International Summer School 2013

Selected issues of safety engineering and exploitation of nuclear power plants in the context of EU energy policy

Trnava, 1-12.09.2013

nuclear reactor simulator

” The investigation and analysis of the main reactor parameters variation during perturbations and accident situations part II”

Laboratory is devoted to simulate and analysis of the main reactor parameters variation during abnormal perturbations and accident situations.

Exercise 1. Loss of Normal Feedwater

This is an event characterized by a loss of feedwater flow in the secondary system. It results in a reactor trip on high RCS pressure or low SG level. RCS temperature and pressurizer level will increase due to a reduction of heat transfer until a secondary heat sink is established. This is established by the Emergency Feedwater (EFW) automatically starting on low SG level.

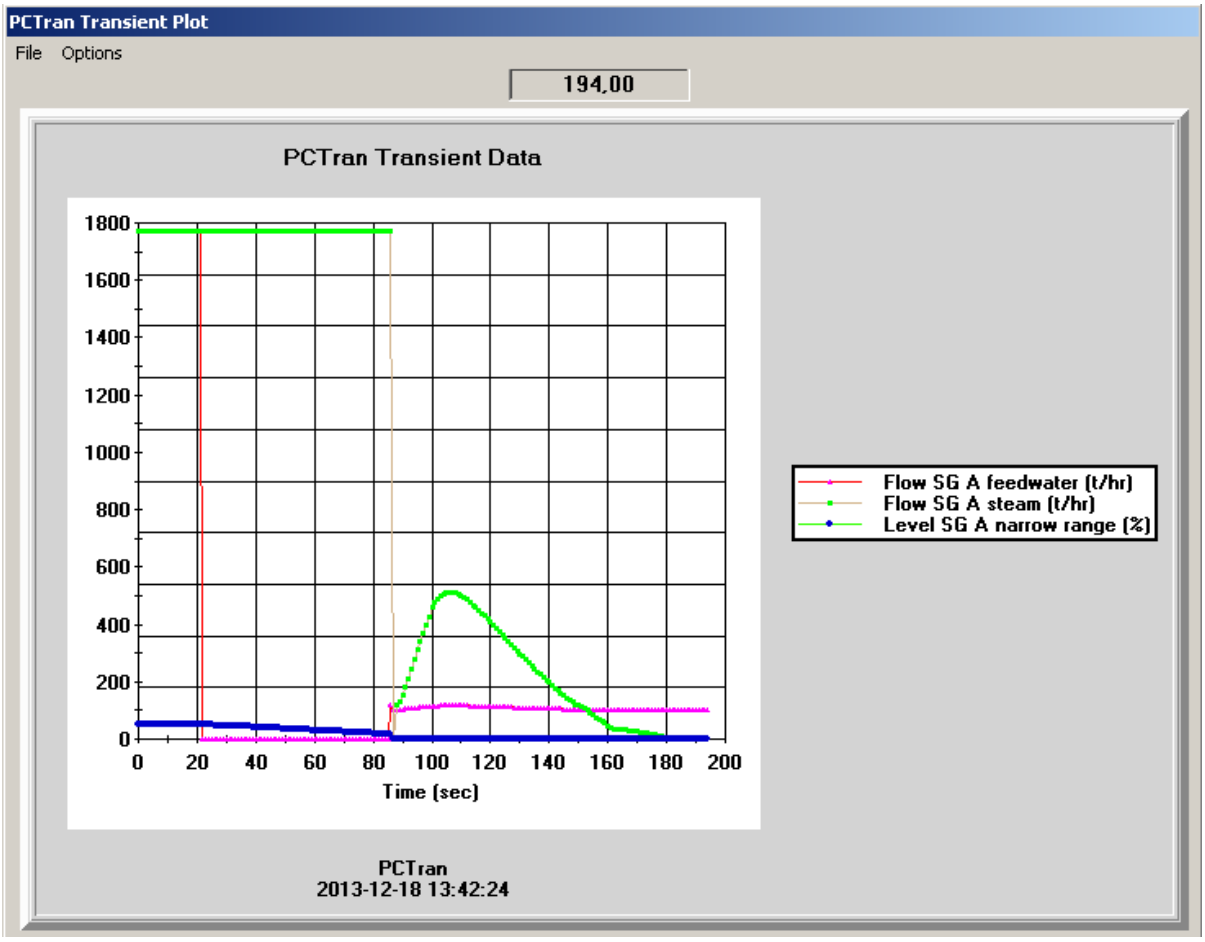


Figure 1. Changes of the flow SG feedwater and flow SG a steam

A loss of feedwater event can be initiated in each of the following ways:

a) by tripping (turning off) all main feedwater pumps,

b) by closing all feedwater valves,

To trip feedwater pumps or close feedwater valves please click them with right mouse button and set malfunction status, then confirm with ”OK”. Disabled pumps or valves will be marked with red line.

c) from the malfunction list (malfunction #5 – Loss of Main Feed Pumps).

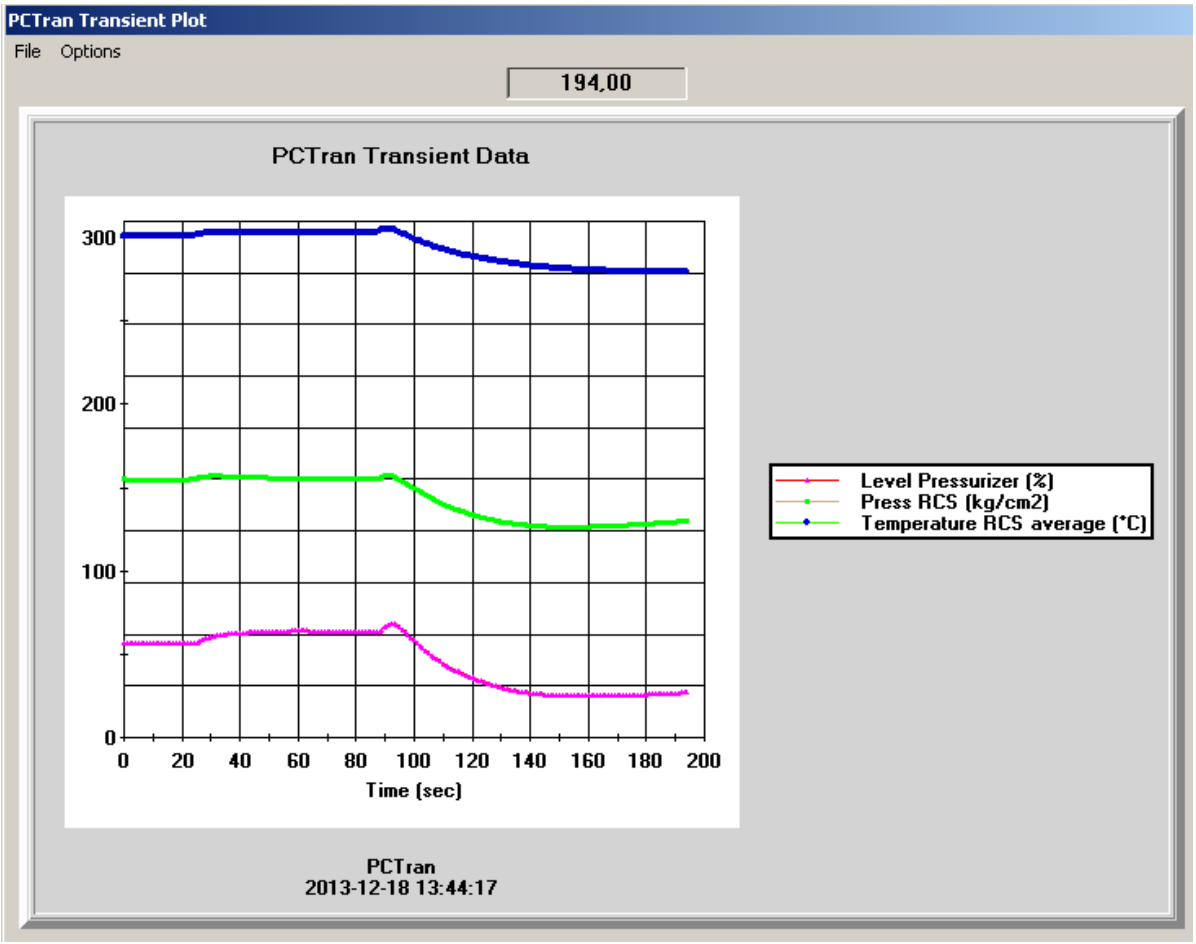


Figure 2. Changes of level pressurizer and temperature RCS

The malfunction parameters to be set, are as follow:

- delay time: 10 seconds
- ramp time: 0 seconds
- failure fraction: 0

The proposed parameters to be observed are as follow:

a) *Power Neutron Flux, Power Turbine Load.*
b) *Flow SG B Steam, Flow SG B Feedwater,*
c) *Pressure SG B, Level SG B Wide Range,*
d) *Temperature RCS Average, Level Pressurizer, Press RCS,*
e) *Reactivity Rod, Reactivity Mod Temperature.*

Please use a transient plots to get the response of the key parameters to the loss of feedwater accident.

Exercise 2. Large Break LOCA

This is a serious accident characterized by a large (double-ended) break of the cold leg, which results in a loss of reactor coolant. The loss of inventory causes RCS pressure and pressurizer level to decrease, and leads to a reactor trip on either low reactor pressure, low pressurizer level or high OTDT.
Due to the low reactor pressure, the safety injection signal soon initiates auxiliary feedwater addition (in turn High Pressure Injection, Accumulators Injection and Low Pressure Injection) in order to maintain pressurizer level.

To initiate Large Break LOCA accident, please select malfunction #2 (Loss of Coolant Accident – Cold Leg) from the malfunction list, and set the malfunction parameters as follow:

- delay time: 10 seconds
- ramp time: 500 seconds
- failure fraction: 200 %

The proposed parameters to be observed are as follow:

a) *Press RCS, Level Pressurizer, Temperature RCS Average, Void of RCS*

b) *Flow HPI, Flow Accumulator, Flow Low Pressure Injection (RHR),*

c) *Temperature RCS Average, Temperature Average Fuel,*

d) *Press Reactor Building, Temp Reactor Building, Flow Containment Spray.*

Please use a transient plots to get the response of the key parameters to the large break LOCA accident

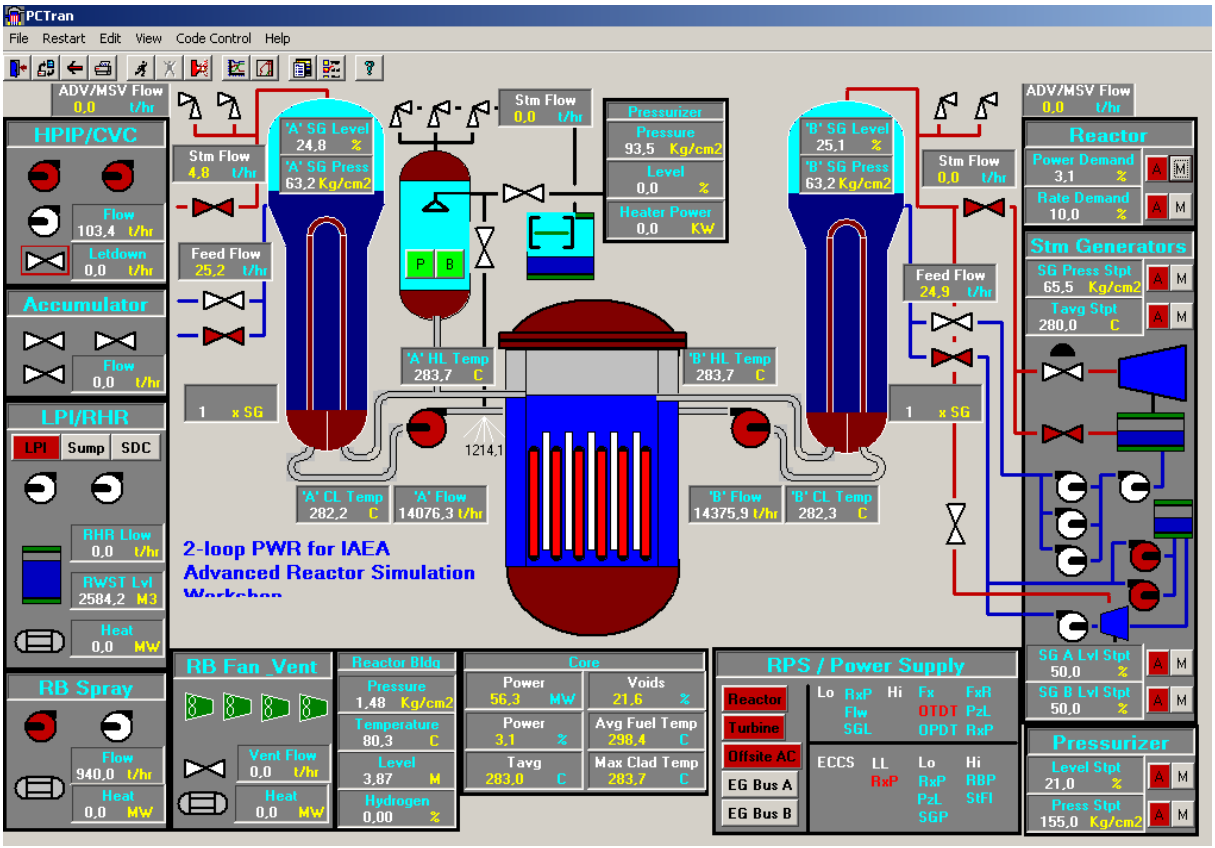
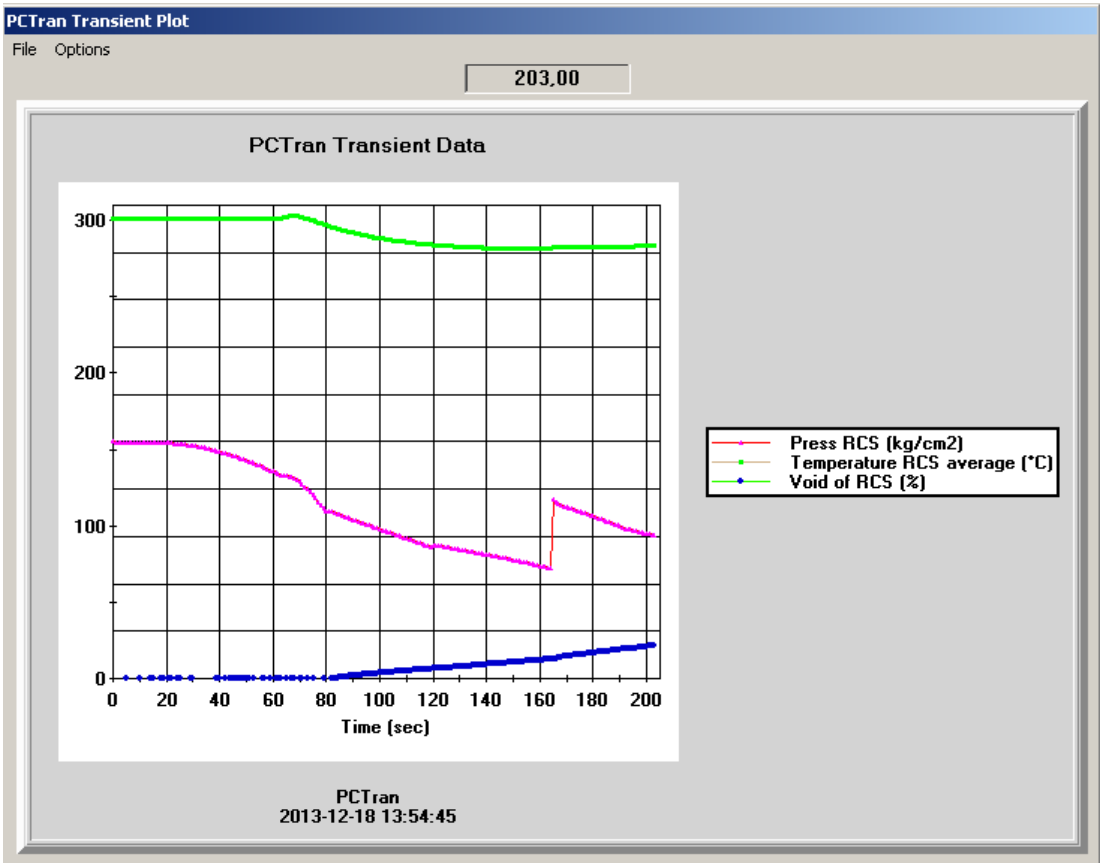
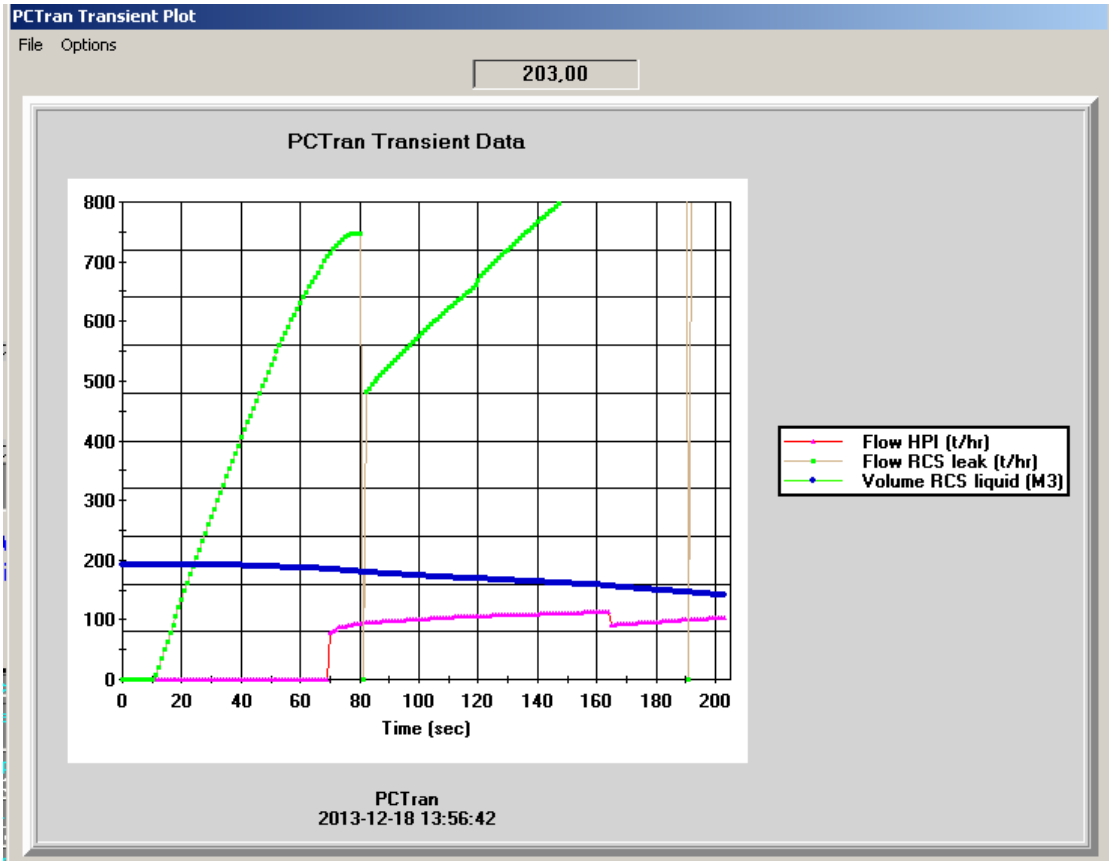
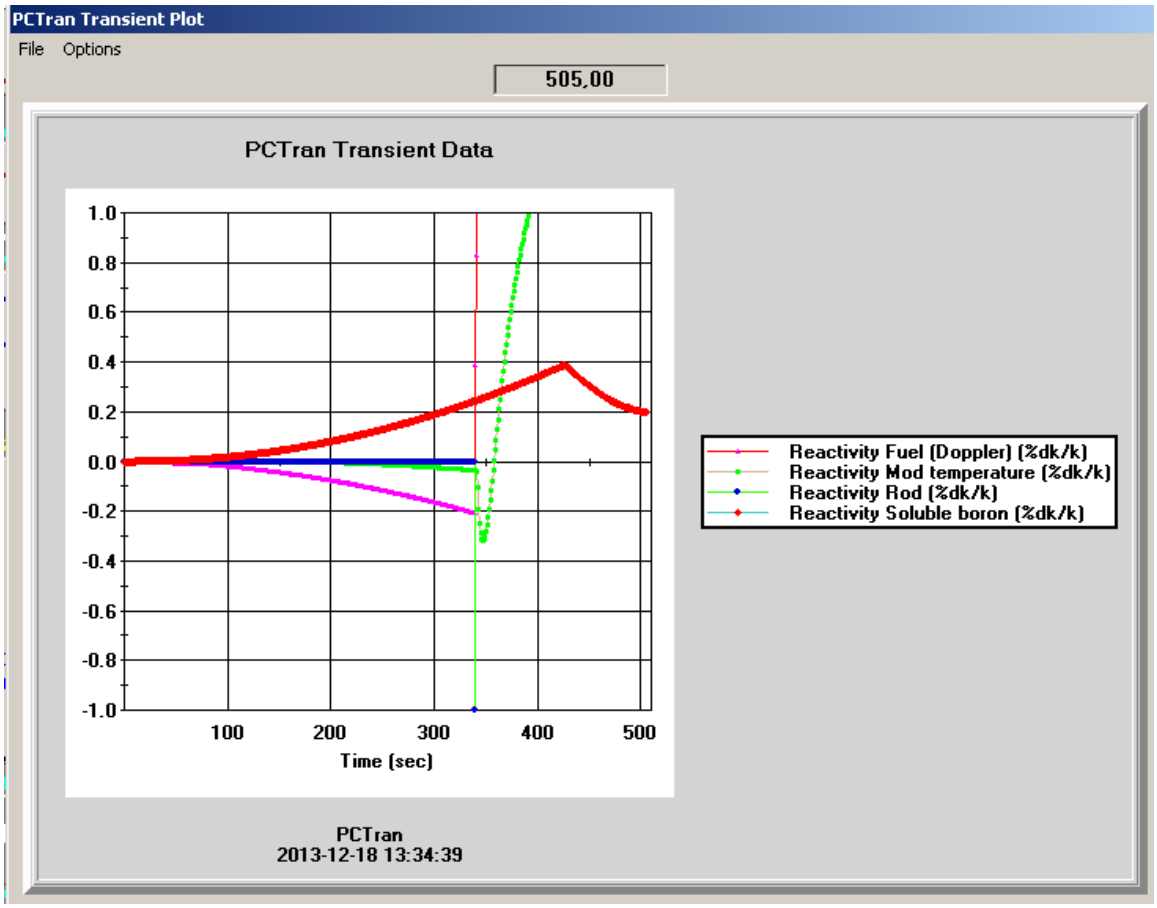


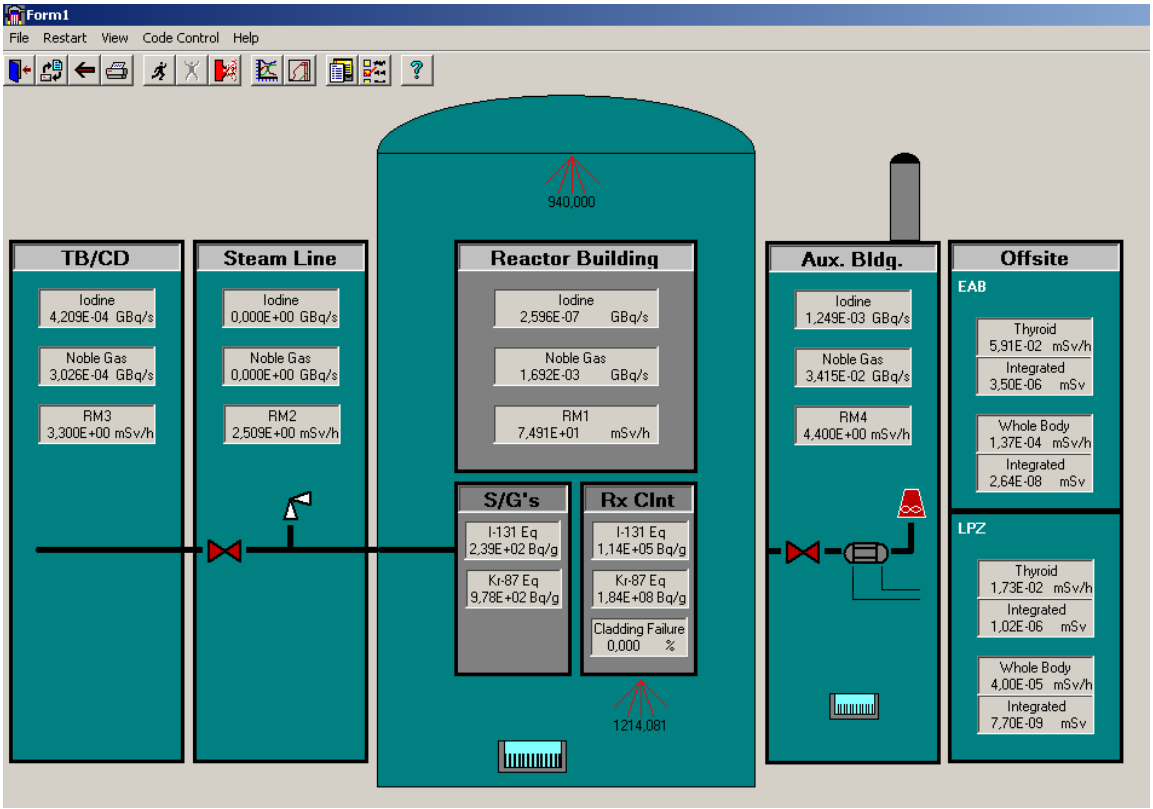
Figure 3. Changes of the nuclear power plant working parameters during LOCA accident (this screen and screens below)

Analyze the screens below and describe the changes of the working parameters of the primary and secondary circles as well as nuclear reactor response.


PCTran Transient Plot
File Options
203,00
PCTran Transient Data
300
200
100
0
0 20 40 60 80 100 120 140 160 180 200
Time (sec)
Press RCS (kg/cm2)
Temperature RCS average (°C)
Void of RCS (%)
PCTran
2013-12-18 13:54:45


PCTran Transient Plot
File Options
203,00
PCTran Transient Data
800
700
600
500
400
300
200
100
0
0 20 40 60 80 100 120 140 160 180 200
Time (sec)
Flow HPI (t/hr)
Flow RCS leak (t/hr)
Volume RCS liquid (M3)
PCTran
2013-12-18 13:56:42


PCTran Transient Plot
File Options
505,00
PCTran Transient Data
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
100
200
300
400
500
Time (sec)
Reactivity Fuel (Doppler) (%dk/k)
Reactivity Mod temperature (%dk/k)
Reactivity Rod (%dk/k)
Reactivity Soluble boron (%dk/k)
PCTran
2013-12-18 13:34:39


Form1
File Restart View Code Control Help
940,000
TB/CD
Iodine 4,209E-04 GBq/s
Noble Gas 3,026E-04 GBq/s
RM3 3,300E+00 mSv/h
Steam Line
Iodine 0,000E+00 GBq/s
Noble Gas 0,000E+00 GBq/s
RM2 2,509E+00 mSv/h
Reactor Building
Iodine 2,596E-07 GBq/s
Noble Gas 1,692E-03 GBq/s
RM1 7,491E+01 mSv/h
S/G's
I-131 Eq 2,39E+02 Bq/g
Kr-87 Eq 9,78E+02 Bq/g
Rx Clnt
I-131 Eq 1,14E+05 Bq/g
Kr-87 Eq 1,84E+08 Bq/g
Cladding Failure 0,000 %
1214,081
Aux. Bldg.
Iodine 1,249E-03 GBq/s
Noble Gas 3,415E-02 GBq/s
RM4 4,400E+00 mSv/h
Offsite
EAB
Thyroid 5,91E-02 mSv/h
Integrated 3,50E-06 mSv
Whole Body 1,37E-04 mSv/h
Integrated 2,64E-08 mSv
LPZ
Thyroid 1,73E-02 mSv/h
Integrated 1,02E-06 mSv
Whole Body 4,00E-05 mSv/h
Integrated 7,70E-09 mSv