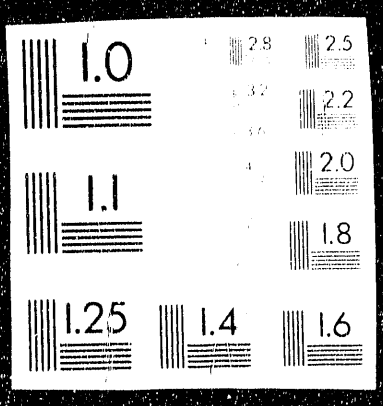


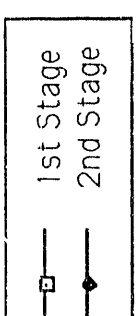

Conf-8910568--2

WSRC-MS--90-52

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# ADVANCED HYDRIDE LABORATORY

by

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A paper for publication in the proceedings of
1989 Storage Science Meeting
Miamisburg, OH
October 23 - 27, 1989

## DISCLAIMER



This paper was prepared in connection with work done under Contract No. DE-AC09-88SR18035 with the U.S. Department of Energy. 

# Advanced Hydride Laboratory

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The Replacement Tritium Facility (RTF) is a $140 million reservoir loading and unloading facility using state-of-the-art technology, scheduled for completion in 1990 and startup in 1991. In the RTF, metal hydride technology will be used to store, separate, purify, pump, and compress hydrogen isotopes. In support of the RTF, a $3.2 million "cold" process demonstration facility began operation in November, 1987. The purpose of the Advanced Hydride Laboratory (AHL) is to demonstrate the RTF's metal hydride technology by integrating the various unit operations into an overall process. While much of the RTF's metal hydride technology had been demonstrated in laboratory bench-scale and pilot-scale units, none of the units had been operated together and integrated into an overall process.

The AHL is divided into three main parts: the nitrogen circulation system, the control room, and the hydrogen hood. The nitrogen circulation system is the process heating and cooling system for the AHL, providing hot and cold nitrogen gas to each of the metal hydride applications in the process hood. The control room houses the major components of the control system. The metal hydride processes in the AHL are sequenced and controlled by a programmable logic controller, allowing the process to be either entirely automated or operated remotely from the control room. In addition to controlling the process, the AHL's control system is also used to evaluate process control schemes and strategies for the plant facility. The hydrogen hood is a 10' by 15' walk-in process hood that contains 13 metal hydride beds. The metal hydride beds in the process are divided into three subsystems: Inert Separation, Isotope Separation, and Compressors.

The Inert Separation system, which separates helium from hydrogen isotopes, consists of a "flow-through" bed, vacuum beds and palladium diffusers. The "flow-through" bed and vacuum beds are filled with palladium coated on kieselguhr (Pd/k). Operation of the primary "flow-through" bed in conjunction with both the palladium diffusers and the vacuum bed has been evaluated. Plant requirements on both hydrogen and helium purity have also been demonstrated. In addition, a new temperature measurement technique has been developed to determine the extent of bed fill for the "flow-through" bed. This technique makes use of the large exothermic heat of absorption and the rapid absorption rate between hydrogen and palladium. As hydrogen is absorbed onto the "flow-through" bed, it has been determined that it is absorbed as a "front" along the depth of the bed. Thermocouples placed at different depths in the bed can record the temperature rise caused by the absorbing hydrogen at each location in the bed.

The Isotope Separation system includes feed and product beds, and the TCAP (Thermal Cycling Absorption Process) unit. TCAP is a semi-continuous chromatographic isotope separation process. The TCAP process, which uses Pd/k as the packing material, takes advantage of palladium's very large isotopic effect. Palladium preferentially absorbs the lighter isotope of hydrogen, protium, over the heavier isotopes, deuterium and tritium. Repeatedly heating and cooling the TCAP column and absorbing and desorbing the hydrogen isotopes in a controlled sequence generates a hydrogen isotope profile in the column. By withdrawing small portions of the column's hydrogen inventory as product from each end of the column during the heating cycle and then supplying an equal amount of feed during the cooling cycle, a semi-continuous isotopic separation process can be created. Continuous operation of the TCAP unit, along with the feed and product beds, has been demonstrated.

The final system consists of two metal hydride compressor beds for pressurizing the hydrogen gas to over 1000 psi. The metal hydride compressor system takes advantage of the ability of different metal hydride materials to absorb and desorb hydrogen gas at different temperature and pressure ranges. The first stage compressor, containing $LaNi_{4.7}Al_{0.3}$ (LANA-0.3), absorbs gas at or near atmospheric pressure and desorbs at higher pressures to deliver gas to the second stage compressor. The second stage compressor contains $Ca_{0.2}M_{0.8}Ni_5$ (CaMN), and is desorbed at pressures over 1000 psi.

In two years of operation, the AHL has demonstrated all the metal hydride unit operations to be used in the RTF. Metal hydride processes have been integrated, and startup and operating information has been transmitted to the plant. During construction and operation of the AHL, several key design changes in the RTF were made which have already led to substantial savings in startup time and costs. The AHL continues to generate plant startup and operating data, and is also being used as a training facility for the full-scale plant facility.

# ADVANCED HYDRIDE LABORATORY (AHL)

October 26, 1989

Anita S. Horen

Contributor: T. Motyka

Savannah River Laboratory
WSRC

# *Replacement Tritium Facility* (RTF)

- Replacement for 234-H Reservoir Loading Building
- $140 MM Capital Project
- Physical Completion, 11/90; "Hot" Startup, 10/91
- Justification
  - Increase Capacity/Flexibility
  - Reduce Tritium Releases
  - Harden Facility
  - Incorporate New Technology
- Metal Hydride Technology used to store, separate, purify, pump, and compress hydrogen isotopes

# *Advanced Hydride Laboratory* (AHL)

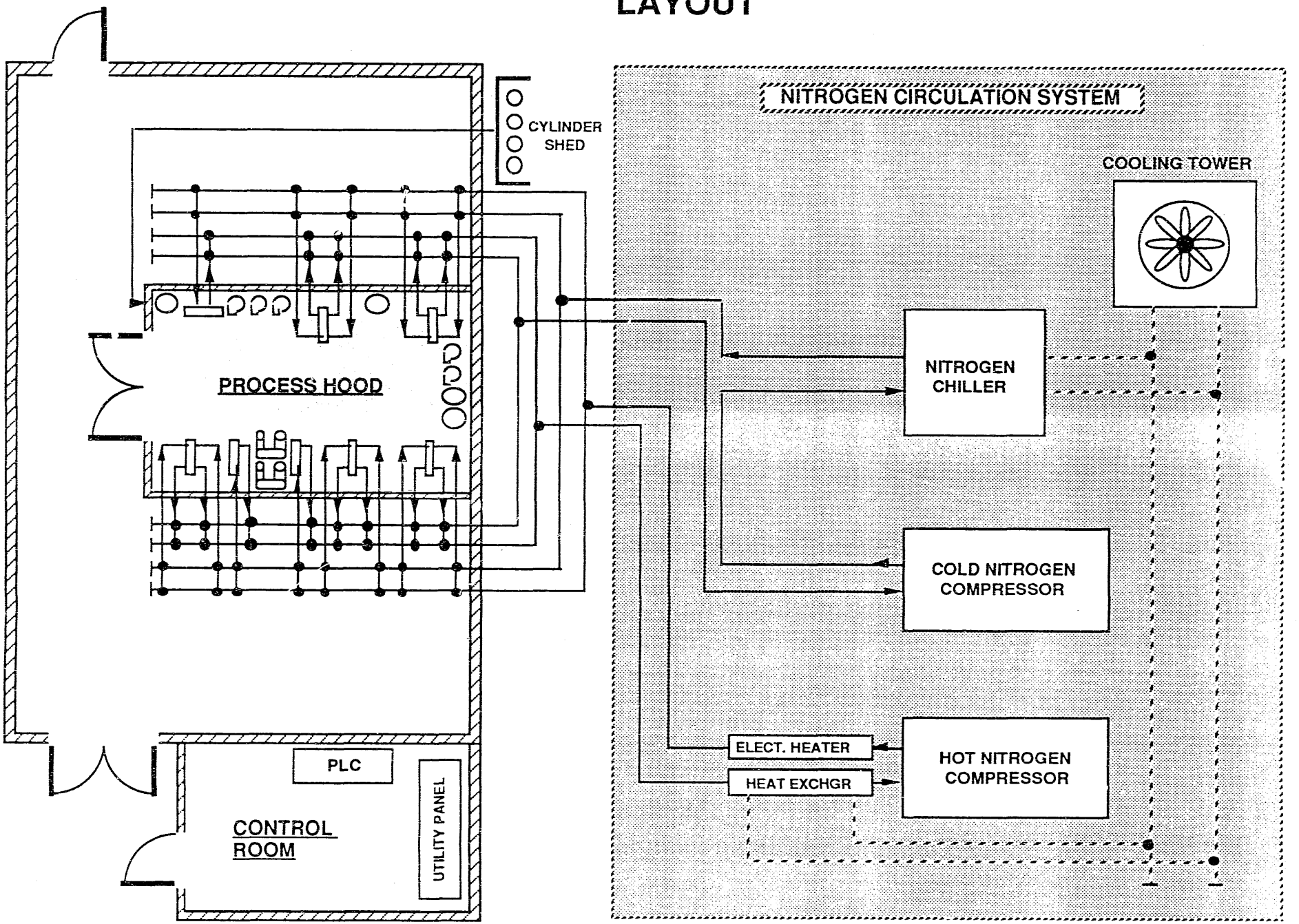
## Objective

". . . provide an early, integrated, large-scale pilot-plant of the technology to be used in the RTF"

## Milestones

- Demonstrate a large-scale, integrated hydride facility
- Verify engineering design
  - Nitrogen heating and cooling
  - Process control strategy
  - Al-block and SS coil TCAP units
- Provide operating experience
- Provide a facility for operator training

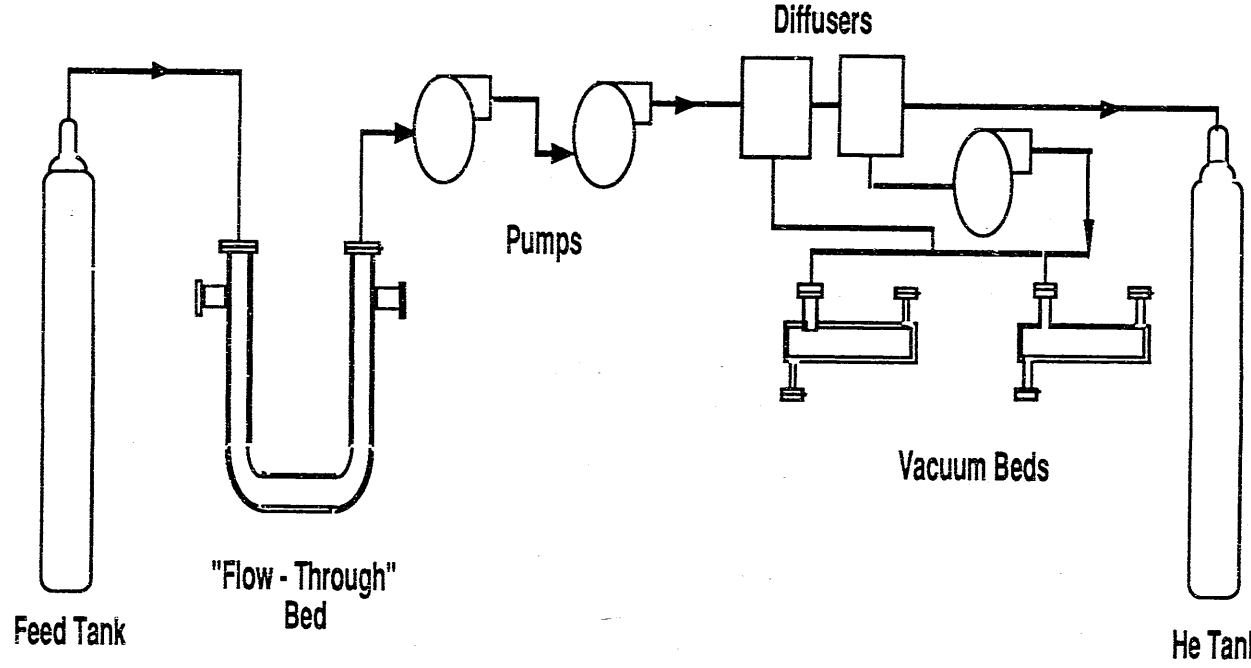
# ADVANCED HYDRIDE LABORATORY LAYOUT



## *AHL Subsystems*

- **Inert Separation**
- **Isotope Separation**
- **Compressors**

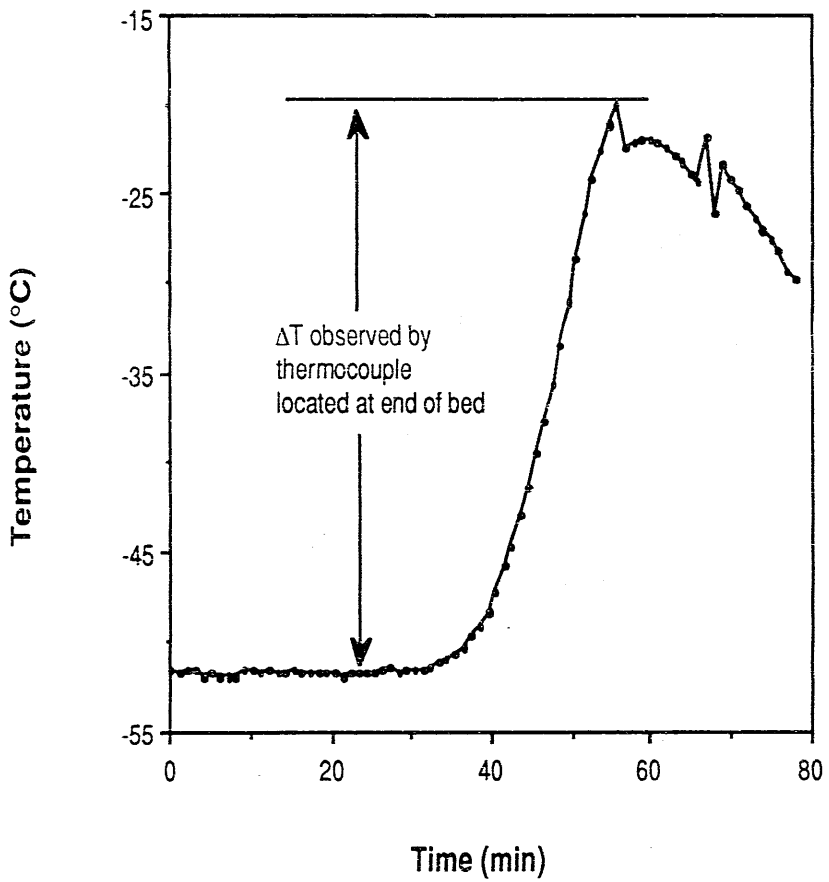
## *Inert Separation*

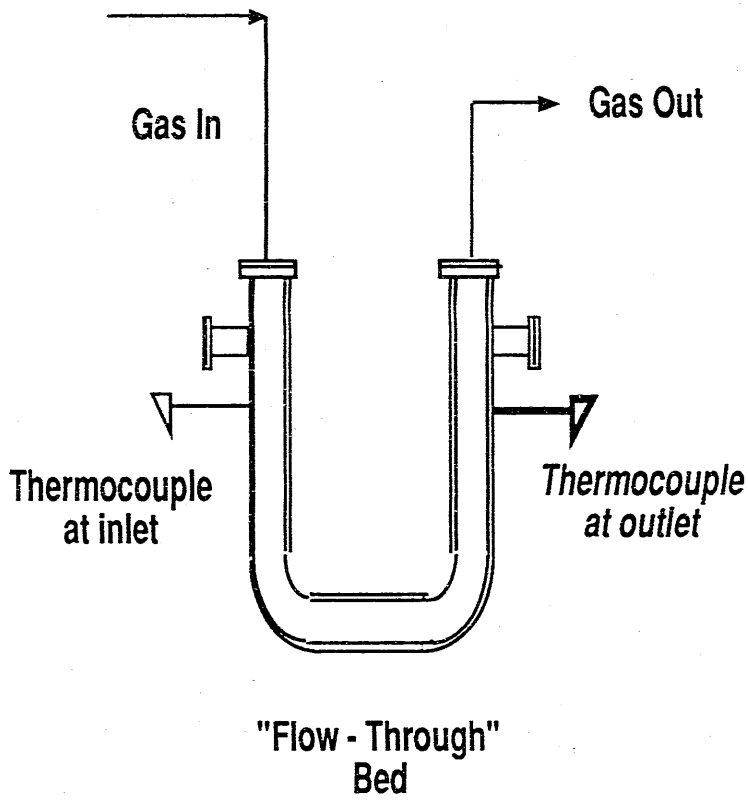



# Accomplishments

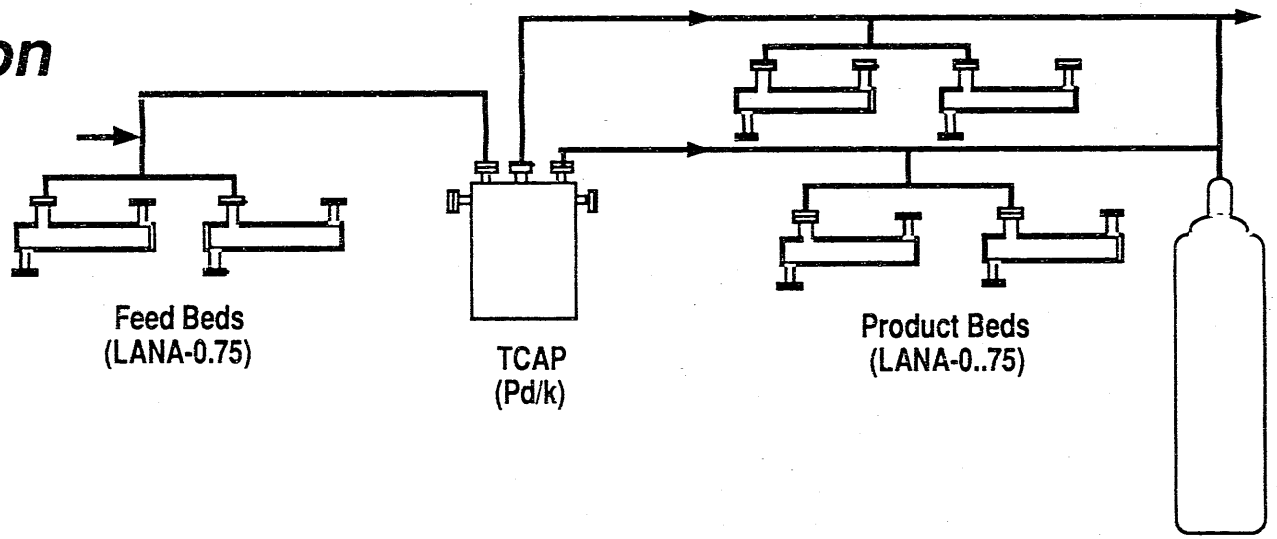
- Demonstrated:
  - "Flow - Through" Bed, > 99.9% hydrogen isotopes
  - RTF Mechanical Pumps and Diffusers with Metal Hydrides
  - Continuous Metal Hydride Vacuum Bed (< 20 torr)
  - He purity, < 500 ppm total hydrogen isotopes
- Operated Integrated Inert Separation System
- Developed Thermocouple Technique to determine extent of bed fill

# Temperature Rise Data for "Flow-Through" Bed



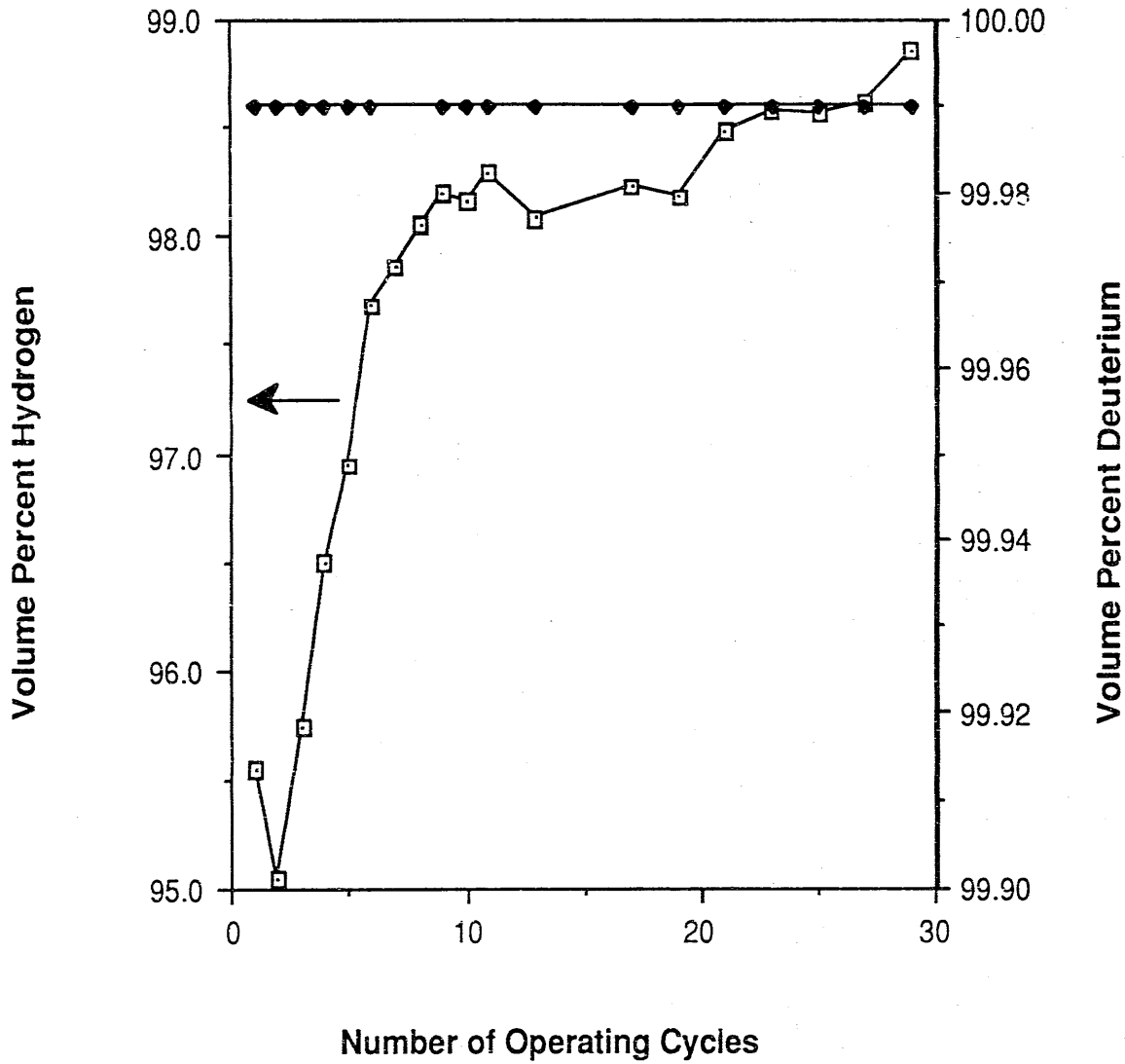
## *Isotope Separation*



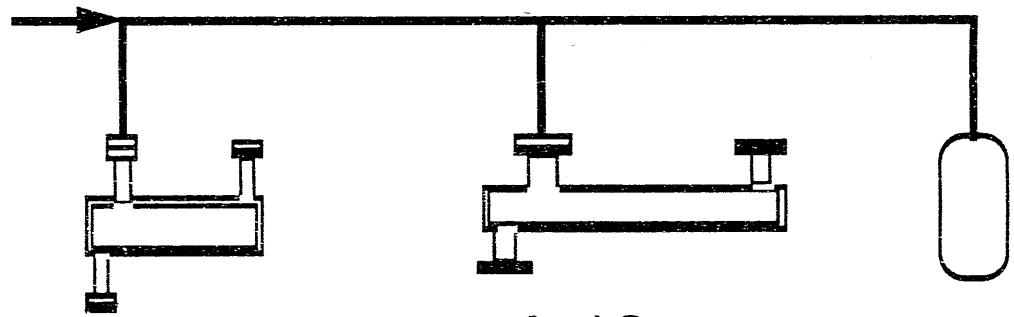

## Accomplishments

- Verified Heat Transfer of Metal Hydride Beds
- Identified and Solved TCAP's Gas Flow Problem
- Experimental Data shows Separation from 50 - 50 Feed

# TCAP Separation Data



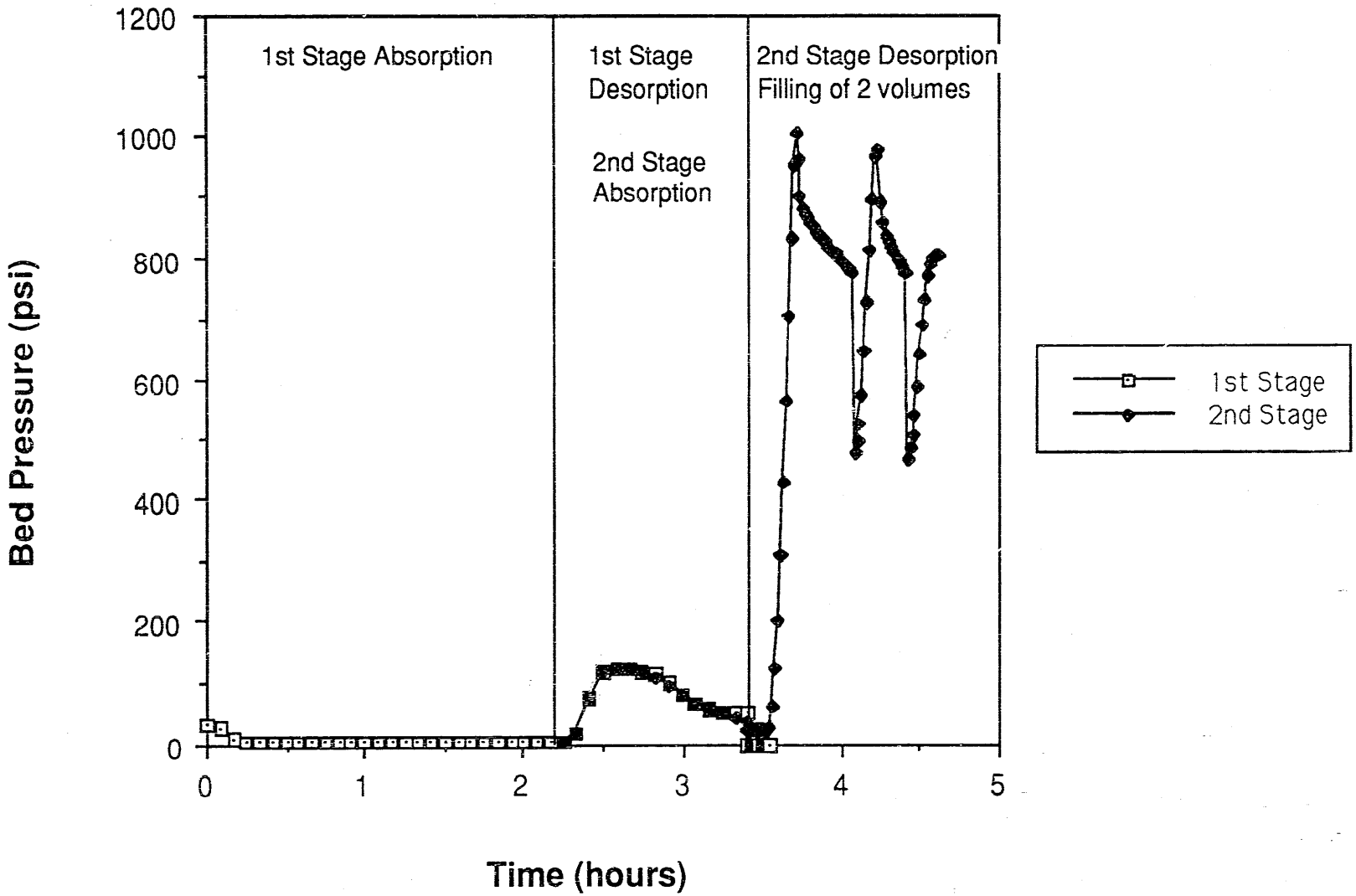
## *Compressors*




# Accomplishments

- Verified Heat Transfer of Metal Hydride Beds
- Demonstrated Integrated Operation

# Metal Hydride Compressor Results



# SUMMARY

- Demonstrated Integrated Operation of Metal Hydride Systems
- Verified Design and Operation of Components
  - Metal Hydride Bed Heat Transfer
  - TCAP Design
  - RTF specified Valves
- Demonstrated Continuous Operation of Nitrogen Heating and Cooling System for over 1 year
- Continue to Identify Key Process Control Parameters and Strategies
- Continue to Provide Operator Training

# END

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5/07/92