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SPACE NUCLEAR THERMAL PROPULSION

SNTP

US AIR FORCE
Phillips Laboratory
Grumman, Babcock & Wilcox
Brookhaven & Sandia National Labs

TESTS

PRESENTATION AT NUCLEAR PROPULSION TECHNICAL INTERCHANGE MEETING

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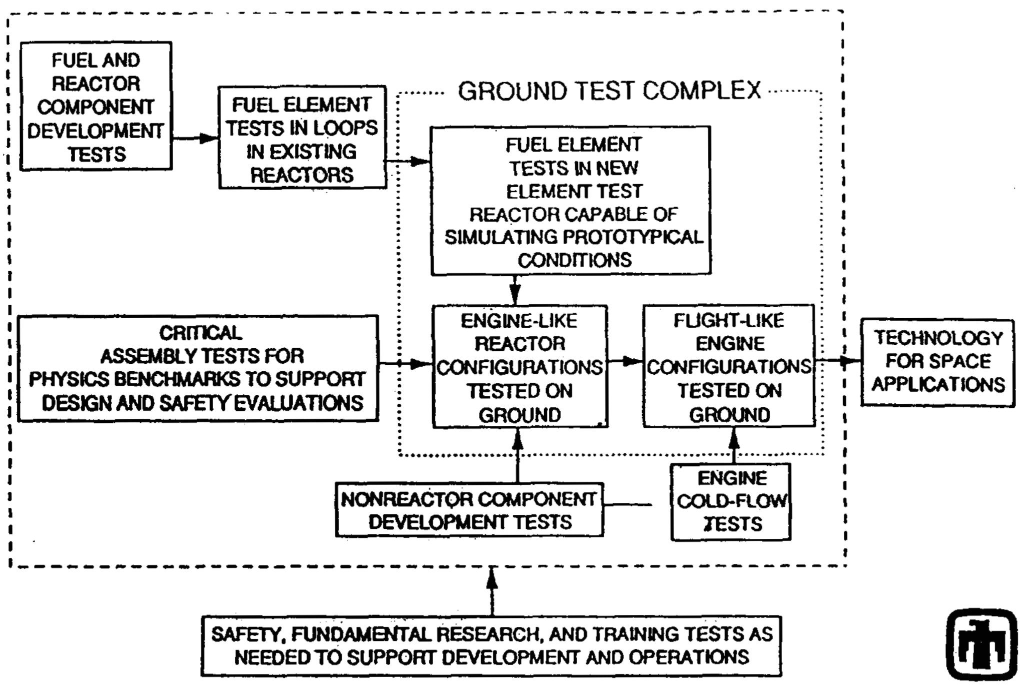
The objective of the SNTP program is to develop advanced nuclear thermal propulsion technology based on the particle bed reactor concept. A strong philosophical commitment exists in the industry/national laboratory team direced by the Air Force Phillips Laboratory to emphasize testing in development activities. This presentation focuses on nuclear testing currently underway to support development of SNTP technology

Summary Test Logic For NTP Development



This is the summary test logic for NTP Development that has been generally accepted in the propulsion community provided resources are available. It is very consistent with the SNTP approach. Because of the limited time for the presentation, I will concentrate on critical assembly tests, fuel nuclear tests, and fuel element tests in loops in an existing reactor. Given time, I would discuss each box.

Critical Experiment (CX)

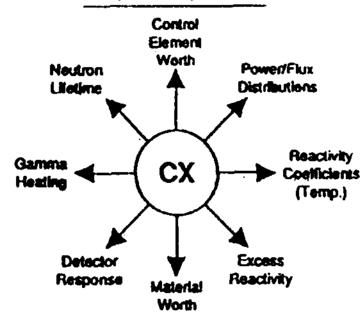
Purpose:

To obtain neutronic information for engineering needs (Safety, Mechanical Design, Control, Power Distribution, Weight, Reactor Design)

Accomplishments:

- Movable test reactor built - critical on October 24, 1989
- Excess reactivity - good agreement with predictions
- Peek-A-Boo control scheme feasibility demonstrated
- Control, safety, and shim element worth determined
- Moderator temperature coefficient determined
- Near-Term Priority:
  - Hot RHO experiment completion
  - Cold moderator follow - on experiment
  - Para/Ortho hydrogen worth

Completed Experiments



In the critical assembly test category, an operating low-power reactor called CX was developed and is operated in the Sandia Pulsed Reactor (SPR) facility. The goal of CX is to perform nuclear measurements that allow for neutronic codes and cross-sections to be benchmarked so that design margins, controllability, and limiting accident scenarios may be predicted and assessed for PBRs with reliability and certainty. The SNTP team successfully fulfilled all approval requirements imposed by DOE for operating a critical assembly. The CX achieved first critical in October 1989. Eight experiment campaigns have been performed to date with over 100 operations logged. Several of the major completed experiments have been listed in this vugraph.

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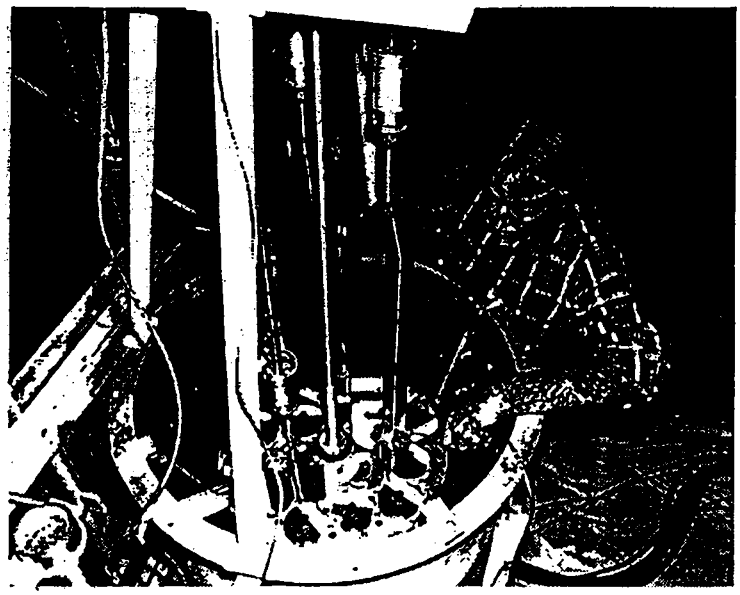
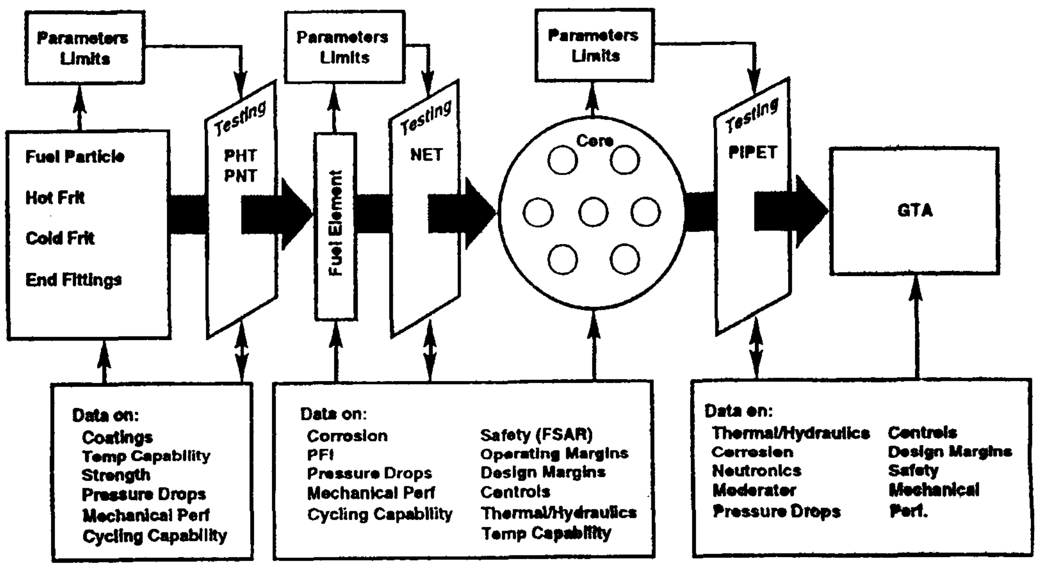
Sandia and the SNTP Team Built and Operate a Low-Power PBR for Reactor Physics Experiments



This is a photograph of the CX assembly with the water moderated removed.

Experiment Data Flow



Moving on to fuel and fuel element tests, this figure shows the experiment data flow for tests on these key nuclear components. Some of the test acronyms are as follows:

PHT = Particle Heating Tests
PNT = Particle Nuclear Tests
NET = Nuclear Element Tests
PIPET = PBR Integral Performance Element Tester
GTA = Ground Test Article (System-level test)

This sequence follows the test logic of going from components to subsystems to systems. The stepwise data achieved in these tests is key technology development and validation.

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Particle Nuclear Test (PNT)

PURPOSE:

To conduct in-reactor testing of fuel particles to provide design verification, identify potential failure modes, and evaluate effects of manufacturing process variables.

ACCOMPLISHMENTS:

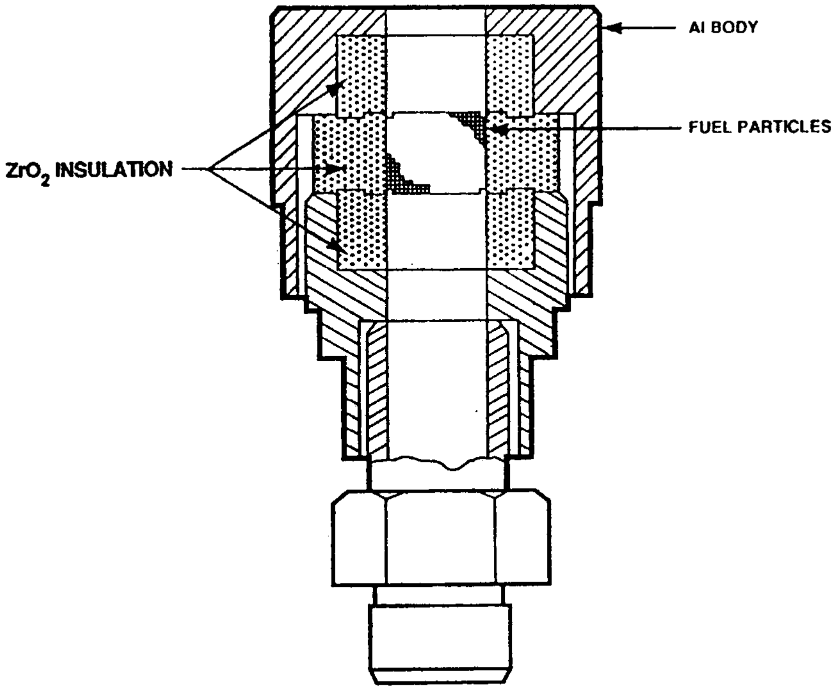
- 4 Capsule Tests
- 12 Fuel Holders
- 200,000 Fuel Particles
- 1800 - 3100K
- 150 - 600 Seconds
- 1 - 4 Cycles
- Fission Product Release Measurements

STATUS:

- **Performance limits determined for baseline fuel. Integrated fission product release Model operational. Additional tests planned as fuel becomes available.**

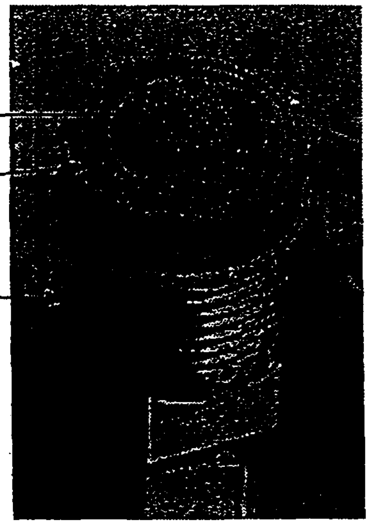
PNTs are performed on fuel particles to provide design verification, identify potential failure modes, and evaluate effects of manufacturing process variables. Since this vugraph was prepared, a fifth capsule test was performed on baseline particle fuels. This vugraph shows the range of test parameters. A computer code called HEISHI is now operational at Sandia to predict particle performance and to estimate fission product releases. The PNTs provide a considerable amount of data for code validation.

PNT-I Fuel Holder



This is a fuel holder used in PNT experiments conducted to date. It holds one cubic centimeter of fuel particles.

PNT Fuel Holder



This is a photo of a PNT fuel holder with the top cap removed after a test.

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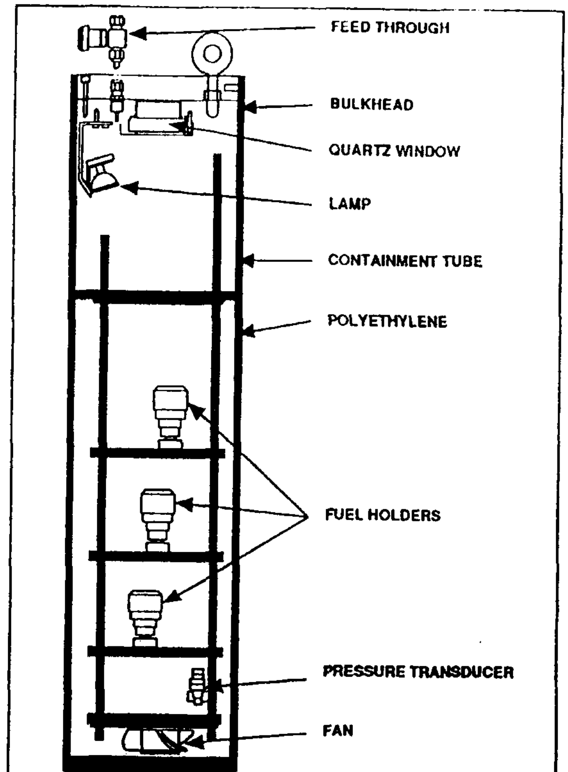
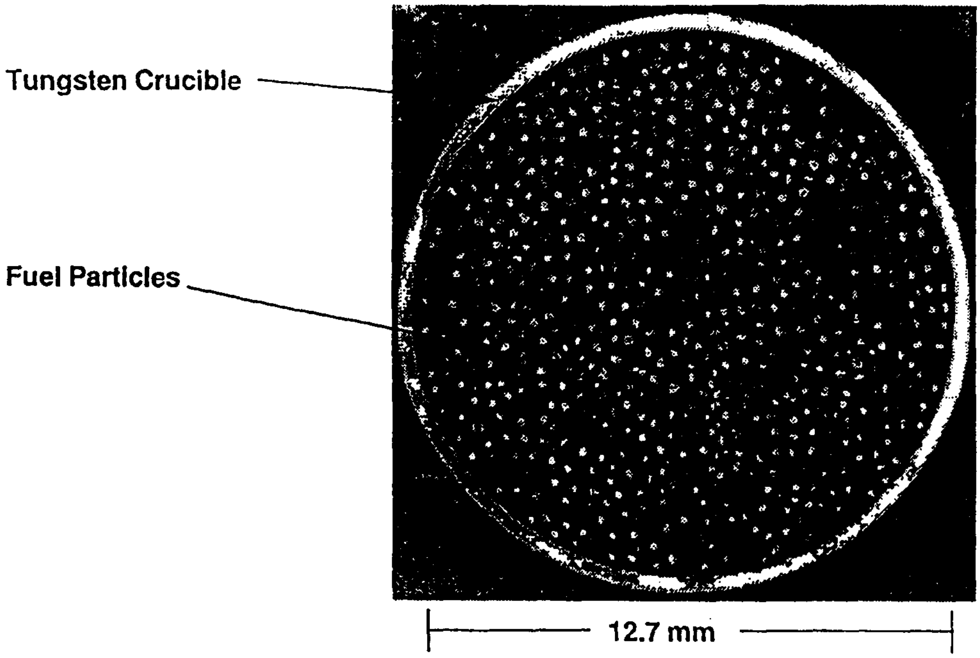
PNT-I Experiment Capsule



Several (typical 3) fuel holders are placed in an experiment capsule for irradiation. The capsule is placed in the central cavity of the Annular Core Research Reactor (ACRR). The ACRR is a pulse-type reactor that serves as the driver core for creating the desired experimental conditions. After an experiment is complete, the fuel is removed for post-irradiation examination.

PNT Particle Bed After Nuclear Irradiation in the ACRR



This photo shows a PNT particle bed after nuclear irradiation in the ACRR.

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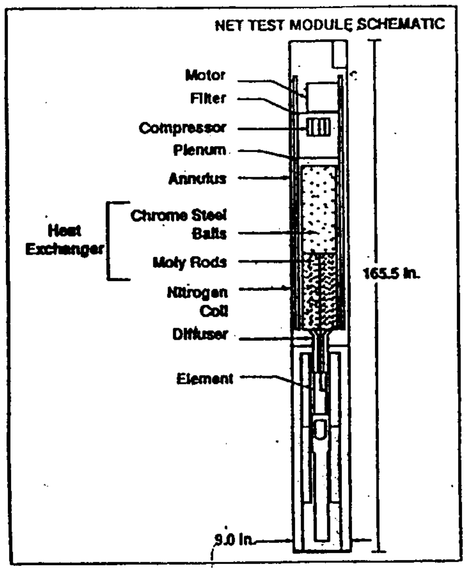
Nuclear Element Test (NET)

Closed Loop, In-Reactor Test Of A Complete Fuel Element In Flowing Cryogenic Hydrogen



Purpose:
- Demonstrate integration of fuel element technologies
- Test to full temperature capability
- Validate fuel element designs
- Support
  - PIPET/GTA development
  - Fuel development
  - Model varification
  - Safety analysis

Accomplishments:
- Test hardware designed and fabricated
- Unfueled experiment assembly and flow loop performance characterized in helium
- Test reactor (ACRR) control capabilities demonstrated

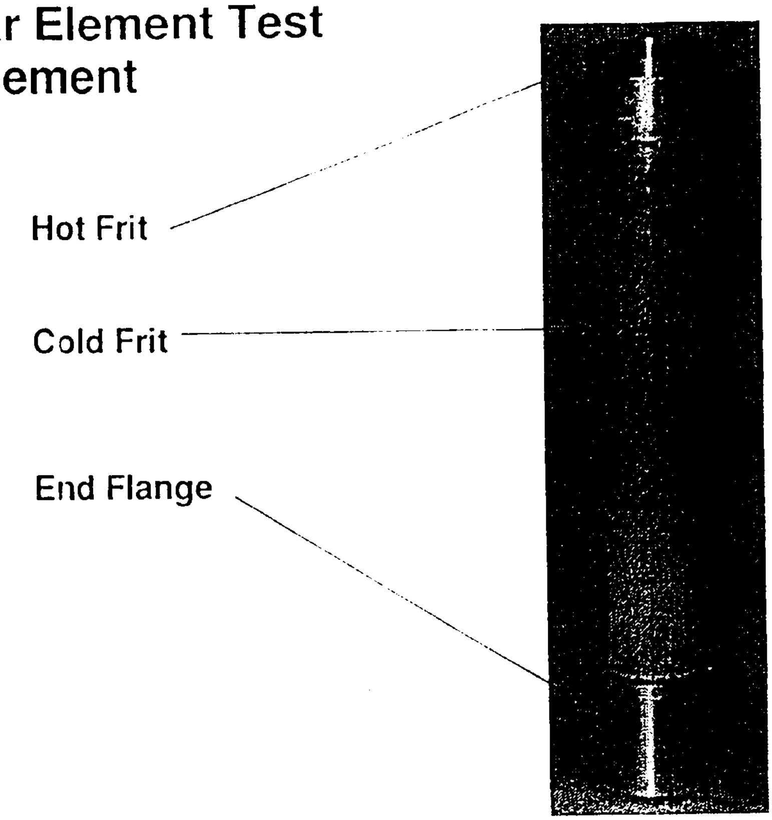
Status:
- Net-0 testing in cryogenic hydrogen summer 1992
- First fueled test (NET-1) early CY 1993

The next step is to assemble particles into a complete fuel element that can be tested incore in flowing hydrogen. The NET experiments provide this demonstration of integrated fuel element performance up to the limits of what environments can be achieved in existing reactor facilities. Since this vugraph was prepared, the unirradiated tests with cryogenic hydrogen in the NET-0 experiment capsule have been successfully completed. Six weeks after receipt of a fuel element, a nuclear test can be completed.

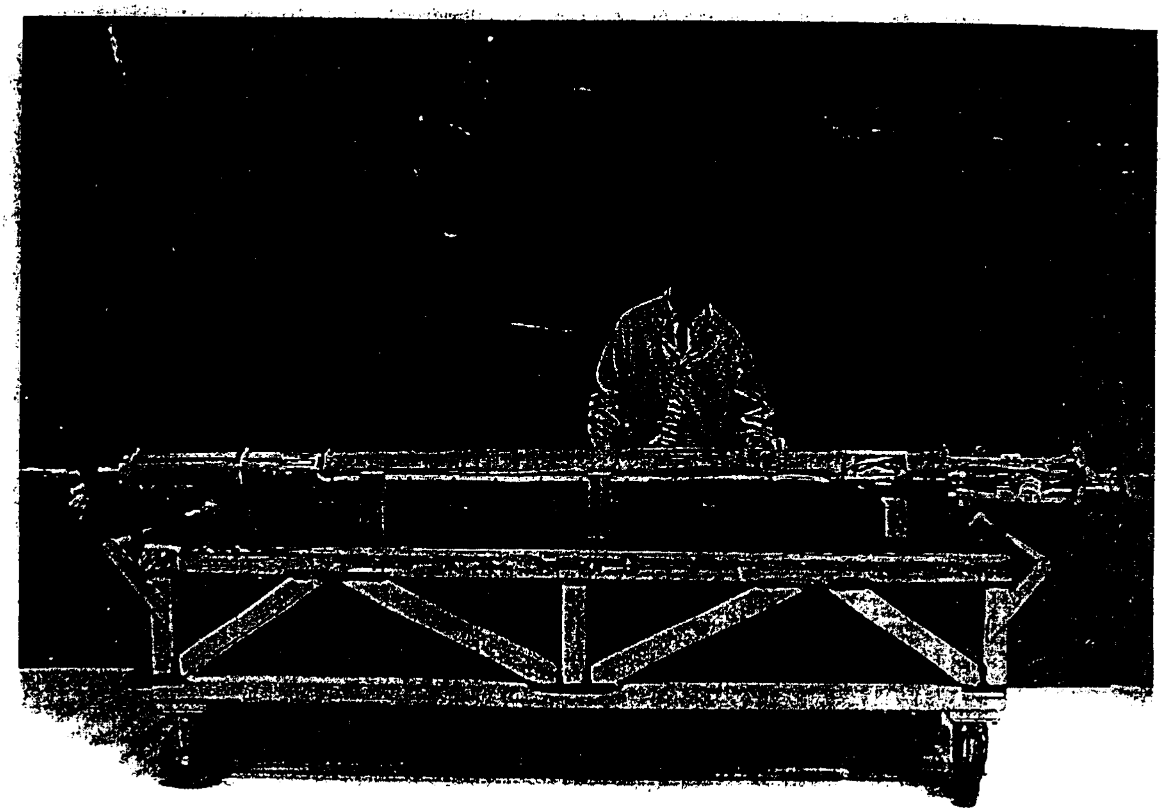
A computer code, F2D, has been developed and is used to predict the thermal-hydraulic performance of the NET element. Codes such as this are being used by the SNTP program to evaluate key thermal-hydraulic issues.

At the systems level, the SAFSIM Code has been developed. A separate paper on SAFSIM is being presented in a later session.

Nuclear Element Test
Fuel Element

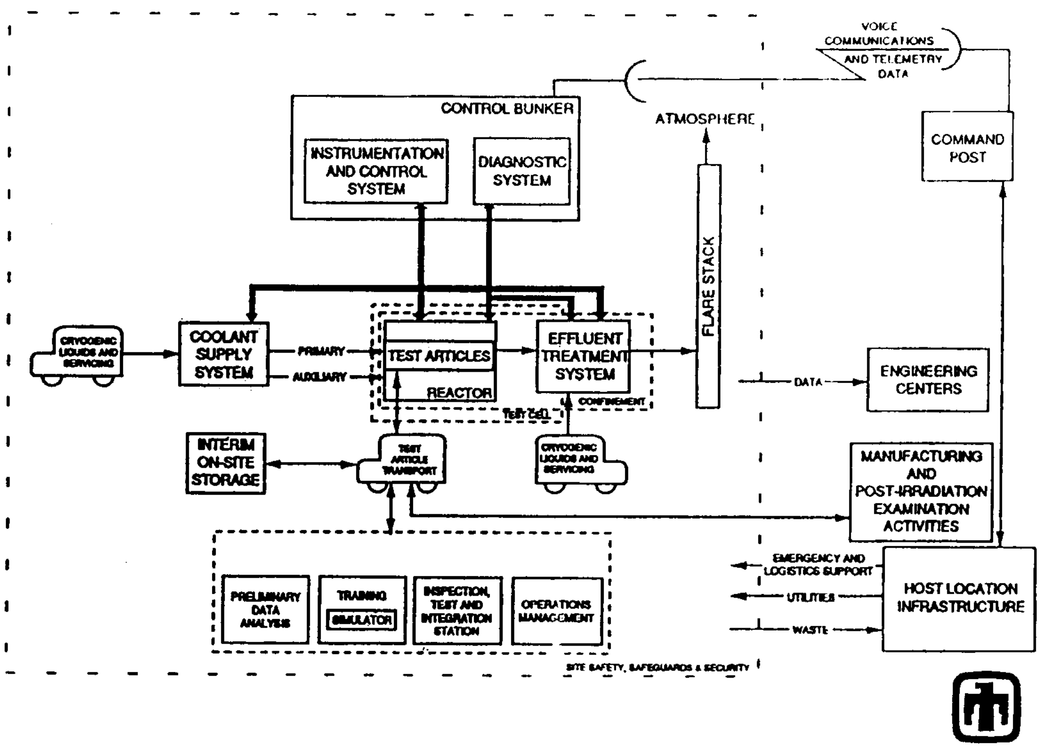


This photo shows the fuel element configuration to be evaluated in the first NET test.



This photo shows the inside portion of a NET capsule. It would be surrounded by the capsule containments for in-core tests

Ground Test Facility System



In closing, I would like to note that extensive testing has already been performed and more will be conducted in the future using existing reactor facilities. However, eventually we will reach the limits of what we can do in existing facilities. A new ground test facility will be required for testing elements and reactor/engine systems. This vugraph shows the functions that must be performed by this facility. The environmental process to be reviewed by the next speaker outlines a key contribution to the decisions defining the scope and location of this ground test facility.