Enclosure 1:

"NRELAP5: Code Description and Assessment," PM-1015-18414-NP, Revision 0, nonproprietary version

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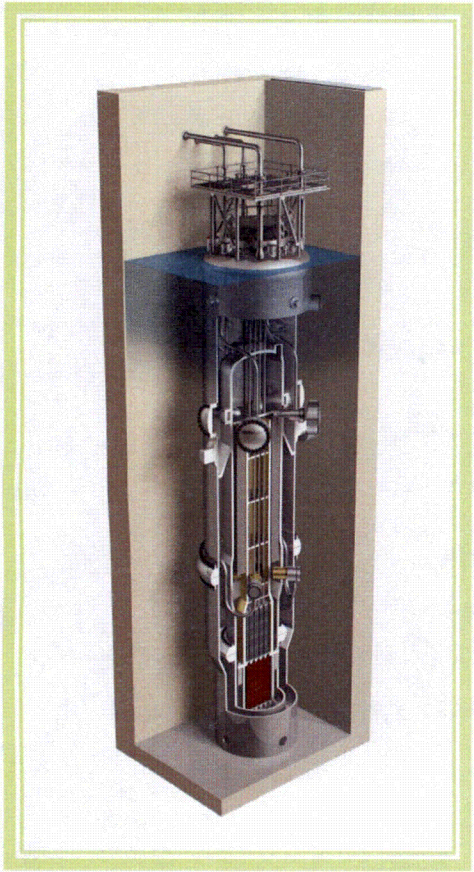
NRELAP5: Code Description and Assessment



Topical Report Pre-Application Meeting with NRC

Robert Houser
Manager, Testing and Code Development

October 29, 2015

PM-1015-18414-NP
Revision: 0

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Acknowledgement and Disclaimer

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Outline of the Presentation

- Introduction
  - NuScale's Code Development unit
  - The NRELAP5 project
  - The NRELAP5 team
- Scope, purpose and outline of the NRELAP5 Topical Report
- A more detailed discussion of selected topics
  - the commercial grade dedication (CGD) baseline code
  - changes to the CGD baseline
  - assessment with experimental data
- Discussion and conclusion

NuScale's Code Development

- The Code Development unit of the Testing & Code Development (T&CD) department is responsible for
  - the development and assessment of NRELAP5 (this presentation)
  - development of the LOCA methodology
  - the development of correlations based on NuScale-proprietary test data (i.e., critical heat flux)
  - test sponsor activities (test needs, pre-test predictions, data review, etc.)
  - development of best-estimate modeling and simulation tools and methods
- T&CD is an organization within the Office of Technology headed by Jose Reyes, NuScale co-founder and CTO

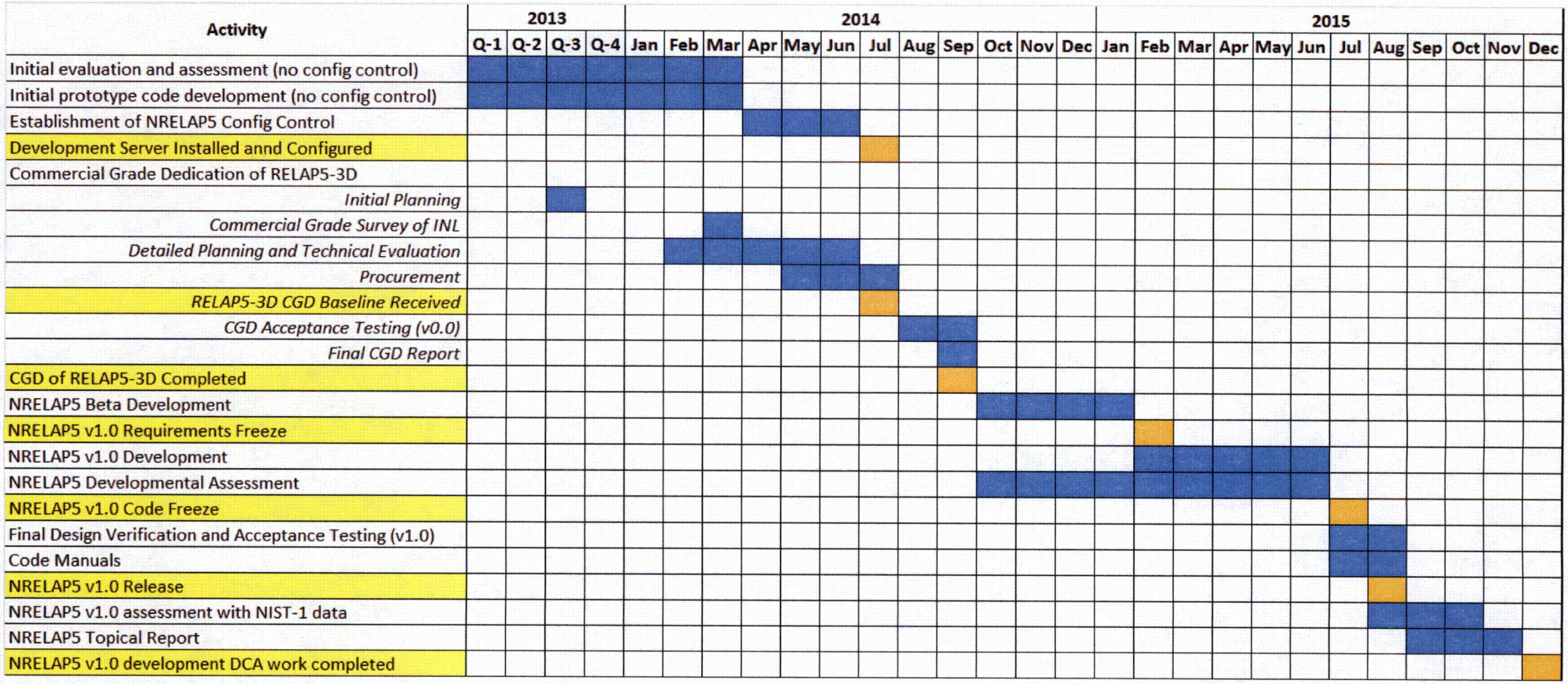
NRELAP5 (DCA Scope)

Needs Statement

"For the nuclear reactor thermal-hydraulic design and safety analysis required by the U.S. Nuclear Regulatory Commission as described in Chapters 4 and 15 of the Standard Review Plan, NuScale needs to use a system thermal-hydraulics code applicable to the unique NuScale reactor design features and operating conditions, such as the emergency core cooling system and natural circulation flow."

The NRELAP5 Project (DCA)

- Extensive effort needed to develop NRELAP5
  - About 40,000 man-hours (20 man-years) from 2013-2015



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The NRELAP5 Team

- 10 NuScale staff
- 14 senior staff augmentation from AREVA, ISL and ZACHRY
- Consulting support from INL, Dr. Graham Wallis, Gary Sozzi, Dr. Don Fletcher, Dr. Dick Schultz and Dr. Cesare Frepoli
- Specialized team with hundreds of man-years of cumulative experience in T-H codes development and assessment
- In this meeting
  - Bob Houser, Manager, Testing & Code Development
  - Steve Blomgren, Software QA and Testing Technical Lead
  - Dr. Jeff Luitjens, NRELAP5 Development Technical Lead
  - Dr. Pravin Sawant, LOCA Methodology Technical Lead
  - Dr. Brian Wolf, NRELAP5 Assessment Technical Lead

Purpose of the NRELAP5 Topical

- To seek NRC's review and approval of NRELAP5 as a thermal-hydraulic system code for the transient analysis of NuScale Power modules
- To facilitate the NRC review of NuScale's Design Certification Application (Q4 of 2016) by early submittal of the NRELAP5 thermal-hydraulic models and assessment that have been finalized in advance of the DCA submittal date
- To provide for a stand-alone topical report that can be referenced by other topical reports and licensing documents, both for NuScale's DCA and for future licensing actions

Scope of NRELAP5 Topical Report

- The scope of the NRELAP5 Topical Report encompasses the features and performance of the computer code that demonstrate its suitability for modeling the thermal-hydraulic phenomena evaluated to play an important role in the LOCA analysis of the NuScale Power module
  - phenomena based on LOCA PIRT
  - the applicability, use and role of NRELAP5 in NuScale's safety analysis will be described together with Ch. 15 event-specific code features in separate topical reports

Analytical Methodologies Topical Reports

- LOCA Methodology Topical Report (June 2016)
  - will describe the development of NuScale's LOCA evaluation model (EM) and LOCA methodology
  - the EM will be NRELAP5-based and developed following the Evaluation Model Development and Assessment Process (EMDAP) of Regulatory Guide (RG) 1.203.
  - will address the requirements of 10 CFR 50, Appendix K, "ECCS Evaluation Models"
  - will describe methodology-specific NRELAP5 models, correlations and techniques

- Non-LOCA Methodology Topical Report (July 2016)
  - will describe NuScale's analytical methodology for Chapter 15 non-LOCA transients, based on non-LOCA PIRT and gap-analysis with LOCA
  - partially based on NRELAP5, with additional non-LOCA assessment

Outline of the NRELAP5 Topical

- Introduction
- Regulatory Requirements
- NRELAP5 Software Quality Assurance
- Models, Correlations and Solution Methods
- Assessment with Test Data
- Conclusion

NRELAP5 Software Quality Assurance

- Selection and commercial grade dedication of baseline code
- Configuration and change control processes
- SQA documentation
  - software project, configuration management and test plans
  - NRELAP5 software requirements specifications
  - NRELAP5 change implementation documents
  - requirements traceability matrix, test reports, assessment reports
- Error reporting and correction process
- Training qualifications
- Theory, input and programming manuals

NRELAP5 Software Quality Assurance

- Internal NuScale QA audit of NRELAP5 Code Development work processes and documentation (October 2014)
- Internal NuScale QA surveillance of NRELAP5 work activities (May 2015)
- NRC audit and inspection (August 2015); inspection letter (October 7, 2015) states that the NRC inspection team concluded "NuScale's process and procedures for the NRELAP5 code development and validation were consistent with the guidance of RG 1.203." No findings and no observations were noted.

Models, Correlations and Solution Methods

I. RELAP5-3D© Baseline Code
   i. Thermal-Hydraulic Models
   ii. Heat Structure Models
   iii. Point Reactor Kinetics Model
   iv. Control System Models
   v. Special solution techniques

II. NuScale Modifications
   i. Design-specific models and correlations
   ii. User-convenience features
   iii. Methodology-specific modifications
   iv. Error fixes

Assessment with Test Data

I. RELAP5-3D© Baseline Code Legacy Assessment

II. Additional Assessment with Legacy Data

III. Assessment with NuScale-proprietary data

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Selected Topics for Today's Presentation

- The commercial grade dedication of RELAP5-3D©
- Example of NuScale modifications in NRELAP5
- Sample assessment results

The "Version 0" CGD Baseline Code

Needs Analysis and Selection	Technical Evaluation	Code Testing, Assessment and Acceptance
• Needs Analysis • Software Evaluation and Selection • Software Classification • Software Requirements Specification	• Safety Function • Critical Characteristics • Acceptance Criteria • Methods of Verification	• Commercial Grade Survey • Receipt Inspection • Software Inspection • Acceptance Testing

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The "Version 0" CGD Baseline Code

- RELAP5-3D© v4.1.3 was procured from INL and commercially dedicated in-house for use as a baseline ("Version 0") for NRELAP5. The commercial grade dedication was in accord with NQA-1 2008/2009a, DOE and EPRI technical reports guidance.

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- Configuration-controlled environment and work procedures were established for NRELAP5 code development and RELAP5-3D© CGD acceptance testing

NuScale Code Modifications in NRELAP5

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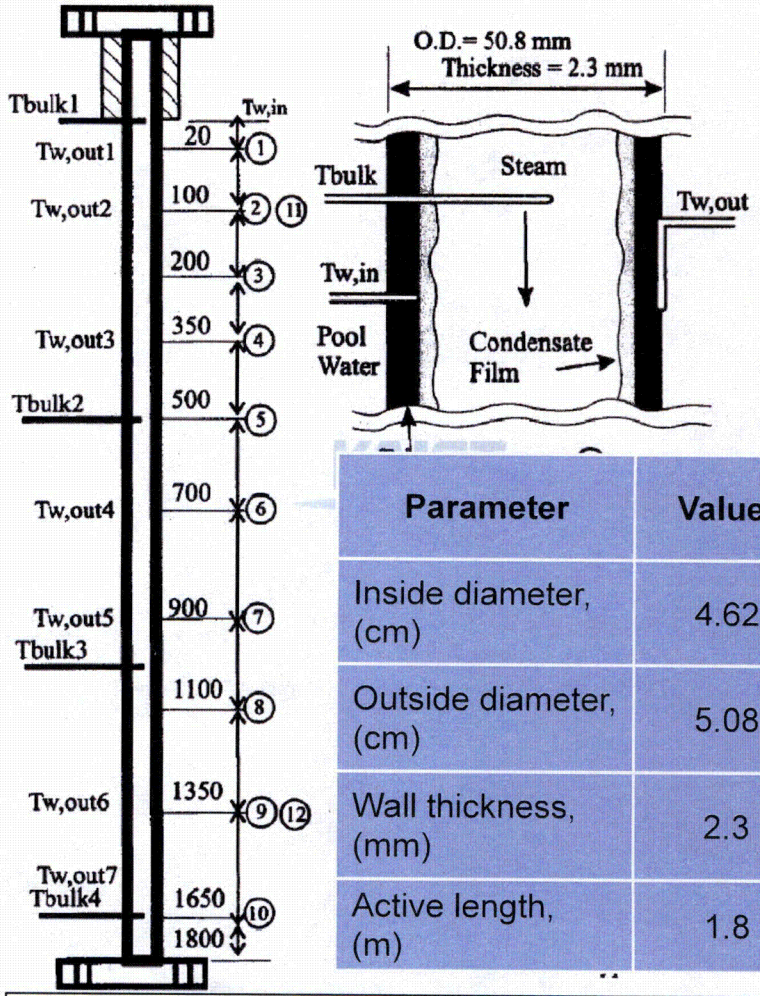
Assessment with Test Data

- Data qualification process
  - all legacy test data used for NRELAP5 assessment is evaluated using NuScale's Data Qualification Process
  - NQA-1 guidance; allows one of, or a combination of 4 methods
    - QA program equivalency
    - data corroboration
    - confirmatory testing
    - technical review
- Selected assessments for this presentation
  - KAIST tube condensation
  - SIET TF-1 and TF-2 helical coil steam generator
  - NuScale Integral Scale Test facility

KAIST Condensation Data

- Phenomenon addressed: film condensation inside tube
- Steam condenses on the inside tube wall and the condensate is drained downwards to the lower plenum. Heat is transferred through the condenser wall to a pool of water.
- Data range: pressure 0.8 to 7.3 Mpa; flow 0.01 to 0.1 kg/s
- Measurements: Inlet steam flow and pressure, test section inside and outside wall temperatures, temperature at test section center, pool temperature.



Parameter	Value*
Inside diameter, (cm)	4.62
Outside diameter, (cm)	5.08
Wall thickness, (mm)	2.3
Active length, (m)	1.8

S.J. Kim, Ph.D. Thesis, Department of Nuclear Engineering, Korea Advanced Institute of Science and Technology, February 2000

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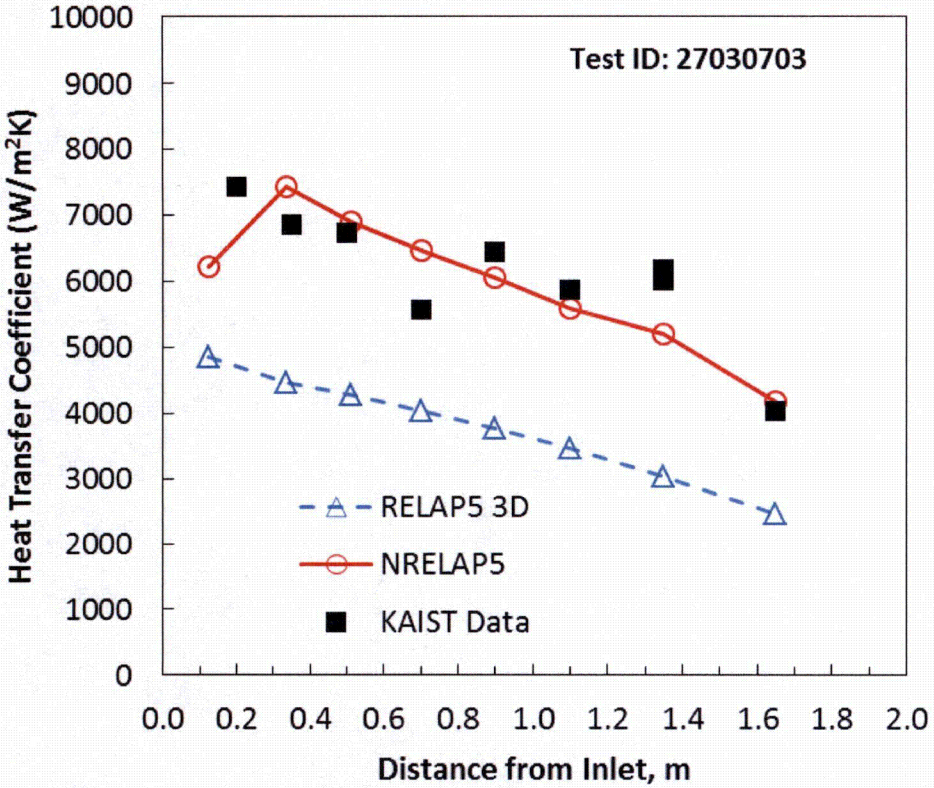
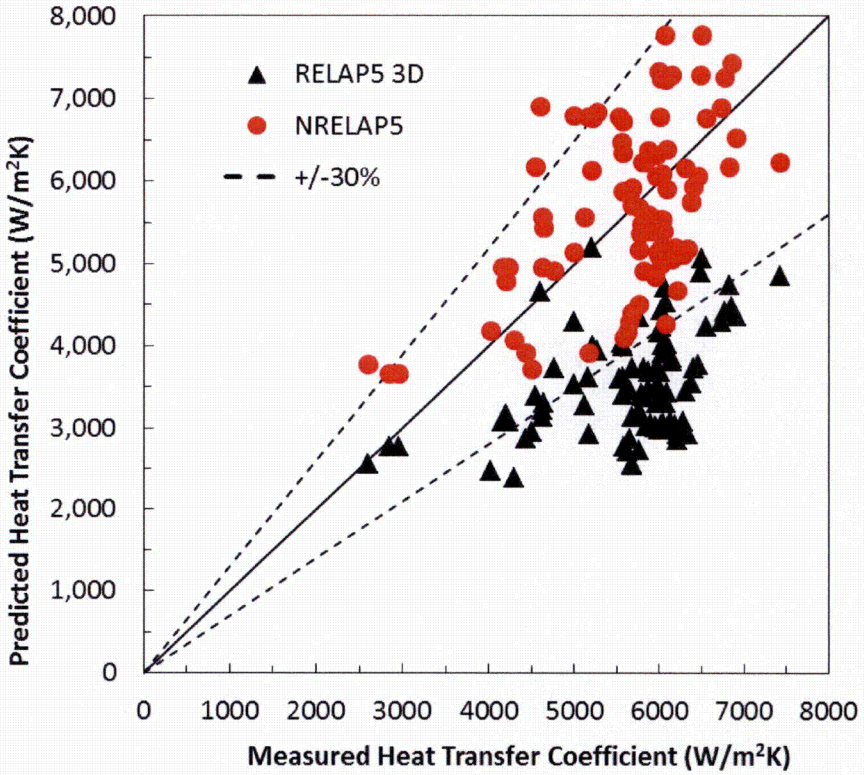
KAIST Condensation Data





- NRELAP5 with extended Shah correlation and KSP multiplier showed significant improvements compared to RELAP5-3D©
- NRELAP5 predictions generally lie within experimental data uncertainty

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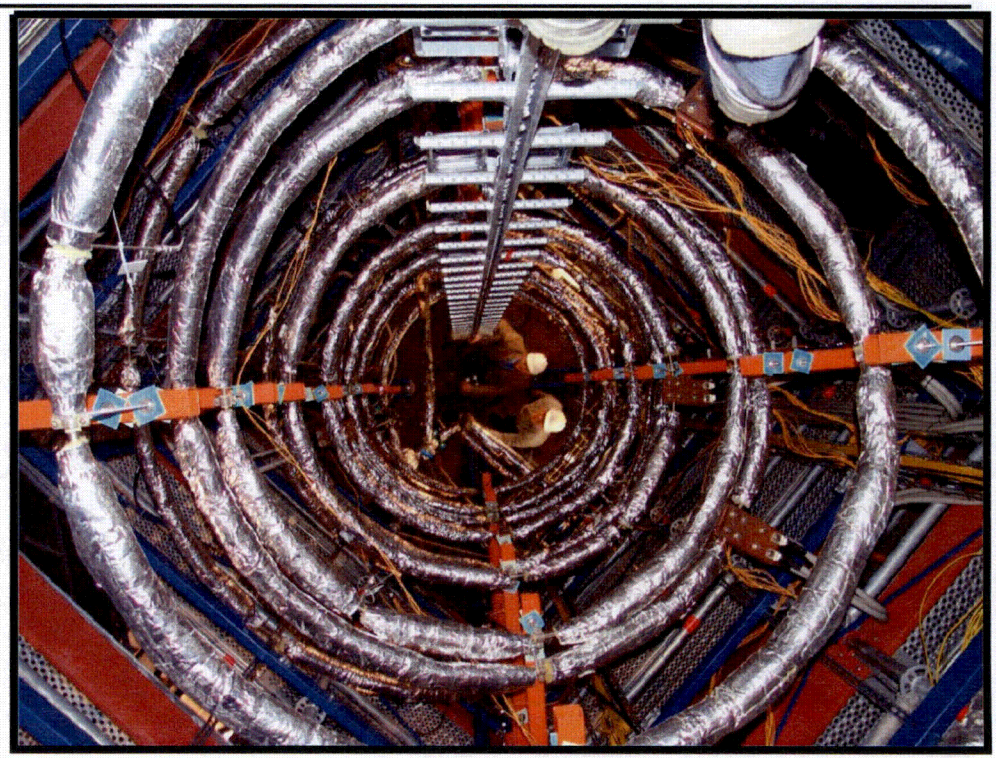
SIET TF-1

- Electrically heated test section, 3 **full scale** coils
- Phenomena: HCSG secondary side heat transfer and pressure drop
- Adiabatic experiments: single-phase characterization tests and two-phase tests
- Diabatic experiments
  - 84 tests
  - test parameters: pressure, power, inlet flow and subcooling
- Measurements: pressure drop, wall temperatures, fluid temperatures



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SIET TF-1 PRELIMINARY

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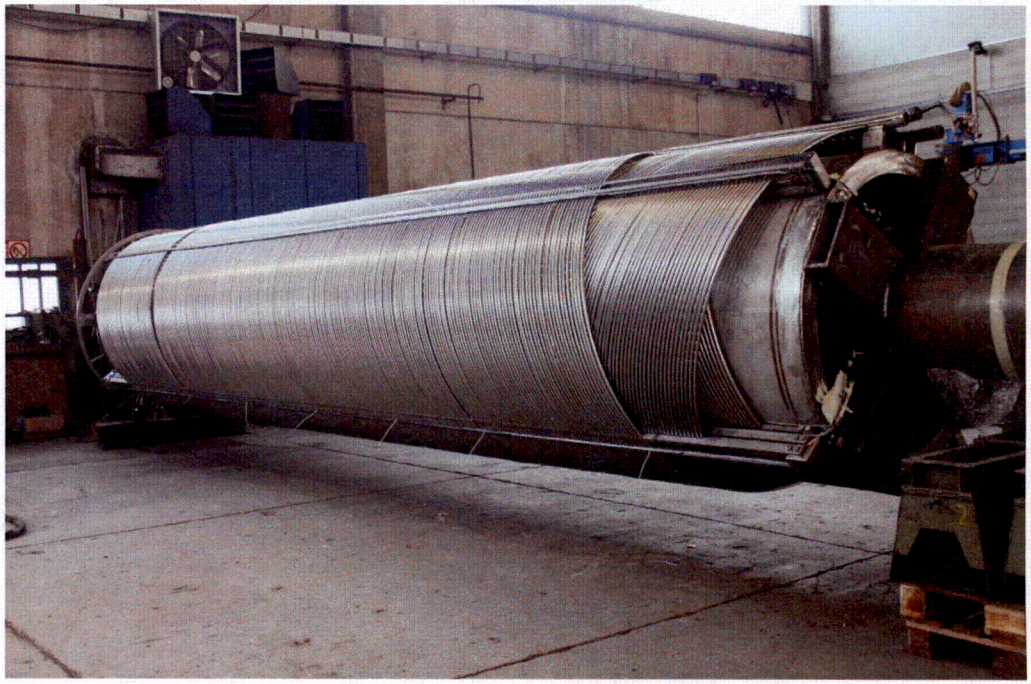
SIET TF-2

- Fluid heated test section, **full scale** 5 tube banks, 252 coils
- Phenomena: HCSG primary and secondary side heat transfer and pressure drop
- Adiabatic tests: Primary side pressure drop characterization (12 tests)
- Diabatic tests (Run 1):
  - 18 tests (11 with one tube bank; and 7 with all tube banks active) {{
  - Test parameters: Number of tube banks, primary and secondary flow rates
- Measurements: pressure drop, wall temperatures, fluid temperatures



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SIET TF-2 PRELIMINARY

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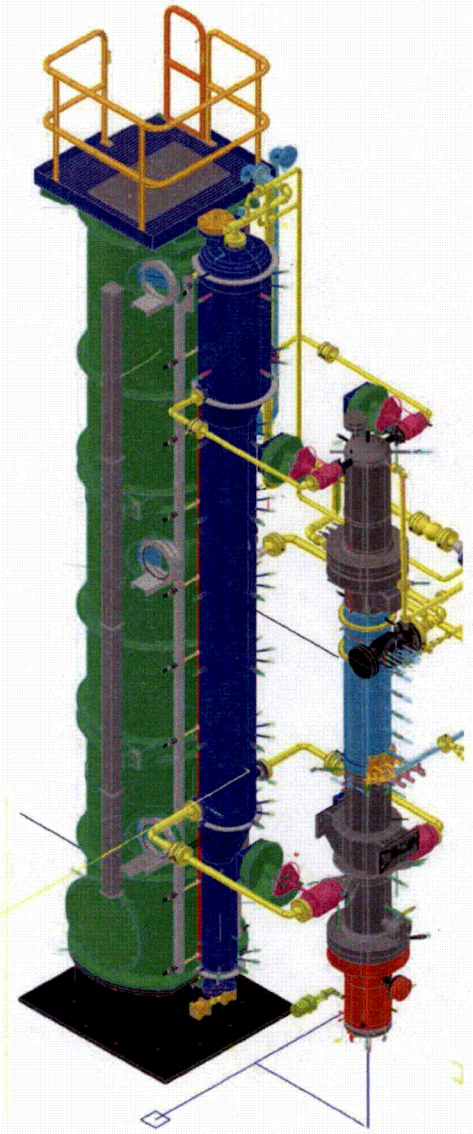
NIST-1 Facility

- Objective: Obtain large-scale real-time integral-effects systems data for SBLOCAs, long-term core cooling, and high pressure condensation data to validate our NRELAP5 code
- 1:3.3 scale in elevation
- Components
  - integral reactor vessel with electrically-heated rod bundle core, helical coil steam generator, and pressurizer
  - DHRS, ECCS
  - CVCS lines
  - containment
  - cooling pool
- Near full pressure and temperatures
- 100% of full decay power on a scaled basis
- Installed approximately 700 instruments
- Laser visualization ports



NIST-1 Steady-State HP-05 PRELIMINARY

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NIST-1 CVCS Line Break HP-06 PRELIMINARY

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Summary and Conclusions

- 20 man-year effort to develop NRELAP5 for NuScale DCA by specialized team
- Software QA program compliant with 10 CFR 50 App B and NQA-1-2008/2009a
- NRELAP5 is based on RELAP5-3D, verified adequate (in-house CGD) for most T-H phenomena important for NuScale transient analysis
- Code changes addressed targeted improvements. Regression testing maintains legacy of RELAP5-3D assessment
- Reasonable to excellent agreement (as defined in RG 1.203) of NRELAP5 code predictions to wide range of relevant experimental data
- NuScale has ownership of NRELAP5, both intellectual property and technical aspects
- NRELAP5 has been validated for modeling the thermal-hydraulic phenomena evaluated to play an important role in the LOCA analysis of the NuScale Power module
- Topical report submittal date: January 31, 2016

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