Oregon State University OSU College of Engineering
Department of Nuclear Engineering & Radiation Health Physics

Phenomena 13: Behavior of Emergency Heat Exchangers and Isolation Condensers

3nd Research Coordination Meeting of the IAEA
CRP on Natural Circulation Phenomena, Modeling and Reliability of Passive Systems that Utilize Natural Circulation

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CEA, Cadarache, France

Outline

- Some New Papers in 2006
- Impact of Thermal Stratification on PRHR Performance

A Few New Papers in 2006

Authors	Organization	Document Title
Antonio C.F. Guimaraes, Celso Marcelo Franklin Lapa	Instituto de Engenharia Nuclear (CNEN)-Divis˜ao de Reatores/Coordena¸c˜ao de Ensino, Ilha do Fund˜ao s/n, P.O. Box 68550, Rio de Janeiro 21945-970, Brazil	**Hazard and operability study using approximate reasoning in light-water reactors passive systems**, Nuclear Engineering and Design 236 (2006) 1256–1263 Guimaraes Paper 2006.pdf
Tauna Leonardi and Mamoru Ishii	School of Nuclear Engineering, Purdue University, West Lafayette, IN 47907, USA	**Condensation heat transfer with noncondensable gas for passive containment cooling of nuclear reactors**, Nuclear Engineering and Design 236 (2006) 1789–1799 Leonardi and Ishii 2006.pdf

A Few New Papers in 2006

Authors	Organization	Document Title
R.K. Sinha ∗, A. Kakodkar	Bhabha Atomic Research Centre, Trombay, Mumbai 400085, India	**Design and development of the AHWR—the Indian thorium fuelled innovative nuclear reactor,** Nuclear Engineering and Design 236 (2006) 683–700 Sinha and Kakodkar Paper 2006.pdf

- Other papers or reports we should be collecting?

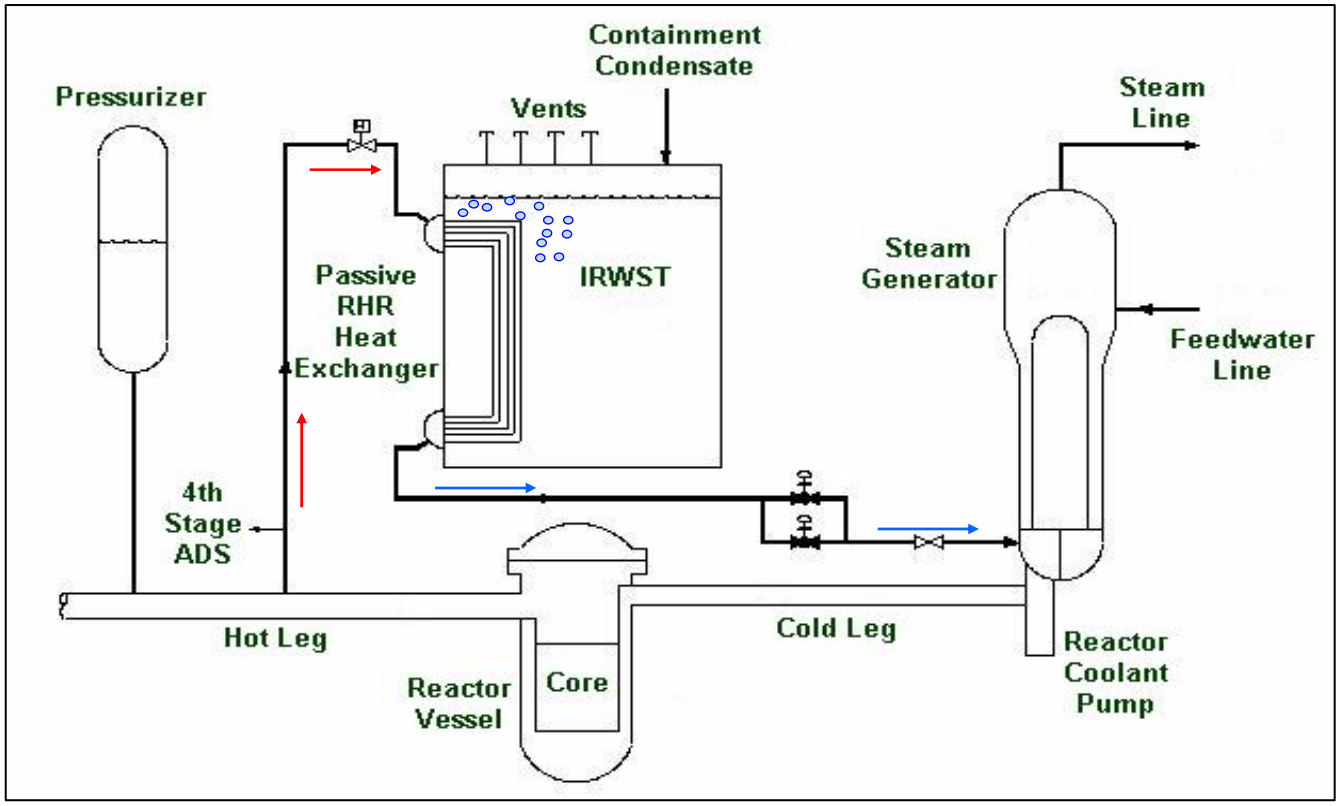
Impact of IRWT Thermal Stratification on PRHR Performance

- As part of the AP600 research, OSU conducted a series of tests for the NRC to assess the impact that thermal stratification in the IRWST has on PRHR heat exchanger performance.
- NRC-2 Station Blackout Test produced long term heat-up of the IRWST and significant thermal stratification. (NUREG/CR-6641)

Description of Station Blackout Test NRC-2

- NRC-2 simulated a a loss of all AC power to all reactor systems.
- Decay heat was removed by the Passive Residual Heat Removal System using the C-Type PRHR Heat Exchanger immersed in the IRWST.
  - 88 Stainless Steel Tubes
- The test duration was ~24,000 seconds.

Passive Residual Heat Removal (PRHR) System (Description of Flow Path)

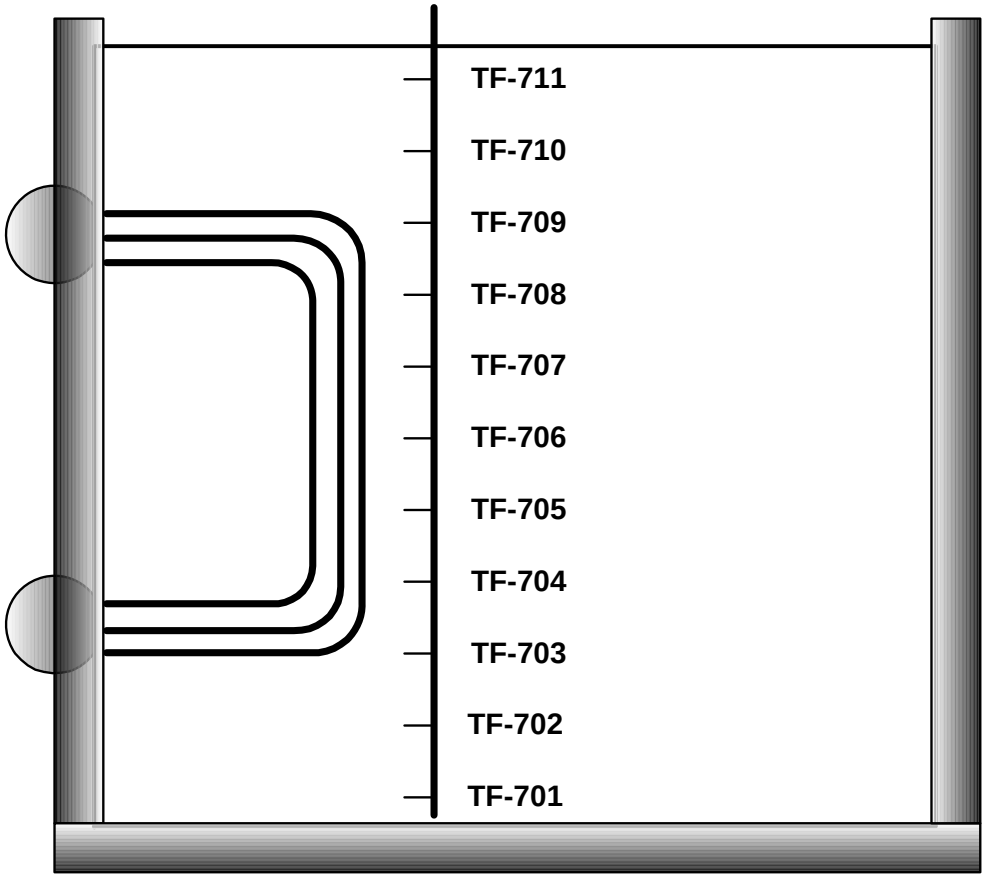


- Actuates on Low PZR Pressure or Level
- Station Blackout

IRWST

PRHR Heat Exchanger

Fluid Temperature Measurements in IRWST and PRHR Tubes



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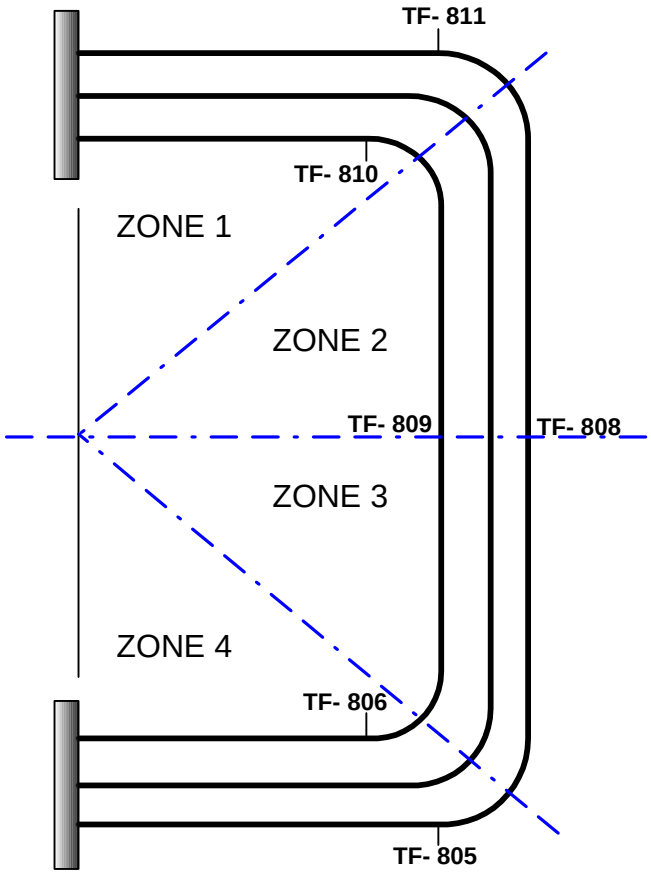

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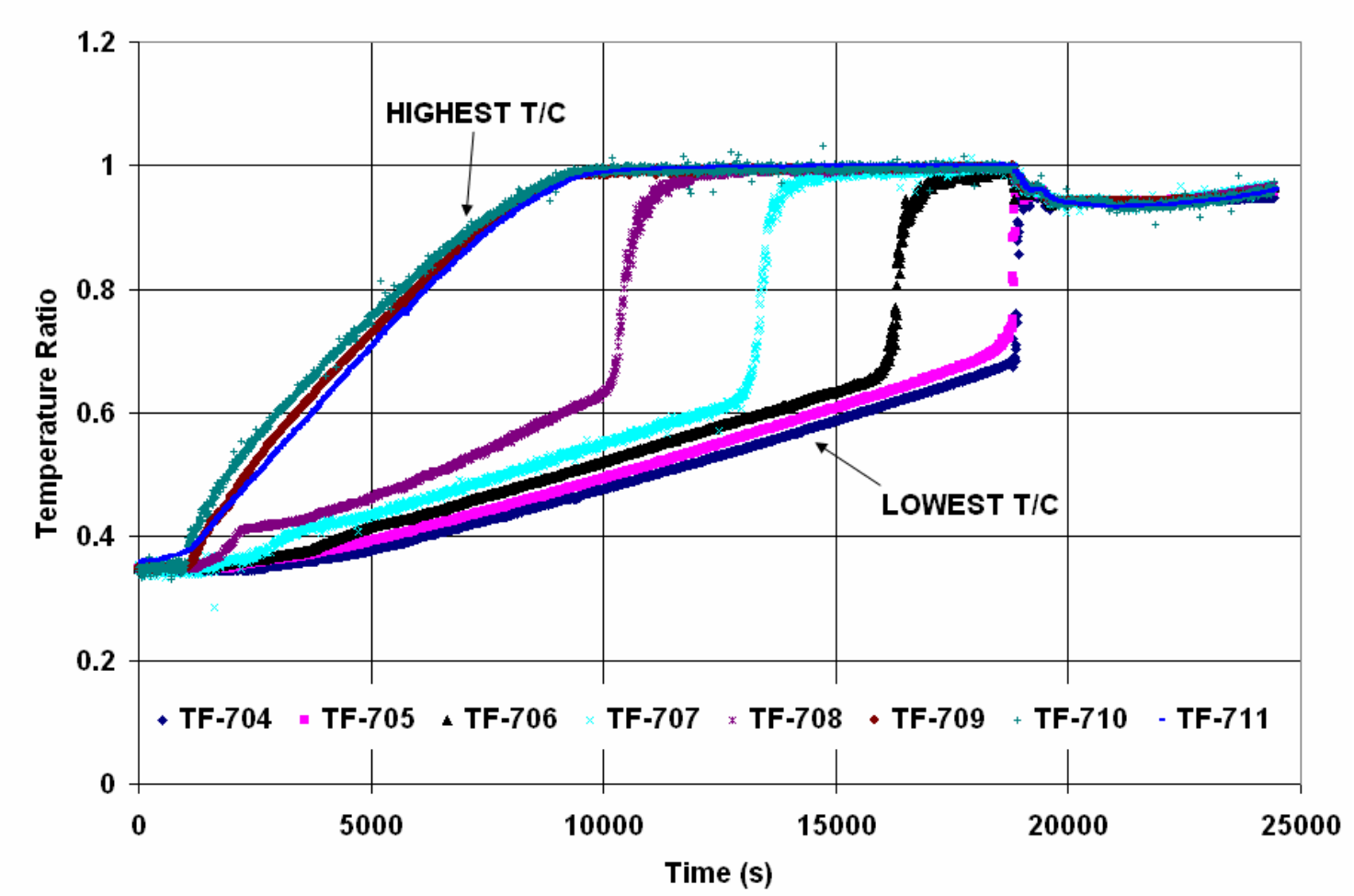
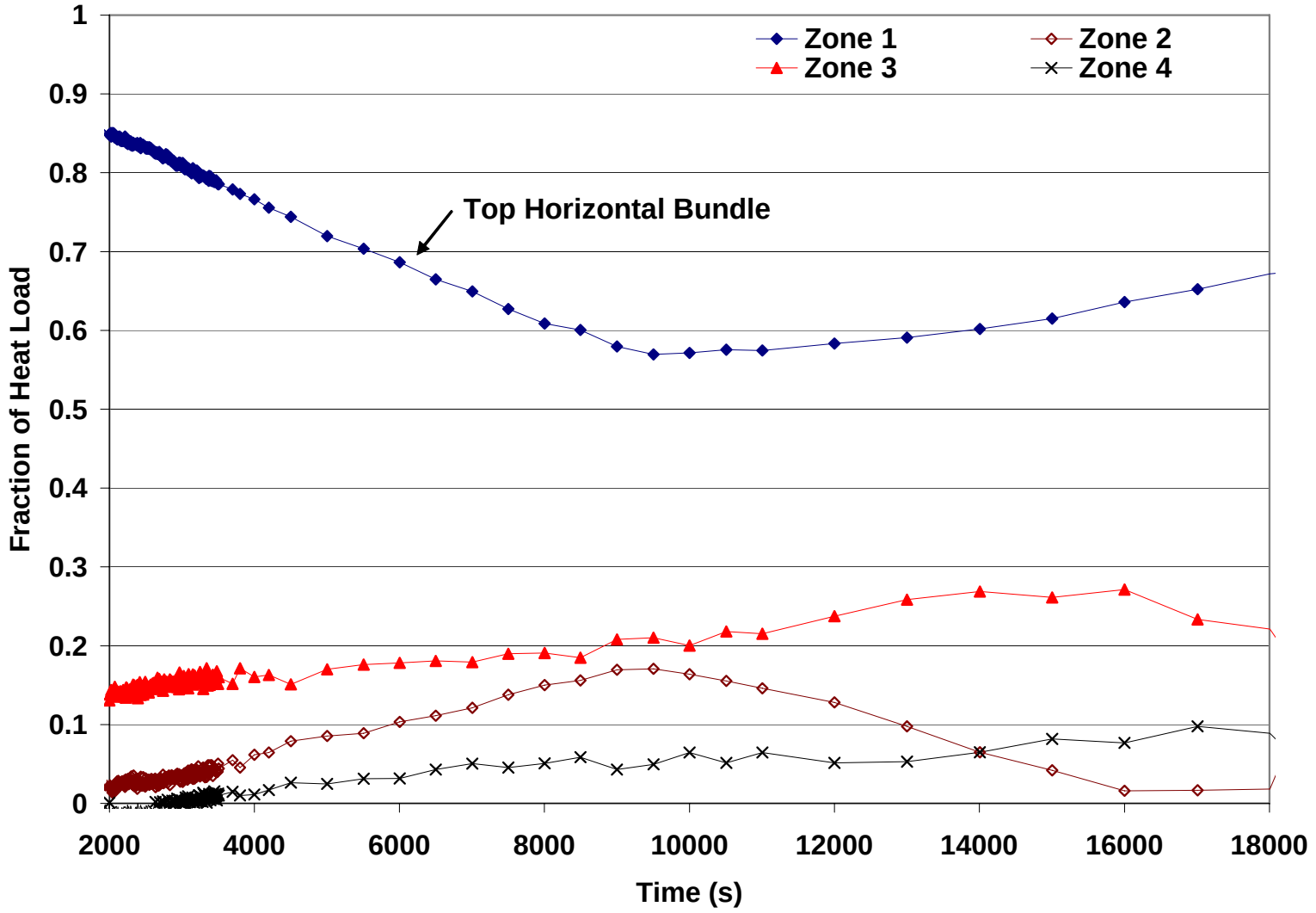
NRC-2 IRWST Thermal Stratification



Fraction of Heat Load Transferred in Each Zone (NRC-2)



Results

- Significant thermal stratification was observed in the IRWST during the Station Blackout Test (NRC-2)
  - A saturated layer forms at the top of the IRWST as the result of a thermal plume rising from the PRHR heat exchanger.
- The data Indicates that the top horizontal bundle in the PRHR (Zone 1) serves to transfer a major portion of the heat load throughout the transient.
- As the saturation layer grows, the top zone becomes less effective and Zones 2 and 3 become more effective.
- Recirculation patterns were observed at the free surface of the IRWST.
- Limited results were published in NUREG/CR-6641

Benchmark Testing

1. OSU is willing to approach NRC to suggest a test to obtain more detailed data to assess PRHR operation during IRWST thermal stratification.
   - Would require additional thermocouples and the addition of velocity measurements.
2. Data would be provided to CRP participants.
3. May be suitable challenge for CFD analyses.