Data Systems & Solutions A Joint Venture of SAIC and Rolls-Royce plc.

NPP Licensed Operator Training

Full-Scope Simulators Running Real-time RELAP5-R/T

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A joint venture between Rolls-Royce and SAIC

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Subject Area

DS&S RELAP5-R/T NPP Simulator Upgrades

- All upgrades must be ANSI/ANS-3.5 compliance
- TXU Comanche Peak PWR NPP Upgrade of the RCS, S/G and all Feedwater Systems
- PSE&G Salem PWR Upgrade of the RCS & Core
- PSE&G Hope Creek BWR Upgrade of the RCS & Core
- APS Palo Verde PWR NPP Upgrade of the RCS and Core
- NAESCO Seabrook PWR RCS, S/G, Core
- Bohunice VVER 440 Upgrade of the RCS & Core



Operator Training with RELAP5-R/T Means Enhanced Confidence & Cost Savings

• *Confidence:* High fidelity simulation of plant response under all modes... "the simulator looks like the plant"

- Complex thermal-hydraulic and neutronic behavior are <u>predicted</u> by "first principle" phenomena models and conservation laws
- Complex NPP Phenomena: Superheating with quality < 1 (e.g., CET), counter-current flows, CCFL, non-condensable gas, condensation shocks, water hammer, loop levels, RHR vortex (air ingress), SG tube "coke bottle"
- Design-basis accidents (including LBLOCA w/ delayed ECCS)
- EOP evaluation with safety-grade engineering code
- DS&S RELAP5 Simulator Users Consortium will keep advancing the code for operator training



Operator Training with RELAP5-R/T Means Enhanced Confidence & Cost Savings

- Cost Savings: Realistic simulator response under all modes allows for training in "new" regimes
 - Realistic training for drain down to mid-loop and refill
 - CPSES has added "purge and vacuum" functionality
 - PVNGS has studied loss of cooling during mid-loop
 - Salem has improved S/G level response under SGTR (WOG interest)
 - EPRI studied degraded SG EOP procedures and briefed to NRC
 - Feedwater responds dynamically: CPSES used the <u>simulator</u> to design heater drain tank mods and eliminated LP heater bypass problem



DS&S Modifications to RELAP5-R/T for SIMULATOR USER CONSORTIUM

- Log-averaged (time) wall htcs
 Log-weighted 0.9 to last time value
- Rate-limited condensation heat transfer
 Applied when P< 10**6 Pa
- Frictional Choking Applied if Ma > 0.8
- Upper limits on heat transfer coefficient htc < 50.000 w/m**2/K
- JCHOKE limits

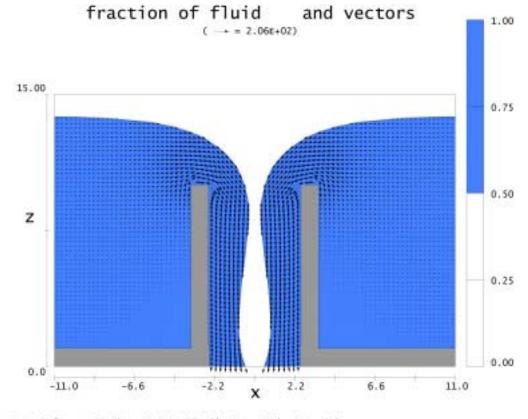
Convergence problems in subroutine

Subcooled boiling

Applied when P < 10**6 Pa no subcooled boiling



RHR Vortex In Cold Leg During Withdrawal



FLOW-3D * t=34.75 y=5.000E-01 (1x=2 to 45 kz=2 to 61) 12:25:18 8- 9-2000fhbk hydr3d: version 7.6 win32 1999 RHR Offtake with Air Ingress: DS&S demo for VEPCO



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