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RELAP-7 Software Verification and Validation Plan

Requirements Traceability Matrix (RTM) Part 1 – Physics and numerical methods

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ABSTRACT

This INL plan describes the Software Verification and Validation Plan (SVVP) and Requirements Traceability Matrix (RTM) on main physics and numerical method of the RELAP-7 software. The plan also describes the testing-based software verification and validation process—a set of specially designed software models used to test RELAP-7.

PREFACE

Document Version

This document is released as Revision 0.

It is the reader's responsibility to ensure he/she has the latest version of this document. Direct Questions may be directed to the owner of the document and project manager:

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TABLES

ACRONYMS

BWR	Boiling Water Reactor
CFD	Computational Fluid Dynamics
DNBR	Departure from nucleate boiling
ECCS	Emergency Core Cooling System
EOS	Equation of State
FDP	Finite Difference Preconditioner
FEM	Finite Element Method
FIST	Full Intergral Simulation
GUI	Graphical User Interface
IFT	Intergral Effect Test
INL	Idaho National Laboratory
JFNK	Jacobian-Free Newton Krylov
HEM	Homogeneous Equilibrium Model
LBLOCA	Large Break LOCA
LOCA	Loss of Coolant Accident
LOFT	Loss of Fluid Test
LWR	Light Water Reactor
MOOSE	Multi-Physics Object-Oriented Simulation Environment
NEA	Nuclear Energy Agency
NPP	Nulcear Power Plan
OECD	Organization for Economics Co-operation and Development
PCICE	Pressure-Corrected Implicit Continuous-fluid Eulerian
PWR	Pressurized Water Reactor
RAVEN	Risk Analysis Virtual control ENvironment
RELAP	Reactor Excursion and Leak Analysis Program
SBP	Single Based Preconditioner
SBLOCA	Small Break LOCA
SBO	Station Black Out
SET	Separate Effect Tests
SGEOS	Stiffend Gas Equation of State
SMP	Single Matrix Preconditioner
SQA	Software Quality Assurance
SV&V	Software Verification and Validation

TDV	Time Dependent Volume
V&V	Verification and Validation

RELATED DOCUMENTS

Item	Reference	Description

RELAP-7
Software Verification and Validation Plan
Requirements Traceability Matrix (RTM)
Part 1 – Physics and numerical methods

1. INTRODUCTION AND OVERVIEW

This plan describes the software RELAP-7 and presents the general, specific and technology requirements informally documented for previous releases of the application. The plan also presents information concerning the testing-based software verification and validation (SV&V) process—a set of specially designed software models and scripts used to test RELAP-7 and subsequent versions. This document is a "living" document in that it will be periodically updated as new or revised information related to the RELAP-7 development is obtained.

This document is a continuous work of "RELAP-7 Software Verification and Validation Plan (INL-EXT-14-33201).

The organization of the document is as follows:

Sections and Appendices	Subject Area
1	Description of the RELAP-7 product, support activities, features and development status.
2	Reauirement Traceability Matrix and three different requirements types
3	List of test samples
4	Concluding remark
A	Detailed description of test samples
B	Classified test samples
C	Requirement Traceability Matrix

1.1 System Description

The RELAP-7 (Reactor Excursion and Leak Analysis Program) code is a nuclear reactor system safety analysis code being developed at Idaho National Laboratory (INL). The code is based on the INL's modern scientific software development framework – MOOSE (Multi-Physics Object-Oriented Simulation Environment). The overall design goal of RELAP-7 is to take advantage of the previous thirty years of advancements in computer architecture, software design, numerical integration methods, and physical models. The end result will be a reactor systems analysis capability that retains and improves upon RELAP5's capability and extends the analysis capability for all reactor system simulation scenarios.

1.2 Plan Objectives

The objective of this plan is to document the software development process for RELAP-7. Additional information provided in this plan includes the software requirements specification (SRS), and the interface requirements specification (IRS), and the software design specification (SDS), which have been informally documented for previous releases of the application.

For the INL, Software Quality Assurance (SQA) requirements are contract driven and interpreted from DOE Order 414.1C, “Quality Assurance”, 10 CFR 830 Subpart A, “Quality Assurance Requirements”, and ASME NQA-1-2000, “Quality Assurance Requirements for Nuclear Facility Applications.” The INL internal document, PDD-13610, "Software Quality Assurance Program," describes the SQA Program at the INL. To implement the SQA Program, two supporting documents are used at the INL:

- LWP-13620, "Software Quality Assurance" is the entry-level document for the SQA work processes. This procedure directs the SQA activities during the software life cycle which consists of requirements, design, implementation, acceptance test, operations, maintenance, and retirement. LWP-13620 is designed to standardize the lab’s SQA implementation by applying a graded approach and utilizing trained personnel in the identification of the required SQA activities. LWP-13620 provides direction in determining the rigor (level of effort) required when (a) performing SQA activities and (b) creating documentation for each phase of the software life cycle.

SQA must be applied to all INL software (including RELAP-7 development) activities that meet the criteria in LWP-13620. Performing SQA is important because it (a) maintains compliance with DOE O 414.1C, "Quality Assurance" and 10 CFR 830 "Nuclear Safety Management", Subpart A "Quality Assurance Requirements"; (b) assists in assuring you are following a stable, repeatable process that is cost effective and consistently meets customer requirements; and (c) provides a foundation for ensuring the quality of software developed, procured, and modified at the INL.

Per PDD-13610, the Software Owner is a representative of the organization responsible for the application of the software. He/she is identified in the INL Enterprise Architecture and is responsible for:

- Identifying and documenting the appropriate safety software categorization to software per LWP-13620.
- Approving software management plan, requirement, acceptance test, and retirement documentation
- Approving results of evaluations of acquired and legacy software to determine adequacy to support the operations, maintenance, and retirement phases
- Procuring software using LWP-4001, "Material Acquisitions" and LWP-4002, "Service Acquisitions."
- Developing and implementing program-specific training for the operational use of safety software
- Considering whether user training is needed for the operational use of Quality Level 1 and Quality Level 2 software.

"Software" as defined by the PDD-13610 procedure pertains to computer programs and associated documentation and data pertaining to the operation of a computer system and includes:

1. Application Software - software designed to fulfill specific needs of a user; for example navigation, payroll, or process control.
2. Support Software such as the following software tools (e.g., compilers, configuration and code management software, editors) or system software (e.g., operating systems).

Note that within the INL SQA process, software that does not fall within the scope of the SQA Program includes any software covered by a contractual agreement, such as Work for Others, that includes references or requires a specific documented SQA process. Applicable documents that apply to RELAP-7 development include:

- Software Quality Assurance Plan for RELAP-7, PLN-4212, 5/31/2012.
- Software Project Management Plan for RELAP-7, PLN-4213, 6/28/2012.
- Software Configuration Management Plant for the RELAP-7 Project, PLN-4214, 6/30/2012.
- RELAP-7 Development Plan, INL/MIS-13-28183, 1/2013.

It is the responsibility of the **Software Owner** to make the determination as to whether a particular software can be classified as "safety software." Safety Software includes the following type of software:

- **Safety System Software**. Software for a nuclear facility that performs a safety function as part of a structure, system, or component *and* is cited in either (a) a DOE approved documented safety analysis or (b) an approved hazard analysis per DOE P 450.4, Safety Management System Policy, dated 10-15-96, and the DEAR clause.
- **Safety Analysis and Design Software**. Software that is used to classify, design, or analyze nuclear facilities. This software is not part of a structure, system, or component (SSC) but helps to ensure that the proper accident or hazards analysis of nuclear facilities or an SSC that performs a safety function.
- **Safety Management and Administrative Controls Software**. Software that performs a hazard control function in support of nuclear facility or radiological safety management programs or technical safety requirements or other software that performs a control function necessary to provide adequate protection from nuclear facility or radiological hazards. This software supports eliminating, limiting or mitigating nuclear hazards to worker, the public, or the environment as addressed in 10 CFR 830, 10 CFR 835, and the DEAR ISMS clause.

For all software that falls within the scope of the SQA Program, a **quality level** must be assigned by a qualified Quality Level Analyst with review and concurrence by a Quality Level Reviewer (i.e., a second Quality Level Analyst) per LWP-13014, "Determining Quality Levels." The Quality Level Analyst should then communicate to the Software Owner the determined quality level.

A quality level is a designator that identifies the relative risk associated with the failure of items or activities. This quality level determination must be performed regardless of the size or complexity of the software. The Quality Levels are defined as follows:

Quality Level 1 software is software whose failure creates "high" risk. This software requires a high degree of rigor during the software life cycle.

Quality Level 2 software is software whose failure creates "medium" risk. This software requires a moderate degree of rigor during the software life cycle.

Quality Level 3 software is software whose failure creates "low" risk. This software requires a low degree of rigor during the software life cycle.

The quality level of the software is a component when determining the level of rigor (graded-approach) that the SQA Specialist must ensure is applied when performing software quality assurance activities or creating documentation for each phase of the software life cycle. The higher the quality level of the software, the more rigorous the quality assurance activities and documentation will need to be as defined in Section 4.2 of LWP-13620.

Per the Requirements Phase Documentation table in LWP-13620:

1. For QL-1 and QL-2 Custom-Developed or Configurable software: include within the software's documentation (e.g., Project Execution Plan (PEP), Software Quality Assurance Plan (SQAP)):

    a. The activities to be performed to support software quality assurance (e.g., design reviews, acceptance testing, reviews and audits),

    b. Identify SQA documentation to be generated,

    c. Identify the roles and responsibilities for SQA activities, and

    d. The methodology for tracing requirements throughout the software life cycle.

2. For QL-3 Custom Developed or Configurable software and all other software types (i.e., acquired, utility calculations, commercial D&A), the described information is optional or not applicable within the software's documentation.

All documentation that furnishes evidence of the software quality is considered a QA record and should be handled as a quality record according to the organization, program, or project's Records Management Plan as required by LWP-1202. QA records generated during the software development life cycle could include project plans, requirement specifications, configuration management plans, software quality assurance plans, security plans, and verification and validation documentation (e.g., test plans, test cases, and design review documents).

It is the responsibility of the contractor to ensure that these quality criteria are adequately addressed throughout the course of the research that is performed.

1.2.1 Software Quality Assurance

Software assurance is the planned and systematic set of activities that ensures that software processes and products conform to requirements, standards, and procedures. These processes are followed in order to enhance the robustness of the development process. Having formal documented development procedures and requirements helps to streamline the development cycle and focus on customer-driven needs.

In an attempt to improve the quality of the RELAP-7 tool set, effort has been made to establish criteria to which the development and control processes adhere. The recording of coding standards and the creation of the Requirements Traceability Matrix (RTM) will be added to improve code use and to establish traceability.

The roles and responsibilities of each team member are described below:

- Project Manager – Executes, maintains, and updates this plan. Monitors SV&V activities for the RELAP-7 Project. Coordinates formal user acceptance testing, when required. Performs as an alternate for technical team members.
- Software Developer – Performs design reviews, test case identification, design, construction, and functional unit testing during software development; reports anomalies and deviations to the Project Manager.
- Quality Assurance – Supports SV&V activities including RELAP-7 reviews. Is independent of the development and testing work

1.3 Supporting Activities

1.3.1 Development of MOOSE Application

RELAP-7 is a MOOSE (Multiphysics Object-Oriented Simulation Environment) based application which uses open source software packages, such as PETSC (a nonlinear solver developed at Argonne National Laboratory) and LibMesh (a Finite Element Analysis package developed at University of Texas). MOOSE provides numerical integration methods and mesh management for parallel computation. Therefore RELAP-7 code developers only need to focus upon the physics and user interface capability. By using the MOOSE development environment, RELAP-7 code is developed by following the same modern software design paradigms used for other MOOSE development efforts.

There are currently over 20 different MOOSE based applications ranging from 3-D transient neutron transport, detailed 3-D transient fuel performance analysis, to long-term material aging. Multi-physics and multiple dimensional analyses capabilities, such as radiation transport, can be obtained by coupling RELAP-7 and other MOOSE-based applications through MOOSE. This allows restricting the focus of RELAP-7 to systems analysis-type simulations.

The RISMC Toolkit is being built using the INL's MOOSE framework. MOOSE has been designed to solve multi-physics systems that involve multiple physical models or multiple simultaneous physical phenomena. Inside MOOSE, the Jacobian-Free Newton Krylov (JFNK) method is implemented as a parallel nonlinear solver that naturally supports effective coupling between physics equation systems (or Kernels). This capability allows for a tightly-coupled set of tools that work together, as shown in Figure 1.

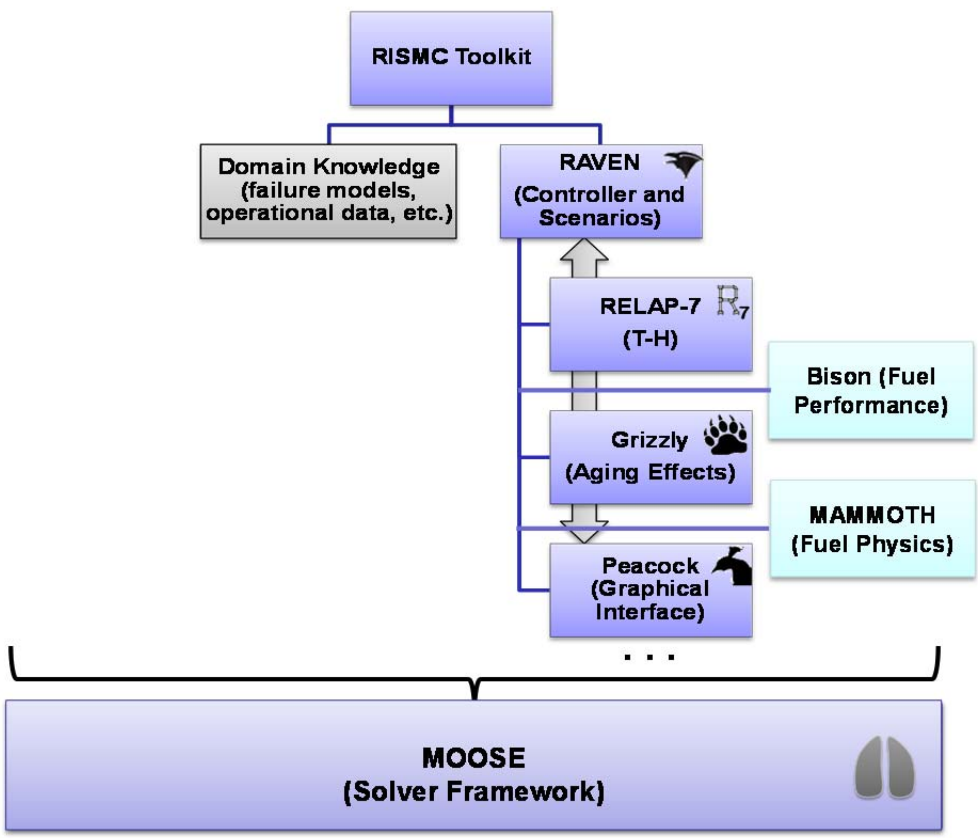


Figure 1 MOOSE-based applications

1.3.2 Technology Transfer

Development of RELAP-7 is to support US nuclear power industry and technical stewardship is envisaged. To realize this long-term vision, several items are considered.

The RELAP-7 code is still undergoing development and the beta-version will be released by December 2014 to get feedback and suggestions for improvement on usability and applicability from the user community.

The RELAP-7 quality assurance (QA) process includes the specific activities of verification, validation, assessment, and related documentation to facilitate reviews of these activities. To support these QA activities, a various results from facility operation, integral effects test, separate effect tests, and fundamental tests including experiments on individual components have been collected. The INL has started the QA process by implementing modern software management processes (including the use of tools such as source code version control) as a part of the RELAP-7 development, conducting NQA-1 audits, and creating a software verification and validation plan (SVVP).

To keep the intellectual property, RELAP-7 is copyrighted software that has been developed by the INL from funding provided by the U.S. Department of Energy. The type of software license for RELAP-7 is still to be determined. RELAP-7 is subject to U.S. Export Control laws, including a complete embargo against any person from a T5 country (currently: Cuba, Iran, North Korea, Syria and Sudan). The software license for the supporting MOOSE framework is the open source license "Lesser GNU Public License (LGPL) version 2.1."

1.4 RELAP-7 Features

In general RELAP-7 provides computational simulation of thermal-hydraulic behavior in a nuclear power plant and its components. Representative thermal hydraulic models are used to depict the major physical components and describe major physical processes. RELAP-7 has five main types of components/capabilities:

- Three-dimensional (3D)
- Two dimensional (2D)
- One-dimensional (1D) components (e.g., pipe)
- Zero-dimensional (0D) components for setting boundary conditions for the 1D components (e.g., Pressure boundary condition of pump)
- 0D components for connecting 1D components

RELAP-7 could be coupled to 3D core modeling MOOSE-based codes to enable detailed resolution.

The RELAP-7 code development started in 2012 based upon development input from the Electric Power Research Institute. During the first year of the code development, the software framework was created to establish the basic reactor system simulation capability with a number of components developed for single-phase thermal fluid flow. Later, two-phase flow modeling capability was implemented in the RELAP-7 code. These capabilities have been demonstrated via application to a boiling water reactor simulation with representative components under extended Station Black Out (SBO) transient conditions.

The RELAP-7 α-0.1 was released in May 2012, and followed by α-0.2 version in August 2013 and α-0.6 version in September 2014. Since 2015, the code developers are using GitLab project which is the web base open community for code developers. Everytime the code has been updated the GitLab will automatically provide code version.

The RELAP-7 application is the next generation nuclear reactor system safety analysis code. The code is based upon the MOOSE (Multi-Physics Object-Oriented Simulation Environment). The goal of RELAP-7 development is to leverage of advancements in software design, numerical integration methods, and physical models.

Table 1 Component-related attributes for the RELAP-7 (as of 2015)

RELAP-7 Component	Dimensionality			Hydrodynamic Model			3D Linkage
	0D	1D	2D	Single Phase	Two Phase HEM	Two Phase 7-Eq.	Application
Pipe	n/a	■		■	■	■	
PipeWithHeatStructure	n/a	■	■	■	■	■	
CoreChannel	n/a	■	■	■	■	■	BISON
HeatExchanger	n/a	■	■	■	■	□	
TimeDependentVolume	■	n/a	n/a	■	■	□	
TimeDependentMassFlowRate	■	n/a	n/a	■	■	■	
Branch	■	n/a	n/a	■	■	□	
Valve	■	n/a	n/a	■	□	□	n/a
CompressibleValve	■	n/a	n/a	■	□	□	n/a
CheckValve	■	n/a	n/a	■	□	□	n/a
Pump	■	n/a	n/a	■	□	□	n/a
PointKinetics	■	n/a	n/a	n/a	n/a	n/a	n/a
SeparatorDryer	■	n/a	n/a	n/a	■	□	n/a
Downcomer	■	n/a	□	n/a	■	□	n/a
WetWell	■	□	n/a	■	■	□	n/a
Reactor	■	n/a	n/a	n/a	n/a	n/a	Rattlesnake+ MAMMOTH
Turbine	■	n/a	n/a	■	□	□	n/a
Pressurizer	■	□	n/a	n/a	■	□	n/a

* ■: Available, □: Planned, n/a: Not available

In summary the RELAP-7 design is based upon:

- Modern Software Design:
    - Object-oriented C++ construction provided by the MOOSE framework
    - Designed to significantly reduce the expense and time of RELAP-7 development
    - Designed to be easily extended and maintain
    - Meets NQA-1 requirements
- Advanced Numerical Integration Methods:
    - Multi-scale time integration, PCICE (operator split), JFNK (implicit nonlinear Newton method), and a point implicit method (long duration transients)
    - New pipe network algorithm based upon Mortar FEM (Lagrange multipliers)
    - Ability to couple to multi-dimensional reactor simulators
- State-of-the-Art Physical Models:
    - All-speed, all-fluid (vapor-liquid, gas, liquid metal) flow
    - Well-posed 7-equation two-phase flow model
    - New reactor heat transfer model based upon fuels performance

Table 1 shows detailed features of RELAP-7.

1.4.1 Software Framework

The RELAP-7 (Reactor Excursion and Leak Analysis Program) code is based on INL developed framework software MOOSE (Multi-Physics Object Oriented Simulation Environment) which may model fully coupled nonlinear partial differential equations. The Graphical User Interface (GUI) of RELAP-7 can be provided by another MOOSE based software named Risk Analysis Virtual control ENvironment (RAVEN).

1.4.2 Governing Theory

Fundamentally, the RELAP-7 code is designed to simulate all-speed and all-fluid for both single and two-phase flow. However, current status RELAP-7 development focuses on simulation of the light water reactors (LWR), thus, two-phase flow model is described here.

The main governing theories of RELAP-7 are: 7-equation two-phase flow; reactor core heat transfer; and reactor kinetics models.

The 7-equation two-phase flow model consists of mass, momentum and energy (or pressure) equation for both liquid and vapor phases and a topological equation which explains the state of the two-phase mixture. This model may solve compressible fluid at all-speed multiphase flow which allows analyzing various transient phenomena and accident scenarios in LWR. In the RELAP-7, the 7-equation model is implemented in the MOOSE finite element framework.

Both convective and conduction heat transfer is simulated for fuel, fluid, and structures. The reactor core heat source is modeled by point kinetic method considering hydraulic reactivity feedback. The three-dimensional reactor kinetics may simulate through coupling with RattleSNake which is a reactor kinetics code with both diffusion and transport capabilities based on MOOSE framework.

1.4.3 Computational Approach

The RELAP-7 uses MOOSE-based applications with a multitude of mathematical and numerical libraries: LibMesh for the second-order accurate spatial discretization by employing linear basis, one-dimensional finite elements; Message Passing Interface (MPI) for distributed parallel processing; Intel Threading Building Blocks (Intel TBB) for parallel C++ programs to take full advantage of multi-core architecture found in most large-scale machines; and PETSc, Trilinos and Hypre for the mathematical libraries and nonlinear solver capabilities for Jacobian-Free Newton Krylov (JFNK).

To cover various time scale range of reactor transient and accident scenarios, the RELAP-7 pursues three-level time integration approaches: Pressure-Corrected Implicit Continuous-fluid Eulerian (PCICE) computational fluid dynamics (CFD) scheme for highly compressible and/or contain significant energy deposition, chemical reactions, or phase change problems; JFNK method for multi-physics problems during the transients; Point Implicit time Integration method for long duration and slow transient scenarios.

2. REQUIREMENT TRACEABILITY MATRIX (RTM)

2.1 Introduction

The Requirements Traceability Matrix (RTM) is created to associate specific requirements with the work products that satisfy them. Tests are also associated the requirements on which they are based so documented proof exists that the product has met the requirement. The matrix provides unique identifiers for each requirement and ensures completeness that lower level requirements come from higher level requirements. This matrix provides a tangible item that can be examined by the customer and the provider alike. Information that may not be clearly explained in descriptive text will be directly traceable forwards and backwards from a requirement or from an associated test. Traceability is used to manage change and provides a basis for test planning. It is a tool to ensure that the software process has been completed from initial definition to completion of a product. Use of an RTM provides a software quality check point.

2.2 Requirements for RELAP-7 development

Based on the previous study (INL-EXT-14-33201), following requirements are identified for physics and numerical methods of RELAP-7. The requirements are categorized into three types: General Requirements (GR); Specific Requirements (SR); and Technology Requirements (TR). The Software and Interface Requirements which deals with issues on software design, GUI, computational stabilities, etc will be discussed in the future studies.

Each requirement is evaluated by using existing test sample files. The results are shown in Appendix C.

2.2.1 General Requirements (GR)

The General Requirements are based on existing system thermal-hydraulic codes. These requirements are categorized into capability of LOCA and/or non-LOCA based scenario and other related phenomena.

- GR-1: Simulate various LWR designs including PWR and BWR
- GR-2: Simulate various PWR manufacturers' designs such as Westinghouse, Combustion Engineering and Babcock&Wilcox
- GR-3: Simulate various containment design such as high and low backpressure
- GR-4: Simulate non-water cooled reactors including Gen-IV reactor type
- GR-5: Simulate steady-state analysis
- GR-6: Simulate Large-break LOCA (LBLOCA) and Small break LOCA (SBLOCA)
- GR-7: Simulate Emergency Core Cooling System (ECCS) design (accumulators and pumped injection system, pumped safety injection system, cold/hot-leg injection)
- GR-8: Simulate excessive heat transfer

- GR-9: Simulate loss of heat transfer and loss of flow
- GR-10: Simulate increase and decrease in inventory
- GR-11: Simulate departure from nucleate boiling (DNBR)
- GR-12: Simulate minimum critical power ratio (MCPR)
- GR-13: Simulate transient analysis during LOCA
- GR-14: Generate physics parameters for reactor kinetics model in system code
- GR-15: Simulate reactivity and core power distribution
- GR-16: Simulate 3-D core power boundary condition coupled with system code
- GR-17: Simulate fuel rod thermal modeling
- GR-18: Simulate mechanical and thermal behavior of fuel pellets, gap and cladding
- GR-19: Simulate fluid/mechanical interaction analysis
- GR-20: Simulate containment analysis
- GR-21: Simulate chemistry effects
- GR-22: Simulate radiological consequence analysis
- GR-23: Simulate prediction of core power distribution
- GR-24: Capability of coupling of codes
- GR-25: Simulate multi-dimensional fluid flow at microscale level of detail

2.2.2 Specific Requirements (SR)

The Specific Requirements (SR) mainly focuses on unresolved legacy issues of the thermal-hydraulic codes partially due to the complexity of the technology and partially due to the challenges in research and development. The legacy issues are categorized into physical phenomena, numerical discretization, code and modeling accuracy, computer science, validation, etc. The requirements for RELAP-7 development are therefore suggested based on the current state of code specification and legacy issues. The requirements are labeled as “Essential” and “Recommended”.

- SR-1: The code will use most advanced computer science technology to optimize accuracy and speed (Essential)
- SR-2: The code will implement 3D modeling for obtaining high level of resolution includes coupling to CFD code (Essential)

- SR-3: The code will provide coordinate system to represent actual design (Recommended)
- SR-4: The code will develop standard modules for meshing to lessen the variability of the result (Recommended)
- SR-5: The code will identify standard or recommended options to lessen the variability of the result (Recommended)
- SR-6: The code will not subject to failure as a result of numerical methods (Essential)
- SR-7: The code will address legacy issues associated with two-phase flow (Recommended)
- SR-8: The code will model droplet for BWR core spray and containment spray of PWR/BWR (Recommended)
- SR-9: The code will model sources and transport of particles in vapor, gas, droplet and liquid (Essential)
- SR-10: The code will model transport of non-condensable gases including heat transfer effect (Essential)
- SR-11: The code will provide multi-scale / multi-physics simulation of following scope by embedded or coupling : fuel rod; fuel assembly reactor primary coolant system; secondary coolant system and balance of plant: instrumentation and controls; containment; site radiological consequences; offsite radiological consequences; and fluid/structure interaction for dynamic loads (Essential)
- SR-12: The code will be user friendly steady-state initialization and restart capabilities (Recommended)
- SR-13: The code will provide clear and easy diagnostics to assist with debugging and workaround (Recommended)
- SR-14: The code will provide detailed documentation of theory, programming, user manual, validation basis and user guidelines (Essential)
- SR-15: The code will provide comprehensive GUI for pre/post-processing and on-line monitoring (Essential)

2.2.3 Technology Requirements (TR)

The Techonology Requirements (TR) is the list of physical models and numerical methods will be handled by the RELAP-7 code. The TR is mainly developed from the aspects that RELAP-7 code development goals and features could be covered by the code.

Aspects on numerical method

- TR-1: Verification of single phase flow

- TR-2: Verification of heat conduction simulation
- TR-3: Grid convergence study by continuous FEM on fluid flow problems
- TR-4: Grid convergence study by continuous FEM on heat conduction problems
- TR-5: Grid convergence study on stabilization schemes using SUPG scheme
- TR-6: Grid convergence study on stabilization schemes using Lapidus scheme
- TR-7: Grid convergence study on stabilization schemes using Entropy based viscosity scheme
- TR-8: Time step convergence study using manufactured solutions Backward Euler
- TR-9: Time step convergence study using manufactured solutions Crank-Nicolson
- TR-10: Time step convergence study using manufactured solutions BDF2
- TR-11: Conservation laws in 0-dimensional components Branches/Junctions
- TR-12: Conservation laws in 0-dimensional components PWR specific components (steam generator and pressurizer as examples)
- TR-13: Conservation laws in 0-dimensional components BWR specific components (steam separator and jet pump as examples)
- TR-14: Simulation of system level conservation laws

Aspects on software design

- TR-15: Code review process capability
- TR-16: Regression test and code coverage test on general coverage test design
- TR-17: Regression test and code coverage test on extreme conditions test design

Aspects on physical phenomena

- TR-18: Single phase shock problems
- TR-19: Single phase pipe and branch system
- TR-20: Single phase pipe network
- TR-21: Two-phase flow water faucet problem
- TR-22: Two-phase flow water over steam problem
- TR-23: Two-phase flow fill-drain problem

- TR-24: Two-phase flow manometer problem
- TR-25: Two-phase flow gravity wave problem
- TR-26: Two-phase shock problems
- TR-27: Evaporation due to heat input or depressurization
- TR-28: Condensation due to heat removal or pressurization
- TR-29: Pressure drop at abrupt geometric changes
- TR-30: Pressure ware propagation

Aspects on separate effects

- TR-27: Single-phase flow wall friction
- TR-28: Single-phase heat transfer
- TR-29: Single-phase water hammer
- TR-30: Single-phase natural circulation
- TR-31: Two-phase flow wall friction
- TR-32: Two-phase flow interfacial friction (vertical/horizontal flow)
- TR-33: Two-phase flow boiling heat transfer
- TR-34: Two-phase flow critical flow and blowdown
- TR-35: Two-phase flow level tracking
- TR-36: Two-phase flow CHF and post-CHF
- TR-37: Two-phase flow reflooding
- TR-38: Two-phase flow counter-current flow
- TR-39: PWR specific component tests
- TR-40: BWR specific component tests

Aspects on integral effect

- TR-41: Single-phase natural circulation
- TR-42: Two-phase Full Integral Simulation Test (FIST) SBO test benchmark

- TR-43: Two-phase flow LOFT tests
- TR-44: Two-phase flow semi-scale natural circulation tests

3. TEST SAMPLES

The RELAP-7 code testing currently provides automated testing of a total of 157 example files representing thermal-hydraulic models, equations of state, component, and loops. The list of test sample files are shown in Appendix A and B. Table 2 categorizes test files into specifications and models. Over time, as the number of plant models and "input decks" increase in RELAP-7, this list of tests will grow.

Table 2 Category of test files

Test specification	Tested models	Test file number
Single-Phase fluid flow	2 Eq. Model	1,54, 55, 57, 60, 75, 76, 77, 79, 80, 83, 84
	3 Eq. Model	2-8, 10-16, 32 33, 35, 36, 38-44, 46, 48-53, 56, 58, 59, 61-69, 71, 72, 78, 81, 82, 87-92, 95-97, 99, 101, 103, 107, 109, 114-116, 118-126, 128, 130, 137-142, 144-146, 152, 155-157
Two-Phase fluid flow	HEM	18-21, 34, 45, 73, 85, 98, 102, 104-106, 108, 110
	7 Eq. Model	23, 26, 28-31, 37, 47, 74, 86, 93, 94, 100, 111-113, 117
Components	Pipe	1, 3, 4, 6-8, 11, 13-20, 13, 26, 28-37, 38, 40, 43, 44, 48-69, 71-100, 104-118, 123-126, 128, 130, 152, 155, 157
	Pipe with heat structure	119-122
	Flow junction	49-53, 155
	Simple junction	99, 100, 128, 130
	Branch	54, 62, 66, 75-81, 88, 89, 152, 157
	Volume branch	64, 68, 69, 82
	Reactor	12, 38, 39, 40-47, 63, 66
	Core channel	5, 21, 39, 40-47, 66, 152, 157
	Subchannel	63
	Point kinetics	65-67
	Downcomer	82
	Turbine	61, 118
	Heat exchanger	2, 38, 101-103, 152, 157
	Pump	54, 55, 57-61
	Ideal pump	56, 64, 152, 155, 157
	Separate dryer	104-106
	Wet well	62, 64
	Valve	123, 124
	Compressible valve	125, 126
Other	Restart	128, 130
	Error checking	129, 131-149
	Displaced components	153
	Control logic	154

4. CONCLUDING REMARK

Three different types of requirements are suggested: General Requirements, Specific Requirements and Technology Requirements. A total of 157 sample files are tested and generated a Requirment Traceability Matrix (RTM), as shown in Appendix C.

Most of test files in this report cover physical and numerical method of the RELAP-7.

The RTM will be updated during FY16 including software and interface requirements such as GUI, integral test, numerical stability, grid convergence study and system level test file development.

APPENDIX A. LIST OF SAMPLE TESTS

Following sample inputs are tested for RTM development of physics and numerical method of RELAP-7. The list of sample files is based on previous study (INL/EXT-14-33201). Some of files are missing due to update of the code sample development.

Test-01, Simple pipe flow

This case tests simplest 1-D isothermal flow with barotropic 2 equations model of water pipe flow at ambient pressure. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. `Inlet` and `Oulet` type of boundary condition was used. The `Pipe` has one volume with zero junctions. The SMP with Newton type solver JFNK is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-02, Heat transfer in heat exchanger

This case tests heat transfer models in a `HeatExchanger` component with sodium fluid on both sides. Primary fluid flows inside circular pipe and secondary side within parallel pipe bundle with square pitch. 1-D non-isotheraml flow 3 equations model with SUPG stabilization type was used. `LinearEquationOfStateProps` was used for both water and sodium. The component geometry was designed using TDV. The SMP with Newton type solver FDP_PJFNK is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 1000 times of calculation step. The output generates `Exodus` type file.

Test-03, Heat transfer of nitrogen in the pipe

This case tests heat transfer models in `Pipe` component filled with nitrogen. 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization type. The pipe has two time dependent volumes linked with one time dependent junction. The working fluid is nitrogen (using `N2Properties`). The `HT_geometry_code` is 101 which stand for single phase fluid flow in pipe. The SMP with Newton type solver PJFNK is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 100 times of calculation step. The output generates `Exodus` type file.

Test-04, Heat transfer of water in the pipe

This case tests heat transfer models in `Pipe` component filled with water. 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization type. The pipe has two time dependent volumes linked with one time dependent junction. The working fluid is water (using `LinearEquationOfStateProps`).

The `HT_geometry_code` is 101 which stand for single phase fluid flow in pipe. The SMP with Newton type solver PJFNK is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 50 times of calculation step. The output generates `Exodus` type file.

Test-05, Heat transfer model in core channel

This case tests heat transfer models in a `CoreChannel` pipe component with typical PWR valve. 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization type. The property of water uses `LinearEquationOfStateProps`. Core fuel, gap and cladding materials are defined. `Reactor` and `CoreChannel` components are used. The `CoreChannel` has two time dependent volumes linked with one time dependent junction. The `HT_geometry_code` is 110 which stand for single phase fluid flow within rod bundles. Cylindrical fuel was modeled. The SMP with Newton type solver PJFNK is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-06, Simple pipe flow with weakly imposed boundary condition

This case tests 1-D non-isothermal flow with 3 equations model using `StiffenedGasEquationOfState`. No stabilization coefficient was used. `Inlet` and `Oulet` type of weakly imposed boundary condition was used. The pipe has one volume with zero junctions. The SMP with Newton type solver PJFNK is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-07, Shock capturing

This case tests shock capturing model in `Pipe` component filled with water. 1-D non-isotheraml flow 3 equations model with SUPG stabilization type. Two `Pipe`s are linked with a `FlowJunction` has two time dependent volumes linked with one time dependent junction. The working fluid is water (using `LinearEquationOfStateProps`). The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 30 times of calculation step. The output generates `Exodus` type file.

Test-08, Simple pipe flow with 3 equation model.

This case tests simple water flow in `Pipe` component using 1-D non-isotheraml flow 3 equations model. No stabilization option. `Inlet` and `Oulet` type of boundary condition was used. The `Pipe` has one volume with zero junctions. Two `Pipe`s are linked with a `FlowJunction` which has two time dependent volumes linked with one time dependent junction. The working fluid is water (using `LinearEquationOfStateProps`). The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-09, Energy hammer (file missing)

Currently this test is not invoked in the RTM.

Test-10, Different stabilization option in components

This case uses two different stabilization options. `Pipe1` component uses `SUPG` and the `Pipe2` has no stabilization option. The 1-D non-isotheraml flow 3 equations model is used for solving the problem. No stabilization option was used. The `Pipe` has one volume with zero junctions. Two `Pipes` are linked with a `Branch`. For boundary condition, the `Inlet` is linked with `Pipe1` and `Oulet` is linked with `Pipe2`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-11, Water hammer

This case tests water hammer effect in `Pipe` component using 1-D non-isotheraml flow 3 equations model. No `SUPG` stabilization option is used. The property of gasr uses `StiffenedGasEquationOfState.` The `Pipe` component has 200 elements. The inlet and outlet boundary condition use `SolidWall`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-12, Decay heat behavior in reactor

This case tests decay heat behavior in the `Reactor` component. 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization type. The water property uses `LinearEquationOfState`. The decay heat function uses `PiecewiseLinear` for the decay heat curve. The `Reactor` has two `CoreChannel` and linked with two pipes with `Branch` for inlet and oulet of water flow. The inlet `Pipe1` is linked with `TimeDependentJunction` and outlet `Pipe2` is linked with `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-13, Simple pipe flow of nitrogen gas

This case tests simple nitrogen gas flow in `Pipe` component using 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization option. The property of nitrogen uses `N2Properites`. The `Pipe` component has 10 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-14, Simple pipe flow of non-isothermal gas

This case tests simple nitrogen gas flow in `Pipe` component using 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization option. The property of gas uses `LinearEquationOfState`. The `Pipe` component has 10 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-15, Stiffened gas equation for liquid

This case tests stiffened gas equation for water in `Pipe` component using 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization option. The property of water uses `StiffenedGasEquationOfStateLiquid.` The `Pipe` component has 100 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-16, Stiffened gas equation for vapor

This case tests stiffened gas equation for water in `Pipe` component using 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization option. The property of water vapor uses `StiffenedGasEquationOfStateVapor.` The `Pipe` component has 10 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-17, Simple non-isothermal flow in pipe

This case tests 1-D non-isothermal flow of water pipe flow with `SUPG` stabilization option. The water property uses `BarotropicEquationOfState`. The `Pipe` component has 10 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with

PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-18, Pipe flow test with two-phase homogeneous equilibrium model (HEM)

This case tests middle void flow without heating in `Pipe` component using HEM two-phase flow model with `SUPG` stabilization option. The property of water uses `TwoPhaseStiffenedGasEquationOfState`. The `Pipe` component has 50 elements. `Inlet` and `Outlet` boundary condition to `Pipe` uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-19, Pipe flow test with transient boundary condition two-phase homogeneous equilibrium model (HEM)

This case tests middle void flow without heating in `Pipe` component using HEM two-phase flow model with `SUPG` stabilization option. The property of water uses `TwoPhaseStiffenedGasEquationOfState`. The `Pipe` component has 50 elements. `Inlet` and `Outlet` boundary condition to `Pipe` uses `TimeDependentVolume`. The both boundary conditions use `ParsedFunction` for analytic function. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-20, Pipe transition flow test with two-phase homogeneous equilibrium model (HEM)

This case tests phase transition from single-phase water to two-phase in `Pipe` component using HEM two-phase flow model. No stabilization option is used. The property of water uses `TwoPhaseStiffenedGasEquationOfState`. The `Pipe` component has 50 elements. `Inlet` and `Outlet` boundary condition to `Pipe` uses `TimeDependentVolume`. The `Inlet` boundary conditions use `ParsedFunction` for analytic heating function. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 5 times of calculation step. The output generates `Exodus` type file.

Test-21, Core channel heat transfer test with two-phase homogeneous equilibrium model (HEM)

This case tests flow through the BWR core channel in `CoreChannel` component using HEM two-phase flow with wall friction and heat transfer model. No stabilization option is used. The property of water uses `TwoPhaseStiffenedGasEquationOfState`. The `Reactor` has one `CoreChannel` of 50 elements and linked with inlet and oulet boundary conditions. `Inlet` and `Outlet` boundary condition to `Pipe` uses `TimeDependentVolume`. The `Inlet` boundary conditions use `ParsedFunction` for analytic heating function. The decay heat curve uses `PiecewiseLinear` function. The fuel, gap and cladding material uses `SolidMaterialProperites`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 5 times of calculation step. The output generates `Exodus` type file.

Test-22, nozzle_liquid_only_stagnationPTinlet_staticPoutlet (file missing)

Currently this test is not invoked in the RTM.

Test-23, Two-phase flow with pressure and volume relaxation model in nozzle

This case tests two-phase flow in `Pipe` component using 1-D 2-phase flow 7 equations model with `LAPIDUS` stabilization option. For 7 equation parameters, both pressure and volume relaxation models are used. The property of water uses `StiffenedGasEquationOfStateLiquid` for liquid phase and `StiffenedGasEquationOfStateVapor` for vapor phase. The nozzle type uses `ParsedFunction`. The `Pipe` component has 100 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme using `SolutionTimeAdaptiveDT` for timstepping. The output generates `Exodus` type file.

Test-24, nozzle_2phase_separated_stagnationPTinlet_staticPoutlet (file missing)

Currently this test is not invoked in the RTM.

Test-25, nozzle_vapor_only_StrongPTinlet_StrongPoutlet (file missing)

Currently this test is not invoked in the RTM.

Test-26, Two-phase flow with interfacial mass transfer model in nozzle

This case tests two-phase flow in `Pipe` component using 1-D 2-phase flow 7 equations model with `LAPIDUS` stabilization option. For 7 equation parameters, both pressure and volume relaxation models are used. The mass transfer at interface model was used. The property of water uses `StiffenedGasEquationOfStateLiquid` for liquid phase and `StiffenedGasEquationOfStateVapor` for vapor phase. The nozzle type uses `ParsedFunction`. The `Pipe` component has 100 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme using `SolutionTimeAdaptiveDT` for timstepping. The output generates `Exodus` type file.

Test-27, nozzle_vapor_only_stagnationPTinlet_staticPoutlet (file missing)

Currently this test is not invoked in the RTM.

Test-28, Two-phase flow in pipe

This case tests two-phase flow in `Pipe` component using 1-D 2-phase flow 7 equations model with `LAPIDUS` stabilization option. For 7 equation parameters, the pressure and volume relaxation models and the interfacial mass transfer model were used. The property of water uses `StiffenedGasEquationOfStateLiquid` for liquid phase and `StiffenedGasEquationOfStateVapor` for vapor phase. The `Pipe` component has 50 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme used for 10 times of calculation step. The output generates `Exodus` type file.

Test-29, Water boling in the pipe

This case tests water boiling in `Pipe` component using 1-D 2-phase flow 7 equations model with `LAPIDUS` stabilization option. For 7 equation parameters, the pressure and volume relaxation models and the interfacial mass transfer model were used. The property of water uses `StiffenedGasEquationOfStateLiquid` for liquid phase and `StiffenedGasEquationOfStateVapor` for vapor phase. The `Pipe` component has 100 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme used for 20 times of calculation step. The output generates `Exodus` type file.

Test-30, Water boling in the pipe using constant source term

This case tests water boiling in `Pipe` component using 1-D 2-phase flow 7 equations model with `LAPIDUS` stabilization option. For 7 equation parameters, the pressure and volume relaxation models and the interfacial mass transfer model were used. The element contstant source term was used for heat source. The property of water uses `StiffenedGasEquationOfStateLiquid` for liquid phase and `StiffenedGasEquationOfStateVapor` for vapor phase. The `Pipe` component has 100 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme used for 20 times of calculation step. The output generates `Exodus` type file.

Test-31, Water boling in the pipe with large void fraction

This case tests water boiling in `Pipe` component using 1-D 2-phase flow 7 equations model with `LAPIDUS` stabilization option. For 7 equation parameters, the pressure and volume relaxation models and the interfacial mass transfer model were used. The void fraction was modeled with wall mass transfer model. The property of water uses `StiffenedGasEquationOfStateLiquid` for liquid phase and `StiffenedGasEquationOfStateVapor` for vapor phase. The `Pipe` component has 50 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme used for 10 times of calculation step. The output generates `Exodus` type file.

Test-32, Lapidus stabilization

This case tests `LAPIDUS` stabilization option in `Pipe` component using 1-D non-isotheraml flow 3 equations model. The property of gas uses `StiffenedGasEquation`. The `Pipe` component has 50 elements. `Inlet` and `Oulet` type of boundary condition of `TimeDependentVolume` was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 5 times of calculation step. The output generates `Exodus` type file.

Test-33, Entropy viscosity stabilization

This case tests `ENTROPY_VISCOSITY` stabilization option in `Pipe` component using 1-D non-isotheraml flow 3 equations model. The property of gas uses `StiffenedGasEquation`. The `Pipe` component has 100 elements. `Inlet` boundary condition uses `TimeDependentMass` and `Oulet` boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `BDF2` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-34, Entropy viscosity stabilization with homogeneous equilibrium model (HEM)

This case tests `ENTROPY_VISCOSITY` stabilization option in `Pipe` component using HEM two-phase flow model. The property of gas uses `TwoPhaseStiffenedGasEquationOfState`. The `Pipe` component has 50 elements. `Inlet` and `Outlet` boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `BDF2` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-35, Pressure stabilization of air flow

This case tests `PRESSURE` stabilization option in `Pipe` component using 1-D non-isotheraml flow 3 equations model. The property of gas uses `StiffenedGasEquationOfState`. The `Pipe` component has 50 elements. `Inlet` and `Outlet` type of boundary condition is used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-36, Pressure stabilization of water flow

This case tests `PRESSURE` stabilization option in `Pipe` component using 1-D non-isotheraml flow 3 equations model. The property of water uses `StiffenedGasEquationOfState`. The `Pipe` component has 50 elements. `Inlet` and `Outlet` type of boundary condition is used. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-37, Wall friction modeling in pipe

This case tests wall friction model of laminar, transitional, to turbulent flow in `Pipe` component using 1-D 2-phase flow 7 equations model with `SUPG` stabilization option. The property of water uses `LinearEquationOfStateProps`. The `Pipe` component has 10 elements. `Inlet` and `Outlet` boundary condition to `Pipe` uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `BDF2` numerical scheme are used for 100 times of calculation step. The output generates `Exodus` type file.

Test-38, Simple liquid metal reactor loop

This case tests liquid metal nuclear reactor one coolant loop with 1D non-isothermal flow 3 equations model. No stabilization option is used. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. The `Reactor` component is modeled with one `CoreChannel`. `Pipe` and `Branch` is used for coolant loop. The IHX is modeled with `HeatExchanger` component. The inlet boundary condition uses the `TimeDependentJunction` and the outlet boundary conditions are set with `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 5 times of calculation step. The output generates `Exodus` type file.

Test-39, PWR core channel flow using 1-D non-isothermal 3 equation model

This case tests 1-D non-isothermal flow in PWR core channel flow using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The material properties of fuel, gap and cladding use `SolidMaterialProperties`. The `Reactor` and `CoreChannel` components are used for PWR core simulation. The `Inlet` and `Outlet` use `TimeDependentVolume` boundary condition. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-40, PWR multiple core channel flow using 1-D non-isothermal 3 equation model

This case tests 1-D non-isothermal flow in PWR multiple core channel flow using 3 equations model with `SUPG` stabilization option. The property of liquid uses `IdealGasEquationOfState`. The material properties of fuel, gap and cladding use `SolidMaterialProperties`. The `Reactor` and two `CoreChannel` components are used for PWR core simulation. Each `CoreChannel` is linked with `Pipe` component with `Branch`. The `Pipe` is linked with `TimeDependentVolume` `Inlet` and `Outlet` boundary condition. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-41, PWR core channel flow using 1-D non-isothermal 3 equation model with functional material property

This case tests 1-D non-isothermal flow in PWR core channel flow using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The material properties of fuel, gap and cladding use `PiecewiseLinear` functional `SolidMaterialProperties`. The `Reactor` and `CoreChannel` components are used for PWR core simulation. The `Inlet` and `Outlet` use `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-42, Cylinder fuel core channel flow using 1-D non-isothermal 3 equation model

This case tests 1-D non-isothermal flow in cylinder fuel core channel flow using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The material properties of fuel and cladding use `SolidMaterialProperties`. The `Reactor` and `CoreChannel` components are used for cylinder fuel core simulation. The `Inlet` and `Outlet` use `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-43, Multiple core channel flow using 1-D non-isothermal 3 equation model

This case tests 1-D non-isothermal flow in multiple core channel flow using 3 equations model with `SUPG` stabilization option. The property of liquid uses `IdealGasEquationOfState`. The material properties of fuel, gap and cladding use `SolidMaterialProperties`. The `Reactor` and two `CoreChannel` components are used for multiple core simulation. Each `CoreChannel` is linked with `Pipe` component with `Branch`. The `Pipe` is linked with boundary conditions. The `Inlet` uses `TimeDependentJunction` boundary condition and the `Outlet` uses `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is

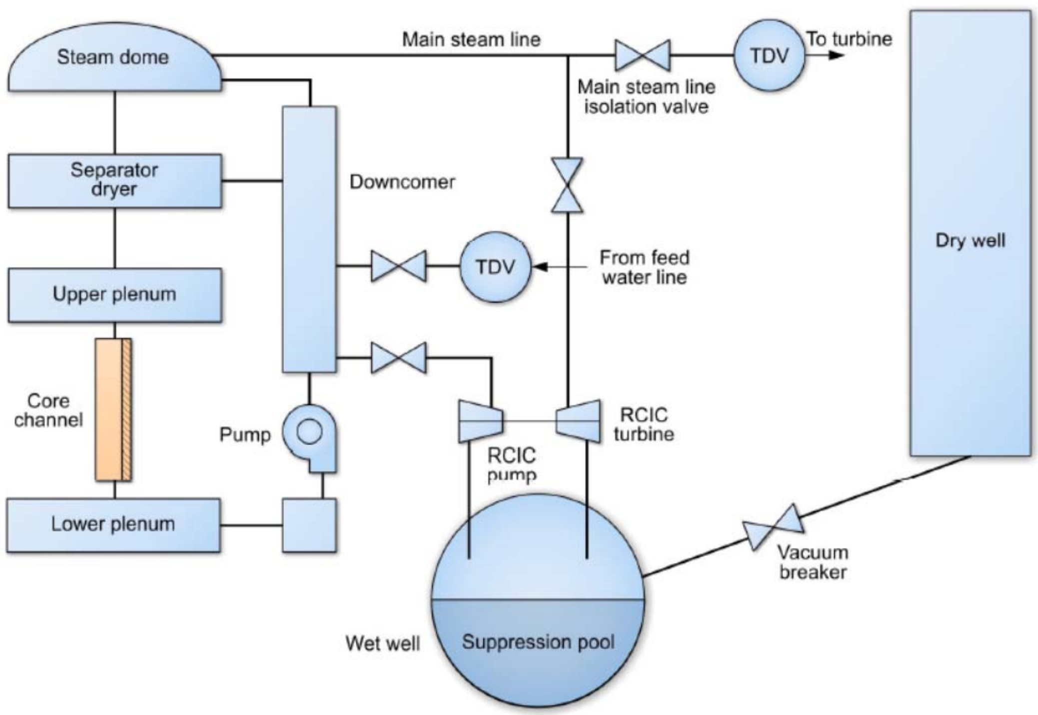
`Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-44, Plate fuel core channel flow using 1-D non-isothermal 3 equation model

This case tests 1-D non-isothermal flow in plate fuel core channel flow using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The material properties of fuel, gap and cladding use `SolidMaterialProperties`. The `Reactor` and `CoreChannel` components are used for plate core simulation. The `Pipe` is linked with boundary conditions. The `Inlet` uses `TimeDependentJunction` boundary condition and the `Outlet` uses `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` numerical scheme are used for 50 times of calculation step. The output generates `Exodus` type file.

Test-45, BWR core channel flow using HEM two-phase model (OECD/NEA benchmark case)

This case tests two-phase flow in BWR core channel flow using HEM model with `SUPG` stabilization option. The property of two-phases uses `TwoPhaseStiffenedGasEquationOfState`. The material properties of fuel, gap and cladding use `SolidMaterialProperties`. The `Reactor` and `CoreChannel` components are used for BWR core simulation. The `Inlet` and `Outlet` use `TimeDependentVolume` boundary condition. The Inlet boundary condition uses `ParsedFunction`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for maximum 1000 times of calculation step. The output generates `Exodus` type file.



Test-46, User defined power shaped core channel flow using 1-D non-isothermal 3 equations model

This case tests 1-D non-isothermal flow in cylinder fuel core channel flow using user defined power shape and 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The material properties of fuel and cladding use `SolidMaterialProperties`. The `Reactor` and `CoreChannel` components are used for cylinder fuel core simulation. The core power is defined with `PicewiseFunction`. The `Inlet` uses `TimeDependentJunction` boundary condition and the `Outlet` uses `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 2 times of calculation step. The output generates `Exodus` type file.

Test-47, Core channel flow using 1-D two-phase 7 equations model

This case tests 1-D two-phase flow in cylinder fuel core channel flow using 7 equations model with `SUPG` stabilization option. The properties of liquid uses `StiffenedGasEquationOfStateLiquid` and gas uses `StiffenedGasEquationOfStateGas`. The material properties of fuel use `SolidMaterialProperties`. The `Reactor` and `CoreChannel` components are used for cylinder fuel core simulation. The `Inlet` and `Outlet` use as boundary conditions. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-48, Junction flow test (basic model without junction)

This case is basic model for junction flow with one `Pipe` component. The model uses 1-D non-isothermal 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The `Pipe` component has 25 elements. The inlet boundary condition uses `TDM` and outlet boundary condition uses `Outlet`. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-49, Junction flow test with one junction and two pipes

This case tests junction flow linked with two identical `Pipe` components. The model uses 1-D non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `LinearEquationOfState`. Both `Pipe` components have 25 elements and linked with one `FlowJunction` component. The inlet boundary condition uses `TDM` and outlet boundary condition uses `Outlet`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 30 times of calculation step. The output generates `Exodus` type file.

Test-50, Junction flow test with one junction and two pipes of different size (flow from small to large pipe)

This case tests junction flow linked with two different size `Pipe` components. The model uses 1-D non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `LinearEquationOfState`. Both `Pipe` components have 25 elements and linked with one `FlowJunction` component. The flow area of pipe2 is twice larger than pipe1 component. The inlet boundary condition uses `TDM` and outlet boundary condition uses `Outlet`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 30 times of calculation step. The output generates `Exodus` type file.

Test-51, Junction flow test with one junction and two pipes of different size (flow from large to small pipe)

This case tests junction flow linked with two different size `Pipe` components. The model uses 1-D non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `LinearEquationOfState`. Both `Pipe` components have 25 elements and linked with one `FlowJunction` component. The flow area of pipe1 is twice larger than pipe2 component. The inlet boundary condition uses `TDM` and outlet boundary condition uses `Outlet`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 30 times of calculation step. The output generates `Exodus` type file.

Test-52, Junction flow test with one junction and three pipes

This case tests junction flow linked with three identical `Pipe` components. The model uses 1-D non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `LinearEquationOfState`. Both `Pipe` components have 25 elements and linked with one `FlowJunction` component. The junction input is pipe1 and outputs are pipe2 and pipe3. The inlet boundary condition uses `TDM` and outlet boundary conditions use `Outlet`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 30 times of calculation step. The output generates `Exodus` type file.

Test-53, Junction flow test with one junction and three pipes (flow from large to small pipe)

This case tests junction flow linked with one large `Pipe` component to two small identical `Pipe` components. The model uses 1-D non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `LinearEquationOfState`. Both `Pipe` components have 25 elements and linked with one `FlowJunction` component. The junction input is large pipe1 and outputs are small pipe2 and pipe3. The inlet boundary condition uses `TDM` and outlet boundary conditions use `Outlet`. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-54, Isothermal pump loop flow

This case tests isothermal pump loop flow using 2 equations model. No stabilization option is used. The property of liquid uses `BarotropicEquationOfState`. An isothermal `Pump` component is linked with two `Pipe` components. Other `Pipe` components are linked using `Branch` components. The outlet boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 time steps. The output generates `Exodus` type file.

Test-55, Isothermal pump flow

This case tests isothermal pump flow using 2 equations model. No stabilization option is used. The property of liquid uses `BarotropicEquationOfState`. An isothermal `Pump` component is linked between two `Pipe` components. The inlet and outlet boundary conditions of `Pipe` components use `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 time steps. The output generates `Exodus` type file.

Test-56, Ideal pump flow

This case tests non-isothermal pump flow using 3 equations model. No stabilization option is used. The property of liquid uses `LinearEquationOfState`. An `IdealPump` component is linked between two `Pipe` components. The inlet and outlet boundary conditions of `Pipe` components use `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 time steps. The output generates `Exodus` type file.

Test-57, Isothermal pump reverse flow

This case tests isothermal pump reserve flow using 2 equations model using `SUPG` stabilization option. The property of liquid uses `BarotropicEquationOfState`. An isothermal `Pump` component is linked between two `Pipe` components. The inlet and outlet boundary conditions of `Pipe` components use `TimeDependentVolume`. The pressure of outlet boundary condition is higher than inlet boundary condition makes reverse pump flow. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 time steps. The output generates `Exodus` type file.

Test-58, Non-isothermal pump loop flow

This case tests non-isothermal pump loop flow using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. A `Pump` component is linked with two `Pipe` components. Other `Pipe` components are linked using `Branch` components. The outlet boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 time steps. The output generates `Exodus` type file.

Test-59, Non-isothermal pump flow

This case tests non-isothermal pump flow using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. A `Pump` component is linked between two `Pipe` components. The inlet and outlet boundary conditions of `Pipe` components use `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 time steps. The output generates `Exodus` type file.

Test-60, Isothermal pump start flow

This case tests isothermal pump start flow using 2 equations model. No stabilization option is used. The property of liquid uses `BarotropicEquationOfState`. An isothermal `Pump` component is linked between two `Pipe` components. The form loss coefficient of the pump is set with 1000 to model the pump start. The inlet and outlet boundary conditions of `Pipe` components use `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 time steps. The output generates `Exodus` type file.

Test-61, Turbine driven pump flow

This case tests turbine driven non-isothermal pump flow using 3 equations model. The property of water uses `StiffenedGasEquationOfStateLiquid` and the property of vapor uses `StiffenedGasEquationOfStateVapor`. Two loops are designed: vapor loop with turbine; and water loop with pump. The `Turbine` of vapor loop is linked between two `Pipe` components. The `LAPIDUS` stabilization option is used for both pipe components. The `Pump` of water loop uses turbine as driving component. The linked `Pipe` components use `SUPG` stabilization option. The inlet and outlet boundary conditions of both loops use `TimeDependentVolume`. The inlet boundary condition of vapor loop uses `ParsedFunction`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 time steps. The output generates `Exodus` type file.

Test-62, BWR wet well test with given boundary condition

This case tests BWR wet well non-isothermal 3 equations model with `SUPG` stabilization option. The property of vapor uses `StiffenedGasEquationOfStateVapor`, liquid uses `StiffenedGasEquationOfStateLiquid` and nitrogen property uses `N2Properties`. A vapor loop is modeled for steam injection and water loop is modeled for water drawing back. A gas vent loop is designed for venting to dry well. The valve is modeled with `Branch` component and wet well uses `WetWell` component. Five `Pipe` components are used. The inlet and outlet boundary conditions use `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 5 time steps. The output generates `Exodus` type file.

Test-63, Sub-channel flow test

This case test sub-channel flow in the `Reactor` component using 1-D non-isotheraml flow 3 equations model. No stabilization option is used. The water property uses `LinearEquationOfStateProps`. The fuel, gap and clad material properties are modeled with `SolidMaterialProperties`. The `Reactor` has one `Subchannel` and linked with two `Pipe` components with `SubchannelBranch` for inlet and oulet of water flow. The inlet boundary condition uses `TimeDependentMass` and outlet boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` numerical scheme are used for 5 times of calculation step. The output generates `Exodus` type file.

Test-64, BWR wet well test with zero flow rates into the volume

This case tests BWR wet well non-isothermal 3 equations model. No stabilization option is used. The property of vapor uses `StiffenedGasEquationOfStateVapor`, liquid uses `StiffenedGasEquationOfStateLiquid` and nitrogen property uses `N2Properties`. A vapor loop is modeled for steam injection using `VolumeBranch` type valve. The water loop uses `SUPG` stabilization option and `IdealPump` to simulate water drawing back. A gas vent loop also uses `SUPG` stabilization option and SolidWall type valve for venting to dry well. The wet well uses `WetWell` component. Five `Pipe` components are used. The inlet and outlet boundary conditions use `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 5 time steps. The output generates `Exodus` type file.

Test-65, Point kinetics model with reactivity table

This case tests varying reactivity point kinetics model using 1-D non-isothermal flow 3 equations model with `SUPG` stabilization option. The water property uses `LinearEquationOfState`. A `Reactor` is with `PointKinetics` option of `PicewiseLinear` reactivity function. The `Pipe` component has 20 elements. `Inlet` and `Outlet` boundary conditions are `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-66, Coupled point kinetics model with reactivity table

This case test coupled point kinetics model using 1-D non-isothermal flow 3 equations model. No stabilization option is used. The water property uses `LinearEquationOfState`. The fuel, gap and clad material properties are modeled with `SolidMaterialProperties`. The `Reactor` has two `CoreChannel` components and linked with two `Pipe` components with `Branch` for inlet and oulet of water flow. The `PointKinetics` option uses `PicewiseLinear` reactivity function. The inlet and outlet boundary conditions are `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-67, Point kinetics model with constant reactivity test

This case tests constant reactivity point kinetics model using 1-D non-isothermal flow 3 equations model with `SUPG` stabilization option. The water property uses `LinearEquationOfState`. A

`Reactor` is with `PointKinetics` option of constant reactivity value. The `Pipe` component has 20 elements. `Inlet` and `Outlet` boundary conditions are `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-68, Branch flow test with two pipes

This case tests branch flow linked with two identical `Pipe` components. The model uses 1-D non-isothermal 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. Both `Pipe` components have 10 elements and linked with one `VolumeBranch` component. The inlet boundary condition uses `TimeDependentJunction` and outlet boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-69, Branch flow test with three pipes in and two pipes out

This case tests branch flow linked with five identical `Pipe` components. The model uses 1-D non-isothermal 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. All `Pipe` components have 10 elements. Three pipes are linked with one `VolumeBranch` component as inlet and two pipes are linked as outlet. The inlet boundary condition uses `TimeDependentJunction` and outlet boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-70, components/pipe_to_pipe_junction pipe_to_pipe_1_1 (file missing)

Currently this test is not invoked in the RTM.

Test-71, Solid wall modeling with 3 equation model

This case tests solid wall boundary condition of `Pipe` component using 1-D non-isotheraml flow 3 equations model with `PRESSURE` stabilization model. The property of gas uses `IdealGasEquationOfState`. The `Pipe` component has 100 elements. `Inlet` boundary condition has constant temperature and pressure. The `Outlet` boundary condition is uses `SolidWall` option. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-72, Non-isothermal pipe flow with strong time dependent volume boundary conditions

This case tests strong time dependent volume boundary conditions using 1-D non-isothermal flow 3 equations model with `SUPG` stabilization option. The water property uses `NonIsothermalEquationOfState`. The `Pipe` component has 10 elements. `Inlet` and `Outlet` boundary conditions are `TimeDependentVolume` and set as weak boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 40 times of calculation step. The output generates `Exodus` type file.

Test-73, HEM two-phase pipe flow with strong time dependent volume boundary conditions

This case tests strong time dependent volume boundary conditions using HEM two-phase flow model with `SUPG` stabilization option. The water property uses `TwoPhaseStiffenedGasEquationOfState`. The `Pipe` component has 10 elements. `Inlet` and `Outlet` boundary conditions are `TimeDependentVolume` and set as weak boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 40 times of calculation step. The output generates `Exodus` type file.

Test-74, Solid wall modeling with 7 equation model

This case tests solid wall boundary condition of `Pipe` component using 1-D two-phase flow 7 equations model with `PRESSURE` stabilization model. The property of water uses `StiffenedGasEquationOfStateLiquid` for liquid phase and `StiffenedGasEquationOfStateVapor` for vapor phase. The `Pipe` component has 100 elements. `Inlet` boundary condition has constant properties. The `Outlet` boundary condition is uses `SolidWall` option. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-75, Isothermal pipe chain flow

This case tests three pipe chain flow linked with two junctions. The model uses isothermal 2 equations model. No stabilization option is used. The property of liquid uses `BarotropicEquationOfState`. Each `Pipe` components are linked with a `Branch` component. The inlet and outlet boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-76, Isothermal pipe chain flow with two pipes in and three pipes out

This case tests isothermal two pipe in and three pipes out linked with one junction. The model uses isothermal 2 equations model. No stabilization option is used. The property of liquid uses

`BarotropicEquationOfState`. Two `Pipe` components are linked with three `Pipe` components with one `Branch` component. The inlet and outlet boundary condition uses `TimeDependentVolume`. The pressure of outlet boundary condition is lower than inlet boundary condition for natural flow. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used until 0.02 sec. The output generates `Exodus` type file.

Test-77, Isothermal pipe chain flow with two pipes in and three pipes out (no flow)

This case tests isothermal two pipe in and three pipes out linked with one junction. The model uses isothermal 2 equations model. No stabilization option is used. The property of liquid uses `BarotropicEquationOfState`. Two `Pipe` components are linked with three `Pipe` components with one `Branch` component. The inlet and outlet boundary condition uses `TimeDependentVolume`. The pressure of both inlet and outlet boundary conditions are same and no flow will be occurred. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 100 time steps. The output generates `Exodus` type file.

Test-78, Non-isothermal pipe chain flow with two pipes in and three pipes out

This case tests non-isothermal two pipe in and three pipes out linked with one junction. The model uses non-isothermal 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. Two `Pipe` components are linked with three `Pipe` components with one `Branch` component. The inlet boundary condition uses `TimeDependentJunction` and outlet boundary condition uses `TimeDependentVolume`. The pressure of outlet boundary condition is lower than inlet boundary condition for natural flow. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 time steps. The output generates `Exodus` type file.

Test-79, Isothermal pipe chain flow with two pipes in and three pipes out (no form loss)

This case tests isothermal two pipe in and three pipes out linked with one junction. The model uses isothermal 2 equations model. No stabilization option is used. The property of liquid uses `BarotropicEquationOfState`. Two `Pipe` components are linked with three `Pipe` components with one `Branch` component. Form loss with friction is not modeled. The inlet and outlet boundary condition uses `TimeDependentVolume`. The pressure of both inlet and outlet boundary conditions are same and no flow will be occurred. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 100 time steps. The output generates `Exodus` type file.

Test-80, Isothermal pipe chain flow with stabilization option

This case tests three pipe chain flow linked with two junctions. The model uses isothermal 2 equations model with `SUPG` stabilization option. The property of liquid uses `BarotropicEquationOfState`. Each `Pipe` components are linked with a `Branch` component. The inlet and outlet boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-81, Non-isothermal pipe chain flow

This case tests three pipe chain flow linked with two junctions. The model uses non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `LinearEquationOfState`. Each `Pipe` components are linked with a `Branch` component. The inlet and outlet boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-82, BWR down comer test

This case tests BWR down comer using non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `StiffenedGasEquationOfStateLiquid`. Four `Pipe` components are used. The dome of BWR is modeled with `VolumeBranch` and down comer is modeled with `DownComer`. The inlet and outlet boundary conditions use `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 time steps. The output generates `Exodus` type file.

Test-83, Isothermal pipe flow with time dependent volume boundary conditions

This case tests 1-D isothermal flow with barotropic 2 equations model with `SUPG` stabilization option. The water property uses `BarotropicEquationOfState`. The `Pipe` component has 10 elements. `Inlet` and `Outlet` boundary conditions are time dependent volume. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 20 times of calculation step. The output generates `Exodus` type file.

Test-84, Isothermal pipe flow with time dependent volume boundary conditions and functional initial conditions

This case tests 1-D isothermal flow with barotropic 2 equations model with `SUPG` stabilization option. The water property uses `BarotropicEquationOfState`. The initial pressure and velocity distribution is set by `PiecewiseLinear` function. The `Pipe` component has 10 elements. `Inlet` and `Outlet` boundary conditions are time dependent volume. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 20 times of calculation step. The output generates `Exodus` type file.

Test-85, Two-phase pipe flow with HEM model using time dependent volume boundary conditions and functional initial conditions

This case tests two-phase flow with HEM model. No stabilization option was used. The property uses `TwoPhaseStiffenedGasEquationOfState`. The initial pressure, velocity, temperature and void fraction distribution is set by `PiecewiseLinear` function. The `Pipe` component has 100 elements. `Inlet` and `Outlet` boundary conditions are time dependent volume. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 20 times of calculation step. The output generates `Exodus` type file.

Test-86, Two-phase pipe flow with 7 equation model using time dependent volume boundary conditions and functional initial conditions

This case tests two-phase flow with 1-D 7 equation model using `LAPIDUS` stabilization option. The property of both liquid and vapor uses `TwoPhaseStiffenedGasEquationOfState`. The initial pressure, velocity, temperature and void fraction distribution is set by `PiecewiseLinear` function. The `Pipe` component has 50 elements. `Inlet` and `Outlet` boundary conditions have constant pressure, temperature and volume franction. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-87, Constant wall heat flux pipe water flow 1-D non-isothermal 3 equation model

This case tests 1D non-isothermal flow with 3 equation model using `LAPIDUS` stabilization option. The property of liquid uses `IdealGasEquationOfState`. The pipe wall is heated with constant heat flux of 1000 and has 20 elements. `Inlet` boundary condition has constant heat transfer coefficient and momentum. The `Outlet` boundary condition has constant pressure. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` numerical scheme is used for 20 times of calculation step. The output generates `Exodus` type file.

Test-88, 1-D Non-isothermal flow through 3 pipes and 2 junctions

This case tests 1-D non-isothermal flow through 3 pipes and 2 junctions using 3 equations model with `SUPG` stabilization option. The water property uses `BarotropicEquationOfState`. Three `Pipe` components has same geometric configuration (20 elements). `Branch` type of junction is used to link pipes. `Inlet` and `Outlet` boundary conditions are time dependent volume. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-89, 1-D Non-isothermal flow through vertical chain pipes having gravity effect

This case tests 1-D non-isothermal flow through vertical chain pipes using 3 equations model with `SUPG` stabilization option. The water property uses `LinearEquationOfState`. Five `Pipe` components are linked as vertical position, and the liquid has gravity effect. `Branch` type of junction is used to link pipes. `Inlet` and `Outlet` boundary conditions are time dependent volume. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 20 times of calculation step. The output generates `Exodus` type file.

Test-90, Heated wall pipe flow with time dependent junction and volume boundary conditions

This case tests heated wall `Pipe` component using 1-D non-isotheraml flow 3 equations model. No stabilization option. The water property uses `LinearEquationOfState`. The `Pipe` has 20 elements, and has constant wall temperature and heat transfer coefficient. The `Inlet` uses `TimeDependentJunction` boundary condition and the `Outlet` uses `TimeDependentVolume` boundary condition. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-91, Friction analysis of heated wall pipe flow with time dependent junction and volume boundary conditions

This case tests heated wall `Pipe` component using 1-D non-isotheraml flow 3 equations model. No stabilization option. Element friction term will be analyzied. The water property uses `LinearEquationOfState`. The `Pipe` has 20 elements, and has constant wall temperature and heat transfer coefficient. The `Inlet` uses `TimeDependentJunction` boundary condition and the `Outlet` uses `TimeDependentVolume` boundary condition. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-92, Pipe flow with time dependent mass and volume boundary conditions

This case tests time dependent mass boundary condition `Pipe` component using 1-D non-isotheraml flow 3 equations model. No stabilization option. Element friction term will be analyzied. The water property uses `LinearEquationOfState`. The `Pipe` has 10 elements. The `Inlet` uses `TimeDependentMass` boundary condition and the `Outlet` uses `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-93, Pipe flow with time dependent mass boundary condition using 7 equations model

This case tests time dependent mass boundary condition of `Pipe` component using 1-D two-phase flow 7 equations model with `LAPIDUS` stabilization option. The property of liquid uses `StiffenedGasEquationOfStateLiquid` and vapor uses `StiffenedGasEquationOfStateVapor`. The `Pipe` has 20 elements. The `Inlet` uses `TimeDependentMass` boundary condition and the `Outlet` has constant pressure. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-94, Pipe flow with fuinctional time dependent mass boundary condition using 7 equations model

This case tests time dependent mass boundary condition of `Pipe` component using 1-D two-phase flow 7 equations model with `LAPIDUS` stabilization option. The property of liquid uses `StiffenedGasEquationOfStateLiquid` and vapor uses `StiffenedGasEquationOfStateVapor`. The `Pipe` has 20 elements. The `Inlet` uses `TimeDependentMass` boundary condition with `PiecewiseLinear` function. The `Outlet` has constant pressure. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-95, Pipe flow with time dependent junction and volume boundary conditions

This case tests `Pipe` component using 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization option. The water property uses `LinearEquationOfState`. The `Pipe` has 20 elements. The `Inlet` uses `TimeDependentJunction` boundary condition and the `Outlet` uses `TimeDependentVolume` boundary condition. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 100 times of calculation step. The output generates `Exodus` type file.

Test-96, Vertical pipe flow with time dependent junction and volume boundary conditions

This case tests vertical `Pipe` component using 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization option. The water property uses `LinearEquationOfState`. The vertical `Pipe` has 50 elements. The `Inlet` uses `TimeDependentJunction` boundary condition and the `Outlet` uses `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 100 times of calculation step. The output generates `Exodus` type file.

Test-97, Pipe flow with time dependent volume boundary conditions

This case tests `Pipe` component using 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization option. The water property uses `LinearEquationOfState`. The `Pipe` has 20 elements. The `Inlet` and `Outlet` use `TimeDependentVolume` boundary conditions. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 100 times of calculation step. The output generates `Exodus` type file.

Test-98, Pipe flow with functional time dependent junction and time dependent volume boundary conditions using HEM two-phase flow model

This case tests `Pipe` component using HEM two-phase flow model with `SUPG` stabilization option. The water property uses `TwoPhaseStiffenedGasEquationOfState`. The `Pipe` has 50 elements, and has constant wall temperature and heat transfer coefficient. The `Inlet` uses `TimeDependentJunction` boundary condition with `ParsedFunction`. The `Outlet` uses `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-99, Junction flow test with two junctions and three pipes using 3 equation model

This case tests junction flow linked with three `Pipe` components. The model uses 1-D non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `StiffenedGasEquationOfStateLiquid`. Three `Pipe` components are linked with `SimpleJunction` component. The inlet boundary condition uses `Inlet` and outlet boundary condition uses `Outlet`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-100, Junction flow test with two junctions and three pipes using 7 equation model

This case tests junction flow linked with three `Pipe` components. The model uses two-phase 7 equations model with `LAPIDUS` stabilization option. The property of liquid uses `StiffenedGasEquationOfStateLiquid` and vapor property uses `StiffenedGasEquationOfStateVapor`. Three `Pipe` components are linked with `SimpleJunction` component. The inlet boundary condition uses `Inlet` and outlet boundary condition uses `Outlet`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file.

Test-101, Heat exchanger flow using 1-D non-isothermal 3 equation model (1-D heat exchanger wall)

This case tests 1-D non-isothermal flow through heat exchanger using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The material property uses `SolidMaterialProperties`. The `HeatExchanger` component has 10 elements. The heat exchanger wall is 1-D modeled. The primary and secondary inlets and outlets use `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-102, Heat exchanger flow using HEM two-phase model

This case tests two-phase flow through heat exchanger using HEM model with `SUPG` stabilization option. The properties of two-phase liquid uses `TwoPhaseStiffenedGasEquationOfState` and water uses `StiffenedGasEquationOfStateLiquid`. The material property uses `SolidMaterialProperties`. The `HeatExchanger` component has 30 elements. The primary and secondary inlets and outlets use `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 5 times of calculation step. The output generates `Exodus` type file.

Test-103, Heat exchanger flow using 1-D non-isothermal 3 equation model (2-D heat exchanger wall

This case tests 1-D non-isothermal flow through heat exchanger using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The material property uses `SolidMaterialProperties`. The `HeatExchanger` component has 10 elements. The heat exchanger wall is 2-D modeled. The primary and secondary inlets and outlets use `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-104, Separate dryer test with zero initial vapor volume fraction

This case test separate fryer with zero initial vapor volume fraction using the HEM two-phase flow. No stabilization option is used. The property of two phase uses `TwoPhaseStiffenedGasEquationOfState`, vapor uses `StiffenedGasEquationOfStateVapor` and liquid uses `StiffenedGasEquationOfStateLiquid.` The `SeparateDryer` is linked with steam out and discharge `Pipe` components. The inlet and outlet boundary condition of `Pipe` uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-105, Separate dryer test with medium initial vapor volume fraction

This case test separate fryer with medium initial vapor volume fraction using the HEM two-phase flow. No stabilization option is used. The property of two phase uses `TwoPhaseStiffenedGasEquationOfState`, vapor uses `StiffenedGasEquationOfStateVapor` and liquid uses `StiffenedGasEquationOfStateLiquid.` The `SeparateDryer` is linked with steam out and discharge `Pipe` components. The inlet and outlet boundary condition of `Pipe` uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-106, Separate dryer test with large initial vapor volume fraction

This case test separate fryer with large initial vapor volume fraction using the HEM two-phase flow. No stabilization option is used. The property of two phase uses `TwoPhaseStiffenedGasEquationOfState`, vapor uses `StiffenedGasEquationOfStateVapor` and liquid uses `StiffenedGasEquationOfStateLiquid.` The `SeparateDryer` is linked with steam out and discharge `Pipe` components. The inlet and outlet boundary condition of `Pipe` uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-107, Constant inlet boundary condition with 3 equation model

This case tests constant boundary condition of `Pipe` component using 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The `Pipe` component has 10 elements. `Inlet` boundary condition has constant temperature and pressure. The `Outlet` boundary condition is uses `TimeDependentVolume` option. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 20 times of calculation step. The output generates `Exodus` type file.

Test-108, Constant inlet boundary condition with two-phase homogeneous equilibrium model (HEM)

This case tests constant boundary condition of `Pipe` component using two-phase homogeneous equilibrium model (HEM) with `SUPG` stabilization option. The property of vapor uses `TwoPhaseStiffenedGasEquationOfState`. The `Pipe` component has 20 elements. `Inlet` boundary condition has constant temperature and pressure. The `Outlet` boundary condition is uses

`TimeDependentVolume` option. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 20 times of calculation step. The output generates `Exodus` type file.

Test-109, Constant inlet and outlet boundary condition with 3 equation model

This case tests constant boundary condition of `Pipe` component using 1-D non-isotheraml flow 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The `Pipe` component has 10 elements. `Inlet` boundary condition has constant temperature and pressure. The `Outlet` boundary condition has constant pressure. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 100 times of calculation step. The output generates `Exodus` type file.

Test-110, Constant inlet and outlet boundary condition with two-phase homogeneous equilibrium model (HEM)

This case tests constant boundary condition of `Pipe` component using two-phase homogeneous equilibrium model (HEM) with `SUPG` stabilization option. The property of vapor uses `TwoPhaseStiffenedGasEquationOfState`. The `Pipe` component has 20 elements. `Inlet` boundary condition has constant temperature and pressure. The `Outlet` boundary condition has constant pressure. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 50 times of calculation step. The output generates `Exodus` type file.

Test-111, Stagnation inlet and static outlet boundary conditions with 7 equation model

This case tests stagnation inlet and static outlet boundary condition of `Pipe` component using 1-D two-phase flow 7 equations model with `LAPIDUS` stabilization option. The property of liquid uses `StiffenedGasEquationOfStateLiquid` and vapor uses `StiffenedGasEquationOfStateVapor`. The `Pipe` component has 50 elements. The `Inlet` uses stagnation boundary condition. The `Outlet` uses static boundary condition. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-112, Static boundary conditions with 7 equation model

This case tests static inlet and outlet boundary conditions of `Pipe` component using 1-D two-phase flow 7 equations model with `LAPIDUS` stabilization option. The property of liquid uses `StiffenedGasEquationOfStateLiquid` and vapor uses `StiffenedGasEquationOfStateVapor`. The `Pipe` component has 50 elements. The `Inlet` and

`Outlet` use static boundary condition. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-113, Mass transferring inlet boundary condition with 7 equation model

This case tests stagnation inlet and static outlet boundary condition of `Pipe` component using 1-D two-phase flow 7 equations model with `LAPIDUS` stabilization option. The `interface_transfer` option is used for defining mass flow rate of inlet boundary condition. The property of liquid uses `StiffenedGasEquationOfStateLiquid` and vapor uses `StiffenedGasEquationOfStateVapor`. The `Pipe` component has 100 elements. The `Inlet` boundary condition has constant mass flow rate and `Outlet` use static boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-114, Enthalpy and momentum inlet boundary condition with 3 equation model

This case tests enthalpy and momentum defiened inlet boundary condition of `Pipe` component using 1-D two-phase flow 3 equations model with `PRESSURE` stabilization option. The property of gas uses `IdealGasEquationOfState`. The `Pipe` component has 100 elements. The `Inlet` boundary condition has constant enthalpy and momentum. The `Outlet` use static boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-115, Stagnation temperature and pressure inlet boundary condition with steady flow 3 equation model

This case tests temperature and pressure defiened inlet boundary condition of `Pipe` component using 1-D two-phase flow 3 equations model. No stabilization option was used. For steady flow `initial_v` was defined. The property of gas uses `IdealGasEquationOfState`. The `Pipe` component has 100 elements. The `Inlet` boundary condition has constant temperature and pressure. The `Outlet` use static boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-116, Stagnation temperature and pressure inlet boundary condition with transient flow 3 equation model

This case tests temperature and pressure defiened inlet boundary condition of `Pipe` component using 1-D two-phase flow 3 equations model. No stabilization option was used. For transient flow `initial_v` was defined as zero. The property of gas uses `IdealGasEquationOfState`. The `Pipe` component has 100 elements. The `Inlet` boundary condition has constant temperature and pressure. The `Outlet` use static boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-117, Stagnation temperature and pressure inlet boundary condition with transient flow 7 equation model

This case tests temperature and pressure defiened inlet boundary condition of `Pipe` component using 1-D two-phase flow 7 equations model. No stabilization option was used. For transient flow `initial_v` was defined as zero. The property of liquid uses `StiffenedGasEquationOfStateLiquid` and vapor uses `StiffenedGasEquationOfStateVapor`. The `Pipe` component has 100 elements. The `Inlet` boundary condition has constant temperature and pressure for both liquid and vapor. The `Outlet` use static boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` is used for 10 times of calculation step. The output generates `Exodus` type file.

Test-118, Non-isothermal turbine flow

This case tests non-isothermal turbine flow using 3 equations model. No stabilization option is used. The property of vapor uses `StiffenedGasEquationOfStateVapor`. A `Turbine` component is linked between two `Pipe` components. The inlet boundary condition uses `ParsedFunction` and outlet boundary condition uses `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 time steps. The output generates `Exodus` type file.

Test-119, Pipe with heat structute water of temperature boundary condition type flow using 1-D non-isothermal 3 equations model

This case tests 1-D non-isothermal flow in pipe with heat structure using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The pipe uses `PipeWithHeatStructure` component of 20 elements with `SolidMaterialProperties` heat stracuture material property. The heat structure boundary condition uses `Temperature`. The `Inlet` uses `TimeDependentJunction` boundary condition and the `Outlet` uses `TimeDependentVolume` boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-120, Pipe with heat structute of convective boundary condition type water flow using 1-D non-isothermal 3 equations model

This case tests 1-D non-isothermal flow in pipe with heat structure using 3 equations model with `SUPG` stabilization option. The property of liquid uses `LinearEquationOfState`. The pipe uses

PipeWithHeatStructure component of 20 elements with SolidMaterialProperties heat stracuture material property. The heat structure boundary condition uses Convective. The Inlet uses TimeDependentJunction boundary condition and the Outlet uses TimeDependentVolume boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is Transient and implicit-euler numerical scheme are used for 10 times of calculation step. The output generates Exodus type file.

Test-121, Pipe with heat structute of adiabatic boundary condition type water flow using 1-D non-isothermal 3 equations model

This case tests 1-D non-isothermal flow in pipe with heat structure using 3 equations model with SUPG stabilization option. The property of liquid uses LinearEquationOfState. The pipe uses PipeWithHeatStructure component of 20 elements with SolidMaterialProperties heat stracuture material property. The heat structure boundary condition uses Adiabatic. The Inlet uses TimeDependentJunction boundary condition and the Outlet uses TimeDependentVolume boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is Transient and implicit-euler numerical scheme are used for 10 times of calculation step. The output generates Exodus type file.

Test-122, Pipe with cylindrical heat structute of convective boundary condition type water flow using 1-D non-isothermal 3 equations model

This case tests 1-D non-isothermal flow in pipe with heat structure using 3 equations model with SUPG stabilization option. The property of liquid uses LinearEquationOfState. The pipe uses cylindrical PipeWithHeatStructure component of 20 elements with SolidMaterialProperties heat stracuture material property. The heat structure boundary condition uses Convective. The Inlet uses TimeDependentJunction boundary condition and the Outlet uses TimeDependentVolume boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is Transient and implicit-euler numerical scheme are used for 10 times of calculation step. The output generates Exodus type file.

Test-123, Valve opening

This case tests valve opening action using non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses LinearEquationOfState. A Valve component is linked between two Pipe components. The initial status of the valve is closed and open at response time. The inlet and outlet boundary condition use TimeDependentVolume. The SMP with PJFNK slover is used for preconditioning. The calculation type is Transient and implicit-euler numerical scheme are used for 2000 time steps. The output generates Exodus type file.

Test-124, Valve closing

This case tests valve closing action using non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `LinearEquationOfState`. A `Valve` component is linked between two `Pipe` components. The initial status of the valve is opened and close at response time. The inlet and outlet boundary condition use `TimeDependentVolume`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 2000 time steps. The output generates `Exodus` type file.

Test-125, Compressible valve test

This case tests compressible valve using non-isothermal 3 equations model with `LAPIDUS` stabilization option. The property of vapor uses `StiffenedGasEquationOfStateVapor`. A `CompressibleValve` component is linked between two `Pipe` components. The valve is remaining closed during the simulation. The inlet and outlet boundary condition use `TimeDependentVolume`. The inlet boundary condition uses `ParsedFunction`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 40 time steps. The output generates `Exodus` type file.

Test-126, Compressible valve with sub-sonic flow

This case tests compressible valve with sub-sonic flow using non-isothermal 3 equations model with `LAPIDUS` stabilization option. The property of vapor uses `StiffenedGasEquationOfStateVapor`. A `CompressibleValve` component is linked between two `Pipe` components. The valve is remaining closed during the simulation. The inlet and outlet boundary condition use `TimeDependentVolume`. The inlet boundary condition uses `ParsedFunction`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 40 time steps. The output generates `Exodus` type file.

Test-127 Check_valve (file missing)

Currently this test is not invoked in the RTM.

Test-128, Restart test part 1 – create of check point file

This case tests restart option by creating check point file. Two `Pipe` components are linked with `SimpleJunction`. The test uses 1-D non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `StiffenedGasEquationOfStateLiquid`. The inlet boundary condition uses `Inlet` and outlet boundary condition uses `Outlet`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file and one `Checkpoint` file is created.

Test-129, Wrong pipe end error

This case shows error due to wrong pipe end. One `Pipe` component is modeled using 1-D isothermal flow equation. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. `Inlet` and `Oulet` type of boundary condition was used. The inlet boundary condition has pipe end error. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-130, Restart test part 1 – restart from check point file

This case tests restart option by restarting from check point file. Two `Pipe` components are linked with `SimpleJunction`. The test uses 1-D non-isothermal 3 equations model. No stabilization option is used. The property of liquid uses `StiffenedGasEquationOfStateLiquid`. The inlet boundary condition uses `Inlet` and outlet boundary condition uses `Outlet`. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` numerical scheme are used for 20 times of calculation step. The output generates `Exodus` type file and one `Checkpoint` file is created.

Test-131, Multiple point kinetics components error

This case shows error due to multiple point kinetics components. Two `PointKinetics` components will show error. The 1-D isothermal flow equation is used. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-132, Multiple reactor components error

This case shows error due to multiple reactor components. Two `Reactor` components will show error. The 1-D isothermal flow equation is used. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-133, Missing reactor component error

This case shows error due to missing `Reactor` component. The 1-D non-isothermal flow `CoreChannel` component flow using 3 equations is modeled. No stabilization option is used. The property of liquid uses `LinearEquationOfState`. The material properties of fuel, gap and cladding use `SolidMaterialProperties`. The `CoreChannel` component is used but `Reactor` component is missed. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-134, No input and output boundary condition error

This case shows error due to missing boundary conditions. One `Pipe` component is modeled using isothermal flow equation. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. No boundary conditions are defined. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-135, No inlet junction error

This case shows error due to missing input of junction component. One `FlowJunction` component is modeled using isothermal flow equation. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. No input of `FlowJunction` component is defined. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-136, No outlet junction error

This case shows error due to missing output of junction component. One `FlowJunction` component is modeled using isothermal flow equation. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. No output of `FlowJunction` component is defined. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-137, Heat exchanger inlet and outlet error

This case shows error due to missing inlet and outlet of the `HeatExchanger` component modeling with the 1-D non-isotheraml flow 3 equations model. No stabilization type is used. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. No primary and secondary inlet and outlet are defined in the `HeatExchanger` component. The FDP with PJFNK solver is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-138, Heat exchanger structure type error

This case shows error due to miss define of heat structure type of the `HeatExchanger` component modeling with the 1-D non-isotheraml flow 3 equations model. The `SUPG` stabilization type is used. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. The primary and secondary inlet and outlet are defined as `TimeDependentVolume`. The SMP with Newton solver is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-139, Core channel inlet and outlet error

This case shows error due to missing inlet and outlet of the `CoreChannel` component modeling with the 1-D non-isotheraml flow 3 equations model. No stabilization type is used. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. One `Reactor` and `CoreChannel` component is modeled. No inlet and outlet are defined in the `CoreChannel` component. The FDP with PJFNK solver is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-140, Core channel bad fuel type error

This case shows error due to bad fuel type in the `CoreChannel` component modeling with the 1-D non-isotheraml flow 3 equations model. No stabilization type is used. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. One `Reactor` and `CoreChannel` component is modeled. Fuel type in the `CoreChannel` is badly defined. The `Inlet` and `Outlet` type boundary conditions are used. The FDP with PJFNK solver is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-141, Junction input definition error

This case shows error due to input type of `FlowJunction` component modeling with the 1-D non-isotheraml flow 3 equations model. No stabilization type is used. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. One `Reactor` and `CoreChannel` component is modeled. Input type in the `FlowJunction` is badly defined. The `Inlet` and `Outlet` type boundary conditions are used. The FDP with PJFNK solver is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-142, Junction output definition error

This case shows error due to output type of `FlowJunction` component modeling with the 1-D non-isotheraml flow 3 equations model. No stabilization type is used. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. One `Reactor` and `CoreChannel` component is modeled. Output type in the `FlowJunction` is badly defined. The `Inlet` and `Outlet` type boundary conditions are used. The FDP with PJFNK solver is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-143, Over-specified pipe boundary condition error

This case shows error due to over-specified pipe boundary condition. One `Pipe` component is modeled using 1-D isothermal flow equation. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. Both `Inlet` and `Oulet` type of boundary conditions are set two times and shows error. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-144, Over-specified heat exchanger boundary conditions error

This case shows error due to over-specified inlet and outlet boundary conditions of the `HeatExchanger` component modeling with the 1-D non-isotheraml flow 3 equations model. No stabilization type is used. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. Both primary and secondary inlet and outlet are defined two times and shows error. The FDP with PJFNK solver is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-145, Over-specified core channel inlet and outlet boundary conditions error

This case shows error due to over-specified inlet and outlet boundary conditions of the `CoreChannel` component modeling with the 1-D non-isotheraml flow 3 equations model. No stabilization type is used. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. One `Reactor` and `CoreChannel` component is modeled. Both inlet and outlet boundary conditions are defiened twice and show error. The FDP with PJFNK solver is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-146, Pipe with heat structure type error

This case shows error due to wrong definition of heat structure type of the `PipeWithHeatStructure` component modeling with the 1-D non-isotheraml flow 3 equations model. No stabilization type is used. The property of liquid is set with `LinearEquationOfState`. The `Inlet` and `Outlet` boundary conditions are used. The SMP with Newton solver is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-147, Under-specified pipe boundary condition error (1-D isothermal)

This case shows error due to under-specified pipe boundary condition. One `Pipe` component is modeled using 1-D isothermal flow equation. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. The `Inlet` type of boundary conditions is under-specified and shows error. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-148, Under-specified pipe boundary condition error (1-D non-isothermal)

This case shows error due to under-specified pipe boundary condition. One `Pipe` component is modeled using 1-D non-isothermal flow equation. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. The `Inlet` type of boundary conditions is under-specified and shows error. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-149, Over-specified pipe boundary condition error (1-D non-isothermal)

This case shows error due to over-specified pipe boundary condition. One `Pipe` component is modeled using 1-D non-isothermal flow equation. No stabilization coefficient was used. The water property uses `BarotropicEquationOfState`. The `Inlet` type of boundary conditions is over-specified and shows error. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-150, Wrong type of equation of state error in pipe

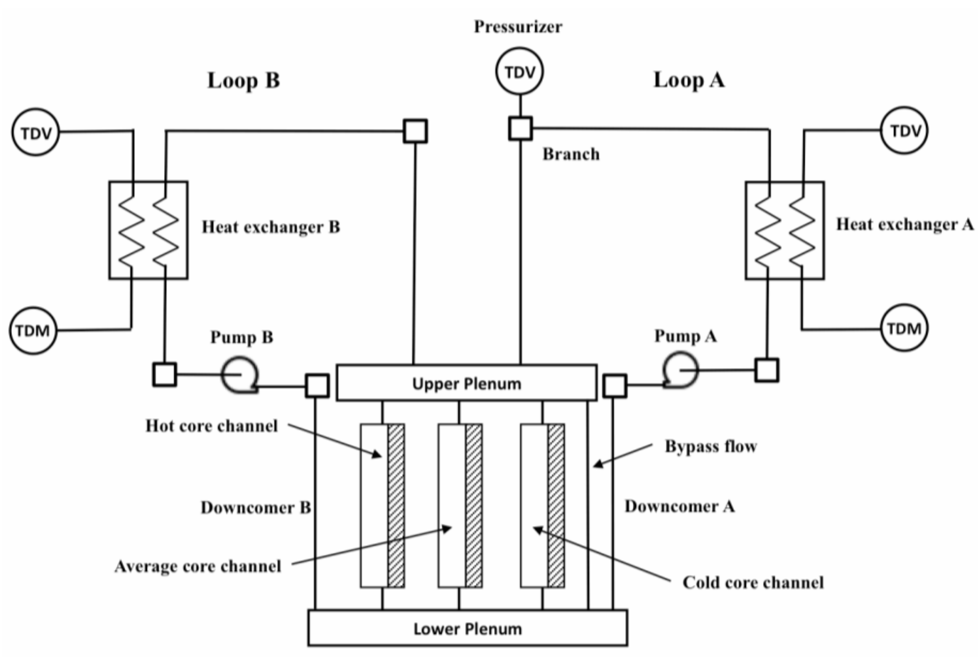
This case shows error due to wrong equation of state type. One `Pipe` component is modeled using 1-D isothermal flow equation. No stabilization coefficient was used. The water property uses `NonIsothermalEquationOfState` which does not exist and shows error. `Inlet` and `Oulet` type of boundary condition was used. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 5 times of calculation step. The output generates `Exodus` type file.

Test-151, Wrong type of equation of state error in junction

This case shows error due to wrong equation of state type. Two `Pipe` and one `FlowJunction` components are modeled using 1-D non-isothermal flow equation. The `SUPG` stabilization option was used. The water property uses `NonIsothermalEquationOfState` which does not exist and shows error. `Inlet` and `SolidWall` type of boundary condition was used. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 10 times of calculation step. The output generates `Exodus` type file.

Test-152, TMI 2-loop simulation

This case tests TMI 2-loop nuclear power plant single-phase steady-state normal reactor operation with 1D non-isothermal flow 3 equations model and `SUPG` stabilization option. The property of liquid is set with `LinearEquationOfState` and property of material is set with `SolidMaterialProperties`. The `Reactor` component is modeled with three `CoreChannel` components; `Pipe` is used for bypass pipe; and `Branch` is used for lower and upper plenum of core. Both coolant loops are designed with `Pipe`, `Branch`, `IdealPump` and `HeatExchanger` components. The inlet boundary condition of the both coolant loops are set with mass flow rate by `TimeDependentJunction`. The outlet boundary conditions are set with `TimeDependentVolume`. The first loop has pressurizer modeled with `Pipe` component and `TimeDependentVolume` outlet boundary condition. The SMP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 5 times of calculation step. The output generates `Exodus` type file.



Test-153, Displaced pipe component

This case test displaced pipe components with 1-D non-isothermal flow equation and the SUPG stabilization option. The water property uses LinearEquationOfState. Three Pipe components are linked with a FlowJunction. SolidWall type of boundary condition was used. The SMP with PJFNK slover is used for preconditioning. The calculation type is Transient and implicit-euler numerical scheme are used for 1 times of calculation step. The output generates Exodus type file.

Test-154, Pump control logic test

This case test pump control logic with 1-D non-isothermal flow equation and the SUPG stabilization option. The water property uses LinearEquationOfState. Two Pipe components are linked with a Pump. TimeDependentVolume type of both inlet and outlet boundary conditions are used. The SMP with PJFNK slover is used for preconditioning. The calculation type is ControlLogicExecutioner with control logic file 'pump_control.py'. The implicit-euler numerical scheme is used for 10 times of calculation step. The output generates Exodus type file. Both of Controlled and Monitored options are used to identify input files to be controlled and to monitor values during simulation.

Test-155, Component/simple_pipe_loop/IdealPump_test.i

This case tests pipe loop with ideal pump using 1-D non-isotheraml flow 3 equations model. No stabilization option is used. The water property uses LinearEquationOfState. The one Pipe1 is linked with Pipe2 and Pipe3 components using FlowJunction. The IdealPump component is located between output of Pipe2 and input of Pipe1. The Inlet and Outlet use TimeDependentVolume boundary conditions. The FDP with PJFNK slover is used for preconditioning. The calculation type is Transient and implicit-euler numerical scheme are used for 100 times of calculation step. The output generates Exodus type file.

Test-156, Pipe flow with time dependent junction and volume boundary conditions (SMP Newton)

This case tests Pipe component using 1-D non-isotheraml flow 3 equations model with SUPG stabilization option. The water property uses LinearEquationOfState. The Pipe has 20 elements. The Inlet uses TimeDependentJunction boundary condition and the Outlet uses TimeDependentVolume boundary condition. The SMP with Newton slover is used for preconditioning. The calculation type is Transient and implicit-euler numerical scheme are used for 500 times of calculation step. The output generates Exodus type file.

Test-157, Typical PWR loop

This case is typical PWR loop test with 1D non-isothermal flow 3 equations model. No stabilization option is used. The property of liquid is set with LinearEquationOfState. Three

`CoreChannel` components are linked with coolant loops are designed with `Pipe`, `Branch`, `IdealPump` and `HeatExchanger` components. The inlet boundary condition is set with `TimeDependentJunction`. The outlet boundary conditions are set with `TimeDependentVolume`. The first loop has pressurizer modeled with `Pipe` component and `TimeDependentVolume` outlet boundary condition. The FDP with PJFNK slover is used for preconditioning. The calculation type is `Transient` and `implicit-euler` numerical scheme are used for 20 times of calculation step. The time step range is set with `FunctionDT`. The output generates `Exodus` type file.

APPENDIX B. TEST SAMPLE CLASSIFICATION

Table. B. 1 List of Test Samples (classified by test ID)

Test ID #	Description	Source	Physical phenomena	Global Parameters	EOS/ Material Properties	Functions	Components/Boundary Condition (BC)	Preconditioning	Executioner	Output	Time integragion	Status	Remark
Test-1	**Simple pipe flow** - testing the simplest 1-D isothermal water pipe flow at ambient pressure.	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (water)		Pipe (1 volume, no junction)	SMP_JFNK	Tranisent	Exodus		Ok	
Test-2	**Heat transfer in HX** - Testing the heat trnasfer models in a heat exchanger component with sodium fluid on both sides. Primary fluid flows inside circular pipe while secondary fluid flows within parallel pipe bundle with square pitch.	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (both water and sodium)		TDV	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-3	**Heat transfer of N2 in the pipe** - Testing heat transfer models in Pipe component filled with nitrogen.	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	N2 property		pipe having 2 TDV & 1 TDJ HT_geometry_code: 101 (single phase fluid flow in pipe)	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-4	**Heat transfer of water in the pipe** - Testing heat transfer models in Pipe component filled with water	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		pipe having 2 TDV & 1 TDJ HT_geometry_code: 101 (single phase fluid flow in pipe)	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-5	**Heat transfer model in core channel** - Testing heat transfer models in a CoreChannel pipe component with typical PWR valve	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		Core channel with 2 TDV & 1 TDJ (modeling cylindrical fuel) HT_geometry_code: 101 (single phase fluid flow in pipe)	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-6	**Simple pipe flow with weakly imposed boundary condition** - testing 1-D non-isothermal flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Stiffened gas EOS		Pipe (1 volume, no junction) Inlet and Oulet type of weakly imposed BC was used.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-7	**Shock capturing** - testing shock capturing model in Pipe component filled with water	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (Shock)	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		Two pipes are linked with flow juctions which has two TDV and 1 TDJ.	FDP_PJFNK	Tranisent	Exodus		Ok	
Test-8	**Simple pipe flow with 3 equation model** - testing simple water flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		Pipe (1 volume, no junction) Two pipes are linked with a flow junction which has two TDV and 1 TDJ. Inlet and Oulet type of BC was used.	FDP_PJFNK	Tranisent	Exodus		Ok	

Test-9	Removed												
Test-10	**Different stabilization option in components** - using two different stabilization options	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) Pipe1 component uses SUPG and the Pipe2 has no stabilization option			Pipe (1 volume, no junctions) Two Pipes are linked with a Branch (Inlet is linked with Pipe1 and Outlet is linked with Pipe2).	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-11	**Water hammer** - testing water hammer effect in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No SUPG stabilization	Stiffened gas EOS		The Pipe component has 200 elements. Inlet and outlet BCs use SolidWall.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-12	**Decay heat behavior in reactor** - testing decay heat behavior in the Reactor component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)	Piecewiselinear (Decay heat curve)	The Reactor has two CoreChannel and linked with two pipes with Branch for inlet and oulet of water flow. Inlet pipe1 is linked with TDJ and outlet pipe2 is linked with TDV.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-13	**Simple pipe flow of nitrogen gas** - testing simple nitrogen gas flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	N2 property		The Pipe component has 10 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-14	**Simple pipe flow of non-isothermal gas** - testing simple nitrogen gas flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (nitrogen)		The Pipe component has 10 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-15	**Stiffened gas equation for liquid** - testing stiffened gas equation for water in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Stiffened gas EOS (water)		The Pipe component has 100 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-16	**Stiffened gas equation for vapor** - testing stiffened gas equation for water in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Stiffened gas EOS (water vapor)		The Pipe component has 10 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-17	**Simple non-isothermal flow in pipe** - testing 1-D non-isothermal flow of water pipe flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	SUPG stabilization	Barotropic EOS		The Pipe component has 10 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-18	**Pipe flow test with two-phase homogeneous equilibrium model (HEM)** - testing middle void flow without heating in Pipe component using HEM two-phase flow model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-19	**Pipe flow test with transient boundary condition two-phase homogeneous equilibrium model (HEM)** - testing middle void flow without heating in Pipe component using HEM two-phase flow model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS	Parsed function	The Pipe component has 50 elements. TDV is used for inlet and outlet BCs to Pipes (Both BCs use ParsedFunction for analytic function).	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-20	**Pipe transition flow test with two-phase homogeneous equilibrium model (HEM)** - testing phase transition from single-phase water to two-phase in Pipe component using HEM two-phase flow model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs to Pipes (Both BCs use ParsedFunction for analytic function).	SMP_PJFNK	Tranisent	Exodus		Ok	

Test-21	**Core channel heat transfer test with two-phase homogeneous equilibrium model (HEM) -** testing flow through the BWR core channel in CoreChannel component using HEM two-phase flow with wall friction and heat transfer model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (The fuel, gap and cladding material uses SolidMaterialProperties)	Piecewiselinear (Decay heat curve)	The Reactor has one CoreChannel of 50 elements and linked with inlet and oulet BCs. TDV is used for inlet and outlet BCs to Pipes (ParsedFunction is used for inlet BC for analytic heating function).	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-22	Removed	INL/EXT-14-33201 (Ch. 2 & Ch. 3)											
Test-23	**Two-phase flow with pressure and volume relaxation model in nozzle -** testing two-phase flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)	Parsed function (nozzel type)	The Pipe component has 100 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus		Ok	For 7 eq parameters, both pressure and volume relaxation models were used.
Test-24	Removed												
Test-25	Removed												
Test-26	**Two-phase flow with interfacial mass transfer model in nozzle -** testing two-phase flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)	Parsed function (nozzel type)	The Pipe component has 100 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus		Ok	For 7 eq parameters, both pressure and volume relaxation models were used.
Test-27													
Test-28	**Two-phase flow in pipe** - testing two-phase flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus		Ok	The pressure and volume relaxation models and the interfacial mass transfer model were used.
Test-29	**Water boiling in the pipe -** testing water boiling in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe component has 100 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	For 7 eq parameters, both pressure and volume relaxation models and interfacial mass transfer model were used.
Test-30	**Water boiling in the pipe using constant source term** - testing water boiling in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)	Constant heat source	The Pipe component has 100 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	For 7 eq parameters, both pressure and volume relaxation models and interfacial mass transfer model were used.

Test-31	**Water boling in the pipe with large void fraction** - testing water boiling in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	For 7 eq parameters, both pressure and volume relaxation models and interfacial mass transfer model were used. The void fraction is modeled with wall mass transfer model.
Test-32	**Lapidus stabilization** - testing LAPIDUS stabilization option in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) LAPIDUS stabilization	Stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-33	**Entropy viscosity stabilization** - testing ENTROPY_VISCOSITY stabilization option in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal)	Stiffened gas EOS		The Pipe component has 100 elements. Time dependent mass is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus	BDF2	Ok	
Test-34	**Entropy viscosity stabilization with homogeneous equilibrium model (HEM)** - testing ENTROPY_VISCOSITY stabilization option in Pipe component using HEM two-phase flow model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	HEM model	Two-phase stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	BDF2	Ok	
Test-35	**Pressure stabilization of air flow** - testing PRESSURE stabilization option in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal)	Stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	-	Ok	
Test-36	**Pressure stabilization of water flow** - testing PRESSURE stabilization option in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal)	Stiffened gas EOS		The Pipe component has 50 elements.	SMP_PJFNK	Tranisent	Exodus	-	Ok	
Test-37	**Wall friction modeling in pipe** - testing wall friction model of laminar, transitional, to turbulent flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)		7 eq model (1-D) SUPG stabilization	Linear EOS (water)		The Pipe component has 10 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus	BDF2	Ok	
Test-38	**Simple liquid metal reactor loop** - testing liquid metal nuclear reactor one coolant loop	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) SolidMaterialProperties (material)		The Reactor component is modeled with one CoreChannel. Pipe and Branch is used for coolant loop. The IHX is modeled with HeatExchanger component. The inlet BC uses the TDJ and the outlet BC are set with TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-39	**PWR core channel flow using 1-D non-isothermal 3 equation model** - testing 1-D non-isothermal flow in PWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. TDV is used for inlet and outlet BCs.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-40	**PWR multiple core channel flow using 1-D non-isothermal 3 equation model** - testing 1-D non-isothermal flow in PWR multiple core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Ideal gas EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. Each CoreChannel is linked with Pipe component with Branch. The Pipe is linked with TDV Inlet and TDV Outlet boundary condition.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-41	**PWR core channel flow using 1-D non-isothermal 3 equation model with functional material property** - testing 1-D non-isothermal flow in PWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use PiecewiseLinear functional SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-42	**Cylinder fuel core channel flow using 1-D non-isothermal 3 equation model -** testing 1-D non-isothermal flow in cylinder fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for cylinder fuel core simulation. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-43	**Multiple core channel flow using 1-D non-isothermal 3 equation model** - testing 1-D non-isothermal flow in multiple core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Ideal gas EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and two CoreChannel components are used for multiple core simulation. Each CoreChannel is linked with Pipe component with Branch. TDJ is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-44	**Plate fuel core channel flow using 1-D non-isothermal 3 equation model** - testing 1-D non-isothermal flow in plate fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for plate core simulation. The Pipe is linked with boundary conditions. TDJ is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus	-	Ok	
Test-45	**BWR core channel flow using HEM two-phase model (OECD/NEA benchmark case)** - testing two-phase flow in BWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS The material properties of fuel, gap and cladding use SolidMaterialProperties.	ParsedFunction for inlet BC	The Reactor and CoreChannel components are used for BWR core simulation. The Inlet and Outlet use TDV for BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-46	**User defined power shaped core channel flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in cylinder fuel core channel flow using user defined power shape	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel and cladding use SolidMaterialProperties.	PieceWiseFunction (core power)	The Reactor and CoreChannel components are used for cylinder fuel core simulation. The Inlet uses TDJ and Outlet uses TDV for BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-47	**Core channel flow using 1-D two-phase 7 equations model -** testing 1-D two-phase flow in cylinder fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) SUPG stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) The material properties of fuel use SolidMaterialProperties.		The Reactor and CoreChannel components are used for cylinder fuel core simulation. The Inlet and Outlet are used as BC	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-48	**Junction flow test (basic model without junction) -** basic model for junction flow with one Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		The Pipe component has 25 elements. Inlet BC uses TDV and outlet BC uses Outlet.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-49	**Junction flow test with one junction and two pipes** - testing junction flow linked with two identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. Inlet BC uses TDM and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-50	**Junction flow test with one junction and two pipes of different size (flow from small to large pipe) -** testing junction flow linked with two different size Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (abrupt area change)	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. The flow area of pipe2 is twice larger than pipe1 component. Inlet BC uses TDM and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-51	**Junction flow test with one junction and two pipes of different size (flow from large to small pipe) -** testing junction flow linked with two different size Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (abrupt area change)	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. The flow area of pipe1 is twice larger than pipe2 component. Inlet BC uses TDM and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-52	**Junction flow test with one junction and three pipes -** testing junction flow linked with three identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (abrupt area change)	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. The junction input is pipe1 and outputs are pipe2 and pipe3. Inlet BC uses TDM and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-53	**Junction flow test with one junction and three pipes (flow from large to small pipe) -** testing junction flow linked with one large Pipe component to two small identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (abrupt area change)	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. The junction input is large pipe1 and outputs are small pipe2 and pipe3. Inlet BC uses TDM and outlet BC uses Outlet.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-54	**Isothermal pump loop flow -** testing isothermal pump loop flow using 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked with two Pipe components. Other Pipe components are linked using Branch components. The outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-55	**Isothermal pump flow** - testing isothermal pump flow using 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-56	**Ideal pump flow** - testing non-isothermal pump flow using 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Linear EOS (liquid)		An IdealPump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-57	**Isothermal pump reverse flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model SUPG stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV. The pressure of outlet BC is higher than inlet BC makes reverse pump flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-58	**Non-isothermal pump loop flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Linear EOS (liquid)		A Pump component is linked with two Pipe components. Other Pipe components are linked using Branch components. The outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-59	**Non-isothermal pump flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Linear EOS (liquid)		A Pump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-60	**Isothermal pump start flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked between two Pipe components. The form loss coefficient of the pump is set with 1000 to model the pump start. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-61	**Turbine driven pump flow** - testing turbine driven non-isothermal pump flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) LAPIDUS stabilization (vapor loop) SUPG stabilization (water loop)	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		Two loops are designed: vapor loop with turbine; and water loop with pump. The Turbine of vapor loop is linked between two Pipe components. The Pump of water loop uses turbine as driving component. The inlet and outlet BCs of both loops use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-62	**BWR wet well test with given boundary condition**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) N2Properties (nigrogen)		A vapor loop is modeled for steam injection and water loop is modeled for water drawing back. A gas vent loop is designed for venting to dry well. The valve is modeled with Branch component and wet well uses WetWell component. Five Pipe components are used. The inlet and outlet BCs use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-63	**Sub-channel flow test** - testing sub-channel flow in the Reactor component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor has one Subchannel and linked with two Pipe components with SubchannelBranch for inlet and oulet of water flow. The inlet BC uses TDM and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	-	Ok	
Test-64	**BWR wet well test with zero flow rates into the volume** - testing BWR wet well non-isothermal 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) N2Properties (nigrogen)		A vapor loop is modeled for steam injection using VolumeBranch type valve. The water loop uses SUPG stabilization option and IdealPump to simulate water drawing back. A gas vent loop also uses SUPG stabilization option and SolidWall type valve for venting to dry well. The wet well uses WetWell component. Five Pipe components are used. The inlet and outlet BCs use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-65	**Point kinetics model with reactivity table** - testing varying reactivity point kinetics model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Reactor physics	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)	A Reactor is with PointKinetics option of PicewiseLinear reactivity function.	The Pipe component has 20 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-66	**Coupled point kinetics model with reactivity table** - testing coupled point kinetics model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Reactor physics	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water) The material properties of fuel, gap and cladding use SolidMaterialProperties.	The PointKinetics option uses PicewiseLinear reactivity function.	The Reactor has two CoreChannel components and linked with two Pipe components with Branch for inlet and oulet of water flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-67	**Point kinetics model with constant reactivity test** - testing constant reactivity point kinetics model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Reactor physics	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)	A Reactor is with PointKinetics option of constant reactivity value.	The Pipe component has 20 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-68	**Branch flow test with two pipes** - testing branch flow linked with two identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		Both Pipe components have 10 elements and linked with one VolumeBranch component. The inlet BC uses TDJ and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-69	**Branch flow test with three pipes in and two pipes out** - testing branch flow linked with five identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		All Pipe components have 10 elements. Three pipes are linked with one VolumeBranch component as inlet and two pipes are linked as outlet. The inlet BC uses TDJ and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-70	Removed												
Test-71	**Solid wall modeling with 3 equation model** - testing solid wall boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) PRESSURE stabilization	Ideal gas EOS		The Pipe component has 100 elements. Inlet BC has constant temperature and pressure. The Outlet BC uses SolidWall option.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-72	**Non-isothermal pipe flow with strong time dependent volume boundary conditions** - testing strong time dependent volume boundary conditions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Non-isothermal EOS (water)		The Pipe component has 10 elements. Inlet and Outlet BCs are TDV and set as weak BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-73	**HEM two-phase pipe flow with strong time dependent volume boundary conditions** - testing strong time dependent volume boundary conditions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	HEM model SUPG stabilization	Two-phase stiffened gas EOS (water)		The Pipe component has 10 elements. Inlet and Outlet BCs are TDV and set as weak BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-74	**Solid wall modeling with 7 equation model** - testing solid wall boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) PRESSURE stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe component has 100 elements. Inlet BC has constant properties. The Outlet BC uses SolidWall option.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-75	**Isothermal pipe chain flow** - testing three pipe chain flow linked with two junctions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) No stabilization	Barotropic EOS (liquid)		Each Pipe components are linked with a Branch component. The inlet and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-76	**Isothermal pipe chain flow with two pipes in and three pipes out** - testing isothermal two pipe in and three pipes out linked with one junction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) No stabilization	Barotropic EOS (liquid)		Two Pipe components are linked with three Pipe components with one Branch component. The inlet and outlet BC uses TDV. The pressure of outlet BC is lower than inlet BC for natural flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-77	**Isothermal pipe chain flow with two pipes in and three pipes out (no flow)** - testing isothermal two pipe in and three pipes out linked with one junction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) No stabilization	Barotropic EOS (liquid)		Two Pipe components are linked with three Pipe components with one Branch component. The inlet and outlet BC uses TDV. The pressure of both inlet and outlet boundary conditions are same and no flow will be occurred.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-78	**Non-isothermal pipe chain flow with two pipes in and three pipes out** - testing non-isothermal two pipe in and three pipes out linked with one junction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Linear EOS (liquid)		Two Pipe components are linked with three Pipe components with one Branch component. The inlet BC uses TDJ and outlet BC uses TDV. The pressure of outlet BC is lower than inlet BC for natural flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-79	**Isothermal pipe chain flow with two pipes in and three pipes out (no form loss)** - testing isothermal two pipe in and three pipes out linked with one junction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) No stabilization	Barotropic EOS (liquid)		Two Pipe components are linked with three Pipe components with one Branch component. Form loss with friction is not modeled. The inlet and outlet BCs use TDV. The pressure of both inlet and outlet BCs are same and no flow will be occurred.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-80	**Isothermal pipe chain flow with stabilization option** - testing three pipe chain flow linked with two junctions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) SUPG stabilization	Barotropic EOS (liquid)		Each Pipe component is linked with a Branch component. The inlet and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-81	**Non-isothermal pipe chain flow** - testing three pipe chain flow linked with two junctions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Linear EOS (liquid)		Each Pipe component is linked with a Branch component. The inlet and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-82	**BWR downcomer test** - testing BWR down comer using non-isothermal 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Stiffened Gas EOS Liquid (liquid)		Four Pipe components are used. The dome of BWR is modeled with VolumeBranch and downcomer is modeled with DownComer. The inlet and outlet BCs use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-83	**Isothermal pipe flow with time dependent volume boundary conditions** - testing 1-D isothermal flow with barotropic 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (1-D, isothermal) SUPG stabilization	Barotropic EOS (water)		The Pipe component has 10 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-84	**Isothermal pipe flow with time dependent volume boundary conditions and functional initial conditions** - testing 1-D isothermal flow with barotropic 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (1-D, isothermal) SUPG stabilization	Barotropic EOS (water)	PiecewiseLinear function (initial pressure and velocity distribution)	The Pipe component has 10 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-85	**Two-phase pipe flow with HEM model using time dependent volume boundary conditions and functional initial conditions** - testing two-phase flow with HEM model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS	PiecewiseLinear function (initial pressure, velocity, temperature and void fraction distribution)	The Pipe component has 100 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-86	**Two-phase pipe flow with 7 equation model using time dependent volume boundary conditions and functional initial conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Two-phase stiffened gas EOS (liquid, vapor)	PiecewiseLinear function (initial pressure, velocity, temperature and void fraction distribution)	The Pipe component has 50 elements. Inlet and Outlet BCs have constant pressure, temperature and volume franction.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-87	**Constant wall heat flux pipe water flow 1-D non-isothermal 3 equation model**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) LAPIDUS stabilization	Ideal gas EOS (liquid)		The pipe wall is heated with constant heat flux of 1000 and has 20 elements. Inlet BC has constant heat transfer coefficient and momentum. The Outlet BC has constant pressure.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-88	**1-D Non-isothermal flow through 3 pipes and 2 junctions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Barotropic EOS (water)		Three Pipe components has same geometric configuration (20 elements). Branch type of junction is used to link pipes. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-89	**1-D Non-isothermal flow through vertical chain pipes having gravity effect**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		Five Pipe components are linked as vertical position, and the liquid has gravity effect. Branch type of junction is used to link pipes. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-90	**Heated wall pipe flow with time dependent junction and volume boundary conditions** - testing heated wall Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		The Pipe has 20 elements, and has constant wall temperature and heat transfer coefficient. The Inlet uses TDJ BC and the Outlet uses TDV BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-91	**Friction analysis of heated wall pipe flow with time dependent junction and volume boundary conditions** - testing heated wall Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		The Pipe has 20 elements, and has constant wall temperature and heat transfer coefficient. The Inlet uses TDJ BC and the Outlet uses TDB BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-92	**Pipe flow with time dependent mass and volume boundary conditions** - testing time dependent mass boundary condition Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		The Pipe has 10 elements. The Inlet uses TDM BC and the Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	Element friction term will be analyzied.
Test-93	**Pipe flow with time dependent mass boundary condition using 7 equations model** - testing time dependent mass boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe has 20 elements. The Inlet uses TDM BC and the Outlet has constant pressure.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-94	**Pipe flow with fuinctional time dependent mass boundary condition using 7 equations model** - testing time dependent mass boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)	PiecewiseLinear (inlet BC)	The Pipe has 20 elements. The Inlet uses TDM BC with PiecewiseLinear function. The Outlet has constant pressure.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-95	**Pipe flow with time dependent junction and volume boundary conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		The Pipe has 20 elements. The Inlet uses TDJ BC and the Outlet uses TDB BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-96	**Vertical pipe flow with time dependent junction and volume boundary conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		The vertical Pipe has 50 elements. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-97	**Pipe flow with time dependent volume boundary conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		The Pipe has 20 elements. The Inlet and Outlet use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-98	**Pipe flow with functional time dependent junction and time dependent volume boundary conditions using HEM two-phase flow model**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	HEM model SUPG stabilization	Two-phase stiffened gas EOS (water)	ParsedFunction (inlet BC)	The Pipe has 50 elements, and has constant wall temperature and heat transfer coefficient. The Inlet uses TDJ BC with ParsedFunction. The Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-99	**Junction flow test with two junctions and three pipes using 3 equation model**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Stiffened Gas EOS Liquid (for liquid phase)		Three Pipe components are linked with SimpleJunction component. The inlet BC uses Inlet and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-100	**Junction flow test with two junctions and three pipes using 7 equation model**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		Three Pipe components are linked with SimpleJunction component. The inlet BC uses Inlet and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus		Ok	

Test-101	**Heat exchanger flow using 1-D non-isothermal 3 equation model (1-D heat exchanger wall)**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material property uses SolidMaterialProperties.		The HeatExchanger component has 10 elements. The heat exchanger wall is 1-D modeled. The primary and secondary inlets and outlets use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-102	**Heat exchanger flow using HEM two-phase model** - testing two-phase flow through heat exchanger using HEM model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS (two-phase liquid) Stiffened gas EOS liquid (water) The material property uses SolidMaterialProperties.		The HeatExchanger component has 30 elements. The primary and secondary inlets and outlets use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-103	**Heat exchanger flow using 1-D non-isothermal 3 equation model (2-D heat exchanger wall)**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material property uses SolidMaterialProperties.		The HeatExchanger component has 10 elements. The heat exchanger wall is 2-D modeled. The primary and secondary inlets and outlets use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-104	**Separate dryer test with zero initial vapor volume fraction**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (two-phase) Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The SeparateDryer is linked with steam out and discharge Pipe components. The inlet and outlet BC of Pipe uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-105	**Separate dryer test with medium initial vapor volume fraction**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (two-phase) Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The SeparateDryer is linked with steam out and discharge Pipe components. The inlet and outlet BC of Pipe uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-106	**Separate dryer test with large initial vapor volume fraction**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (two-phase) Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The SeparateDryer is linked with steam out and discharge Pipe components. The inlet and outlet BC of Pipe uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-107	**Constant inlet boundary condition with 3 equation model** - testing constant boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		The Pipe component has 10 elements. Inlet BC has constant temperature and pressure. The Outlet BC uses TDV option.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-108	**Constant inlet boundary condition with two-phase homogeneous equilibrium model (HEM)** - testing constant boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)		HEM model SUPG stabilization	Two-phase stiffened gas EOS (vapor)		The Pipe component has 20 elements. Inlet BC has constant temperature and pressure. The Outlet BC uses TDV option.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-109	**Constant inlet and outlet boundary condition with 3 equation model** - testing constant boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		The Pipe component has 10 elements. Inlet BC has constant temperature and pressure. The Outlet BC has constant pressure.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-110	**Constant inlet and outlet boundary condition with two-phase homogeneous equilibrium model (HEM)** - testing constant boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	HEM model SUPG stabilization	Two-phase stiffened gas EOS (vapor)		The Pipe component has 20 elements. Inlet BC has constant temperature and pressure. The Outlet BC has constant pressure.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-111	**Stagnation inlet and static outlet boundary conditions with 7 equation model** - testing stagnation inlet and static outlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The Pipe component has 50 elements. The Inlet uses stagnation BC. The Outlet uses static BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-112	**Static boundary conditions with 7 equation model** - testing static inlet and outlet boundary conditions of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The Pipe component has 50 elements. The Inlet and Outlet use static BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-113	**Mass transferring inlet boundary condition with 7 equation model** - testing stagnation inlet and static outlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The interface_transfer option is used for defining mass flow rate of inlet BC. The Pipe component has 100 elements. The Inlet BC has constant mass flow rate and Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	

Test-114	**Enthalpy and momentum inlet boundary condition with 3 equation model** - testing enthalpy and momentum defiened inlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D) PRESSURE stabilization	Ideal gas EOS (gas)		The Pipe component has 100 elements. The Inlet BC has constant enthalpy and momentum. The Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	
Test-115	**Stagnation temperature and pressure inlet boundary condition with steady flow 3 equation model** - testing temperature and pressure defiened inlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D) No stabilization	Ideal gas EOS (gas)		The Pipe component has 100 elements. The Inlet BC has constant temperature and pressure. The Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	For steady flow initial_v was defined.
Test-116	**Stagnation temperature and pressure inlet boundary condition with transient flow 3 equation model** - testing temperature and pressure defiened inlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D) No stabilization	Ideal gas EOS (gas)		The Pipe component has 100 elements. The Inlet BC has constant temperature and pressure. The Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	For transient flow initial_v was defined as zero.
Test-117	**Stagnation temperature and pressure inlet boundary condition with transient flow 7 equation model** - testing temperature and pressure defiened inlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) No stabilization	Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The Pipe component has 100 elements. The Inlet BC has constant temperature and pressure for both liquid and vapor. The Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	For transient flow initial_v was defined as zero.
Test-118	**Non-isothermal turbine flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Stiffened gas EOS vapor (vapor)	ParsedFunction (inlet BC)	A Turbine component is linked between two Pipe components. The inlet BC uses ParsedFunction and outlet BC uses TDV.	SMP_PJFNK	Transient	Exodus	implicit-euler	Ok	
Test-119	**Pipe with heat structure water of temperature boundary condition type flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in pipe with heat structure	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) SolidMaterialProperties for heat stracuture material property.		The pipe uses PipeWithHeatStructure component of 20 elements. The heat structure BC uses Temperature. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Transient	Exodus	implicit-euler	Ok	
Test-120	**Pipe with heat structute of convective boundary condition type water flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in pipe with heat structure	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) SolidMaterialProperties for heat stracuture material property.		The pipe uses PipeWithHeatStructure component of 20 elements. The heat structure boundary condition uses Convective. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Transient	Exodus	implicit-euler	Ok	
Test-121	**Pipe with heat structute of adiabatic boundary condition type water flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in pipe with heat structure	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) SolidMaterialProperties for heat stracuture material property.		The pipe uses PipeWithHeatStructure component of 20 elements. The heat structure boundary condition uses Adiabatic. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Transient	Exodus	implicit-euler	Ok	

Test-122	**Pipe with cylindrical heat structute of convective boundary condition type water flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in pipe with heat structure	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) SolidMaterialProperties for heat stracuture material property.		The pipe uses cylindrical PipeWithHeatStructure component of 20 elements. The heat structure boundary condition uses Convective. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-123	**Valve opening** - testing valve opening action	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Linear EOS (liquid)		A Valve component is linked between two Pipe components. The initial status of the valve is closed and open at response time. The inlet and outlet BC use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-124	**Valve closing** - testing valve closing action	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Linear EOS (liquid)		A Valve component is linked between two Pipe components. The initial status of the valve is opened and close at response time. The inlet and outlet BC use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-125	**Compressible valve test** - testing compressible valve using non-isothermal 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) LAPIDUS stabilization	Stiffened gas EOS vapor (vapor)	ParsedFunction (inlet BC)	A CompressibleValve component is linked between two Pipe components. The valve is remaining closed during the simulation. The inlet and outlet BC use TDV. The inlet BC uses ParsedFunction.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-126	**Compressible valve with sub-sonic flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) LAPIDUS stabilization	Stiffened gas EOS vapor (vapor)	ParsedFunction (inlet BC)	A CompressibleValve component is linked between two Pipe components. The valve is remaining closed during the simulation. The inlet and outlet BC use TDV. The inlet BC uses ParsedFunction.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-127	Removed												
Test-128	**Restart test part 1 – creat of check point file:** testing restart option by creating check point file	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Stiffened gas EOS liquid (liquid)		Two Pipe components are linked with SimpleJunction. The inlet BC uses Inlet and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus Checkpoint		Ok	
Test-129	**Wrong pipe end error** - showing error due to wrong pipe end	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	1-D isothermal flow eq No stabilization	Barotropic EOS (water)		Inlet and Oulet type of BC was used. The inlet boundary condition has pipe end error.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-130	**Restart test part 1 – restart from check point file**: testing restart option by restarting from check point file	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Stiffened gas EOS liquid (liquid)		Two Pipe components are linked with SimpleJunction. The inlet BC uses Inlet and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus Checkpoint		Ok	

Test-131	**Multiple point kinetics components error** - showing error due to multiple point kinetics components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	1-D isothermal flow eq No stabilization	Barotropic EOS (water)		Two PointKinetics components will show error.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-132	**Multiple reactor components error** - showing error due to multiple reactor components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	1-D isothermal flow eq No stabilization	Barotropic EOS (water)		Two Reactor components will show error.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-133	**Missing reactor component error** - showing error due to missing Reactor component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	1-D non-isothermal flow 3 eq No stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The CoreChannel component is used but Reactor component is missed.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-134	**No input and output boundary condition error** - showing error due to missing boundary conditions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Isothermal flow eq No stabilization	Barotropic EOS (water)		One Pipe component is modeled using isothermal flow equation. No boundary conditions are defined.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-135	**No inlet junction error** - showing error due to missing input of junction component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Isothermal flow eq No stabilization	Barotropic EOS (water)		One FlowJunction component is modeled using isothermal flow equation. No input of FlowJunction component is defined.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-136	**No outlet junction error** - showing error due to missing output of junction component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Isothermal flow eq No stabilization	Barotropic EOS (water)		One FlowJunction component is modeled using isothermal flow equation. No output of FlowJunction component is defined.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-137	**Heat exchanger inlet and outlet error** - showing error due to missing inlet and outlet of the HeatExchanger component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		No primary and secondary inlet and outlet are defined in the HeatExchanger component.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-138	**Heat exchanger structure type error** - showing error due to miss define of heat structure type of the HeatExchanger component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		The primary and secondary inlet and outlet are defined as TimeDependentVolume.	SMP with Newton solver	Tranisent	Exodus	implicit-euler	Ok	
Test-139	**Core channel inlet and outlet error** - showing error due to missing inlet and outlet of the CoreChannel component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. No inlet and outlet are defined in the CoreChannel component.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-140	**Core channel bad fuel type error** - showing error due to bad fuel type in the CoreChannel component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. Fuel type in the CoreChannel is badly defined. The Inlet and Outlet type BCs are used.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-141	**Junction input definition error** - showing error due to input type of FlowJunction component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. Input type in the FlowJunction is badly defined. The Inlet and Outlet type BCs are used.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-142	**Junction output definition error** - showing error due to output type of FlowJunction component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. Output type in the FlowJunction is badly defined. The Inlet and Outlet type BCs are used.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-143	**Over-specified pipe boundary condition error** - showing error due to over-specified pipe boundary condition	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Isothermal flow eq (1-D) No stabilization	Barotropic EOS (water)		One Pipe component is modeled using 1-D isothermal flow equation. Both Inlet and Oulet type of BCs are set two times and shows error.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-144	**Over-specified heat exchanger boundary conditions error** - showing error due to over-specified inlet and outlet boundary conditions of the HeatExchanger component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		Both primary and secondary inlet and outlet are defined two times and shows error.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-145	**Over-specified core channel inlet and outlet boundary conditions error** - showing error due to over-specified inlet and outlet boundary conditions of the CoreChannel component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. Both inlet and outlet BCs are defiened twice and show error.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-146	**Pipe with heat structure type error** - showing error due to wrong definition of heat structure type of the PipeWithHeatStructure component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		The Inlet and Outlet BCs are used.	SMP with Newton solver	Tranisent	Exodus	implicit-euler	Ok	
Test-147	**Under-specified pipe boundary condition error (1-D isothermal)** - showing error due to under-specified pipe boundary condition	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Isothermal flow eq (1-D) No stabilization	Barotropic EOS (water)		The Inlet type of BCs is under-specified and shows error.		Tranisent	Exodus	implicit-euler	Ok	
Test-148	**Under-specified pipe boundary condition error (1-D non-isothermal)** - showing error due to under-specified pipe boundary condition	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Non-isothermal flow eq (1-D) No stabilization	Barotropic EOS (water)		One Pipe component is modeled. The Inlet type of BCs is under-specified and shows error.		Tranisent	Exodus	implicit-euler	Ok	
Test-149	**Over-specified pipe boundary condition error (1-D non-isothermal)** - showing error due to over-specified pipe boundary condition	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Non-isothermal flow eq (1-D) No stabilization	Barotropic EOS (water)		One Pipe component is modeled. The Inlet type of BCs is over-specified and shows error.		Tranisent	Exodus	implicit-euler	Ok	
Test-150	**Wrong type of equation of state error in pipe** - showing error due to wrong equation of state type	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Isothermal flow eq (1-D) No stabilization	Non-isothermal EOS (water)		One Pipe component is modeled. The water property uses NonIsothermalEquationOfState which does not exist and shows error. Inlet and Oulet type of BC was used.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Test-151	**Wrong type of equation of state error in junction** - showing error due to wrong equation of state type	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Non-isothermal flow eq (1-D) SUPG stabilization	Non-isothermal EOS (water)		Two Pipe and one FlowJunction components are modeled. The water property uses NonIsothermalEquationOfState which does not exist and shows error. Inlet and SolidWall type of BC was used.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-152	**TMI 2-loop simulation** - testing TMI 2-loop nuclear power plant single-phase steady-state normal reactor operation	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		The Reactor component is modeled with three CoreChannel components; Pipe is used for bypass pipe; and Branch is used for lower and upper plenum of core. Both coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC of the both coolant loops are set with mass flow rate by TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-153	**Displaced pipe component** - testing displaced pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Non-isothermal flow eq (1-D) SUPG stabilization	Linear EOS (water)		Three Pipe components are linked with a FlowJunction. SolidWall type of BC was used.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-154	**Pump control logic test** - testing pump control logic	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	Non-isothermal flow eq (1-D) SUPG stabilization	Linear EOS (water)		Two Pipe components are linked with a Pump. TDV type of both inlet and outlet BCs are used.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	The calculation type is ControlLogicExecutioner with control logic file 'pump_control.py'. Both of Controlled and Monitored options are used to identify input files to be controlled and to monitor values during simulation.
Test-155	testing pipe loop with ideal pump	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		The one Pipe1 is linked with Pipe2 and Pipe3 components using FlowJunction. The IdealPump component is located between output of Pipe2 and input of Pipe1. The Inlet and Outlet use TDV BCs.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Test-156	**Pipe flow with time dependent junction and volume boundary conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		The Pipe has 20 elements. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP with Newton solver	Tranisent	Exodus	implicit-euler	Ok	
Test-157	**Typical PWR loop**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		Three CoreChannel components are linked with coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC is set with TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Table. B. 2 List of Test Samples (classified by model type)

Problem type	Model Type (Governing Eq.)	Test ID #	Problem description	Source	Physical phenomena	Global Parameters	Equation of State/ Material Properties	Functions	Components/Boundary Condition (BC)	Preconditioning	Executioner	Output	Time integragion	Status	Remark
Single-Phase Problems	2 equation model	Test-1	**Simple pipe flow** - testing the simplest 1-D isothermal water pipe flow at ambient pressure.	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (water)		Pipe (1 volume, no junction)	SMP_JFNK	Tranisent	Exodus		Ok	
Single-Phase Problems	2 equation model	Test-54	**Isothermal pump loop flow** - testing isothermal pump loop flow using 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked with two Pipe components. Other Pipe components are linked using Branch components. The outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Single-Phase Problems	2 equation model	Test-55	**Isothermal pump flow** - testing isothermal pump flow using 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Single-Phase Problems	2 equation model	Test-57	**Isothermal pump reverse flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model SUPG stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV. The pressure of outlet BC is higher than inlet BC makes reverse pump flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
Single-Phase Problems	2 equation model	Test-60	**Isothermal pump start flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked between two Pipe components. The form loss coefficient of the pump is set with 1000 to model the pump start. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

		Test-75	**Isothermal pipe chain flow -** testing three pipe chain flow linked with two junctions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) No stabilization	Barotropic EOS (liquid)		Each Pipe components are linked with a Branch component. The inlet and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-76	**Isothermal pipe chain flow with two pipes in and three pipes out -** testing isothermal two pipe in and three pipes out linked with one junction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) No stabilization	Barotropic EOS (liquid)		Two Pipe components are linked with three Pipe components with one Branch component. The inlet and outlet BC uses TDV. The pressure of outlet BC is lower than inlet BC for natural flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-77	**Isothermal pipe chain flow with two pipes in and three pipes out (no flow) -** testing isothermal two pipe in and three pipes out linked with one junction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) No stabilization	Barotropic EOS (liquid)		Two Pipe components are linked with three Pipe components with one Branch component. The inlet and outlet BC uses TDV. The pressure of both inlet and outlet boundary conditions are same and no flow will be occurred.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-79	**Isothermal pipe chain flow with two pipes in and three pipes out (no form loss) -** testing isothermal two pipe in and three pipes out linked with one junction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) No stabilization	Barotropic EOS (liquid)		Two Pipe components are linked with three Pipe components with one Branch component. Form loss with friction is not modeled. The inlet and outlet BCs use TDV. The pressure of both inlet and outlet BCs are same and no flow will be occurred.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-80	**Isothermal pipe chain flow with stabilization option -** testing three pipe chain flow linked with two junctions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (isothermal) SUPG stabilization	Barotropic EOS (liquid)		Each Pipe component is linked with a Branch component. The inlet and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-83	**Isothermal pipe flow with time dependent volume boundary conditions -** testing 1-D isothermal flow with barotropic 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (1-D, isothermal) SUPG stabilization	Barotropic EOS (water)		The Pipe component has 10 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-84	**Isothermal pipe flow with time dependent volume boundary conditions and functional initial conditions -** testing 1-D isothermal flow with barotropic 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model (1-D, isothermal) SUPG stabilization	Barotropic EOS (water)	PiecewiseLinear function (initial pressure and velocity distribution)	The Pipe component has 10 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

	3 equation model	Test-2	**Heat transfer in HX -** Testing the heat trnasfer models in a heat exchanger component with sodium fluid on both sides. Primary fluid flows inside circular pipe while secondary fluid flows within parallel pipe bundle with square pitch.	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (both water and sodium)		TDV	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-3	**Heat transfer of N2 in the pipe** - Testing heat transfer models in Pipe component filled with nitrogen.	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	N2 property		pipe having 2 TDV & 1 TDJ HT_geometry_code: 101 (single phase fluid flow in pipe)	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-4	**Heat transfer of water in the pipe** - Testing heat transfer models in Pipe component filled with water	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		pipe having 2 TDV & 1 TDJ HT_geometry_code: 101 (single phase fluid flow in pipe)	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-5	**Heat transfer model in core channel** - Testing heat transfer models in a CoreChannel pipe component with typical PWR valve	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		Core channel with 2 TDV & 1 TDJ (modeling cylindrical fuel) HT_geometry_code: 101 (single phase fluid flow in pipe)	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-6	**Simple pipe flow with weakly imposed boundary condition** - testing 1-D non-isothermal flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Stiffened gas EOS		Pipe (1 volume, no junction) Inlet and Oulet type of weakly imposed BC was used.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-7	**Shock capturing** - testing shock capturing model in Pipe component filled with water	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (Shock)	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		Two pipes are linked with flow juctions which has two TDV and 1 TDJ.	FDP_PJFNK	Tranisent	Exodus		Ok	
		Test-8	**Simple pipe flow with 3 equation model** - testing simple water flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		Pipe (1 volume, no junction) Two pipes are linked with a flow junction which has two TDV and 1 TDJ. Inlet and Oulet type of BC was used.	FDP_PJFNK	Tranisent	Exodus		Ok	
		Test-10	**Different stabilization option in components** - using two different stabilization options	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) Pipe1 component uses SUPG and the Pipe2 has no stabilization option			Pipe (1 volume, no junctions) Two Pipes are linked with a Branch (Inlet is linked with Pipe1 and Outlet is linked with Pipe2).	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-11	**Water hammer** - testing water hammer effect in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No SUPG stabilization	Stiffened gas EOS		The Pipe component has 200 elements. Inlet and outlet BCs use SolidWall.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-12	**Decay heat behavior in reactor** - testing decay heat behavior in the Reactor component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)	Piecewiselinear (Decay heat curve)	The Reactor has two CoreChannel and linked with two pipes with Branch for inlet and oulet of water flow. Inlet pipe1 is linked with TDJ and outlet pipe2 is linked with TDV.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-13	**Simple pipe flow of nitrogen gas** - testing simple nitrogen gas flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	N2 property		The Pipe component has 10 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	

		Test-14	**Simple pipe flow of non-isothermal gas** - testing simple nitrogen gas flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (nitrogen)		The Pipe component has 10 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-15	**Stiffened gas equation for liquid** - testing stiffened gas equation for water in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Stiffened gas EOS (water)		The Pipe component has 100 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-16	**Stiffened gas equation for vapor** - testing stiffened gas equation for water in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Stiffened gas EOS (water vapor)		The Pipe component has 10 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-32	**Lapidus stabilization** - testing LAPIDUS stabilization option in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) LAPIDUS stabilization	Stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-33	**Entropy viscosity stabilization** - testing ENTROPY_VISCOSITY stabilization option in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal)	Stiffened gas EOS		The Pipe component has 100 elements. Time dependent mass is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus	BDF2	Ok	
		Test-35	**Pressure stabilization of air flow** - testing PRESSURE stabilization option in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal)	Stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	-	Ok	
		Test-36	**Pressure stabilization of water flow** - testing PRESSURE stabilization option in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal)	Stiffened gas EOS		The Pipe component has 50 elements.	SMP_PJFNK	Tranisent	Exodus	-	Ok	
		Test-38	**Simple liquid metal reactor loop** - testing liquid metal nuclear reactor one coolant loop	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) SolidMaterialProperties (material)		The Reactor component is modeled with one CoreChannel. Pipe and Branch is used for coolant loop. The IHX is modeled with HeatExchanger component. The inlet BC uses the TDJ and the outlet BC are set with TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-39	**PWR core channel flow using 1-D non-isothermal 3 equation mode**l - testing 1-D non-isothermal flow in PWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. TDV is used for inlet and outlet BCs.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-40	**PWR multiple core channel flow using 1-D non-isothermal 3 equation model** - testing 1-D non-isothermal flow in PWR multiple core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Ideal gas EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. Each CoreChannel is linked with Pipe component with Branch. The Pipe is linked with TDV Inlet and TDV Outlet boundary condition.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-41	**PWR core channel flow using 1-D non-isothermal 3 equation model with functional material property** - testing 1-D non-isothermal	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use PiecewiseLinear functional		The Reactor and CoreChannel components are used for PWR core simulation. TDV is used for inlet and	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

			flow in PWR core channel flow				SolidMaterialProperties.		outlet BCs.						
		Test-42	**Cylinder fuel core channel flow using 1-D non-isothermal 3 equation model** - testing 1-D non-isothermal flow in cylinder fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for cylinder fuel core simulation. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-43	**Multiple core channel flow using 1-D non-isothermal 3 equation model** - testing 1-D non-isothermal flow in multiple core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Ideal gas EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and two CoreChannel components are used for multiple core simulation. Each CoreChannel is linked with Pipe component with Branch. TDJ is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-44	**Plate fuel core channel flow using 1-D non-isothermal 3 equation model** - testing 1-D non-isothermal flow in plate fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for plate core simulation. The Pipe is linked with boundary conditions. TDJ is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus	-	Ok	
		Test-46	**User defined power shaped core channel flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in cylinder fuel core channel flow using user defined power shape	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel and cladding use SolidMaterialProperties.	PieceWiseFunction (core power)	The Reactor and CoreChannel components are used for cylinder fuel core simulation. The Inlet uses TDJ and Outlet uses TDV for BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-48	**Junction flow test (basic model without junction)** - basic model for junction flow with one Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		The Pipe component has 25 elements. Inlet BC uses TDV and outlet BC uses Outlet.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-49	**Junction flow test with one junction and two pipes** - testing junction flow linked with two identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. Inlet BC uses TDM and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-50	**Junction flow test with one junction and two pipes of different size (flow from small to large pipe)** - testing junction flow linked with two different size Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (abrupt area change)	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. The flow area of pipe2 is twice larger than pipe1 component. Inlet BC uses TDM and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-51	**Junction flow test with one junction and two pipes of different size (flow from large to small pipe)** - testing junction flow linked with two different size Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (abrupt area change)	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. The flow area of pipe1 is twice larger than pipe2 component. Inlet BC uses TDM and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

		Test-52	**Junction flow test with one junction and three pipes -** testing junction flow linked with three identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (abrupt area change)	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. The junction input is pipe1 and outputs are pipe2 and pipe3. Inlet BC uses TDM and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-53	**Junction flow test with one junction and three pipes (flow from large to small pipe)** - testing junction flow linked with one large Pipe component to two small identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow (abrupt area change)	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		Both Pipe components have 25 elements and linked with one FlowJunction component. The junction input is large pipe1 and outputs are small pipe2 and pipe3. Inlet BC uses TDM and outlet BC uses Outlet.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-56	**Ideal pump flow** - testing non-isothermal pump flow using 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Linear EOS (liquid)		An IdealPump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-58	**Non-isothermal pump loop flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Linear EOS (liquid)		A Pump component is linked with two Pipe components. Other Pipe components are linked using Branch components. The outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-59	**Non-isothermal pump flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Linear EOS (liquid)		A Pump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-61	**Turbine driven pump flow** - testing turbine driven non-isothermal pump flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) LAPIDUS stabilization (vapor loop) SUPG stabilization (water loop)	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		Two loops are designed: vapor loop with turbine; and water loop with pump. The Turbine of vapor loop is linked between two Pipe components. The Pump of water loop uses turbine as driving component. The inlet and outlet BCs of both loops use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-62	**BWR wet well test with given boundary condition**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) N2Properties (nigrogen)		A vapor loop is modeled for steam injection and water loop is modeled for water drawing back. A gas vent loop is designed for venting to dry well. The valve is modeled with Branch component and wet well uses WetWell component. Five Pipe components are used. The inlet and outlet BCs use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-63	**Sub-channel flow test -** testing sub-channel flow in the Reactor component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor has one Subchannel and linked with two Pipe components with SubchannelBranch for inlet and oulet of water flow. The inlet BC uses TDM	SMP_PJFNK	Tranisent	Exodus	-	Ok	

									and outlet BC uses TDV.						
		Test-64	**BWR wet well test with zero flow rates into the volume** - testing BWR wet well non-isothermal 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) N2Properties (nigrogen)		A vapor loop is modeled for steam injection using VolumeBranch type valve. The water loop uses SUPG stabilization option and IdealPump to simulate water drawing back. A gas vent loop also uses SUPG stabilization option and SolidWall type valve for venting to dry well. The wet well uses WetWell component. Five Pipe components are used. The inlet and outlet BCs use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-65	**Point kinetics model with reactivity table** - testing varying reactivity point kinetics model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Reactor physics	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)	A Reactor is with PointKinetics option of PicewiseLinear reactivity function.	The Pipe component has 20 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-66	**Coupled point kinetics model with reactivity table** - testing coupled point kinetics model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Reactor physics	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water) The material properties of fuel, gap and cladding use SolidMaterialProperties.	The PointKinetics option uses PicewiseLinear reactivity function.	The Reactor has two CoreChannel components and linked with two Pipe components with Branch for inlet and oulet of water flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-67	**Point kinetics model with constant reactivity test** - testing constant reactivity point kinetics model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Reactor physics	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)	A Reactor is with PointKinetics option of constant reactivity value.	The Pipe component has 20 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-68	**Branch flow test with two pipes** - testing branch flow linked with two identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		Both Pipe components have 10 elements and linked with one VolumeBranch component. The inlet BC uses TDJ and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-69	**Branch flow test with three pipes in and two pipes out** - testing branch flow linked with five identical Pipe components	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		All Pipe components have 10 elements. Three pipes are linked with one VolumeBranch component as inlet and two pipes are linked as outlet. The inlet BC uses TDJ and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-71	**Solid wall modeling with 3 equation model** - testing solid wall boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) PRESSURE stabilization	Ideal gas EOS		The Pipe component has 100 elements. Inlet BC has constant temperature and pressure. The Outlet BC uses SolidWall option.	SMP_PJFNK	Transient	Exodus		Ok	
		Test-72	**Non-isothermal pipe flow with strong time dependent volume boundary conditions** - testing strong time dependent volume boundary conditions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Non-isothermal EOS (water)		The Pipe component has 10 elements. Inlet and Outlet BCs are TDV and set as weak BC.	SMP_PJFNK	Transient	Exodus	implicit-euler	Ok	

		Test-78	**Non-isothermal pipe chain flow with two pipes in and three pipes out** - testing non-isothermal two pipe in and three pipes out linked with one junction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Linear EOS (liquid)		Two Pipe components are linked with three Pipe components with one Branch component. The inlet BC uses TDJ and outlet BC uses TDV. The pressure of outlet BC is lower than inlet BC for natural flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-81	**Non-isothermal pipe chain flow** - testing three pipe chain flow linked with two junctions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Linear EOS (liquid)		Each Pipe component is linked with a Branch component. The inlet and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-82	**BWR downcomer test** - testing BWR down comer using non-isothermal 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Stiffened Gas EOS Liquid (liquid)		Four Pipe components are used. The dome of BWR is modeled with VolumeBranch and downcomer is modeled with DownComer. The inlet and outlet BCs use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-87	**Constant wall heat flux pipe water flow 1-D non-isothermal 3 equation model**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) LAPIDUS stabilization	Ideal gas EOS (liquid)		The pipe wall is heated with constant heat flux of 1000 and has 20 elements. Inlet BC has constant heat transfer coefficient and momentum. The Outlet BC has constant pressure.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-88	**1-D Non-isothermal flow through 3 pipes and 2 junctions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Barotropic EOS (water)		Three Pipe components has same geometric configuration (20 elements). Branch type of junction is used to link pipes. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-89	**1-D Non-isothermal flow through vertical chain pipes having gravity effect**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		Five Pipe components are linked as vertical position, and the liquid has gravity effect. Branch type of junction is used to link pipes. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-90	**Heated wall pipe flow with time dependent junction and volume boundary conditions** - testing heated wall Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		The Pipe has 20 elements, and has constant wall temperature and heat transfer coefficient. The Inlet uses TDJ BC and the Outlet uses TDV BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-91	**Friction analysis of heated wall pipe flow with time dependent junction and volume boundary conditions** - testing heated wall Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		The Pipe has 20 elements, and has constant wall temperature and heat transfer coefficient. The Inlet uses TDJ BC and the Outlet uses TDB BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-92	**Pipe flow with time dependent mass and volume boundary conditions** - testing time dependent mass boundary condition Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		The Pipe has 10 elements. The Inlet uses TDM BC and the Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	Element friction term will be analyzied.

		Test-95	**Pipe flow with time dependent junction and volume boundary conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		The Pipe has 20 elements. The Inlet uses TDJ BC and the Outlet uses TDB BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-96	**Vertical pipe flow with time dependent junction and volume boundary conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		The vertical Pipe has 50 elements. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-97	**Pipe flow with time dependent volume boundary conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		The Pipe has 20 elements. The Inlet and Outlet use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-99	**Junction flow test with two junctions and three pipes using 3 equation model**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Stiffened Gas EOS Liquid (for liquid phase)		Three Pipe components are linked with SimpleJunction component. The inlet BC uses Inlet and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-101	**Heat exchanger flow using 1-D non-isothermal 3 equation model (1-D heat exchanger wall)**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material property uses SolidMaterialProperties.		The HeatExchanger component has 10 elements. The heat exchanger wall is 1-D modeled. The primary and secondary inlets and outlets use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-103	**Heat exchanger flow using 1-D non-isothermal 3 equation model (2-D heat exchanger wall)**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material property uses SolidMaterialProperties.		The HeatExchanger component has 10 elements. The heat exchanger wall is 2-D modeled. The primary and secondary inlets and outlets use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-107	**Constant inlet boundary condition with 3 equation model** - testing constant boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		The Pipe component has 10 elements. Inlet BC has constant temperature and pressure. The Outlet BC uses TDV option.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-109	**Constant inlet and outlet boundary condition with 3 equation model** - testing constant boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid)		The Pipe component has 10 elements. Inlet BC has constant temperature and pressure. The Outlet BC has constant pressure.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-114	**Enthalpy and momentum inlet boundary condition with 3 equation model** - testing enthalpy and momentum defiened inlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D) PRESSURE stabilization	Ideal gas EOS (gas)		The Pipe component has 100 elements. The Inlet BC has constant enthalpy and momentum. The Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-115	**Stagnation temperature and pressure inlet boundary condition with steady flow 3 equation model** - testing temperature and pressure defiened inlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D) No stabilization	Ideal gas EOS (gas)		The Pipe component has 100 elements. The Inlet BC has constant temperature and pressure. The Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	For steady flow initial_v was defined.

		Test-116	**Stagnation temperature and pressure inlet boundary condition with transient flow 3 equation model** - testing temperature and pressure defiened inlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D) No stabilization	Ideal gas EOS (gas)		The Pipe component has 100 elements. The Inlet BC has constant temperature and pressure. The Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	For transient flow initial_v was defined as zero.
		Test-118	**Non-isothermal turbine flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Stiffened gas EOS vapor (vapor)	ParsedFunction (inlet BC)	A Turbine component is linked between two Pipe components. The inlet BC uses ParsedFunction and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-119	**Pipe with heat structure water of temperature boundary condition type flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in pipe with heat structure	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) SolidMaterialProperties for heat stracuture material property.		The pipe uses PipeWithHeatStructure component of 20 elements. The heat structure BC uses Temperature. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-120	**Pipe with heat structute of convective boundary condition type water flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in pipe with heat structure	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) SolidMaterialProperties for heat stracuture material property.		The pipe uses PipeWithHeatStructure component of 20 elements. The heat structure boundary condition uses Convective. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-121	**Pipe with heat structute of adiabatic boundary condition type water flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in pipe with heat structure	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) SolidMaterialProperties for heat stracuture material property.		The pipe uses PipeWithHeatStructure component of 20 elements. The heat structure boundary condition uses Adiabatic. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-122	**Pipe with cylindrical heat structute of convective boundary condition type water flow using 1-D non-isothermal 3 equations model** - testing 1-D non-isothermal flow in pipe with heat structure	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) SolidMaterialProperties for heat stracuture material property.		The pipe uses cylindrical PipeWithHeatStructure component of 20 elements. The heat structure boundary condition uses Convective. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-123	**Valve opening** - testing valve opening action	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Linear EOS (liquid)		A Valve component is linked between two Pipe components. The initial status of the valve is closed and open at response time. The inlet and outlet BC use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-124	**Valve closing** - testing valve closing action	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Linear EOS (liquid)		A Valve component is linked between two Pipe components. The initial status of the valve is opened and close at response time. The inlet and outlet BC use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-125	**Compressible valve test** - testing compressible valve using non-isothermal 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) LAPIDUS stabilization	Stiffened gas EOS vapor (vapor)	ParsedFunction (inlet BC)	A CompressibleValve component is linked between two Pipe components. The valve is remaining closed during	SMP_PJFNK	Transient	Exodus	implicit-euler	Ok	

									the simulation. The inlet and outlet BC use TDV. The inlet BC uses ParsedFunction.						
		Test-126	**Compressible valve with sub-sonic flow**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) LAPIDUS stabilization	Stiffened gas EOS vapor (vapor)	ParsedFunction (inlet BC)	A CompressibleValve component is linked between two Pipe components. The valve is remaining closed during the simulation. The inlet and outlet BC use TDV. The inlet BC uses ParsedFunction.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-128	**Restart test part 1 – creat of check point file:** testing restart option by creating check point file	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Stiffened gas EOS liquid (liquid)		Two Pipe components are linked with SimpleJunction. The inlet BC uses Inlet and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus Checkpoint		Ok	
		Test-130	**Restart test part 1 – restart from check point file**: testing restart option by restarting from check point file	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Stiffened gas EOS liquid (liquid)		Two Pipe components are linked with SimpleJunction. The inlet BC uses Inlet and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus Checkpoint		Ok	
		Test-137	**Heat exchanger inlet and outlet error** - showing error due to missing inlet and outlet of the HeatExchanger component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		No primary and secondary inlet and outlet are defined in the HeatExchanger component.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-138	**Heat exchanger structure type error** - showing error due to miss define of heat structure type of the HeatExchanger component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		The primary and secondary inlet and outlet are defined as TimeDependentVolume.	SMP with Newton solver	Tranisent	Exodus	implicit-euler	Ok	
		Test-139	**Core channel inlet and outlet error** - showing error due to missing inlet and outlet of the CoreChannel component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. No inlet and outlet are defined in the CoreChannel component.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-140	**Core channel bad fuel type error** - showing error due to bad fuel type in the CoreChannel component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. Fuel type in the CoreChannel is badly defined. The Inlet and Outlet type BCs are used.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-141	**Junction input definition error** - showing error due to input type of FlowJunction component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. Input type in the FlowJunction is badly defined. The Inlet and Outlet type BCs are used.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-142	**Junction output definition error** - showing error due to output type of FlowJunction component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. Output type in the FlowJunction is badly defined. The Inlet and Outlet type BCs are used.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-144	**Over-specified heat exchanger boundary conditions error** - showing error due to over-specified inlet and outlet boundary conditions of the HeatExchanger component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		Both primary and secondary inlet and outlet are defined two times and shows error.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

		Test-145	**Over-specified core channel inlet and outlet boundary conditions error** - showing error due to over-specified inlet and outlet boundary conditions of the CoreChannel component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		One Reactor and CoreChannel component is modeled. Both inlet and outlet BCs are defiened twice and show error.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-146	**Pipe with heat structure type error** - showing error due to wrong definition of heat structure type of the PipeWithHeatStructure component modeling	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid)		The Inlet and Outlet BCs are used.	SMP with Newton solver	Tranisent	Exodus	implicit-euler	Ok	
		Test-152	**TMI 2-loop simulation -** testing TMI 2-loop nuclear power plant single-phase steady-state normal reactor operation	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		The Reactor component is modeled with three CoreChannel components; Pipe is used for bypass pipe; and Branch is used for lower and upper plenum of core. Both coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC of the both coolant loops are set with mass flow rate by TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-155	testing pipe loop with ideal pump	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		The one Pipe1 is linked with Pipe2 and Pipe3 components using FlowJunction. The IdealPump component is located between output of Pipe2 and input of Pipe1. The Inlet and Outlet use TDV BCs.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-156	**Pipe flow with time dependent junction and volume boundary conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		The Pipe has 20 elements. The Inlet uses TDJ BC and the Outlet uses TDV BC.	SMP with Newton solver	Tranisent	Exodus	implicit-euler	Ok	
		Test-157	**Typical PWR loop**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		Three CoreChannel components are linked with coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC is set with TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

Two-Phase Problems	***Homogeneous equilibrium model (HEM)***	Test-18	**Pipe flow test with two-phase homogeneous equilibrium model (HEM) -** testing middle void flow without heating in Pipe component using HEM two-phase flow model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-19	**Pipe flow test with transient boundary condition two-phase homogeneous equilibrium model (HEM) -** testing middle void flow without heating in Pipe component using HEM two-phase flow model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS	Parsed function	The Pipe component has 50 elements. TDV is used for inlet and outlet BCs to Pipes (Both BCs use ParsedFunction for analytic function).	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-20	**Pipe transition flow test with two-phase homogeneous equilibrium model (HEM) -** testing phase transition from single-phase water to two-phase in Pipe component using HEM two-phase flow model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs to Pipes (Both BCs use ParsedFunction for analytic function).	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-21	**Core channel heat transfer test with two-phase homogeneous equilibrium model (HEM)** - testing flow through the BWR core channel in CoreChannel component using HEM two-phase flow with wall friction and heat transfer model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (The fuel, gap and cladding material uses SolidMaterialProperties)	Piecewiselinear (Decay heat curve)	The Reactor has one CoreChannel of 50 elements and linked with inlet and oulet BCs. TDV is used for inlet and outlet BCs to Pipes (ParsedFunction is used for inlet BC for analytic heating function).	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-34	**Entropy viscosity stabilization with homogeneous equilibrium model (HEM)** - testing ENTROPY_VISCOSITY stabilization option in Pipe component using HEM two-phase flow model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	HEM model	Two-phase stiffened gas EOS		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	BDF2	Ok	
		Test-45	**BWR core channel flow using HEM two-phase model (OECD/NEA benchmark case)** - testing two-phase flow in BWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS The material properties of fuel, gap and cladding use SolidMaterialProperties.	ParsedFunction for inlet BC	The Reactor and CoreChannel components are used for BWR core simulation. The Inlet and Outlet use TDV for BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-73	**HEM two-phase pipe flow with strong time dependent volume boundary conditions** - testing strong time dependent volume boundary conditions	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	HEM model SUPG stabilization	Two-phase stiffened gas EOS (water)		The Pipe component has 10 elements. Inlet and Outlet BCs are TDV and set as weak BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

		Test-85	**Two-phase pipe flow with HEM model using time dependent volume boundary conditions and functional initial conditions** - testing two-phase flow with HEM model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS	PiecewiseLinear function (initial pressure, velocity, temperature and void fraction distribution)	The Pipe component has 100 elements. Inlet and Outlet BCs are TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-98	**Pipe flow with functional time dependent junction and time dependent volume boundary conditions using HEM two-phase flow model**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	HEM model SUPG stabilization	Two-phase stiffened gas EOS (water)	ParsedFunction (inlet BC)	The Pipe has 50 elements, and has constant wall temperature and heat transfer coefficient. The Inlet uses TDJ BC with ParsedFunction. The Outlet uses TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-102	**Heat exchanger flow using HEM two-phase model -** testing two-phase flow through heat exchanger using HEM model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS (two-phase liquid) Stiffened gas EOS liquid (water) The material property uses SolidMaterialProperties.		The HeatExchanger component has 30 elements. The primary and secondary inlets and outlets use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-104	**Separate dryer test with zero initial vapor volume fraction**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (two-phase) Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The SeparateDryer is linked with steam out and discharge Pipe components. The inlet and outlet BC of Pipe uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-105	**Separate dryer test with medium initial vapor volume fraction**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (two-phase) Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The SeparateDryer is linked with steam out and discharge Pipe components. The inlet and outlet BC of Pipe uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-106	**Separate dryer test with large initial vapor volume fraction**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (two-phase) Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The SeparateDryer is linked with steam out and discharge Pipe components. The inlet and outlet BC of Pipe uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-108	**Constant inlet boundary condition with two-phase homogeneous equilibrium model (HEM)** - testing constant boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)		HEM model SUPG stabilization	Two-phase stiffened gas EOS (vapor)		The Pipe component has 20 elements. Inlet BC has constant temperature and pressure. The Outlet BC uses TDV option.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-110	**Constant inlet and outlet boundary condition with two-phase homogeneous equilibrium model (HEM) -** testing constant boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	-	HEM model SUPG stabilization	Two-phase stiffened gas EOS (vapor)		The Pipe component has 20 elements. Inlet BC has constant temperature and pressure. The Outlet BC has constant pressure.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	

	7 equation model	Test-23	**Two-phase flow with pressure and volume relaxation model in nozzle** - testing two-phase flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)	Parsed function (nozzel type)	The Pipe component has 100 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus		Ok	For 7 eq parameters, both pressure and volume relaxation models were used.
		Test-26	**Two-phase flow with interfacial mass transfer model in nozzle** - testing two-phase flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)	Parsed function (nozzel type)	The Pipe component has 100 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus		Ok	For 7 eq parameters, both pressure and volume relaxation models were used.
		Test-28	**Two-phase flow in pipe** - testing two-phase flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus		Ok	The pressure and volume relaxation models and the interfacial mass transfer model were used.
		Test-29	**Water boling in the pipe** - testing water boiling in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe component has 100 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Transient	Exodus	implicit-euler	Ok	For 7 eq parameters, both pressure and volume relaxation models and interfacial mass transfer model were used.
		Test-30	**Water boling in the pipe using constant source term** - testing water boiling in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)	Constant heat source	The Pipe component has 100 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Transient	Exodus	implicit-euler	Ok	For 7 eq parameters, both pressure and volume relaxation models and interfacial mass transfer model were used.
		Test-31	**Water boling in the pipe with large void fraction** - testing water boiling in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe component has 50 elements. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Transient	Exodus	implicit-euler	Ok	For 7 eq parameters, both pressure and volume relaxation models and interfacial mass transfer model were used. The void fraction is modeled with wall mass transfer model.
		Test-37	**Wall friction modeling in pipe** - testing wall friction model of laminar, transitional, to turbulent flow in Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)		7 eq model (1-D) SUPG stabilization	Linear EOS (water)		The Pipe component has 10 elements. TDV is used for inlet and outlet BCs to Pipes.	SMP_PJFNK	Transient	Exodus	BDF2	Ok	

		Test-47	**Core channel flow using 1-D two-phase 7 equations model** - testing 1-D two-phase flow in cylinder fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) SUPG stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) The material properties of fuel use SolidMaterialProperties.		The Reactor and CoreChannel components are used for cylinder fuel core simulation. The Inlet and Outlet are used as BC	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-74	**Solid wall modeling with 7 equation model** - testing solid wall boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) PRESSURE stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe component has 100 elements. Inlet BC has constant properties. The Outlet BC uses SolidWall option.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-86	**Two-phase pipe flow with 7 equation model using time dependent volume boundary conditions and functional initial conditions**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D) LAPIDUS stabilization	Two-phase stiffened gas EOS (liquid, vapor)	PiecewiseLinear function (initial pressure, velocity, temperature and void fraction distribution)	The Pipe component has 50 elements. Inlet and Outlet BCs have constant pressure, temperature and volume franction.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-93	**Pipe flow with time dependent mass boundary condition using 7 equations model** - testing time dependent mass boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		The Pipe has 20 elements. The Inlet uses TDM BC and the Outlet has constant pressure.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-94	**Pipe flow with fuinctional time dependent mass boundary condition using 7 equations mode**l - testing time dependent mass boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)	PiecewiseLinear (inlet BC)	The Pipe has 20 elements. The Inlet uses TDM BC with PiecewiseLinear function. The Outlet has constant pressure.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-100	**Junction flow test with two junctions and three pipes using 7 equation model**	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		Three Pipe components are linked with SimpleJunction component. The inlet BC uses Inlet and outlet BC uses Outlet.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-111	**Stagnation inlet and static outlet boundary conditions with 7 equation model** - testing stagnation inlet and static outlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The Pipe component has 50 elements. The Inlet uses stagnation BC. The Outlet uses static BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-112	**Static boundary conditions with 7 equation model** - testing static inlet and outlet boundary conditions of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The Pipe component has 50 elements. The Inlet and Outlet use static BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok	
		Test-113	**Mass transferring inlet boundary condition with 7 equation model** - testing stagnation inlet and static outlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) LAPIDUS stabilization	Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The interface_transfer option is used for defining mass flow rate of inlet BC. The Pipe component has 100 elements. The Inlet BC has constant mass flow rate and Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	
		Test-117	**Stagnation temperature and pressure inlet boundary condition with transient flow 7 equation model** - testing temperature and pressure defiened inlet boundary condition of Pipe component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) No stabilization	Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The Pipe component has 100 elements. The Inlet BC has constant temperature and pressure for both liquid and vapor. The Outlet uses static BC.	SMP_PJFNK	Tranisent	Exodus		Ok	For transient flow initial_v was defined as zero.

Table. B. 3 List of Test Samples (classified by major components used)

Component Tested	Test ID #	Problem description	Source	Physical phenomena	Global Parameters	Equation of State/ Material Properties	Functions	Components/Boundary Condition (BC)	Preconditioning	Executioner	Output	Time integragion	Status
Reactor	Test-12	Decay heat behavior in reactor - testing decay heat behavior in the Reactor component	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)	Piecewiselinear (Decay heat curve)	The Reactor has two CoreChannel and linked with two pipes with Branch for inlet and oulet of water flow. Inlet pipe1 is linked with TDJ and outlet pipe2 is linked with TDV.	SMP_PJFNK	Tranisent	Exodus		Ok
	Test-38	Simple liquid metal reactor loop - testing liquid metal nuclear reactor one coolant loop	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) SolidMaterialProperties (material)		The Reactor component is modeled with one CoreChannel. Pipe and Branch is used for coolant loop. The IHX is modeled with HeatExchanger component. The inlet BC uses the TDJ and the outlet BC are set with TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-39	PWR core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in PWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. TDV is used for inlet and outlet BCs.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-40	PWR multiple core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in PWR multiple core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Ideal gas EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. Each CoreChannel is linked with Pipe component with Branch. The Pipe is linked with TDV Inlet and TDV Outlet boundary condition.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-41	PWR core channel flow using 1-D non-isothermal 3 equation model with functional material property - testing 1-D non-isothermal flow in PWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use PiecewiseLinear functional SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

	Test-42	Cylinder fuel core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in cylinder fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for cylinder fuel core simulation. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-43	Multiple core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in multiple core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Ideal gas EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and two CoreChannel components are used for multiple core simulation. Each CoreChannel is linked with Pipe component with Branch. TDJ is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-44	Plate fuel core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in plate fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for plate core simulation. The Pipe is linked with boundary conditions. TDJ is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus		Ok
	Test-45	BWR core channel flow using HEM two-phase model (OECD/NEA benchmark case) - testing two-phase flow in BWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS The material properties of fuel, gap and cladding use SolidMaterialProperties.	ParsedFunction for inlet BC	The Reactor and CoreChannel components are used for BWR core simulation. The Inlet and Outlet use TDV for BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-46	User defined power shaped core channel flow using 1-D non-isothermal 3 equations model - testing 1-D non-isothermal flow in cylinder fuel core channel flow using user defined power shape	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel and cladding use SolidMaterialProperties.	PieceWiseFunction (core power)	The Reactor and CoreChannel components are used for cylinder fuel core simulation. The Inlet uses TDJ and Outlet uses TDV for BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-47	Core channel flow using 1-D two-phase 7 equations model - testing 1-D two-phase flow in cylinder fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) SUPG stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) The material properties of fuel use SolidMaterialProperties.		The Reactor and CoreChannel components are used for cylinder fuel core simulation. The Inlet and Outlet are used as BC	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

CoreChannel	**Test-5**	Heat transfer model in core channel - Testing heat transfer models in a CoreChannel pipe component with typical PWR valve	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (water)		Core channel with 2 TDV & 1 TDJ (modeling cylindrical fuel) HT_geometry_code: 101 (single phase fluid flow in pipe)	SMP_PJFNK	Tranisent	Exodus		Ok
	Test-21	Core channel heat transfer test with two-phase homogeneous equilibrium model (HEM) - testing flow through the BWR core channel in CoreChannel component using HEM two-phase flow with wall friction and heat transfer model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (The fuel, gap and cladding material uses SolidMaterialProperties)	Piecewiselinear (Decay heat curve)	The Reactor has one CoreChannel of 50 elements and linked with inlet and oulet BCs. TDV is used for inlet and outlet BCs to Pipes (ParsedFunction is used for inlet BC for analytic heating function).	SMP_PJFNK	Tranisent	Exodus		Ok
	Test-39	PWR core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in PWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. TDV is used for inlet and outlet BCs.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-40	PWR multiple core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in PWR multiple core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Ideal gas EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. Each CoreChannel is linked with Pipe component with Branch. The Pipe is linked with TDV Inlet and TDV Outlet boundary condition.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-41	PWR core channel flow using 1-D non-isothermal 3 equation model with functional material property - testing 1-D non-isothermal flow in PWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use PiecewiseLinear functional SolidMaterialProperties.		The Reactor and CoreChannel components are used for PWR core simulation. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-42	Cylinder fuel core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in cylinder fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for cylinder fuel core simulation. TDV is used for inlet and outlet BCs.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

	Test-43	Multiple core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in multiple core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Ideal gas EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and two CoreChannel components are used for multiple core simulation. Each CoreChannel is linked with Pipe component with Branch. TDJ is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-44	Plate fuel core channel flow using 1-D non-isothermal 3 equation model - testing 1-D non-isothermal flow in plate fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel, gap and cladding use SolidMaterialProperties.		The Reactor and CoreChannel components are used for plate core simulation. The Pipe is linked with boundary conditions. TDJ is used for inlet BC while TDV is used for outlet BC.	SMP_PJFNK	Tranisent	Exodus	-	Ok
	Test-45	BWR core channel flow using HEM two-phase model (OECD/NEA benchmark case) - testing two-phase flow in BWR core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS The material properties of fuel, gap and cladding use SolidMaterialProperties.	ParsedFunction for inlet BC	The Reactor and CoreChannel components are used for BWR core simulation. The Inlet and Outlet use TDV for BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-46	User defined power shaped core channel flow using 1-D non-isothermal 3 equations model - testing 1-D non-isothermal flow in cylinder fuel core channel flow using user defined power shape	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material properties of fuel and cladding use SolidMaterialProperties.	PieceWiseFunction (core power)	The Reactor and CoreChannel components are used for cylinder fuel core simulation. The Inlet uses TDJ and Outlet uses TDV for BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-47	Core channel flow using 1-D two-phase 7 equations model - testing 1-D two-phase flow in cylinder fuel core channel flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	7 eq model (1-D, two-phase) SUPG stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) The material properties of fuel use SolidMaterialProperties.		The Reactor and CoreChannel components are used for cylinder fuel core simulation. The Inlet and Outlet are used as BC	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-66	Coupled point kinetics model with reactivity table - testing coupled point kinetics model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Reactor physics	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water) The material properties of fuel, gap and cladding use SolidMaterialProperties.	The PointKinetics option uses PicewiseLinear reactivity function.	The Reactor has two CoreChannel components and linked with two Pipe components with Branch for inlet and oulet of water flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

	Test-152	TMI 2-loop simulation - testing TMI 2-loop nuclear power plant single-phase steady-state normal reactor operation	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		The Reactor component is modeled with three CoreChannel components; Pipe is used for bypass pipe; and Branch is used for lower and upper plenum of core. Both coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC of the both coolant loops are set with mass flow rate by TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-157	Typical PWR loop	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		Three CoreChannel components are linked with coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC is set with TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
HeatExchanger	**Test-2**	Heat transfer in HX - Testing the heat trnasfer models in a heat exchanger component with sodium fluid on both sides. Primary fluid flows inside circular pipe while secondary fluid flows within parallel pipe bundle with square pitch.	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase heat transfer	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (both water and sodium)		TDV	SMP_PJFNK	Tranisent	Exodus		Ok
	Test-38	Simple liquid metal reactor loop - testing liquid metal nuclear reactor one coolant loop	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (liquid) SolidMaterialProperties (material)		The Reactor component is modeled with one CoreChannel. Pipe and Branch is used for coolant loop. The IHX is modeled with HeatExchanger component. The inlet BC uses the TDJ and the outlet BC are set with TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

	Test-101	Heat exchanger flow using 1-D non-isothermal 3 equation model (1-D heat exchanger wall)	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material property uses SolidMaterialProperties.		The HeatExchanger component has 10 elements. The heat exchanger wall is 1-D modeled. The primary and secondary inlets and outlets use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-102	Heat exchanger flow using HEM two-phase model - testing two-phase flow through heat exchanger using HEM model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model SUPG stabilization	Two-phase stiffened gas EOS (two-phase liquid) Stiffened gas EOS liquid (water) The material property uses SolidMaterialProperties.		The HeatExchanger component has 30 elements. The primary and secondary inlets and outlets use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-103	Heat exchanger flow using 1-D non-isothermal 3 equation model (2-D heat exchanger wall)	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) The material property uses SolidMaterialProperties.		The HeatExchanger component has 10 elements. The heat exchanger wall is 2-D modeled. The primary and secondary inlets and outlets use TDV BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-152	TMI 2-loop simulation - testing TMI 2-loop nuclear power plant single-phase steady-state normal reactor operation	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		The Reactor component is modeled with three CoreChannel components; Pipe is used for bypass pipe; and Branch is used for lower and upper plenum of core. Both coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC of the both coolant loops are set with mass flow rate by TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

	Test-157	Typical PWR loop	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		Three CoreChannel components are linked with coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC is set with TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
Pump	**Test-54**	Isothermal pump loop flow - testing isothermal pump loop flow using 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked with two Pipe components. Other Pipe components are linked using Branch components. The outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-55	Isothermal pump flow - testing isothermal pump flow using 2 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-57	Isothermal pump reverse flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model SUPG stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV. The pressure of outlet BC is higher than inlet BC makes reverse pump flow.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-58	Non-isothermal pump loop flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Linear EOS (liquid)		A Pump component is linked with two Pipe components. Other Pipe components are linked using Branch components. The outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-59	Non-isothermal pump flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Linear EOS (liquid)		A Pump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

	Test-60	Isothermal pump start flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase isothermal flow	2 eq model No stabilization	Barotropic EOS (liquid)		An isothermal Pump component is linked between two Pipe components. The form loss coefficient of the pump is set with 1000 to model the pump start. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-61	Turbine driven pump flow - testing turbine driven non-isothermal pump flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) LAPIDUS stabilization (vapor loop) SUPG stabilization (water loop)	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		Two loops are designed: vapor loop with turbine; and water loop with pump. The Turbine of vapor loop is linked between two Pipe components. The Pump of water loop uses turbine as driving component. The inlet and outlet BCs of both loops use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
IdealPump	**Test-56**	Ideal pump flow - testing non-isothermal pump flow using 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Linear EOS (liquid)		An IdealPump component is linked between two Pipe components. The inlet and outlet BCs of Pipe components use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-64	BWR wet well test with zero flow rates into the volume - testing BWR wet well non-isothermal 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) N2Properties (nigrogen)		A vapor loop is modeled for steam injection using VolumeBranch type valve. The water loop uses SUPG stabilization option and IdealPump to simulate water drawing back. A gas vent loop also uses SUPG stabilization option and SolidWall type valve for venting to dry well. The wet well uses WetWell component. Five Pipe components are used. The inlet and outlet BCs use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

	Test-152	TMI 2-loop simulation - testing TMI 2-loop nuclear power plant single-phase steady-state normal reactor operation	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) SUPG stabilization	Linear EOS (liquid) Property of material is set with SolidMaterialProperties.		The Reactor component is modeled with three CoreChannel components; Pipe is used for bypass pipe; and Branch is used for lower and upper plenum of core. Both coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC of the both coolant loops are set with mass flow rate by TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-155	testing pipe loop with ideal pump	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		The one Pipe1 is linked with Pipe2 and Pipe3 components using FlowJunction. The IdealPump component is located between output of Pipe2 and input of Pipe1. The Inlet and Outlet use TDV BCs.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-157	Typical PWR loop	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Linear EOS (water)		Three CoreChannel components are linked with coolant loops are designed with Pipe, Branch, IdealPump and HeatExchanger components. The inlet BC is set with TDJ. The outlet BCs are set with TDV. The first loop has pressurizer modeled with Pipe component and TDV outlet BC.	FDP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
SeparatorDryer	**Test-104**	Separate dryer test with zero initial vapor volume fraction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (two-phase) Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The SeparateDryer is linked with steam out and discharge Pipe components. The inlet and outlet BC of Pipe uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

	Test-105	Separate dryer test with medium initial vapor volume fraction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (two-phase) Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The SeparateDryer is linked with steam out and discharge Pipe components. The inlet and outlet BC of Pipe uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-106	Separate dryer test with large initial vapor volume fraction	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Two-phase non-isothermal flow	HEM model No stabilization	Two-phase stiffened gas EOS (two-phase) Stiffened gas EOS liquid (liquid) Stiffened gas EOS vapor (vapor)		The SeparateDryer is linked with steam out and discharge Pipe components. The inlet and outlet BC of Pipe uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
WetWell	**Test-62**	BWR wet well test with given boundary condition	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) SUPG stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) N2Properties (nigrogen)		A vapor loop is modeled for steam injection and water loop is modeled for water drawing back. A gas vent loop is designed for venting to dry well. The valve is modeled with Branch component and wet well uses WetWell component. Five Pipe components are used. The inlet and outlet BCs use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-64	BWR wet well test with zero flow rates into the volume - testing BWR wet well non-isothermal 3 equations model	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) No stabilization	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase) N2Properties (nigrogen)		A vapor loop is modeled for steam injection using VolumeBranch type valve. The water loop uses SUPG stabilization option and IdealPump to simulate water drawing back. A gas vent loop also uses SUPG stabilization option and SolidWall type valve for venting to dry well. The wet well uses WetWell component. Five Pipe components are used. The inlet and outlet BCs use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

Turbine	**Test-61**	Turbine driven pump flow - testing turbine driven non-isothermal pump flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (non-isothermal) LAPIDUS stabilization (vapor loop) SUPG stabilization (water loop)	Stiffened Gas EOS Liquid (for liquid phase) Stiffened Gas EOS Vapor (for vapor phase)		Two loops are designed: vapor loop with turbine; and water loop with pump. The Turbine of vapor loop is linked between two Pipe components. The Pump of water loop uses turbine as driving component. The inlet and outlet BCs of both loops use TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok
	Test-118	Non-isothermal turbine flow	INL/EXT-14-33201 (Ch. 2 & Ch. 3)	Single-phase non-isothermal flow	3 eq model (1-D, non-isothermal) No stabilization	Stiffened gas EOS vapor (vapor)	ParsedFunction (inlet BC)	A Turbine component is linked between two Pipe components. The inlet BC uses ParsedFunction and outlet BC uses TDV.	SMP_PJFNK	Tranisent	Exodus	implicit-euler	Ok

APPENDIX C. REQUIREMENT TRACEABILITY MATRIX (RTM)

Table. C. 1 General Requirements (GR)

Req #	Category	Requirement Specification	Source(s)	Design Specification (SVVP Section #)	Status
GR-1	Reactor Design, Reactor Type	Simulate various LWR designs including PWR and BWR	INL/EXT-14-33201	Ch. 2 & Ch. 3	Test-45 for BWR (HEM model) Test-152 for PWR (TMI loop)
GR-2		Simulate various PWR manufacturers' designs such as Westinghouse, Combustion Engineering and Babcock&Wilcox	INL/EXT-14-33201	Ch. 2	PWR cores are tested but not compared for different manufactures
GR-3		Simulate various containment design such as high and low backpressure	INL/EXT-14-33201	Ch. 2	Not tested
GR-4		Simulate reactor designs with non-water coolants	Newly added		Not tested
GR-5	Thermal-hydraulic Analysis (Steady-state/transient), Reactor Safety Feature	Simulate steady-state analysis	INL/EXT-14-33201	Ch. 1 & Ch. 2	Test-152
GR-6		Simulate Large-break LOCA (LBLOCA) and Small break LOCA (SBLOCA)	INL/EXT-14-33201	Ch. 2	Not tested
GR-7		Simulate Emergency Core Cooling System (ECCS) design (accumulators, pumped safety injection system - DVI, cold-leg/hot-leg injection)	INL/EXT-14-33201	Ch. 2	Not tested
GR-8		Simulate excessive heat transfer	INL/EXT-14-33201	Ch. 2	Not tested
GR-9		Simulate loss of heat transfer and loss of flow	INL/EXT-14-33201	Ch. 2	Not tested
GR-10		Simulate increase and decrease in inventory	INL/EXT-14-33201	Ch. 2	Not tested
GR-11		Simulate departure from nucleate boiling (DNBR)	INL/EXT-14-33201	Ch. 2	Not tested

GR-12		Simulate minimum critical power ratio (MCPR)	INL/EXT-14-33201	Ch. 2	Not tested
GR-13		Simulate transient analysis during LOCA	INL/EXT-14-33201	Ch. 2	Not tested
GR-14	Multi-physics (Reactor kinetics, fuel components behavior, chemical reactions, etc.)	Generate physics parameters for reactor kinetics model in system code	INL/EXT-14-33201	Ch. 2 & Ch. 3	Test 65-67
GR-15		Simulate reactivity and core power distribution	INL/EXT-14-33201	Ch. 2 & Ch. 3	Test 65-67
GR-16		Simulate 3-D core power boundary condition coupled with system code	INL/EXT-14-33201	Ch. 2	Not tested
GR-17		Simulate fuel rod thermal modeling	INL/EXT-14-33201	Ch. 2	Test-5
GR-18		Simulate mechanical and thermal behavior of fuel pellets, gap and cladding	INL/EXT-14-33201	Ch. 2	Test-5, 21, 39, 40, 41, 43, 44, 45, 63, 66, 133
GR-19		Simulate fluid/mechanical interaction analysis	INL/EXT-14-33201	Ch. 2	Not tested
GR-20		Simulate containment analysis	INL/EXT-14-33201	Ch. 2	Not tested
GR-21		Simulate chemistry effects	INL/EXT-14-33201	Ch. 2	Not tested
GR-22		Simulate radiological consequence analysis	INL/EXT-14-33201	Ch. 1 & Ch. 2	Not tested
GR-23		Simulate prediction of core power distribution	INL/EXT-14-33201	Ch. 2	Test-46
GR-24		Capability of coupling of codes	INL/EXT-14-33201	Ch. 1 & Ch. 2	Not tested
GR-25	Multi-scale	Simulate multi-dimensional fluid flow at microscale level of detail	INL/EXT-14-33201	Ch. 1 & Ch. 2	Not tested

Table. C. 2 Specific Requirements (SR)

Req #	Requirement Specification	Verification/Action Item	Source(s)	Design Specification (SVVP Section #)	Status
SR-1	The code will use most advanced computer science technology to optimize accuracy and speed (Essential)	1. Descritizaton scheme 2. Time integration method 3. Matirix solver 4. Parallel computation capability	INL/EXT-14-33201	Ch. 2	Written with C++. Capable of Multi-scale time integration, PCICE (operator split), JFNK (implicit nonlinear Newton method), and a point implicit method (long duration transients). New pipe network algorithm based upon Mortar FEM (Lagrange multipliers). Ability to couple to multi-dimensional reactor simulators
SR-2	The code will implement 3D modeling for obtaining high level of resolution includes coupling to CFD code (Essential)	1. Mesh management 2. Verification test for coupling with other MOOSE-based applications	INL/EXT-14-33201	Ch. 2	Can be coupled with MOOSE based BISON code for 3D neutron transport model. However, RELAP-7 does not have 3D mesh generation model.
SR-3	The code will provide coordinate system to represent actual design (Recommended)	-	INL/EXT-14-33201	Ch. 2	Provides x, y, z coordination system for components, functions, etc
SR-4	The code will develop standard modules for meshing to lessen the variability of the result (Recommended)	-	INL/EXT-14-33201	Ch. 2	RELAP-7 supports standard component models
SR-5	The code will identify standard or recommended options to lessen the variability of the result (Recommended)	-	INL/EXT-14-33201	Ch. 2	RELAP-7 supports standard component models
SR-6	The code will not subject to failure as a result of numerical methods (Essential)	Numerical stability test	INL/EXT-14-33201	Ch. 2	Not tested
SR-7	The code will address legacy issues associated with two-phase flow (Recommended)	-	INL/EXT-14-33201	Ch. 2	Both HEM and 7 equation two-phase model can be simulated

SR-8	The code will model droplet for BWR core spray and containment spray of PWR/BWR (Recommended)	-	INL/EXT-14-33201	Ch. 2	Not tested
SR-9	The code will model sources and transport of particles in vapor, gas, droplet and liquid (Essential)	Model V&V in RELAP 7 framework and/or code-to-code comparison	INL/EXT-14-33201	Ch. 2	Not tested
SR-10	The code will model transport of non-condensable gases including heat transfer effect (Essential)	Model V&V in RELAP 7 framework and/or code-to-code comparison	INL/EXT-14-33201	Ch. 2	The compressible valve component can handle non-condensible gas model
SR-11	The code will provide multi-scale / multi-physics simulation of following scope by embedded or coupling : fuel rod; fuel assembly reactor primary coolant system; secondary coolant system and balance of plant: instrumentation and controls; containment; site radiological consequences; offsite radiological consequences; and fluid/structure interaction for dynamic loads (Essential)	Coupling test with other MOOSE-based applications	INL/EXT-14-33201	Ch. 2	RELAP-7 can be coupled with MOOSE framework application to simulate multi-scale / multi-physics problems
SR-12	The code will be user friendly steady-state initialization and restart capabilities (Recommended)	-	INL/EXT-14-33201	Ch. 2	Both steady-state and transient cases can be simulated by restart option
SR-13	The code will provide clear and easy diagnostics to assist with debugging and workaround (Recommended)	-	INL/EXT-14-33201	Ch. 2	Code will show highlighted error signal. For example, if wrong model type was give then shows in red: ***ERROR*** Unknown model type

SR-14	The code will provide detailed documentation of theory, programming, user manual, validation basis and user guidelines (Essential)	-	INL/EXT-14-33201	Ch. 2	RELAP-7 provides revised theory manual. Other documents are in progress
SR-15	The code will provide comprehensive GUI for pre/post-processing and on-line monitoring (Essential)	-	INL/EXT-14-33201	Ch. 2	in progress

Table. C. 3 Technical Requirements (TR)

Req #	Test Feature	Requirement Specification	Source(s)	Design Specification (SVVP Section #)	Sample Test ID #
TR-1	Numerical Test (Code Verification)	Verification of single phase flow	INL/EXT-14-33201	Ch. 2 & Ch. 3 & Ch. 5	1,54, 55, 57, 60, 75, 76, 77, 79, 80, 83, 84
TR-2		Verification of heat conduction simulation	INL/EXT-14-33201	Ch. 2 & Ch. 5	Not tested
TR-3		Grid convergence study by continuous FEM on fluid flow problems	INL/EXT-14-33201	Ch. 5	Not tested
TR-4		Grid convergence study by continuous FEM on heat conduction problems	INL/EXT-14-33201	Ch. 5	Not tested
TR-5		Grid convergence study on stabilization schemes using SUPG scheme	INL/EXT-14-33201	Ch. 5	Not tested
TR-6		Grid convergence study on stabilization schemes using Lapidus scheme	INL/EXT-14-33201	Ch. 5	Not tested
TR-7		Grid convergence study on stabilization schemes using Entropy based viscosity scheme	INL/EXT-14-33201	Ch. 5	Not tested
TR-8		Time step convergence study using manufactured solutions Backward Euler	INL/EXT-14-33201	Ch. 5	Not tested
TR-9		Time step convergence study using manufactured solutions Crank-Nicolson	INL/EXT-14-33201	Ch. 5	Not tested

TR-10		Time step convergence study using manufactured solutions BDF2	INL/EXT-14-33201	Ch. 5	Not tested
TR-11		Conservation laws in 0-dimensional components Branches/Junctions	INL/EXT-14-33201	Ch. 5	Not tested
TR-12		Conservation laws in 0-dimensional components PWR specific components (steam generator and pressurizer as examples)	INL/EXT-14-33201	Ch. 5	Not tested
TR-13		Simulation of system level conservation laws	INL/EXT-14-33201	Ch. 5	Not tested
TR-14	Software Design Test (Code Verification)	Code review process capability	INL/EXT-14-33201	Ch. 1 & Ch. 5	Not tested
TR-15		Regression test and code coverage test on general coverage test design	INL/EXT-14-33201	Ch. 5 & Ch. 6	Not tested
TR-16		Regression test and code coverage test on extreme conditions test design	INL/EXT-14-33201	Ch. 5 & Ch. 6	Not tested
TR-17	Basic Performance Test (Code Validation, Phenomenalogical Test)	Single phase shock problems	INL/EXT-14-33201	Ch. 5	7
TR-18		Single phase pipe and branch system	INL/EXT-14-33201	Ch. 2 & Ch. 3 & Ch. 5	1, 3, 4, 6-8, 11, 13-20, 13, 26, 28-37, 38, 40, 43, 44, 48-69, 71-100, 104-126, 128, 130, 152, 155, 157
TR-19		Single phase pipe network	INL/EXT-14-33201	Ch. 2 & Ch. 5	75-79
TR-20		Two-phase flow water faucet problem	INL/EXT-14-33201	Ch. 5	Not tested
TR-21		Two-phase flow water over steam problem	INL/EXT-14-33201	Ch. 5	Not tested
TR-22		Two-phase flow fill-drain problem	INL/EXT-14-33201	Ch. 5	Not tested

TR-23		Two-phase flow manometer problem	INL/EXT-14-33201	Ch. 5	Not tested
TR-24		Two-phase flow gravity wave problem	INL/EXT-14-33201	Ch. 5	Not tested
TR-25		Two-phase shock problems	INL/EXT-14-33201	Ch. 5	Not tested
TR-26		Evaporation due to heat input or depressurization	Newly added		Not tested
TR-27		Condensation due to heat removal or pressurization	Newly added		Not tested
TR-28		Pressure drop at abrupt geometric changes	Newly added		Not tested
TR-29		Pressure wave propagation	Newly added		Not tested
TR-30	Separate Effect Test (Code Validation, SET)	Single-phase flow wall friction	INL/EXT-14-33201	Ch. 2 & Ch. 5	91, 92
TR-31		Single-phase heat transfer	INL/EXT-14-33201	Ch. 2 & Ch. 3 & Ch. 5	2-8, 10-16, 32 33, 35, 36, 38-44, 46, 48-53, 56, 58, 59, 61-69, 71, 72, 78, 81, 82, 87-92, 95-97, 99, 101, 103, 107, 109, 114-116, 118-126, 128, 130, 137-142, 144-146, 152, 155-157
TR-32		Single-phase water hammer	INL/EXT-14-33201	Ch. 5	11
TR-33		Single-phase natural circulation	INL/EXT-14-33201	Ch. 5	76, 78
TR-34		Two-phase flow wall friction	INL/EXT-14-33201	Ch. 5	21 (HEM), 37 (7 eq. model)
TR-35		Two-phase interfacial friction (vertical/horizontal flow)	INL/EXT-14-33201	Ch. 5	Not tested
TR-36		Two-phase flow boiling heat transfer	INL/EXT-14-33201	Ch. 5	21 (HEM)
TR-37		Two-phase flow critical flow and blowdown	INL/EXT-14-33201	Ch. 5	Not tested

TR-38		Two-phase flow level tracking	INL/EXT-14-33201	Ch. 5	Not tested
TR-39		Two-phase flow CHF and post-CHF	INL/EXT-14-33201	Ch. 5	Not tested
TR-40		Two-phase flow reflooding	INL/EXT-14-33201	Ch. 5	Not tested
TR-41		Two-phase flow counter-current flow	INL/EXT-14-33201	Ch. 5	Not tested
TR-42		PWR specific component tests	INL/EXT-14-33201	Ch. 5	Reactor: 12, 39-41 CoreChannel: 5, 39, 40, 41, 152, 157 HeatExchanger: 152 IdealPump: 152, 157
TR-43		BWR specific component tests	INL/EXT-14-33201	Ch. 5	Reactor: 45 WetWell: 62, 64 SeparatorDryer: 104-106 CoreChannel: 21, 45 IdealPump: 64
TR-44	Integral Effect Test (Code Validation, IET)	Single-phase natural circulation	INL/EXT-14-33201	Ch. 5	Not tested
TR-45		Two-phase Full Integral Simulation Test (FIST) SBO test benchmark	INL/EXT-14-33201	Ch. 5	Not tested
TR-46		Two-phase flow LOFT tests	INL/EXT-14-33201	Ch. 5	Not tested
TR-47		Two-phase flow semi-scale natural circulation tests	INL/EXT-14-33201	Ch. 5	Not tested