Simulator ‘Auto’ tools

Problem:

- Each fuel cycle requires re-snapping of all IC’s in BOTH units.
- We have 4 core stages of ICs from 100% power to RHR.
- Considerable man hours of simulator and instructor time.
- Constant battle as the ICs always seemed to be wrong. Switches missed/parameters out of control band, decay heat, metal temperatures etc.
- Need to create new ICs for plant data comparisons

Simulator ‘Auto’ tools

Goals:

- Create mechanism for automatic creation of ICs for all core stages.
- Provide flexibility of simulator configuration to the instructor.
  - Power levels, load/unload rates, RCS temperatures/pressures, system alignments, xenon/decay heat etc.

Simulator ‘Auto’ tools

- Solution at first seemed simple, just create Automated Plant Procedure files (APP files) from the instructor station to perform the actions. You could even simply use the instructor station to ‘record’ the control actions to create them.

- but…..
  - Timing of events. Simply recording the actions of the operator/ instructor would work for specific set of conditions, but is very limited. (SG levels in manual, lake temperatures, core stages etc)
  - Very difficult to provide any real flexibility to the instructor or simulator staff

Simulator ‘Auto’ tools

Solution:

- Use the APP files, but create an instructor interface to create them in text format.
- Also create numerous ‘controllers’ used by the system to accommodate for different system conditions.
- Always for the program to run in ‘real time’ which solves problems with core burnup, decay heat, metal temperatures etc.
- Create the mechanism for running these file offline or online
  - Online was very helpful for creating the program
  - Offline is infinitely useful for performing the actual IC shoot as precious I/O time is not needed.

Simulator ‘Auto’ tools

Controllers created:

1. Auto Temperature
2. Auto AFD
3. Auto SJAE DP
4. Auto Main Feedwater (used at low power when normal SG level is unstable)
5. Auto Pressurizer Level (used to drive Pressurizer Level to desired value for shutdown ICs)
6. Auto Steam Dump Cooldown
7. Auto CCW temperature
8. Auto CCW flow
9. Auto RHR temperature
10. Auto RHR flow

Simulator ‘Auto’ tools

Additional items:

1. Flag to turn I/O on/off
2. Flag to turn off all auto controllers on IC reset

Microsoft Excel - AutoSim

Auto IC Form

Unit	1
Target Load; MWE (zero uses shutdown targets)	0
Shutdown Only	
Target Pressure (psig)	215
Target Temperature (deg F)	158
Target Pressurizer Level (%)	70
Boron Concentration (ppm; set at target temp and press)	2200

IC List			
Power Level 1	80		431
Power Level 2	60		432
Power Level 3	50		433
Power Level 4	20		434
Start of cooldown			435
450 degrees			436
Ready to place RHR in service			437
RHR in service			438
At target temperature and pressure			439

Write SFC File

Set to Defaults

Options

Load Ramp Rate (mw/min)	10	
MSR removal (% power)	90	
FP removal (% power; note: procedure limit < 55%)	55	note: puts FP in standby readiness (3000 rpm)
FP to be removed from service (East/West)	East	note: takes 60 minutes to complete
Time at Target Temp/Press or Power; Hours	0.1	Xe, Sm, decay heat, metal temps etc
Shutdown Only		
RHR Train to be placed in service (east/west)	East	
CCW Train for RHR cooling (east/west)	East	
MSIV Closure Temperature (deg f)	190	Also stops Aux Feedwater

Automatic Functions (non-selectable values)

Heater Drain pumps will be removed at 45% power

Transfer to reserve feed and AMSAC disabled at 30% power

Reactor Trip occurs at 17% power

RCS cooldown started 10 minutes after trip with AFW controlled, Steam dump set to cooldown at approximately 60 degrees per hour.

RCS spray valves opened to control pressure within pressure/temperature limits

RHR placed in service at 350 degrees and 400 psi (cooldown stopped while RHR placed in service)

Additional 45 gpm orifice placed in service is letdown flow drops below 40 gpm

LTOP placed in service at 1000 psi in RCS (Accumulators isolated, SI pps and RHR spray)

Microsoft Excel - AutoSim

Auto IC Form

Unit	1
Target Load; MWE	1200
Critical Rod Height	135
IC snapped ready for Rx Startup (trip breakers open, mg sets off)	301
IC snapped with SD banks pulled, ready to pull control banks	302
IC snapped at 1e-8 amps	303
IC snapped at 4 percent power ready to start MFP	304
IC snapped Ready to roll main turbine	305
IC snapped ready to synchronize main generator	306
IC snapped at 28% power (below P-8)	307
IC snapped at 48% power, ready to start second FP	308
IC snapped at 48% power, both FP running	309
IC snapped 80%	310
IC snapped full power	311

Write SFC File

Options

Load Ramp Rate (mw/min)	4	4 mw/min is approx 5 hours
MSR in service (% power)	60	
First FP to be placed in service (East/West)	East	
Time at Target Temp/Press or Power; Hours	1	Xe, Sm, decay heat, metal temps etc

Automatic Functions (non-selectable values)

Any core stage IC may be used, but simulator must start in an IC with temperature being controlled by steam dump (approx. 547 degrees)

1e-8 amp IC will be snapped with power stabilized and rods at critical rod height

If target load is left at zero, the final power will be 4% ready to roll main turbine with control rods at 165 steps

SG level in auto, transfer from reserve feed, heater drains aligned, and AMSAC enabled at 20% power

Second feedpump will be placed in service at 48% power

HDPs will be placed in service at 80% power

Shutdown | Startup | Sheet1

Simulator ‘Auto’ tools

- Result…success!
  1. Last core cycle (just about a month ago).
  2. Ran program on 4 different machines overnight and created all of the ICs needed to RHR for 2 core stages on each unit.
  3. Just repeated for other core stages and the startup ICs.
  4. Created the ICs for the steady state test needed from the new startup data.

Simulator ‘Auto’ tools

- Takeaways.
  - Start at the beginning figuring out the auto controllers you will need.
  - Put them in a new, separate module and create extra controllers (because you will forget something)
  - Create the I/O flag so the development work can be done on the I/O (remember you cannot use any overrides).
  - Get a picky instructor to help you fine tune the end product.

Questions???

Trending Simulator Variables

Problem:

- Never seem to have data on the points we needed.
- Collecting exam validation (NRC) data was cumbersome and not always complete for specific scenarios.
- Have you heard the phrase: “The simulator didn’t do that when we validated” or “last week when we ran it”
- “I wrote a DR on something I saw on the simulator” (of course no IC was snapped to troubleshoot)

Trending Simulator Variables

- Anyone else here have the instructor that “knows everything” but everything he/she knows is always wrong”
- Everything he/she writes become a science project for the software staff. Trying to reproduced the conditions and explaining system response.

Trending Simulator Variables

Just the facts please:

- So what really did happen?
- When did it happen?
- How did the system really respond?
- What is different this time?

Trending Simulator Variables

- Solution: Use a data historian service to collect historical data on ALL the simulator variables ALL the time.
- Keep the history for a year.
- Build in the tool to store exam validation data on a secure server, and simply switch the IP configuration when not in “Exam” mode.

Trending Simulator Variables

- Data: We collect on the simulator 21,000 data points 4x / Sec. using InStep historian software.
- Data is easy to retrieve and easy to view.
- Data compression is excellent. 1 month of simulator data typically occupies 2GB of hard drive space.
- Exam data is simply routed to a secure server vs. our normal ‘training’ history server.

Trending Simulator Variables

- Results. Much less time spent trying to reproduce conditions as you can now go back into history and view them.
- Instructors are becoming more and more savvy at using the software and researching information BEFORE they write the DR.
- NRC exam history is now painless as all switch manipulations, alarms, and all simulator variables are recorded and trended.

Questions???