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CAPABILITIES AND RESOURCES FOR TRITIUM RESEARCH AND DEVELOPMENT

February 7, 1974

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Capabilities and Resources for Tritium Research and Development

Excerpts from a Presentation
by Mound Laboratory at AEC Headquarters

February 7, 1974

AGENDA

Introduction Warren H. Smith

Metal-Hydrogen Systems Richard J. DeSando

Gas Dynamics and
Cryogenic Separations William L. Taylor

Materials Research Japnell D. Braun

Helium Diffusion
and Tritium Effluent Control. Carl J. Kershner

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Metal-Hydrogen Systems

F - CENTER CONCENTRATION AS INDICATED BY EPR

ISOTHERMS, 200°C

ISOTHERMS, 250°C

CRITICAL REGION ISOTHERMS

THERMODYNAMIC PROPERTIES OF URANIUM HYDRIDES

	ΔH_s (kcal/mole)	ΔS_s (cal/°K/mole)	ΔG_s (kcal/mole)
UH ₃	-30.5	-43.4	-17.65
UD ₃	-30.8	-44.8	-17.5
UD _{2.66}	-28.4	-42.1	-15.9
UT _{2.90}	-27.7	-41.7	-15.3

METAL-HYDROGEN SYSTEMS

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Gas Dynamics and Cryogenic Separations

CRYOGENICS

DISTILLATION
 $H_2/D_2/T_2$ He^3/He^4

ISOTOPIC
VAPOR PRESSURES

ADSORPTION
ISOTHERMS T_2/He

PRESENT STAFF

1 PhD PHYSICAL CHEMISTRY
2 PhD PHYSICS
2 B.S. PHYSICS
1 TECHNICIAN

GAS DYNAMICS

MOLECULAR BEAM

THERMAL DIFFUSION

ORDINARY DIFFUSION

THEORETICAL AND
PROGRAM LIBRARY

BLOCK FLOW DIAGRAM OF HYDROGEN ISOTOPE DISTILLATION SYSTEM

SCHEMATIC OF 2 COLUMN DISTILLATION APPARATUS
FOR THE SEPARATION OF PROTIUM FROM DEUTERIUM

DIAGRAM OF VAPOR PRESSURE MEASUREMENT SYSTEM

SIMPLE SINGLE COMPONENT ADSORPTION ISOTHERM APPARATUS

ADSORPTION ISOTHERMS AT 77.2 K FOR HYDROGEN ON
A COCONUT CHARCOAL AND TWO MOLECULAR SIEVES

TOTAL SCATTERING CROSS SECTIONS

METHOD

DIFFERENTIAL SCATTERING CROSS SECTIONS

THERMAL DIFFUSION FACTORS FOR Kr

PROGRAM LIBRARY

- **MULTICOMPONENT DISTILLATION**
- **THERMOMOLECULAR PRESSURE DIFFERENCE SOLUTION**
- **QUANTUM PHASE SHIFTS**
- **TRANSPORT COLLISION INTEGRALS**
- **TRANSPORT PROPERTIES**
- **SCATTERING CROSS SECTIONS**

GAS DYNAMICS AND CRYOGENIC SEPARATIONS

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Materials Research

SPECIALIZED MECHANICAL TESTING EQUIPMENT

- **HIGH-TEMPERATURE, HIGH-VACUUM CREEP TESTERS**
- **HIGH-TEMPERATURE, HIGH-VACUUM FATIGUE TESTER**
- **HIGH-TEMPERATURE, HIGH-VACUUM, LARGE (6 x 8 in.)
ANNEALING FURNACE**
- **MTS TEST SYSTEM LOCATED IN TRITIUM-CONTROLLED
GLOVE BOX LINE**
- **HIGH-TEMPERATURE IMPACT FACILITY**

RESEARCH ANALYTICAL EQUIPMENT

- **TRANSMISSION ELECTRON MICROSCOPES**
- **SCANNING ELECTRON MICROSCOPES**
- **X-RAY EQUIPMENT**
- **ELECTRON MICROPROBE**

AUTORADIOGRAPHS

10 μm

A.
ANNEALED
STAINLESS STEEL
1000 X

10 μm

B.
COLD-WORKED
STAINLESS STEEL
1000 X

100 μm

C.
ENHANCED PENETRATION
IN WELD METAL
100 X

PERMEABILITY CONSTANTS OF NONRADIOACTIVE HYDROGEN ISOTOPES AT 25°C

<u>MATERIAL</u>	<u>SPECIMEN THICKNESS (cm)</u>	<u>ISOTOPE</u>	<u>MEASURED PERMEABILITY CONSTANT Q (cm²/sec·atm)</u>	<u>LITERATURE VALUE (cm²/sec·atm)</u>
Latex	0.018	H ₂	3.5 x 10 ⁻⁷	3.9 x 10 ⁻⁷
Latex	0.018	D ₂	3.0 x 10 ⁻⁷	
Mylar	0.005	H ₂	4.5 x 10 ⁻⁹	4.4 x 10 ⁻⁹
Mylar	0.005	D ₂	4.1 x 10 ⁻⁹	
Teflon	0.007	H ₂	6.1 x 10 ⁻⁸	
Teflon	0.007	D ₂	5.7 x 10 ⁻⁸	
Saran	0.001	H ₂	3.6 x 10 ⁻⁸	3.1 x 10 ⁻⁷
Saran	0.001	D ₂	2.3 x 10 ⁻⁸	

HELIUM DIFFUSION AND PERMEABILITY STUDIES

- PuO_2 PLASMA-FIRED MICROSPHERES
- PuO_2 SOL-GEL MICROSPHERES
- Pu METAL
- PuO_2 -Mo CERMET
- REFRACTORY METALS

TRITIUM DIFFUSION IN STAINLESS STEELS

MECHANICAL TESTING OF DOPED METALS AND ALLOYS

- **TENSILE TESTS**
- **HOT IMPACT STUDIES**

CREEP STUDIES OF REFRACTORY METALS AND ALLOYS

- **TENSION vs COMPRESSION**
- **SUBSTRUCTURE CORRELATIONS**

MECHANICAL TESTING OF IRIIDIUM

MECHANICAL TESTING OF NEUTRON IRRADIATED MATERIALS

- **COMPRESSIVE CREEP**
- **DYNAMIC ELECTRON MICROSCOPE STUDIES**
- **SUBSTRUCTURE CORRELATIONS**

MATERIALS RESEARCH

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**Helium Diffusion
and Tritium Effluent Control**

**AN ADVANCED TECHNOLOGY PROJECT
WAS INITIATED IN 1972 TO ACHIEVE LONG
RANGE GOALS FOR REDUCING TRITIUM EMISSIONS**

- Facility Evaluation
- Basic Decontamination & Concentration Technology
- Complete Processes & Systems
- High Sensitivity Monitoring Instrumentation

**THERE IS A WIDE VARIATION IN
QUANTITY AND CONTAMINATION LEVEL
OF MOUND'S GASEOUS EFFLUENTS**

CLASS	TYPICAL SOURCE	CONCENTRATION (Ci/m³)	HTO (%)
I-g	G. B.	1-100	1-10
II-g	Room	$\sim 4 \times 10^{-5}$	—
III-g	Stack	$\sim 1 \times 10^{-5}$	10-90

THERE IS A WIDE VARIATION IN QUANTITY AND CONTAMINATION LEVEL OF MOUND'S LIQUID WASTE

CLASS	TYPICAL SOURCE	CONCENTRATION (μ Ci/ml)	QUANTITY (ℓ /yr)
I- ℓ	ERS (aqueous)	$\geq$ II- ℓ	> II- ℓ
II- ℓ	Pump Oil	4×10^4	~ 250
III- ℓ	Decon. H ₂ O	1	60,000

**EXPERIMENTAL WORK IS IN PROGRESS
ON DECONTAMINATION TECHNOLOGY
BASED ON:**

- **Cryogenic Adsorption (Class I-g)**
- **Getters (Class I-g)**
- **Extractive Distillation (Class III-ℓ)**
- **Molecular Excitation (Class III-ℓ)**
- **Catalytic Oxidation/Adsorption (ERS,
ECS, Class I & II-g)**

CRYOGENIC PROCESS SCHEMATIC FOR TRITIUM CONTROL IN GLOVEBOX ATMOSPHERE SYSTEMS

SYSTEM SCHEMATIC FOR EMERGENCY CONTAINMENT OF TRITIUM

HIGH SENSITIVITY TRITIUM MONITOR

**EXPERIMENTAL WORK IS IN PROGRESS
ON RECOVERY TECHNOLOGY BASED ON:**

- **Cryogenic Distillation (Gas)**
- **Pd Column Separation (Gas)**
- **Fuel Cell/Electrolysis (Liquid)**
- **Chemical Decomposition (Liquid)**

THE "TECL" DESIGN IS BASED
ON A CLOSED ^3H CYCLE CONCEPT

< 10% RCG AT STACK

~ZERO AQUEOUS WASTES

TRITIUM EFFLUENT CONTROL LABORATORY

TRITIUM EFFLUENTS HAVE BEEN
REDUCED BY MORE THAN AN
ORDER OF MAGNITUDE

**A VARIETY OF HELIUM DEPOSITION &
MIGRATION STUDIES HAVE BEEN
CARRIED OUT AT MOUND**

- ^4He IN $^{238}\text{PuO}_2$ (α DECAY IMPLANTED)
- ^4He PERMEATION THROUGH TANTALUM
- ^3He IN TANTALUM (T_2 DECAY IMPLANTED)

A HIGH SENSITIVITY QUADRUPOLE
MASS SPECTROMETER SYSTEM HAS
BEEN DEVELOPED FOR He
DIFFUSION STUDIES

PERMEABILITY OF He THROUGH TANTALUM
METAL HAS BEEN DEMONSTRATED
AND A MECHANISM POSTULATED

	VACANCY	INT.	MEAS.
Q_p	202	110	100
D	6×10^{-11}	1×10^{-6}	3×10^{-6}
S	1×10^6	1×10^{10}	$< 3 \times 10^8$
P	9×10^{-5}	1×10^4	1×10^3

HELIUM DIFFUSION AND TRITIUM EFFLUENT CONTROL

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