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Application of the Performance Validation Tool for the Evaluation of NSSS Control System Performance

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Pre-Op Dynamic Test



● Composition

● SBCS

- SG Press. Control
- TBV

● FWCS

- SG Level Control
- DFVCV, EFVCV, MFWP Speed

● RPCS

- Rapid Rx Power Reduction
- CEA Group 5 or 4+5, TCV

● RRS

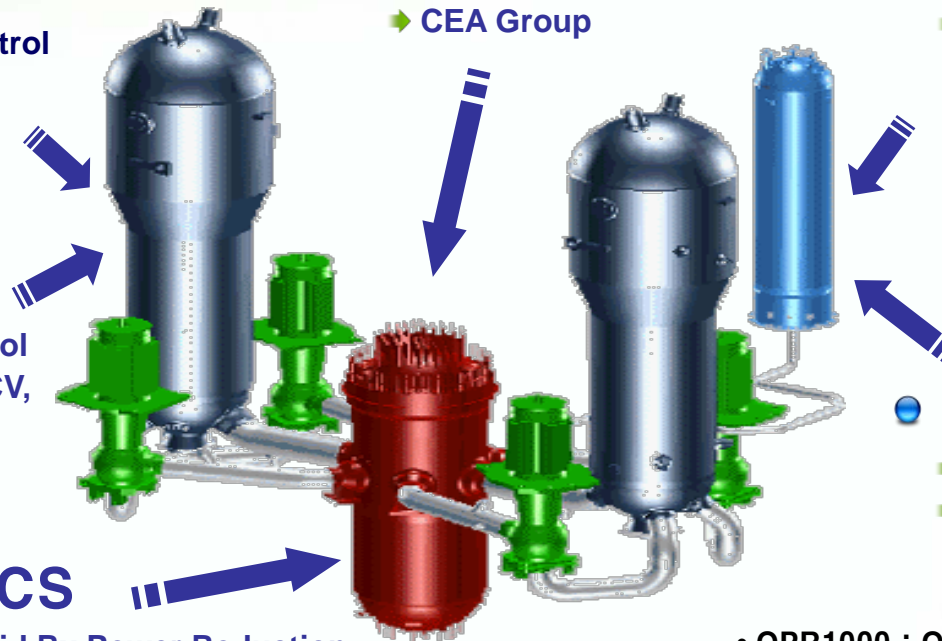
- T_{AVG} Control
- CEA Group

● PPCS

- PZR Press. Control
- Spray Valve, Heaters

● PLCS

- PZR Level Control
- Charging Valve, Letdown Isolation Valve



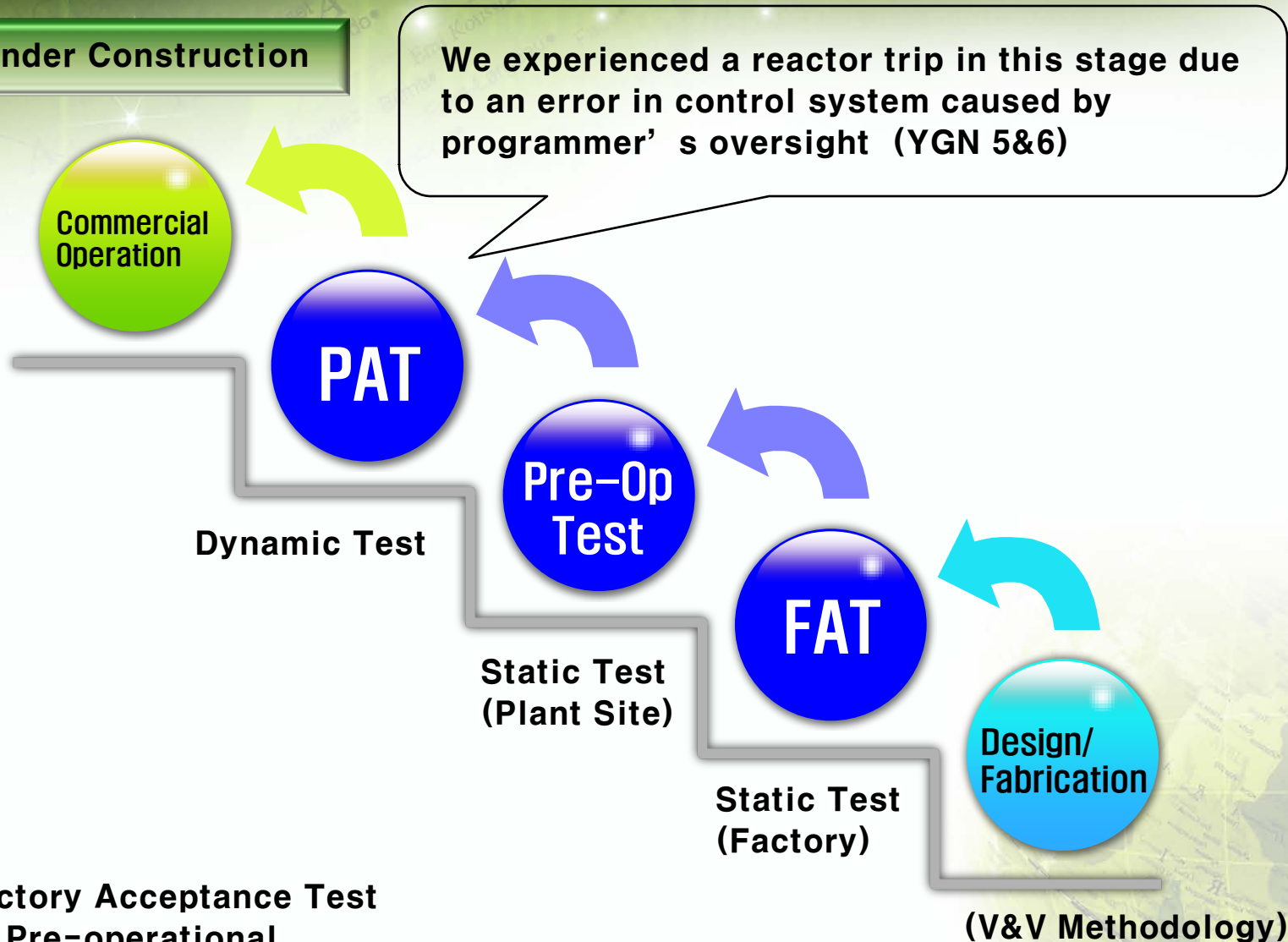
- OPR1000 : Optimized Power Reactor 1000MW
- NSSS : Nuclear Steam Supply System
- SBCS : Steam Bypass Control System
- FWCS : Feedwater Control System
- RRS : Reactor Regulating System
- PPCS : Preaurizer Pressure Control System
- PLCS : Pressurizer Level Control System

● Dormant error can cause the reactor trip.

● Experience : YGN 5&6 Startup Period (Changed Hardware)

Tests during Startup

NPPs under Construction



- FAT : Factory Acceptance Test
- Pre-op : Pre-operational
- PAT : Power Ascension Test

(V&V Methodology)

Tests (Hardware Replacement)

Operating NPPs

Commercial Operation

Pre-op Dynamic Test

Skip Power Ascension Test

- Potential Risk of Real Plant Testing
- Economical Loss : Reduction of Electricity Production

Pre-Op Test

Dynamic Test

Static Test (Plant Site)

FAT

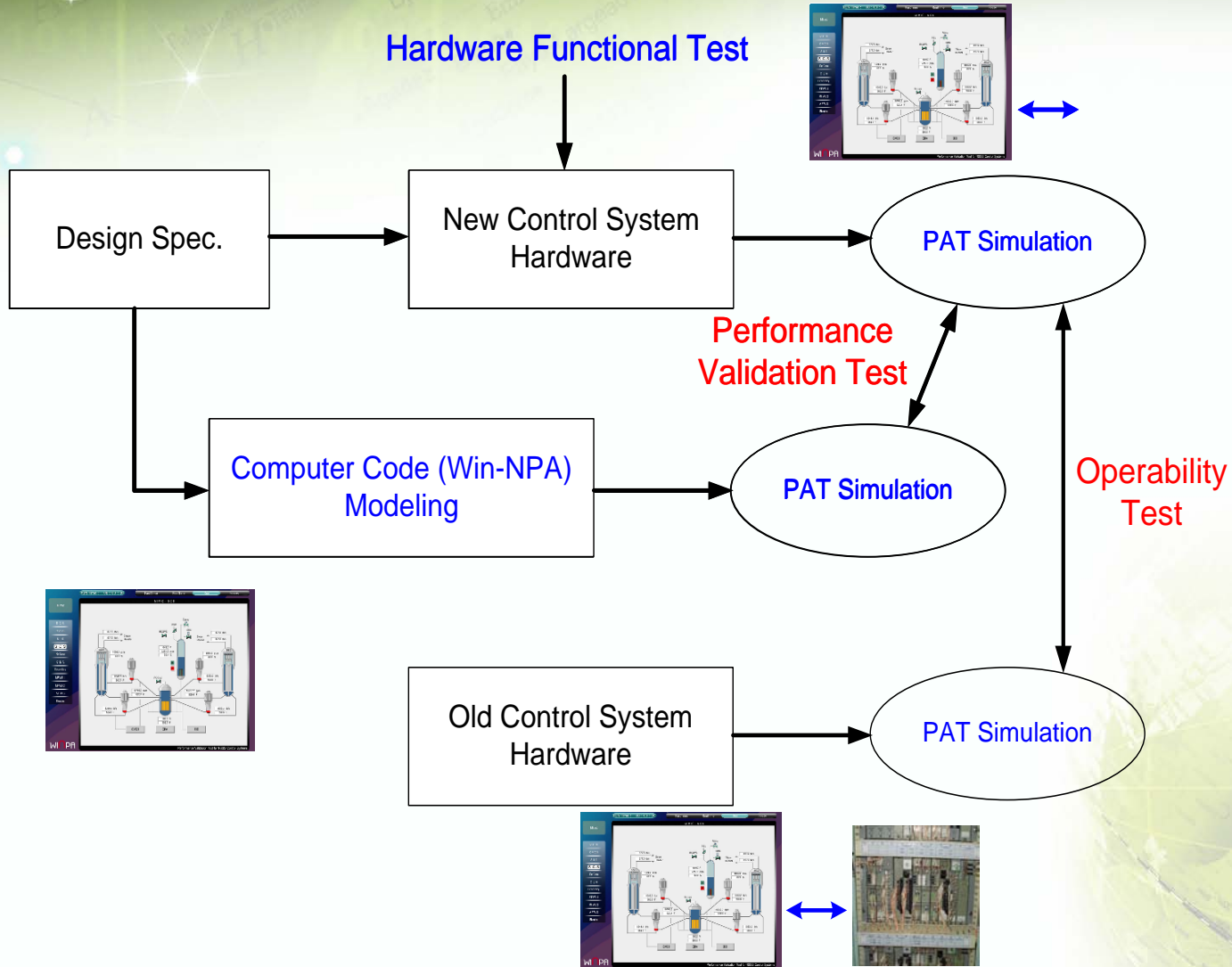
Static Test (Factory)

Design/
Fabrication

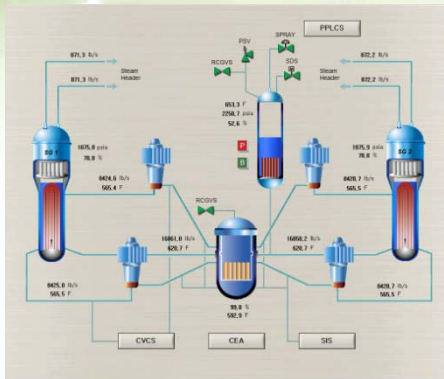
(V&V Methodology)

- FAT : Factory Acceptance Test
- Pre-op : Pre-operational
- PAT : Power Ascension Test

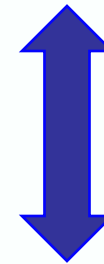
Synopsis of Pre-op Dynamic Test



Performance Validation Test

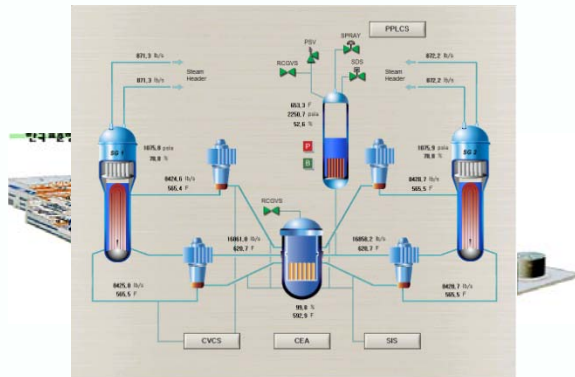


Computer Code Modeling of Control System according to Design Spec.



Compare the results

After bypass its own control system, it connect with replaced H/W



(Control System)

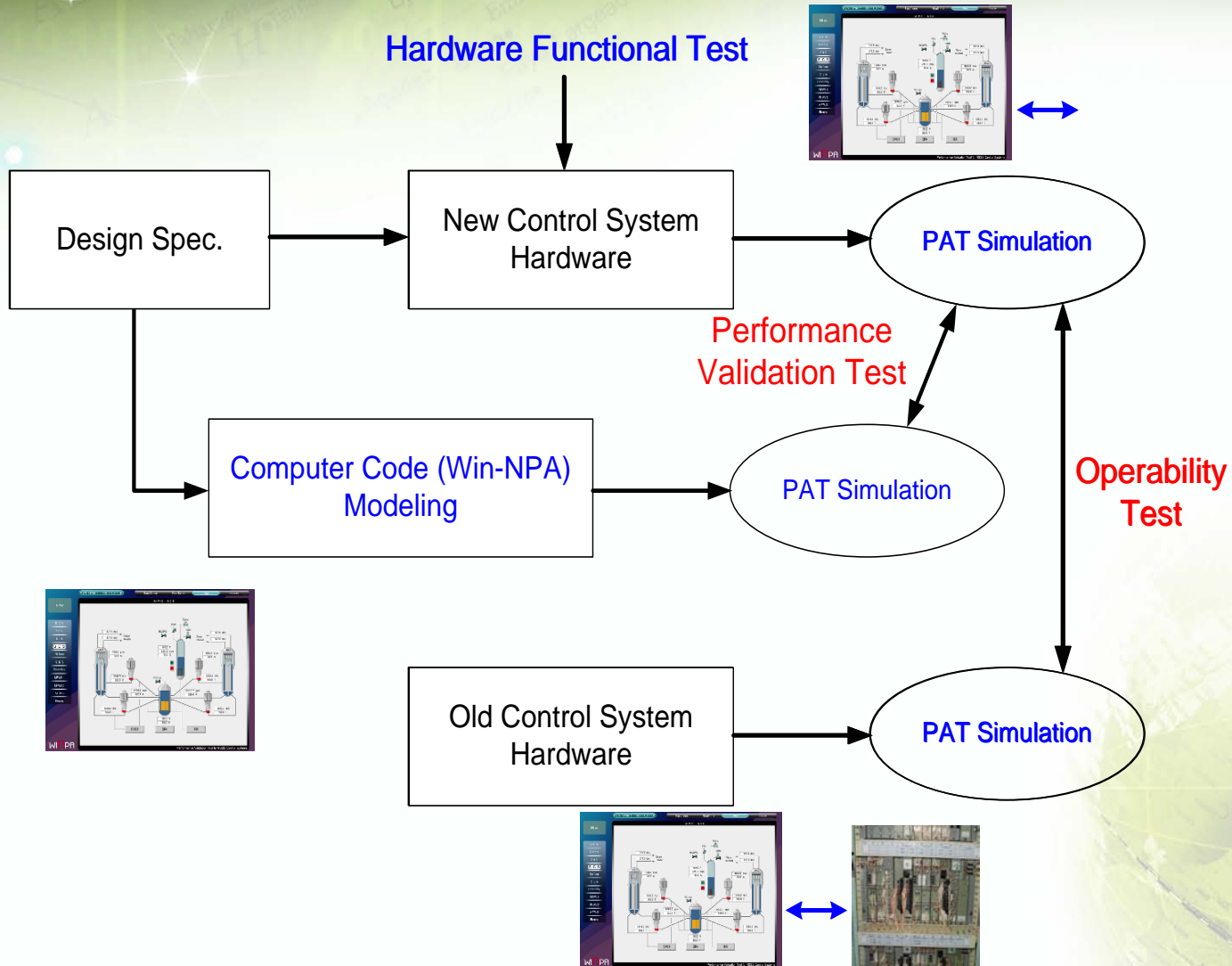
Sensor Signal



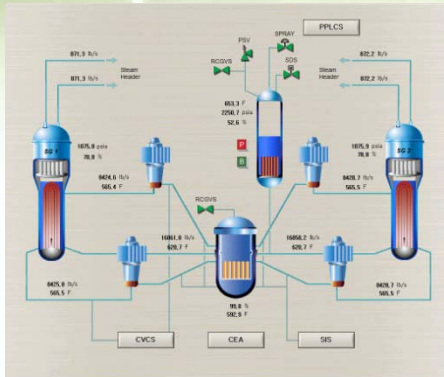
Component Control Signal



Synopsis of Pre-op Dynamic Test



Operability Test

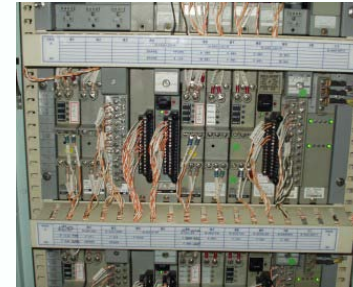


Sensor
Signal

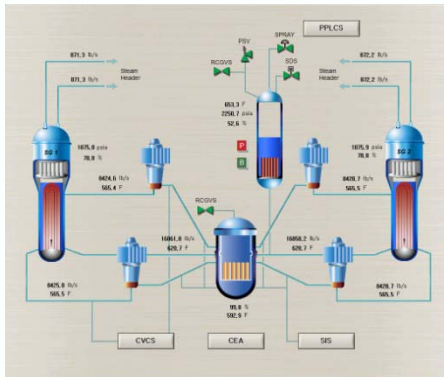


Component
Control
Signal

(Control System)



Compare the results



Sensor
Signal

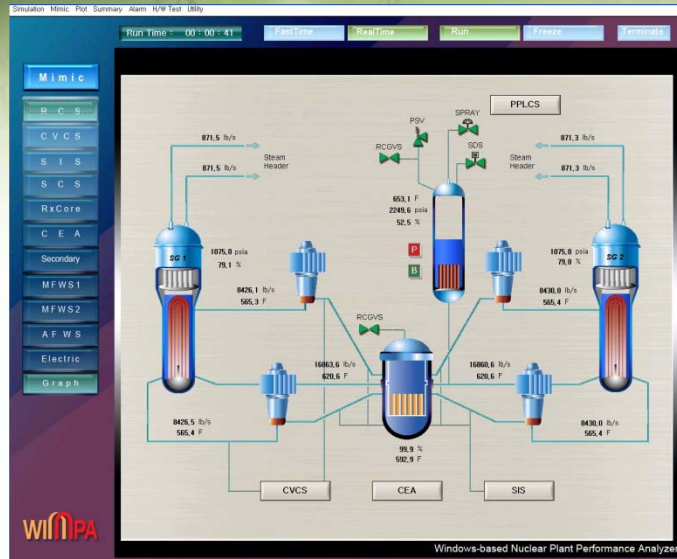


Component
Control
Signal

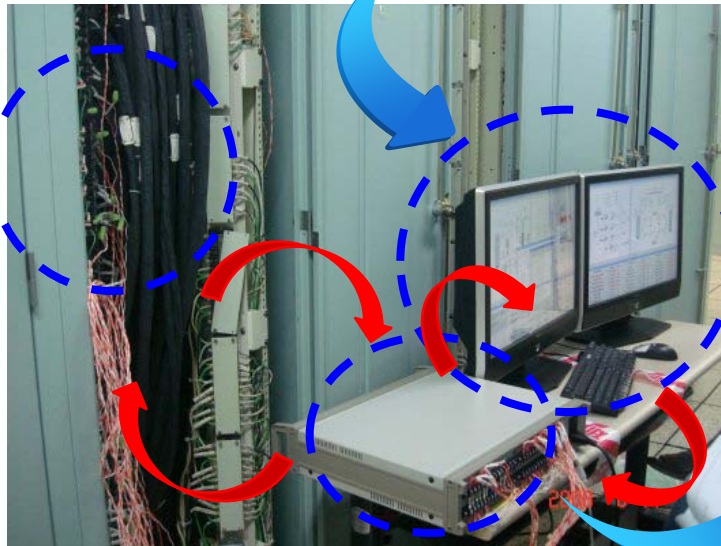
(Control System)



Configuration of Test Equipment



Signal Interface Module



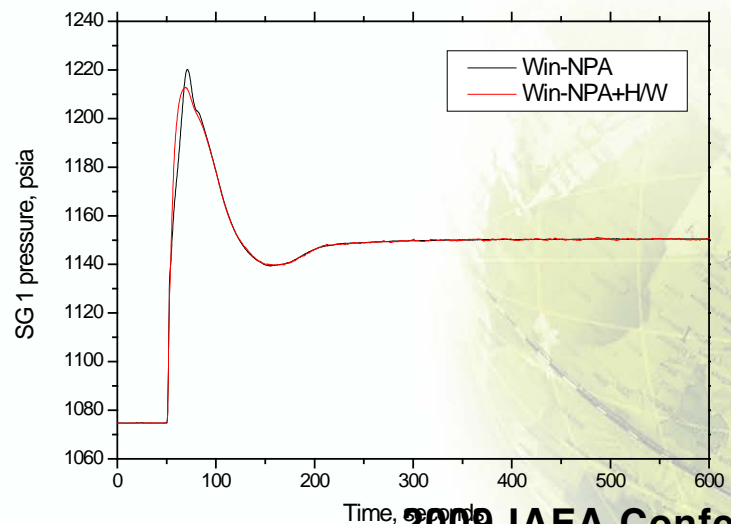
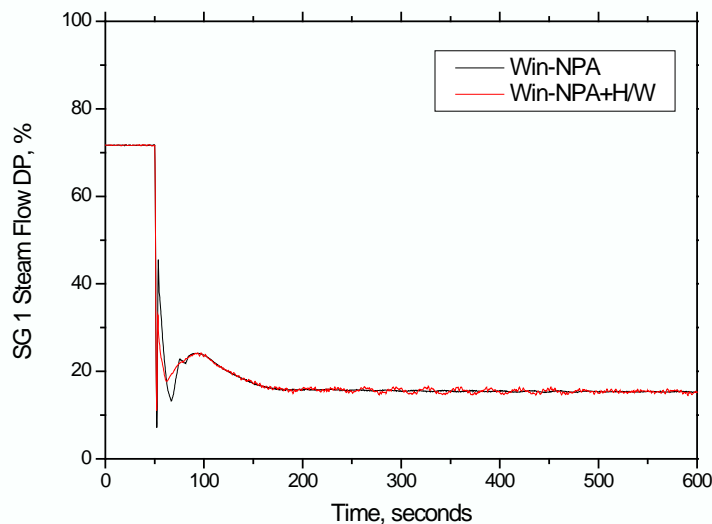
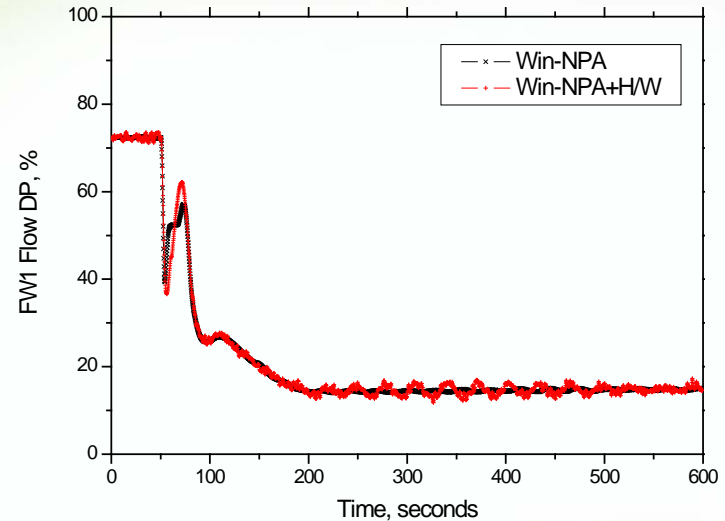
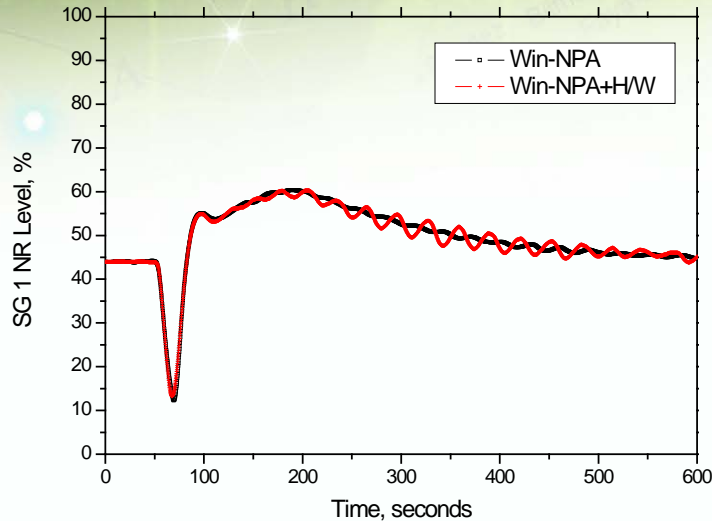


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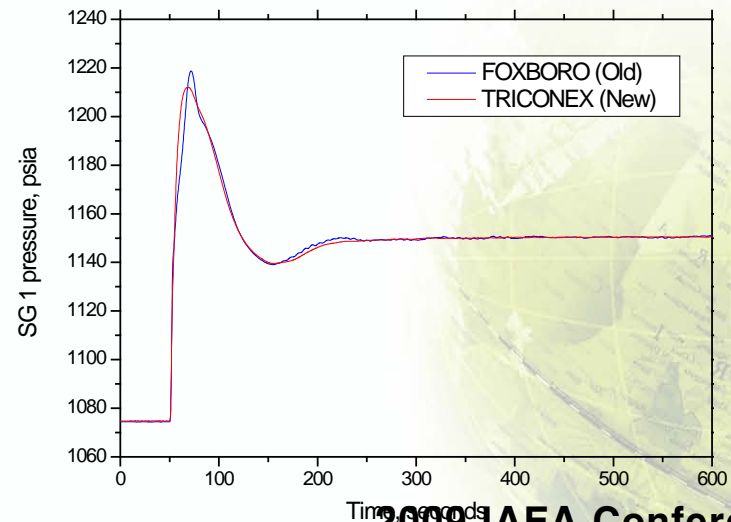
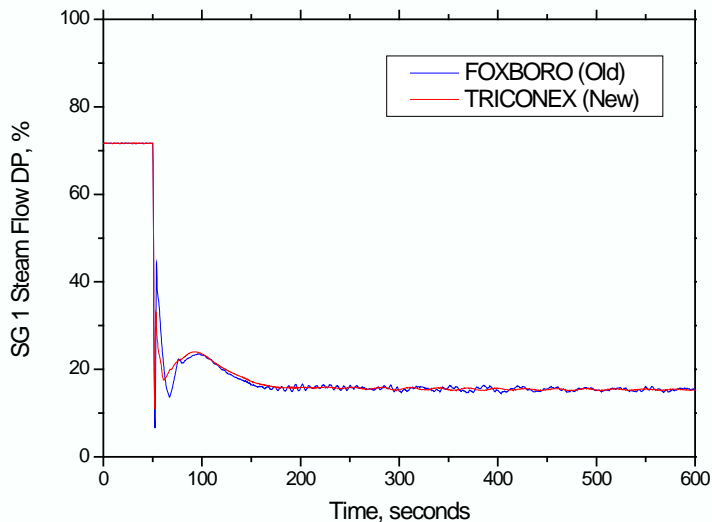
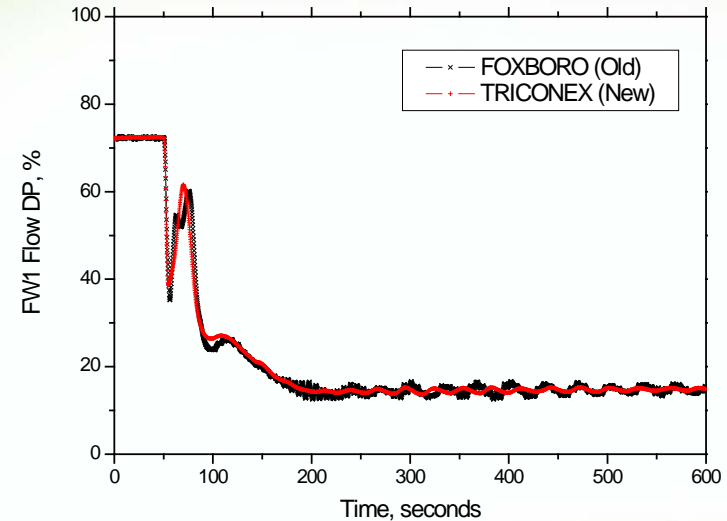
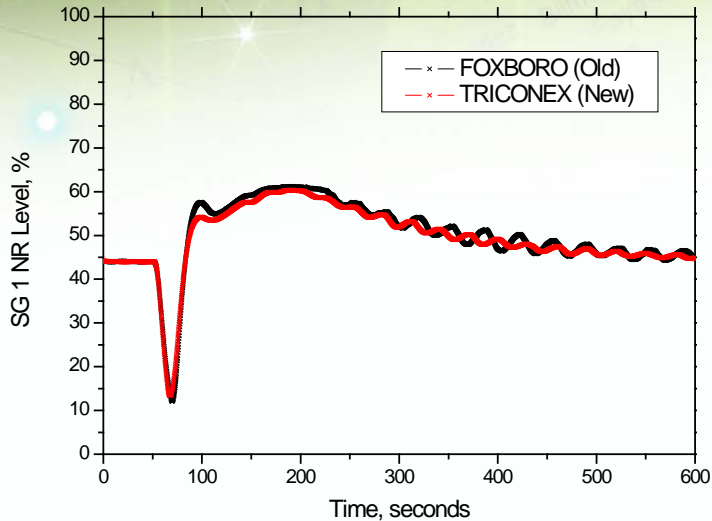
Test Results

- **Load Rejection to House Load**
- **Loss of a Main Feedwater Pump**
- **Reactor Trip**
- **Turbine Power 10% Step Decrease (100 to 90%)**
- **Turbine Power 5%/min Ramp Decrease (100 to 30%)**
- **Valve Transfer (Increasing Direction, 20%)**
- **Valve Transfer (Decreasing Direction, 18%)**

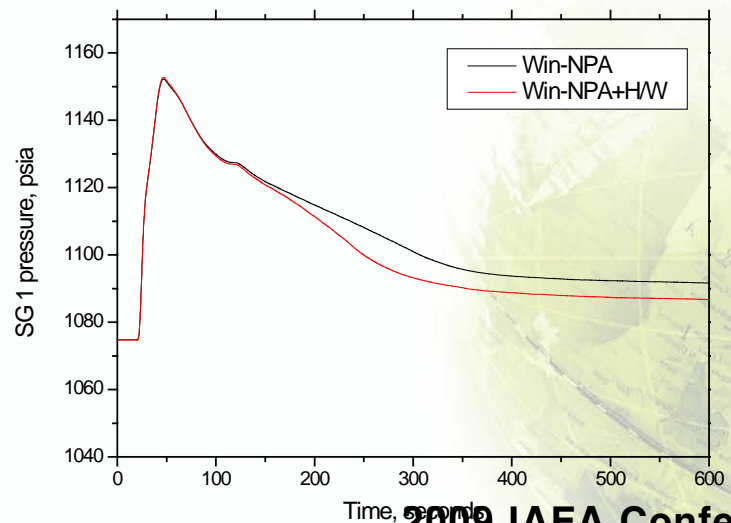
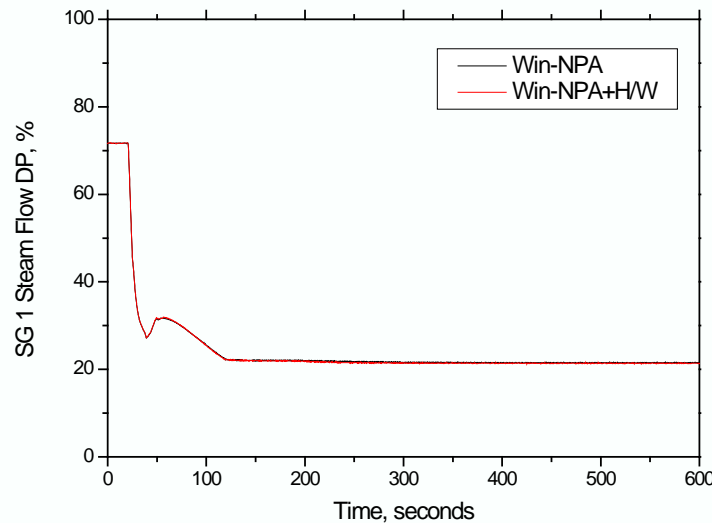
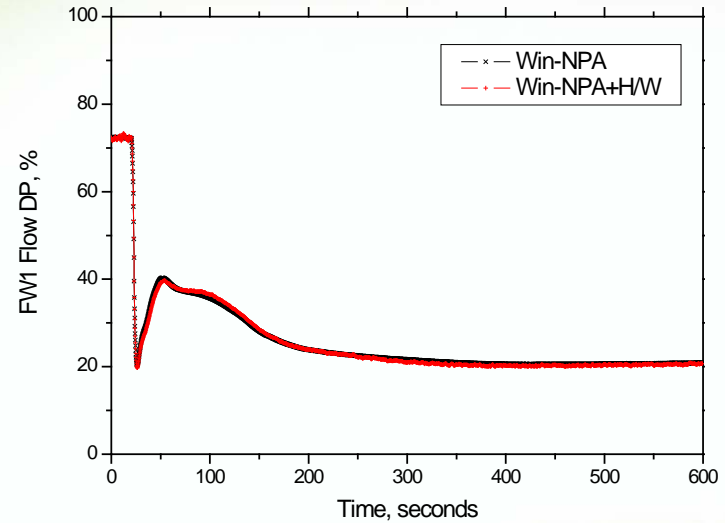
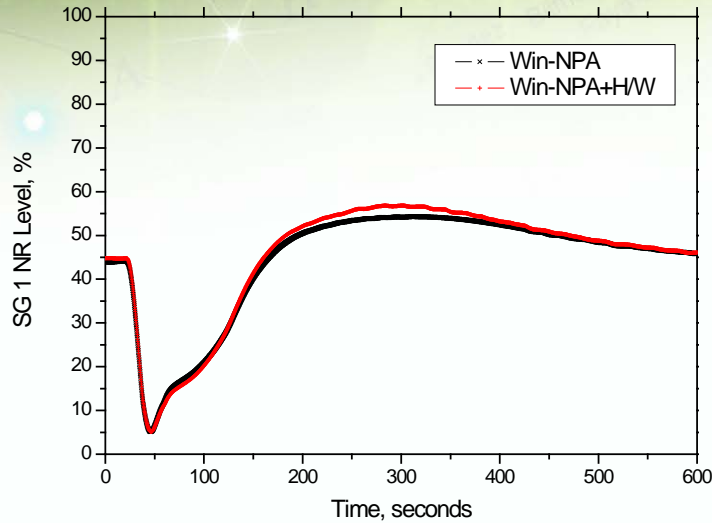
● Load Rejection to House Load (Performance Validation Test)



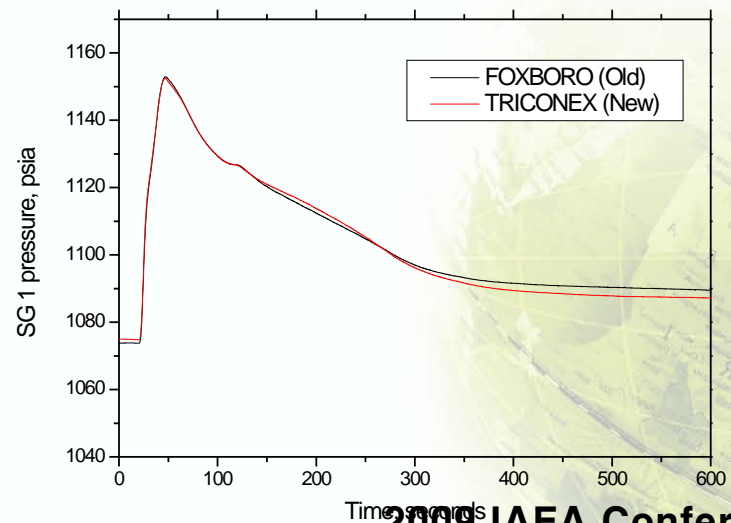
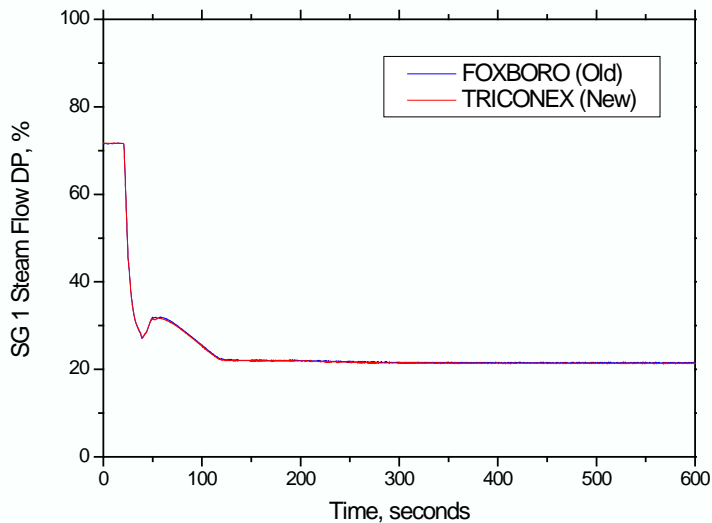
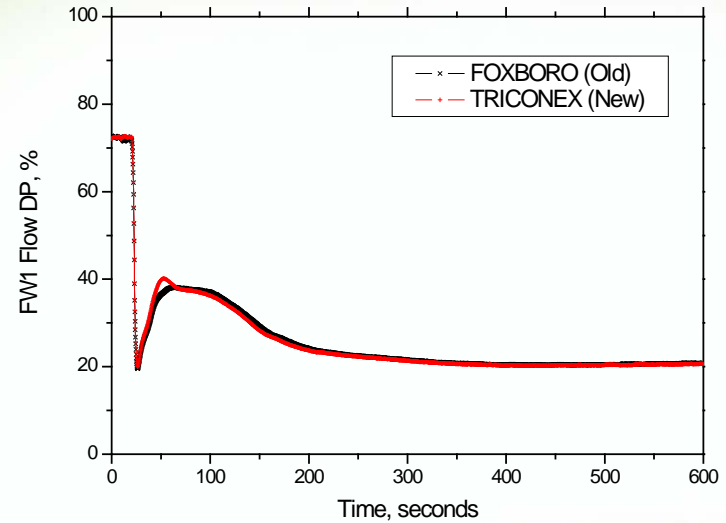
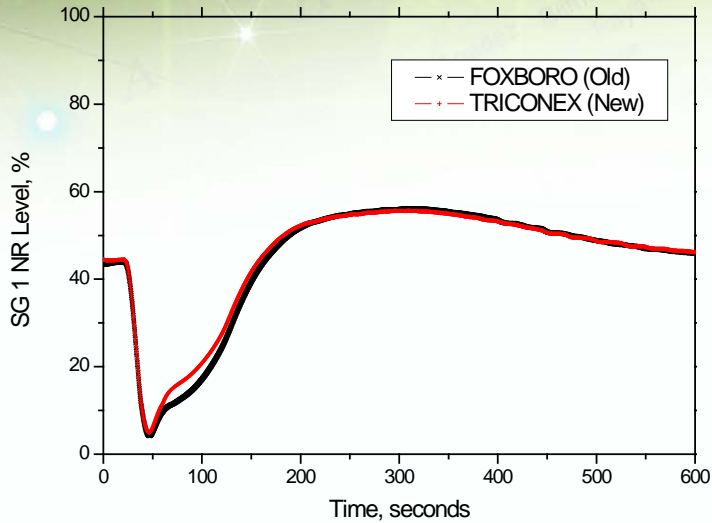
● Load Rejection to House Load (Operability Test)



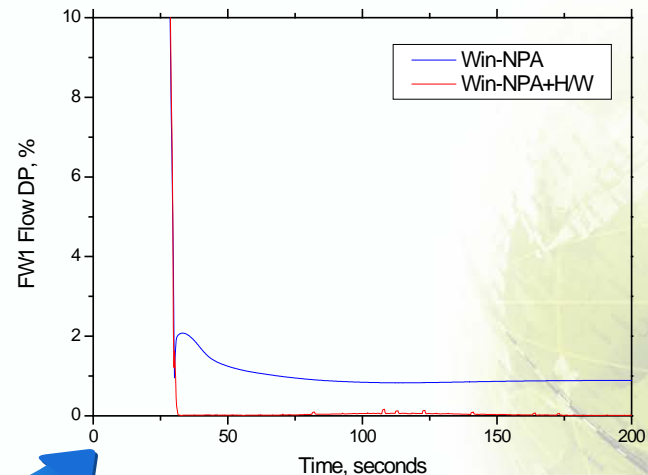
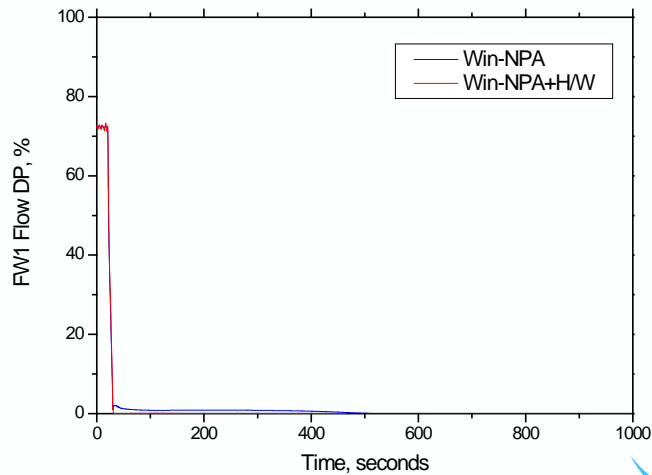
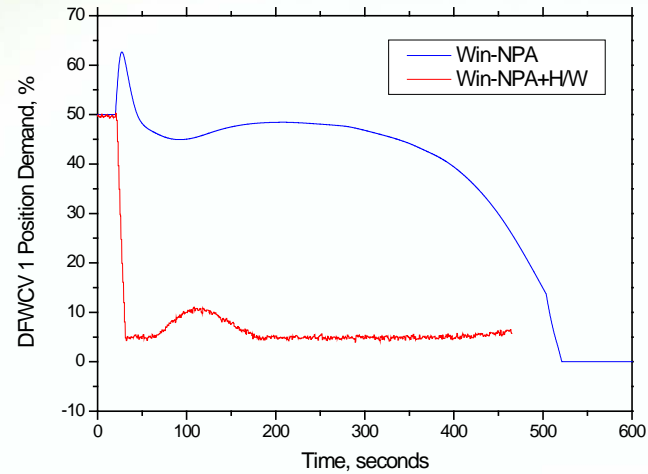
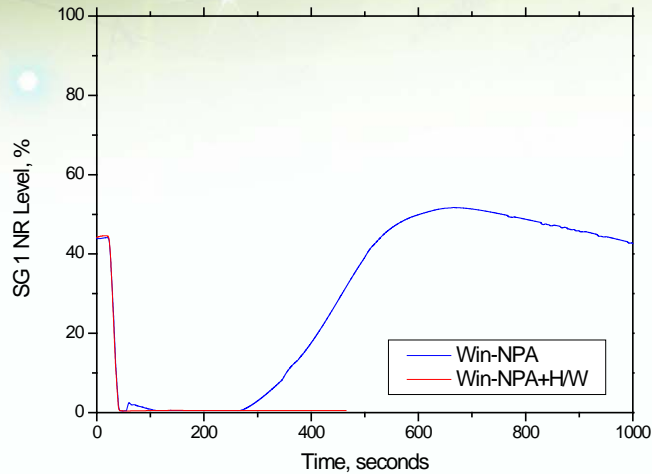
Loss of a Main Feedwater Pump (Performance Validation Test)



Loss of a Main Feedwater Pump (Operability Test)

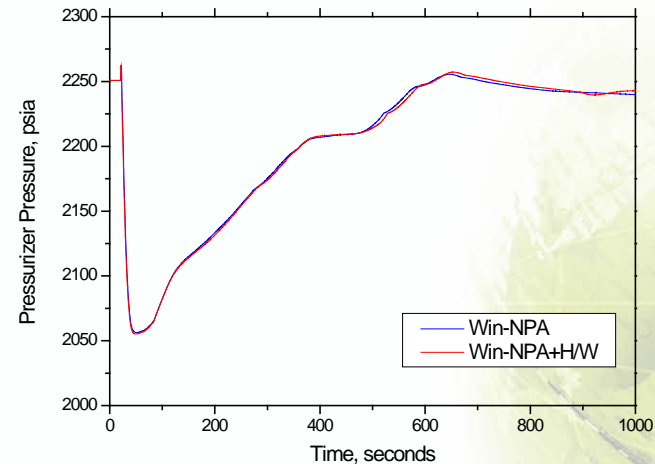
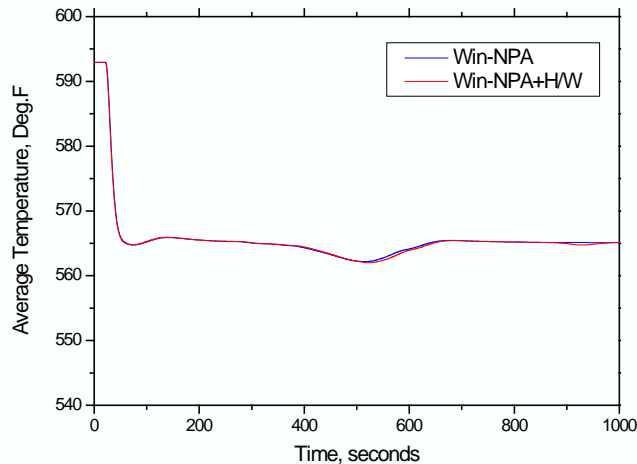
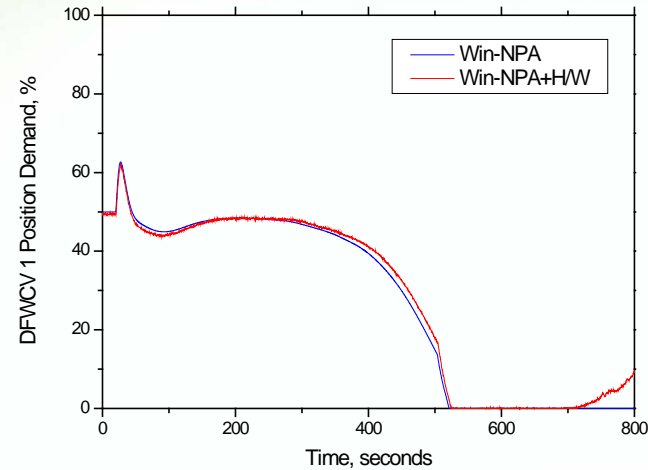
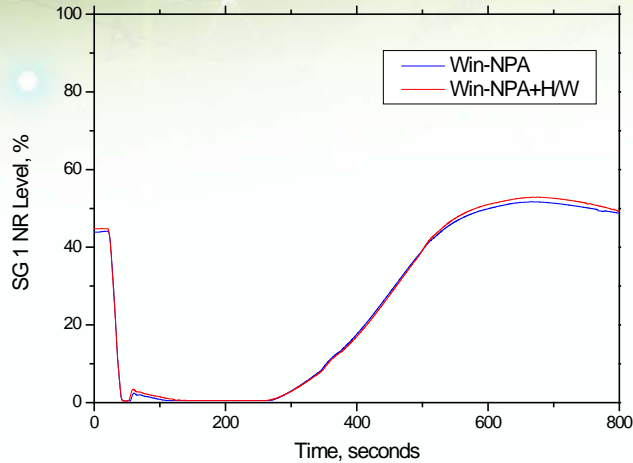


Reactor Trip (Fail Case) : PI Controller Option Related Error




Enlargement

Reactor Trip (Success Case)

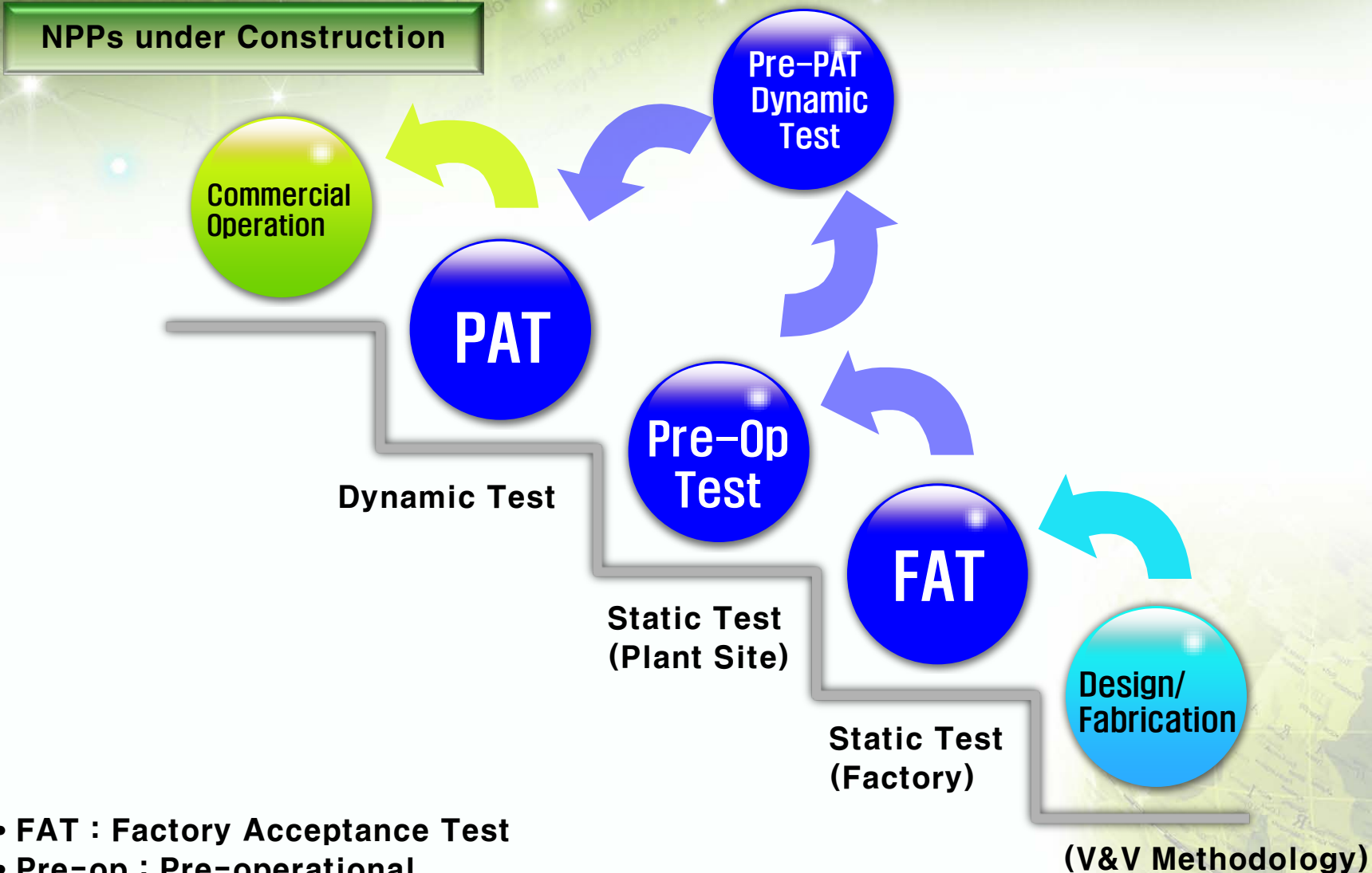




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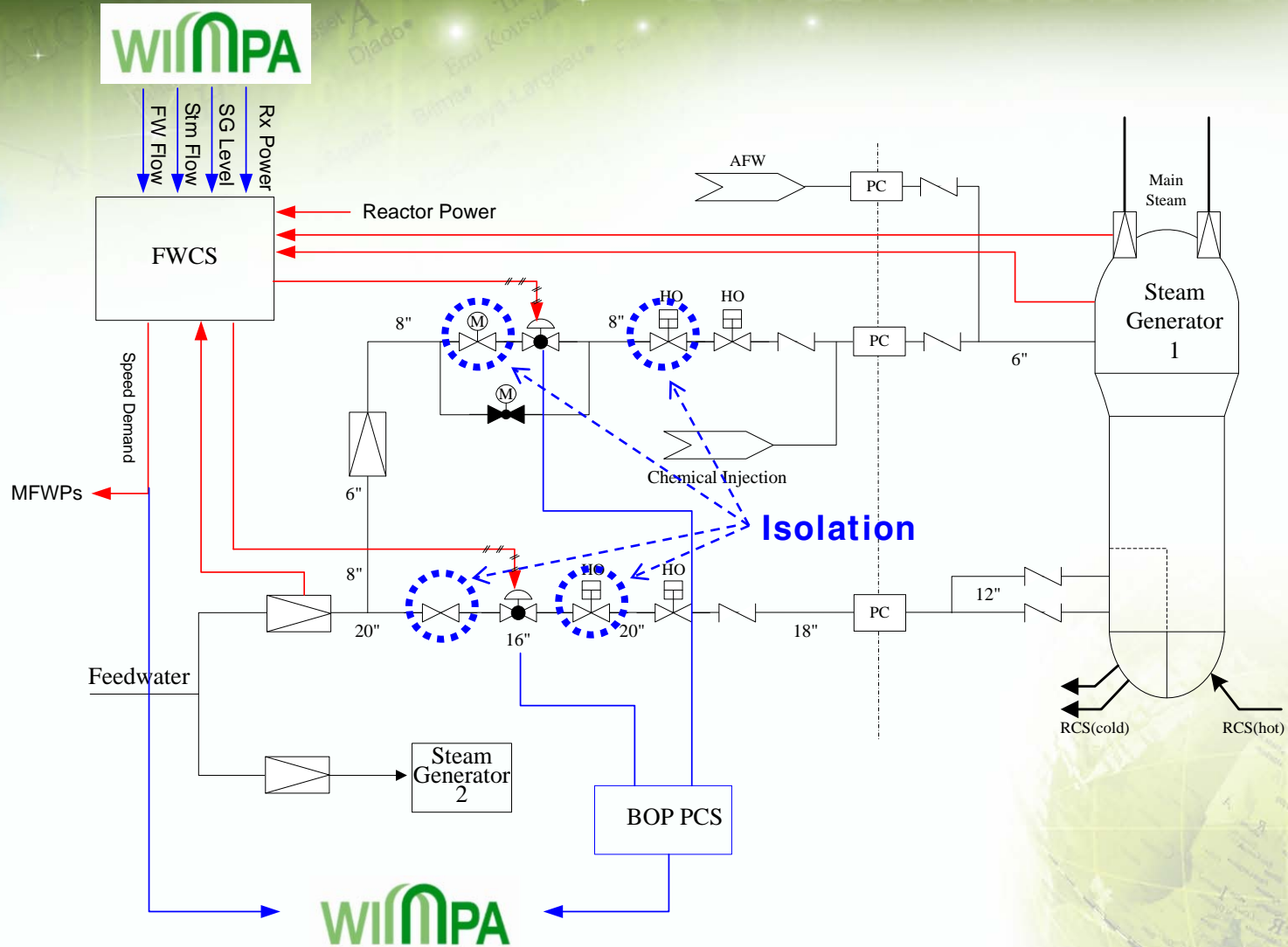
Pre-PAT Dynamic Test

Suggest of Pre-PAT Dynamic Test



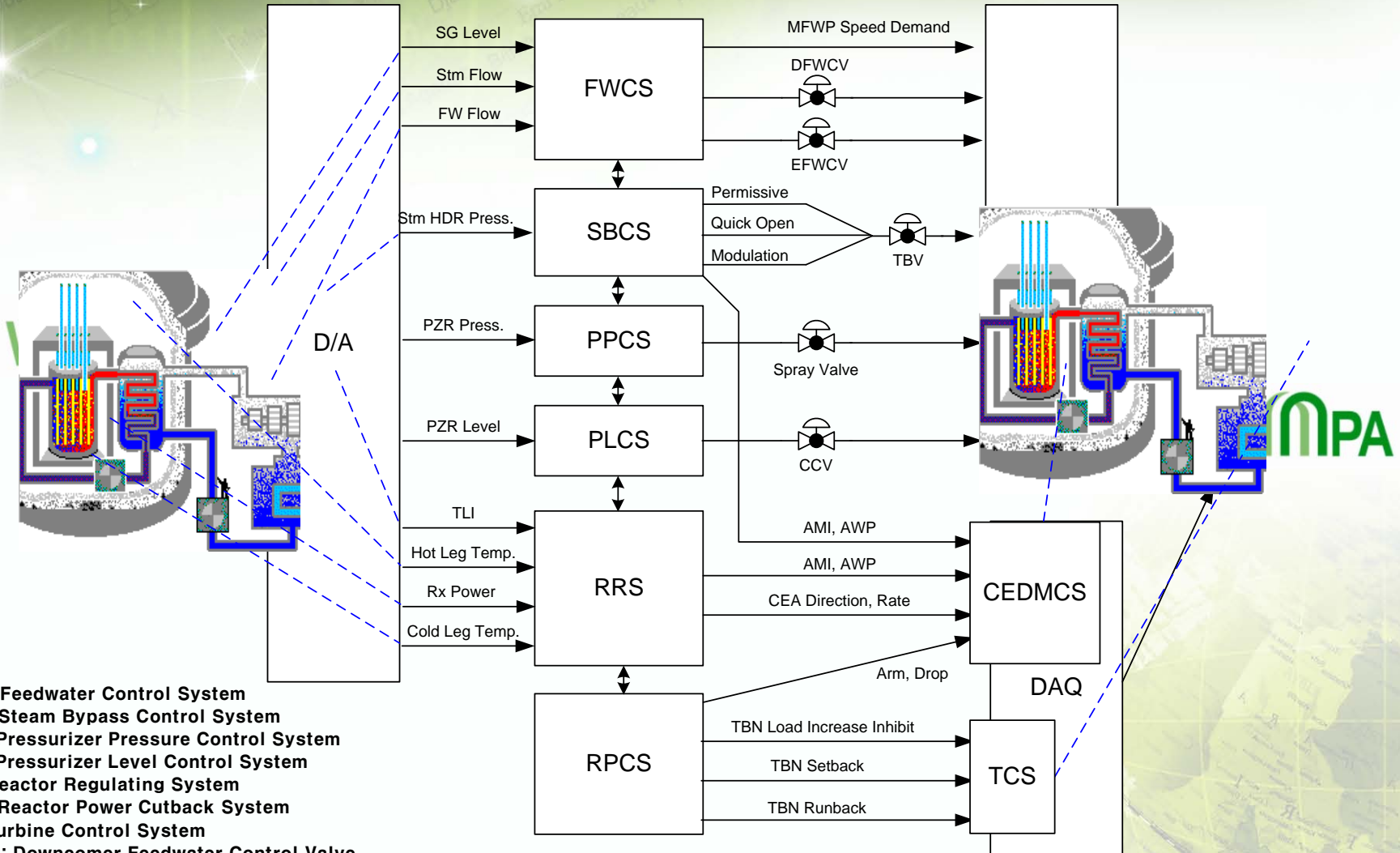
- FAT : Factory Acceptance Test
- Pre-op : Pre-operational
- PAT : Power Ascension Test

Individual Test including Component



- BOP : Balance of Plant
- PCS : Plant Computer System
- FWCS : Feedwater Control System

Integrated Test



- FWCS : Feedwater Control System
- SBSCS : Steam Bypass Control System
- PPCS : Pressurizer Pressure Control System
- PLCS : Pressurizer Level Control System
- RRS : Reactor Regulating System
- RPCS : Reactor Power Cutback System
- TCS : Turbine Control System
- DFWCV : Downcomer Feedwater Control Valve
- EFWCV : Economizer Feedwater Control Valve
- TBV : Turbine Bypass Valve
- AMI : Automatic Motion Inhibit
- AWP : Automatic Withdrawal Prohibit



4

Conclusion

- We develop the new tool to validate the performance of control and monitoring system.
- The tool showed a greater performance than expected. (We found the lots of error during YGN 3&4 Project)
- We try to expand the scope of tool to the NPPs under construction. (Pre-PAT Dynamic Test)
- We changed the name of our engineering simulator from win-NPA to N-Fast.



