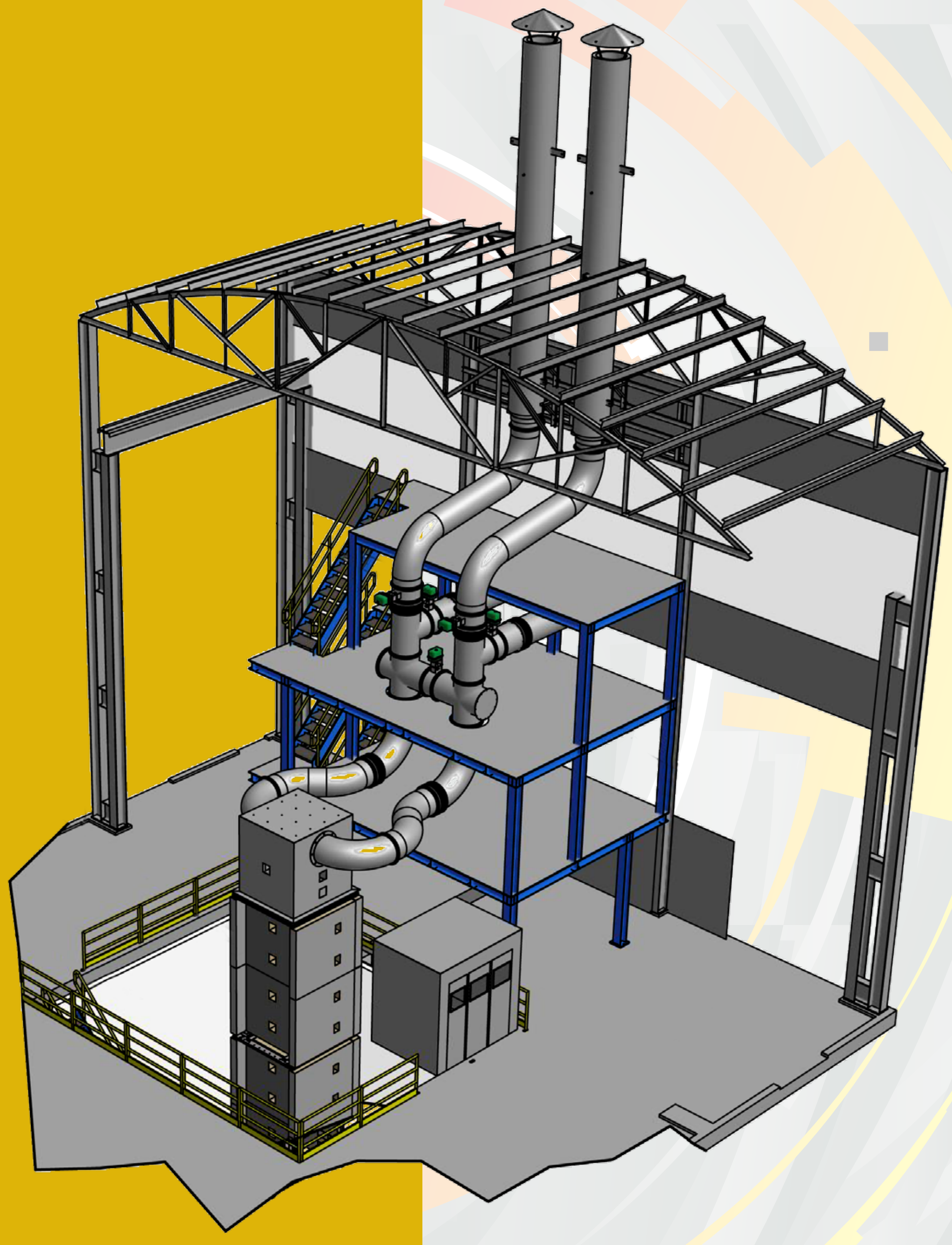
NSTF

Argonne National Laboratory's

Natural Convection Shutdown Heat Removal Test Facility



Argonne NATIONAL LABORATORY

Yesterday's success with GE's PRISM. . .

Originally built to aid in the development of General Electric's Power Reactor Innovative Small Module (PRISM) Reactor Vessel Auxiliary Cooling System (RVACS), Argonne National Laboratory's Natural Convection Shutdown Heat Removal Test Facility (NSTF) provided confirmatory data for the airside of the RVACS.

. . .Fosters Today's Testing on Advanced Reactor Passive Cooling Systems.

Today, as a large-scale integral test facility, the NSTF is being modified for the U.S. Department of Energy's Advanced Reactor Concept (ARC) program. When completed, the NSTF will confirm the performance of the Next Generation Nuclear Plant (NGNP) reactor cavity cooling systems (RCCS) and similar passive confinement or containment decay heat removal systems in Small Modular Reactors. With a height of 26.2 m and a test section area of 150 cm x 132 cm, NSTF will be one of the largest test facilities in the world for ex-vessel passive decay heat removal testing.

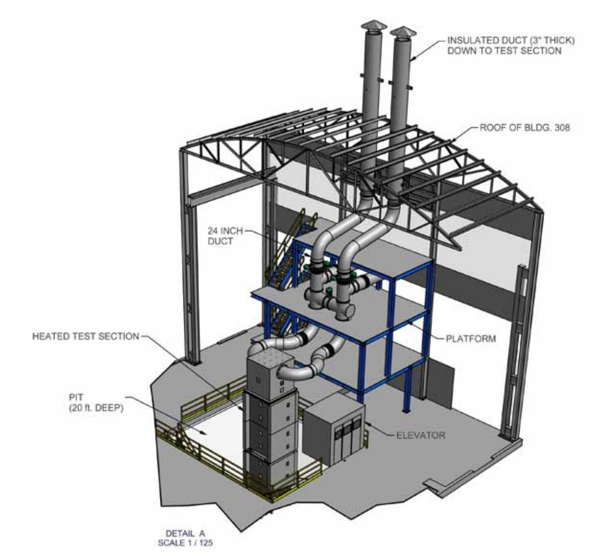


Figure 1

The Natural Convection Shutdown Heat Removal Test Facility

The NSTF can perform ex-vessel cavity or confinement/containment passive decay heat removal tests to assess for an air-cooled system:

- The air-side thermal-hydraulic performance;
- The performance under degraded system operation (partial to complete blockage of the system inlet);
- The performance under different wind conditions, including high wind gusts.

Experimental results for similar test objectives also can be obtained for water-cooled systems.

The facility is highly flexible; it can accommodate a crosscutting variety of ex-vessel cavity or confinement/containment designs.

Argonne also conducts computational fluid dynamics and system code pretest calculations and parametric studies. Such experiment design analyses supported the design, and predicted the performance, of the facility for various operating conditions representing the GE PRISM RVACS range of operation.

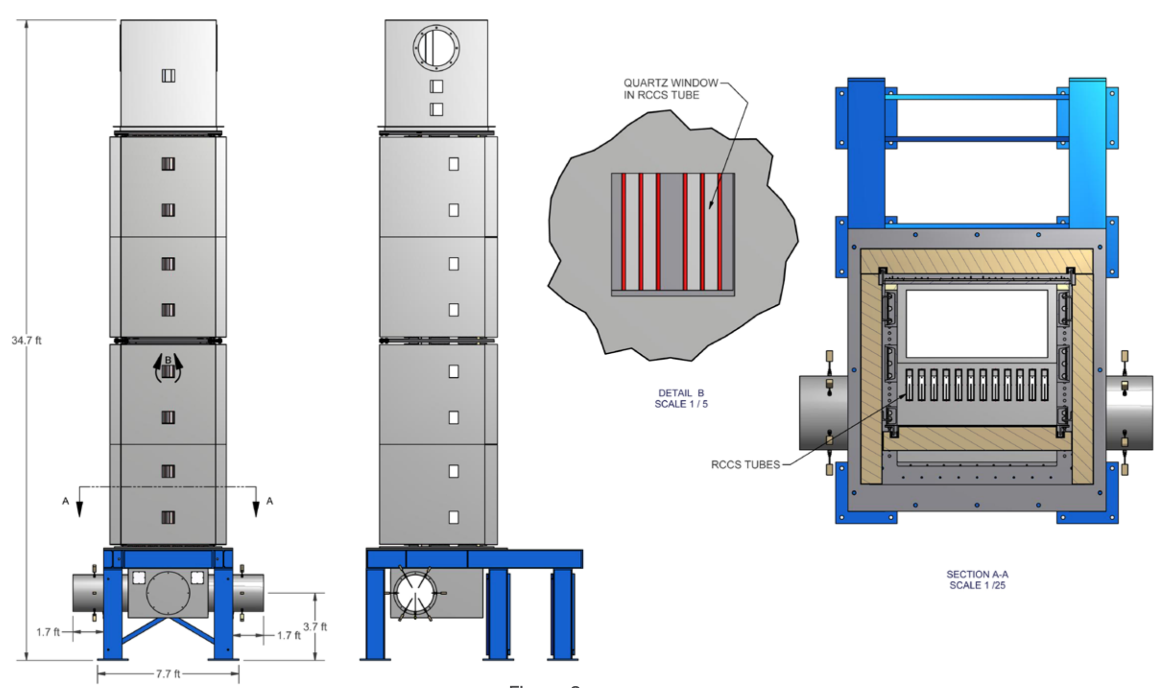


Figure 2

The Facility Design

The principal components of the NSTF are the structural module, electric heaters, instrumentation, insulation, and a computerized data acquisition and control system. Table 1 summarizes facility design and operating parameters.

The mechanical framework supporting the heated and unheated walls, which simulate the vessel and the concrete cavity, is being modified to provide for a larger adjustable test cavity cross-section and a flexible combination of hot and cold plena and stacks.

Parameter	Original Facility	Redesigned Facility
General	Natural convection air-flow thermal-hydraulic test facility	Same, but water-based testing can also be accommodated with thermal centers, separation distance of up to 15 m possible.
Overall Facility Height	26.2 m (86 ft)	Same
Flow Operating Modes	Natural or forced convection	Same
Heated Section Flow Area	Rectangular, 46 cm x 132 cm	Rectangular, 132 cm-wide cavity with adjustable cavity depth that can range from 30 cm to 150 cm in 2.5 cm increments.
Heated Section Length	6.7 m (22 ft)	Same
Heating Distribution	One long side heated; other three sides adiabatic	Same
Heated Section Operating Modes	1) Constant heat flux (heater max is 23 kW/m^2) 2) Constant temperature (677°C max) 3) Arbitrary combination of 1 and 2	Same
Total Input Power	220 kW	Same
Heated Zone Temperature-Heat Flux Control Resolution	• 10-67 cm axial segments • No azimuthal segmentation	• 10-67 cm axial segments • 4 azimuthal control zones at each axial elevation (two central zones plus two guard heater zones)
Chimney Design	• 18.0 m high • 46 cm x 132 cm rectangular cross-section	• 18.0 m high • Two 60 cm diameter circular ducts that allow different vent path configurations to be mocked up.

Table 1. NSTF Design and Operating Parameters

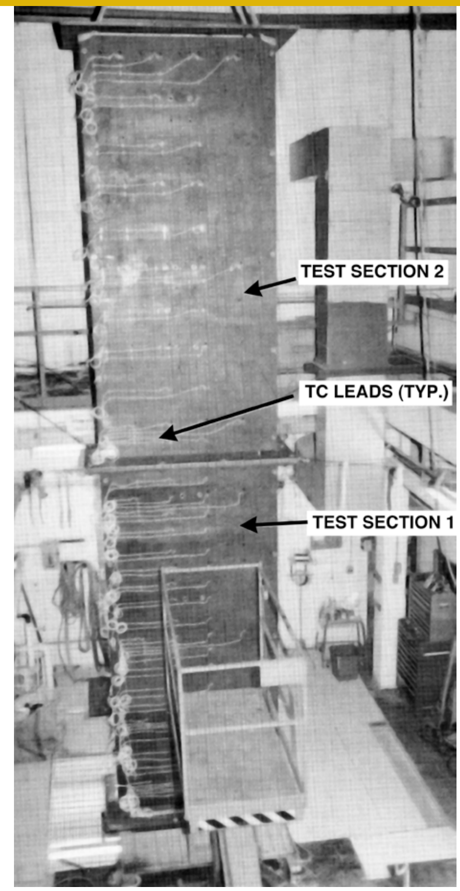


Figure 3

Structural Module

The key features of the structural module (See Figures 1 and 2) are the inlet section, a heated zone that mocks up the exterior of the reactor vessel (see Figure 3) and the concrete wall surrounding the vessel cavity, and an unheated stack or chimney. All sections, with the exception of the inlet section, are thermally insulated to minimize parasitic heat losses to the environment. Some highlights include:

HEATED ZONE AND CAVITY WALL

- The flow channel's cross-section is being expanded from 46 cm to 150 cm x 132 cm; the channel width can be varied between 30 cm and 150 cm.
- Within the heated zone, fins or ribs can be installed on the inner walls of the air channel to enhance turbulence and heat transfer.
- The surfaces that simulate the vessel wall (heated wall) and the cavity wall are smooth, 2.54 cm thick carbon steel plates.

STACKS

- Two stacks with a number of plena interconnections can simulate two hot chimneys, or a hot chimney and a cold chimney in parallel.

COOLING SYSTEMS

- The original air natural convection cooling capability with radiation heat transfer.
- Additional provisions for water-based cooling systems with natural convection and flashing.

Computerized Data Acquisition and Control System

Argonne's NSTF instrumentation includes thermocouples, Pitot-static traversing probes, a Pitot-static air-flow "rake," differential pressure transducers, radiation flux transducers, an anemometer, and air pressure and humidity gauges. Upgrades to the facility include Laser Doppler Velocimetry and Particle Image Velocimetry viewing ports and locations. In addition, fiber optic temperature measurement systems are being incorporated.

Tha facility can measure:

- Local surface temperatures
- Local and bulk air temperatures
- Local and bulk air velocities
- Air volumetric and mass flow rates
- Normal radiative and convective components of the total heat flux
- Electric power input to the heaters
- Local and bulk heat flux
- Water loop parameters

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Seventy years of leadership in nuclear science and technology

Argonne developed and/or built experiments, research reactors, or prototypes of nearly every kind of commercial nuclear reactor in the world today, as well as many research and training reactors. An overview of this history can be found at **http://www.ne.anl.gov/About/ANL-Reactors.shtml.**

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