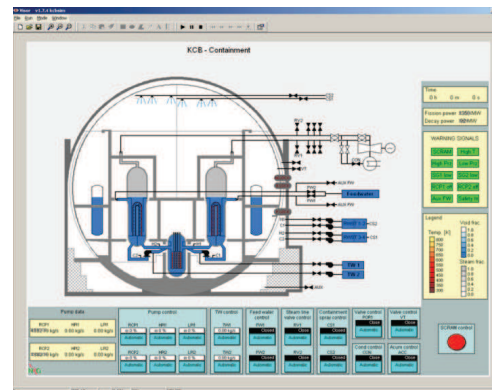


- Sections of the window



Multiple windows

- Primary system
- Chosen plant parameters
- Containment
- Radioactive products
- Radioactive release



Computational Tools

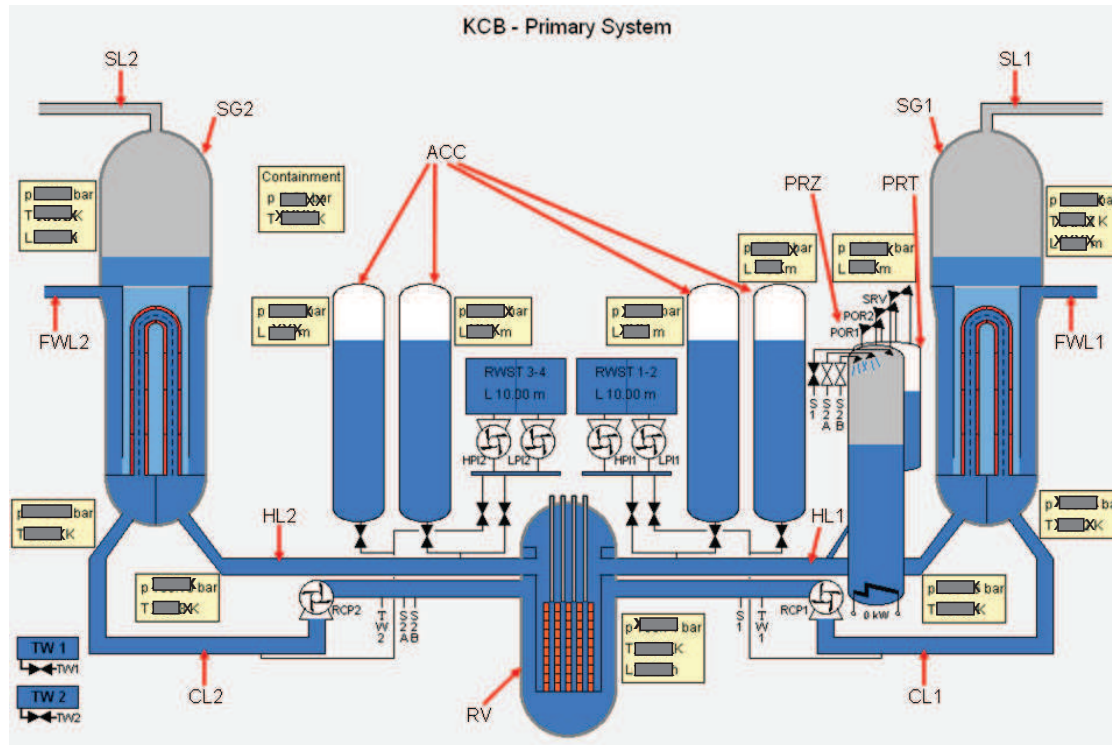


- **Computational tool:** MELCOR 1.8.6.
- **Graphical user interface:** NRG in-house developed visualization tool VISOR

Model



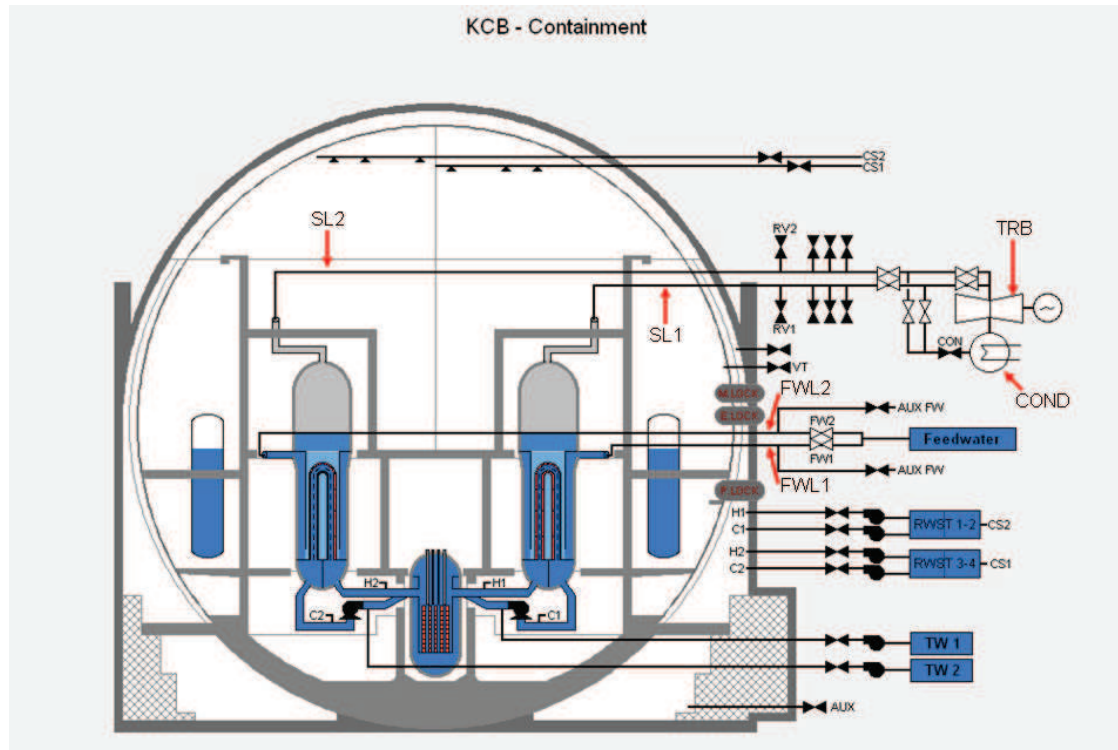
- Primary system



Model



- Containment



Modes of Run

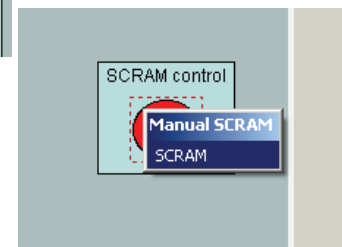
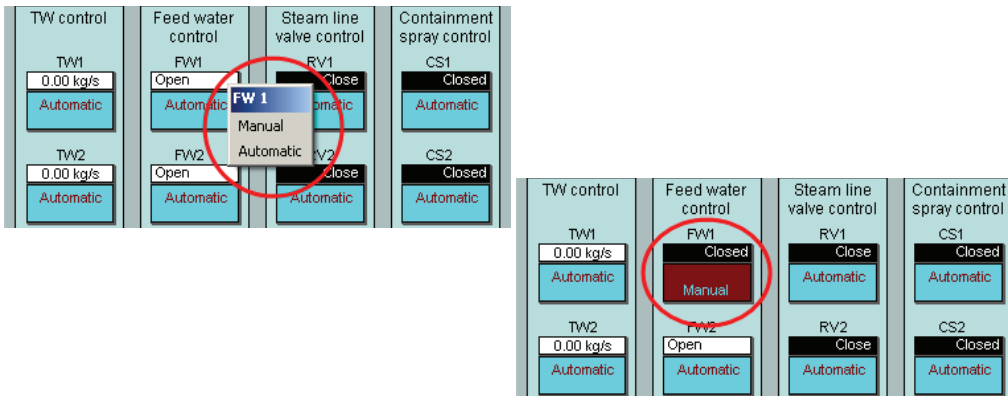


- **Auto run mode:** pre-calculated scenario, user can observe the behaviour of different systems
- **Interactive mode:** user may interfere with the transient and change the response of the plant to events

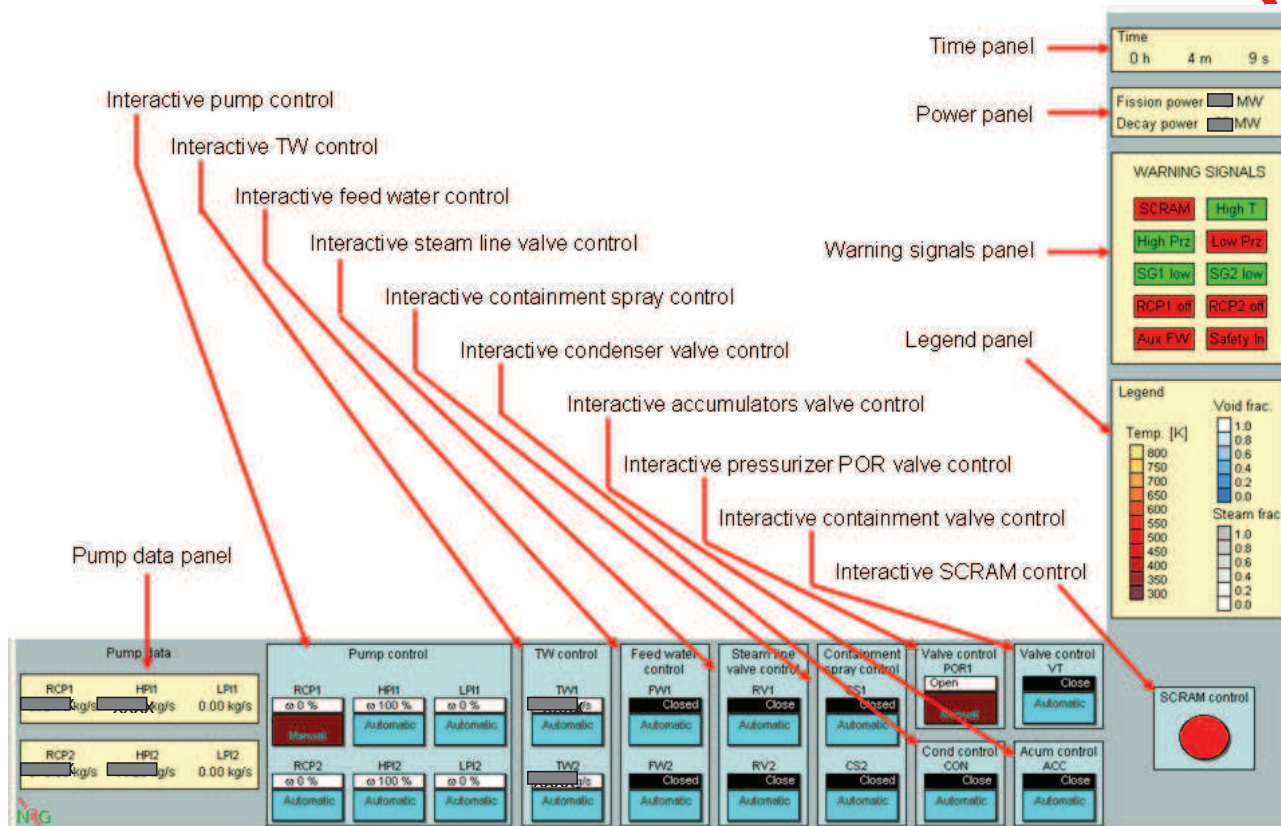


Interaction

- Via combination of monitor displays, mouse and keyboard
- Interactive buttons shown as stylized pictures
- Operated via right and left mouse click



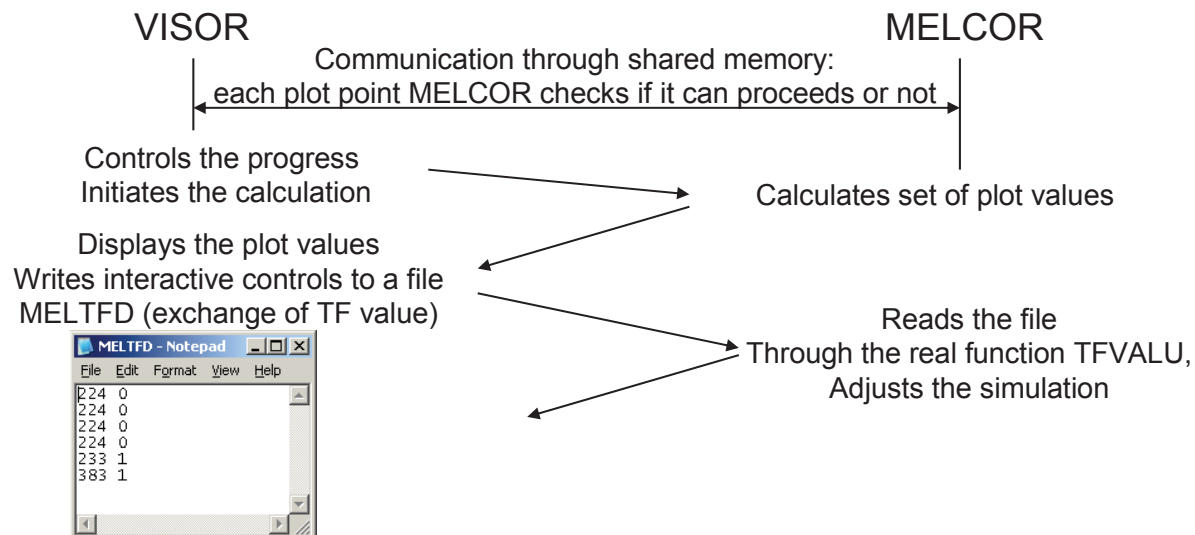
Interaction and Info Panels



MELCOR – VISOR Communication



- **Auto run mode:** pre-calculated MELCOR plot files in combination with VISOR file
- **Interactive mode:** MELCOR and VISOR are running simultaneously; MELCOR uses the information provided by VISOR as an additional input for the calculation → user interacts with the simulator



Accident Scenarios



Various transients in real or close to real time.

Currently available:

- Large break LOCA
- Small break LOCA
- Steam generator tube rupture
- Main steam line break
- Feed water line break
- LOCA with a station black-out
- Steady-state operation

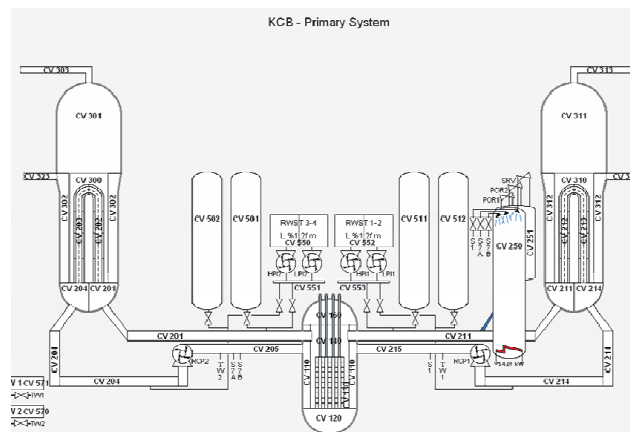
Additional malfunctions can be initiated by the user when operating in an interactive mode (reactor coolant pump trip, stuck-open pressurizer valve and many others).

Adjustments of the Model to Achieve Real-Time



The most important adjustments:

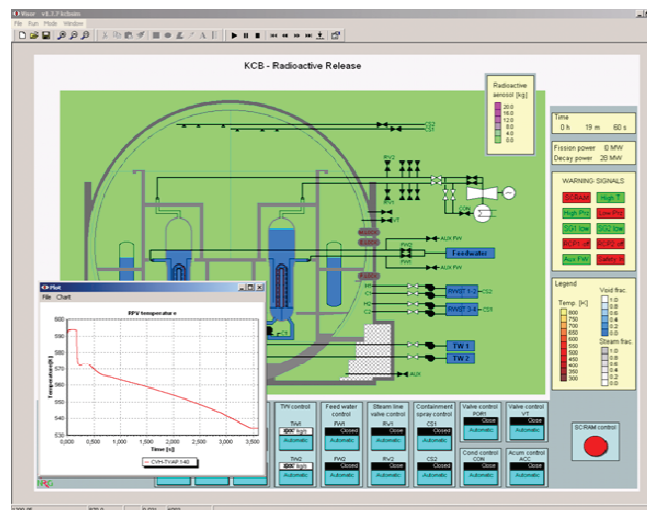
- Small control volumes were combined into larger volumes without compromising model's accuracy too much
- Connection pipes (pressurizer surge line, accumulator pipes, containment spray lines, etc.) were modelled as flow paths only
- Efficient communication between MELCOR and VISOR has been established



Additional Functionality



- Simulation's data can be saved as a Microsoft Excel file or as an ASCII file
- Simulation screen can be saved as an image
- Transient can be saved as an AVI file
- Any parameter can be plotted against time
- Parameter graphs can be saved as an image or exported as a chart format



Desktop Simulator Used as a Training Tool



- Currently used as a training tool for the staff of the Dutch nuclear regulatory body
- Series of exercises, where the response to various accident conditions is tested
- Training includes the use of measures and strategies applied in the Emergency Operating Procedures (EOPs) and the Severe Accident Management Guidelines (SAMGs)
- Exercises are performed in a manner to simulate an event of an accident in KCB as realistically as possible (several hours, multiple number of staff)
- Also used as a single participant tool

Example



- Large break LOCA in auto run mode

Conclusions



- PWR desktop simulator
- MELCOR 1.8.6. as its engine, VISOR as GUI
- Provides close to real simulation of the Dutch nuclear power plant Borssele
- Displays the mimic of the primary system, containment, schematically represented secondary system
- Auto run and interactive mode
- Steady-state and variety of accident conditions
- MELCOR 1.8.6. proved to be a competent computational tool for the simulator and post-processing tool VISOR a user friendly GUI
- An accurate simulator of any other nuclear power plant can be created using the visualization tool VISOR in combination with MELCOR