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MASTER

ION IMPLANTATION OF KRYPTON IN SPUTTER-DEPOSITED METAL MATRICES

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Pacific Northwest Laboratory
Richland, Washington

DISCLAIMER

ION IMPLANTATION OF KRYPTON IN SPUTTER DEPOSITED METAL MATRICES*

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Krypton has been successfully trapped in an amorphous metal matrix by accelerating positively charged krypton ions toward a surface where the metal is being deposited. Studies have shown that krypton concentrations approaching 200 cm^3 of Kr(STP)/cm^3 of deposit can be achieved in amorphous metal deposits under readily attainable sputtering conditions. Furthermore, the gas is incorporated in the matrix such that release of the krypton is largely limited to high temperatures. For the iron and zirconium-based materials, release of krypton occurs at temperatures of from 700 to 1000°C. A very low release rate is observed at lower temperatures but long-term, highly sensitive measurements have shown that the total krypton released at 300°C would be less than 2% of that present during the first 10 years.

The effect of the Kr-85 decay product, Rb-85, on the deposit properties is currently under investigation and preliminary data reveal no significant effect on krypton release when the Rb concentration is limited to about 0.1 atom% of the solid.

A preconceptional design of the facility and the sputtering apparatus will be presented along with cost estimates for this design. Much of the data to be presented is included in the following documents which have been cleared for release earlier:

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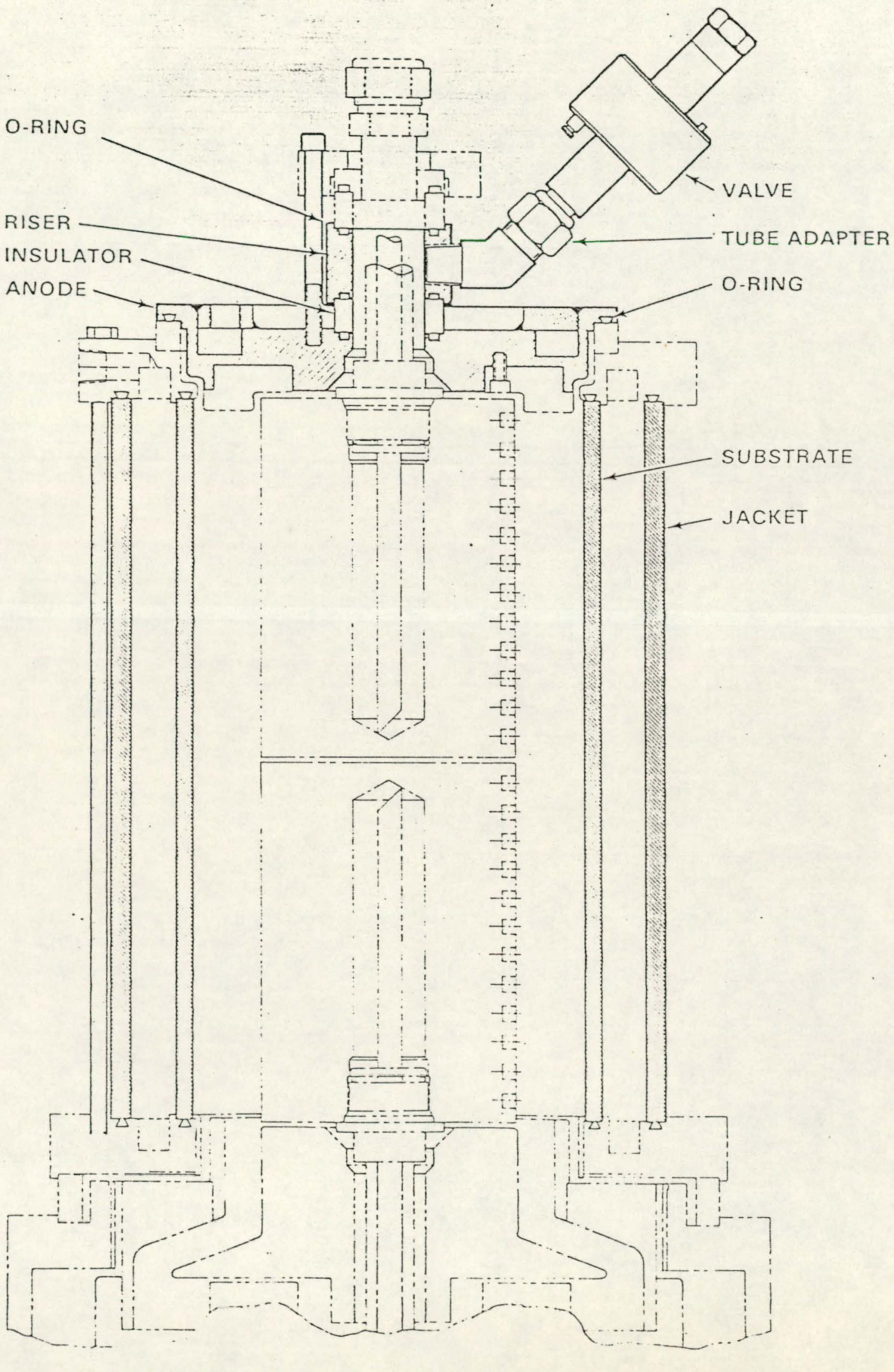
*Work supported by the Department of Energy under Contract DE-AE06-76RLO 1830.

1. G. L. Tingey, E. D. McClanahan, M. A. Bayne, and R. W. Moss, Entrapment of Krypton in Sputter Deposited Metals--A Storage Medium for Rdioactive Gases, PNL-2879, Pacific Northwest Laboratory, Richland, Washington, April 1979.

2. G. L. Tingey, E. D. McClanahan, M. A. Bayne, W. J. Gray, and C. A. Hinman, "Krypton-85 Storage in Solid Matrices," PNL-SA-7752, Pacific Northwest Laboratory, Richland, Washington, October 1979, Presented at the Materials Research Society Meeting, Boston, Massachusetts, November 26-29, 1979.

3. G. L. Tingey, E. D. McClanahan, M. A. Bayne, and W. J. Gray, "Solid State Containment of Noble Gases in Sputter-Deposited Metals and Low-Density Glasses," PNL-SA-1940, Pacific Northwest Laboratory, Richland, Washington, January 1980, Presented at the International Symposium on Management of Gaseous Wastes from Nuclear Facilities, Vienna, Austria, February 18-22, 1980.

Copies of anticipated visual aids are attached.


O-RING
VALVE
RISER
TUBE ADAPTER
INSULATOR
ANODE
O-RING
SUBSTRATE
JACKET

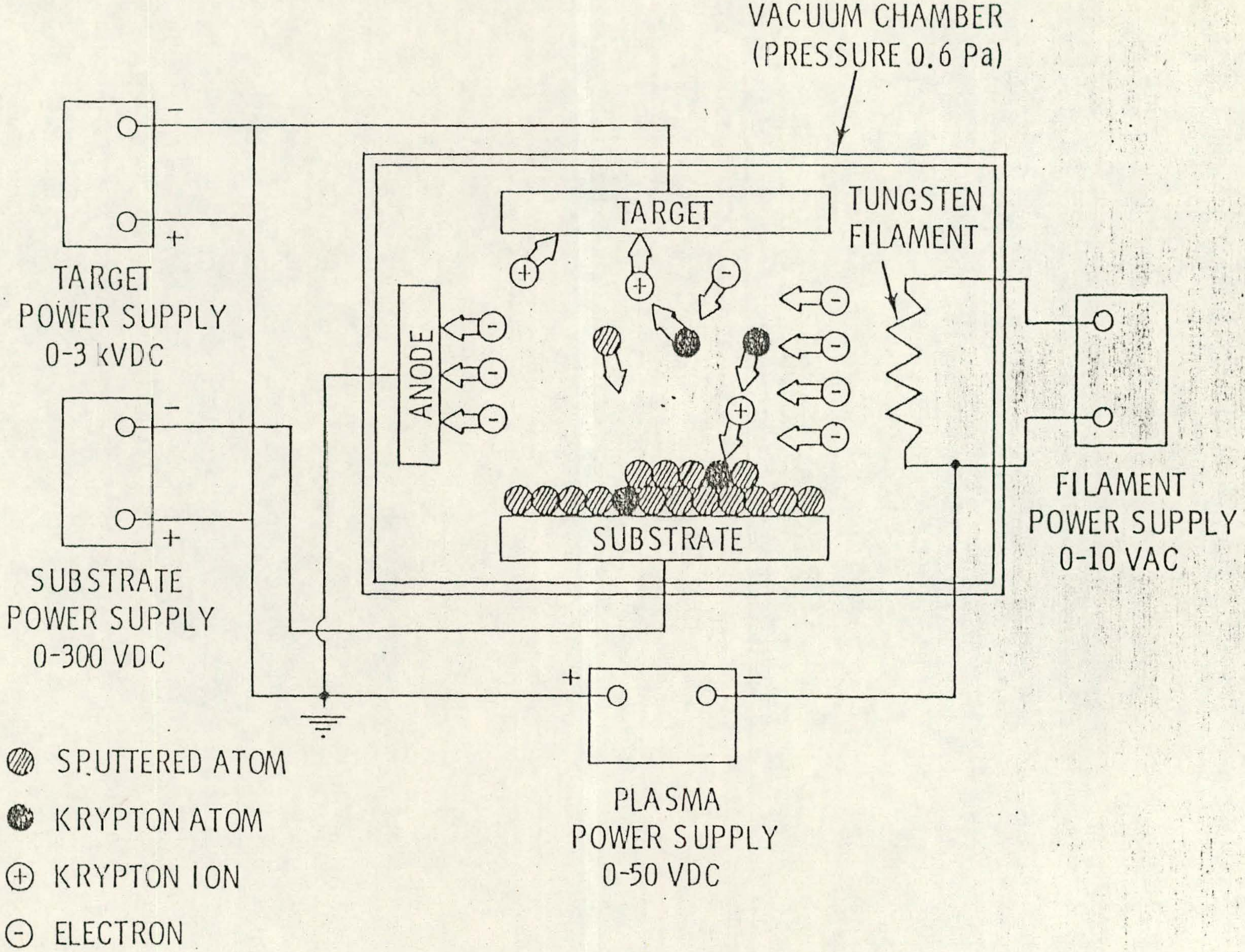


FIG. 1. Thermionically Supported Plasma Sputtering/Ion Implantation System.

SPUTTERING CHAMBER

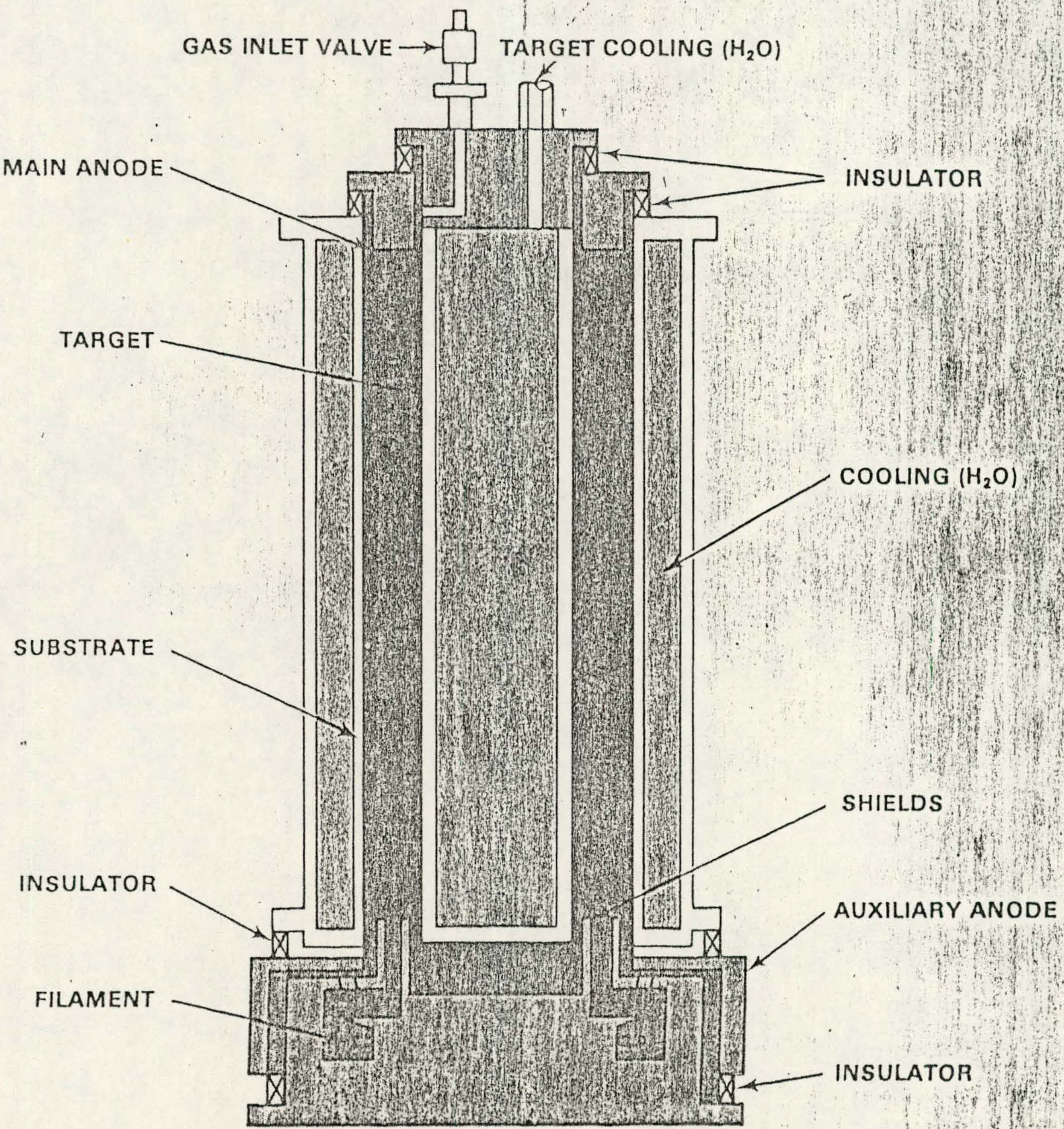
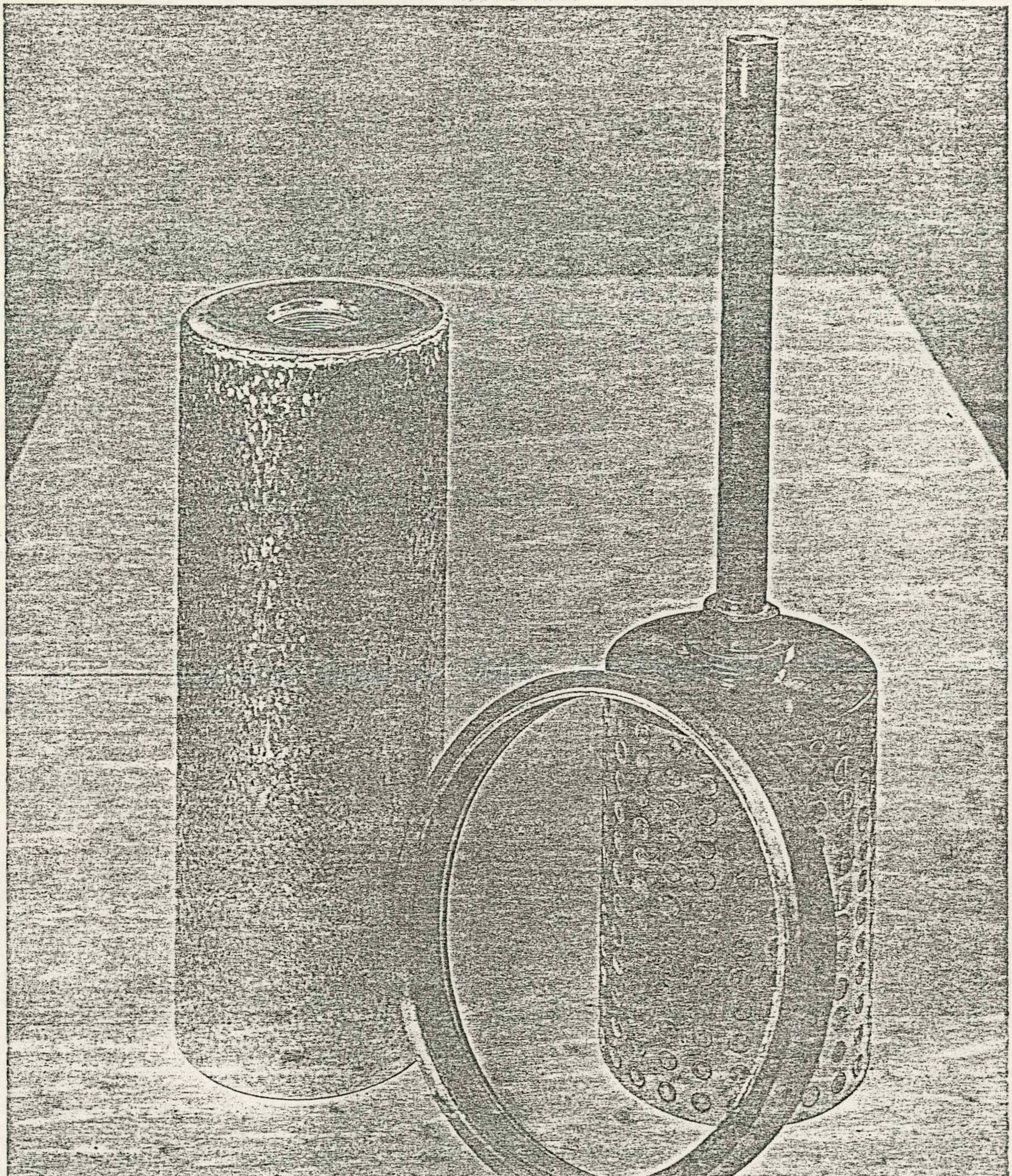


TABLE I. Krypton Loadings in Sputter-Deposited Metals

Target Material	Sputtered* Product	Krypton Content: cm^3 of Kr(STP) / g of Deposit	Krypton Content: cm^3 of Kr(STP) / cm^3 of Deposit	Krypton Content: Pressure Equivalent (MPa)	Substrate Bias Voltage (Volts)	Deposition Rate (nm/sec)
Ni-200	$Ni_{0.95}Kr_{0.5}$ Crystalline	16.9	135	13.8	-1500 Pulsed	6.05
Al	$Al_{0.96}Kr_{0.04}$ Crystalline	30.1	75	7.8	-1300 Pulsed	5.0
A-[illegible]08 Steel	$Fe_{0.95}Kr_{0.05}$ Crystalline	19.8	140	13.8	-2500 Pulsed	2.7
Ti	$Ti_{0.96}Kr_{0.04}$ Crystalline	17.0	70	6.9	-2300 Pulsed	4.1
316SS	$Fe_{0.69}Cr_{0.22}Ni_{0.09}Kr_{0.02}$ Crystalline	8	60	6.0	-2500 Pulsed	7.8
Steel/Y Plugs	$Fe_{0.79}Y_{0.12}Kr_{0.09}$ Glassy	30	189	19.3	-225 Continuous	8.0
Steel/Zr Plugs	$Fe_{0.76}Zr_{0.19}Kr_{0.05}$ Mixed	17	120	12.1	-240 Continuous	15.0
Zircaloy IV/Fe Plugs	$Zr_{0.68}Fe_{0.24}Kr_{0.08}$ Glassy	22	143	14.5	-160 Continuous	11.0
Steel/Zr/Ta	$Fe_{0.70}Zr_{0.20}Ta_{0.05}Kr_{0.05}$ Glassy	16	110	11.0	-220 Continuous	11.0
316SS/Y Plugs	$Fe_{0.60}Cr_{0.20}Ni_{0.06}Y_{0.10}$-$Kr_{0.04}$ Mixed	15	100	9.7	-250 Continuous	12
Ni-200/Y Plugs	$Ni_{0.76}Y_{0.17}Kr_{0.07}$ Glassy	23	160	16.5	-250 Continuous	10

*Composition not specifically determined; previous experimental results show that metal deposit composition is approximately the same as the target. Glassy--no crystals greater than 30 Å; mixed--glassy with crystalline phases.


Battelle Inc.

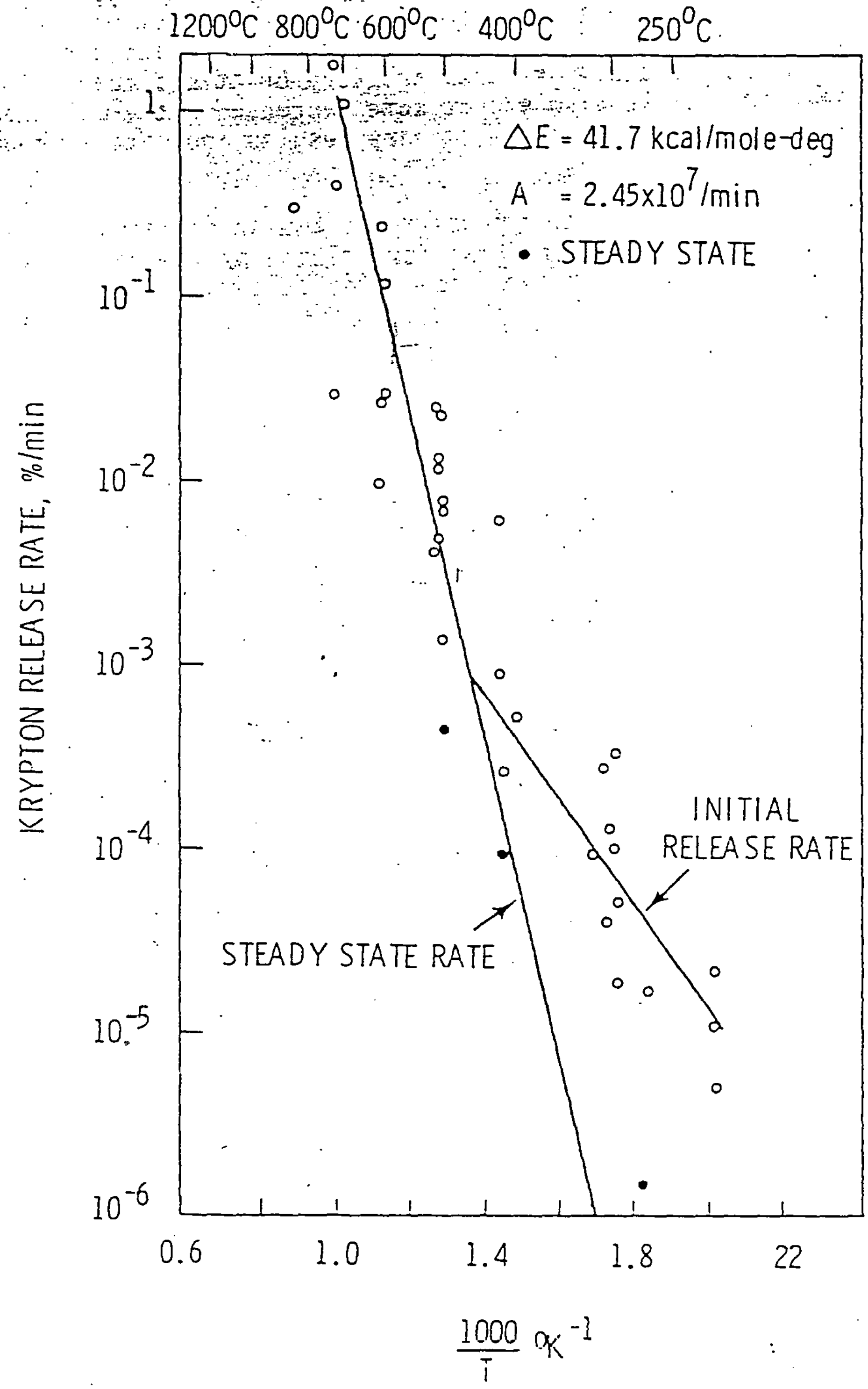


FIG. 2. Krypton Release Rate From Amorphous $Fe_{0.79}Y_{0.12}Kr_{0.09}$.

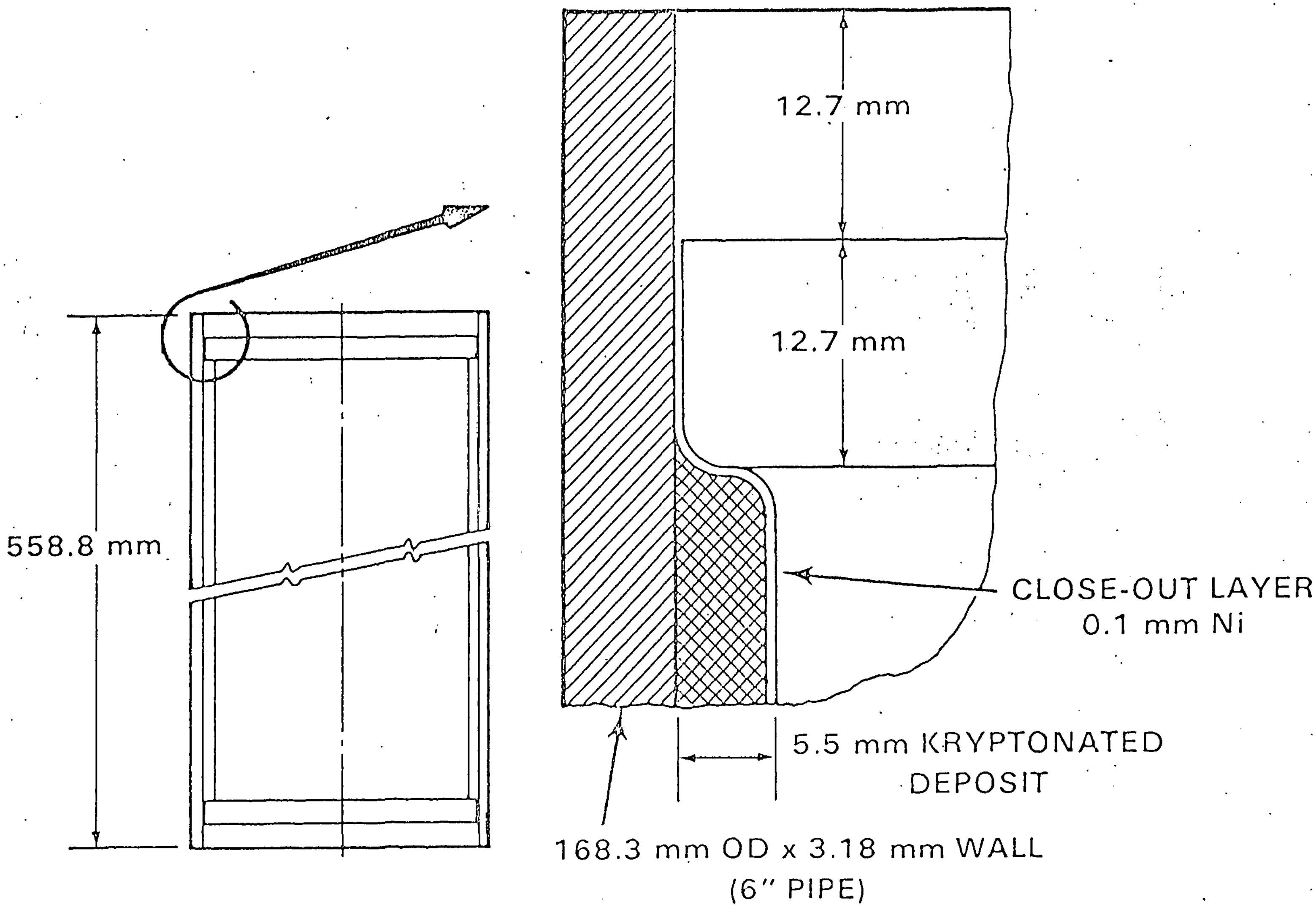
CRITERIA

- DESIGN, CONSTRUCTION AND OPERATION CONFORM TO APPLICABLE FEDERAL, STATE AND LOCAL REGULATIONS AND STANDARDS
- SITING - PORTION OF NUCLEAR FUEL REPROCESSING PLANT
- RADIATION PROTECTION - (ALARA)
- PLANT - 30 YEARS, EQUIPMENT 15 YEARS USEFUL LIFE

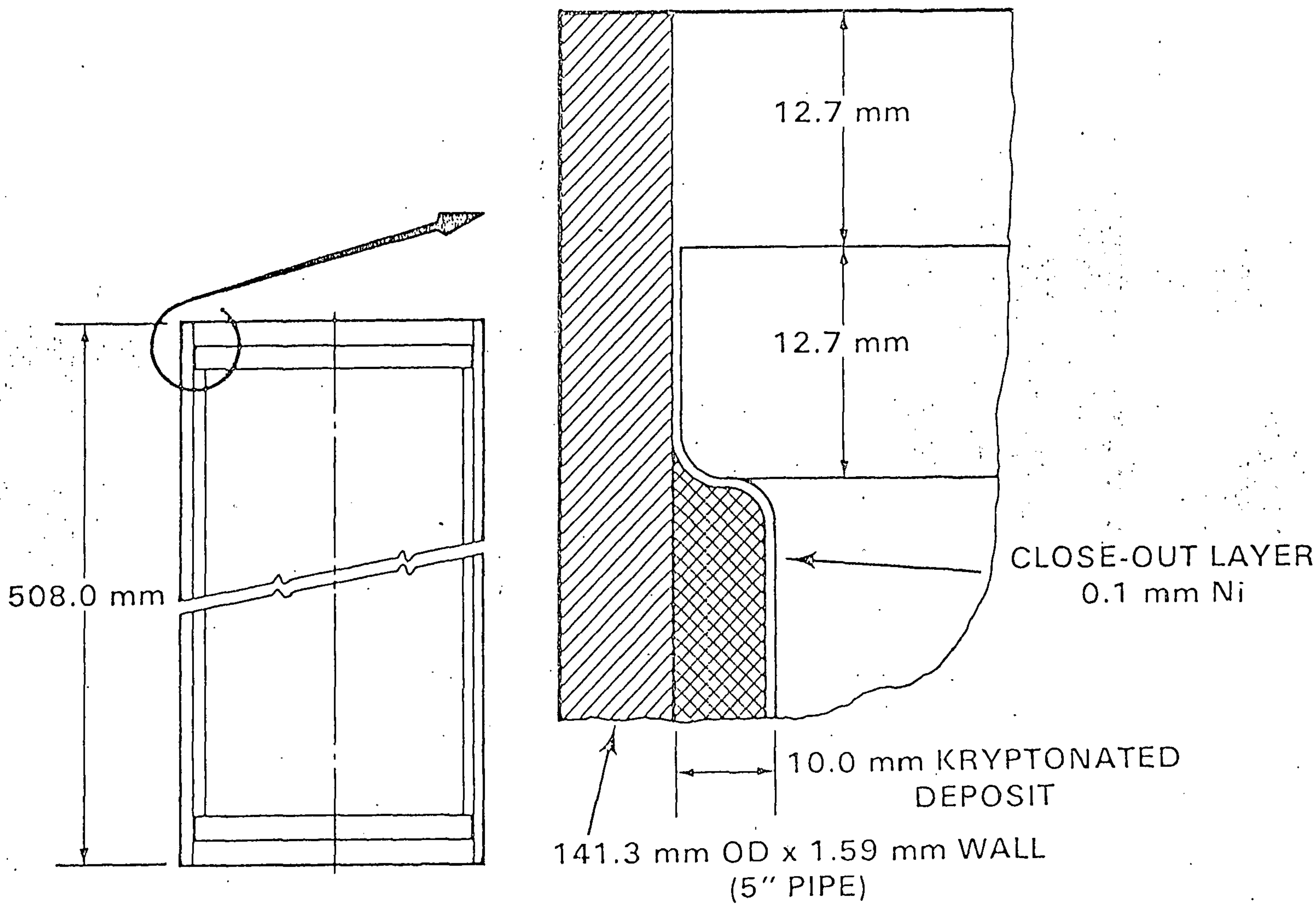
PROCESS BASES

- OPERATE 24 HR/DAY AND 300 DAYS/YEAR
- SERVICES PROVIDED FROM REPROCESSING PLANT
- REMOTELY OPERATED PROCESS
- LIMITED ACCESS TO CELLS

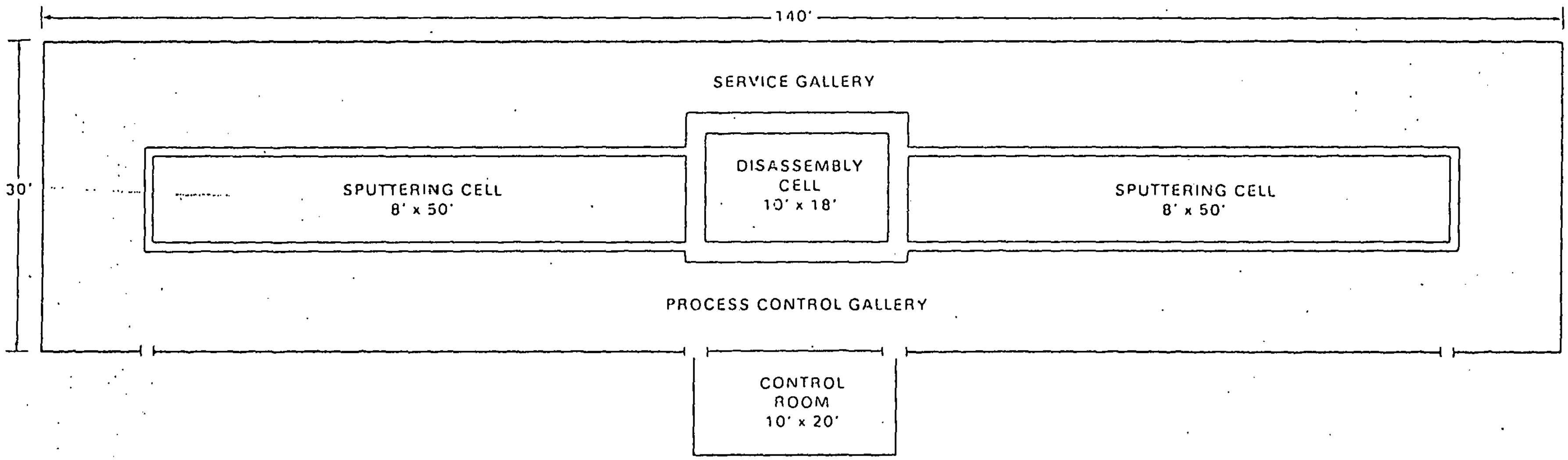
BASE CASE
SPUTTERED DEPOSIT FOR KRYPTON STORAGE OUTER SLEEVE



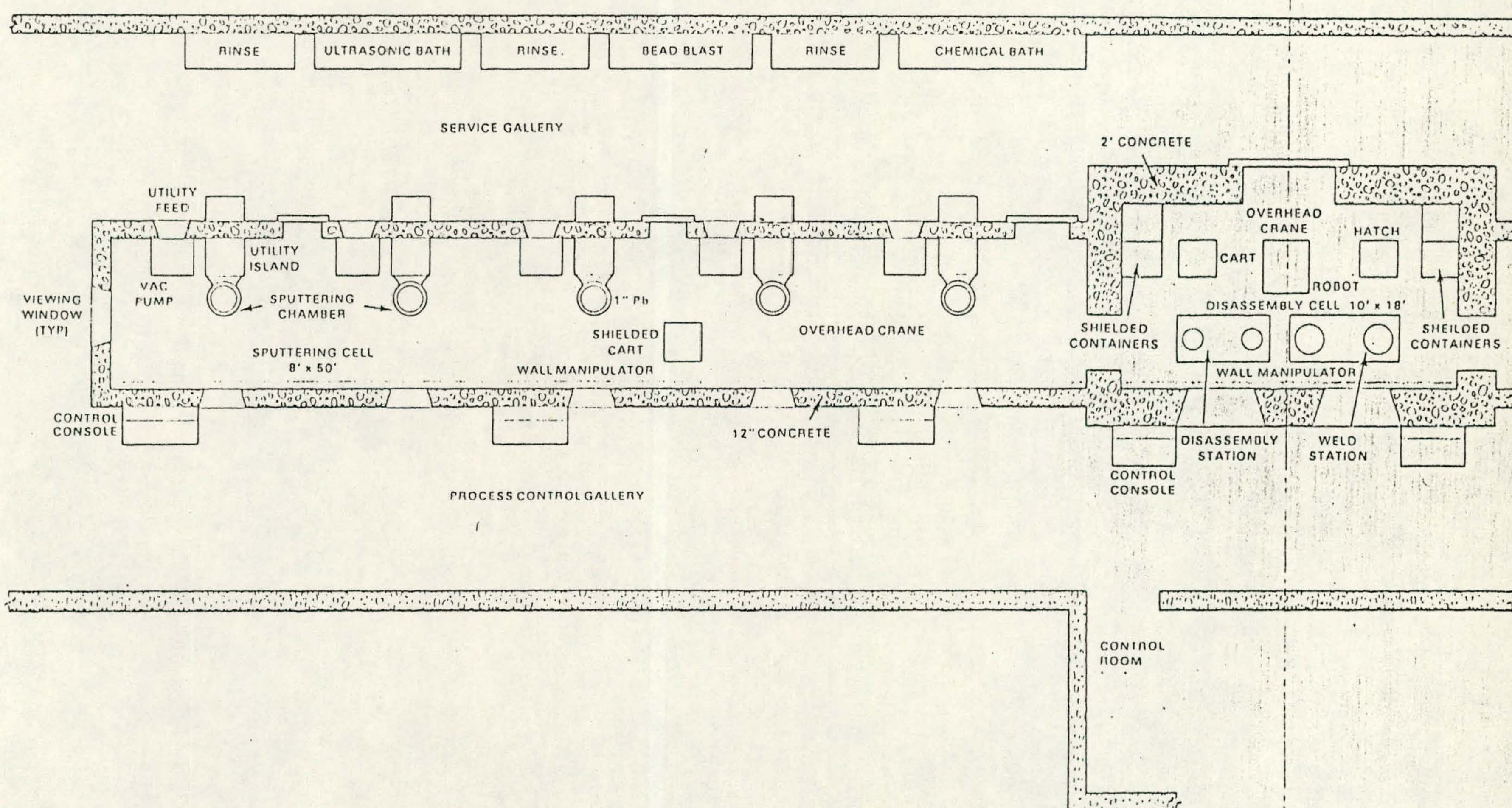
CASE 1-A
TYPICAL SPUTTERED DEPOSIT FOR KRYPTON STORAGE INNER SLEEVE



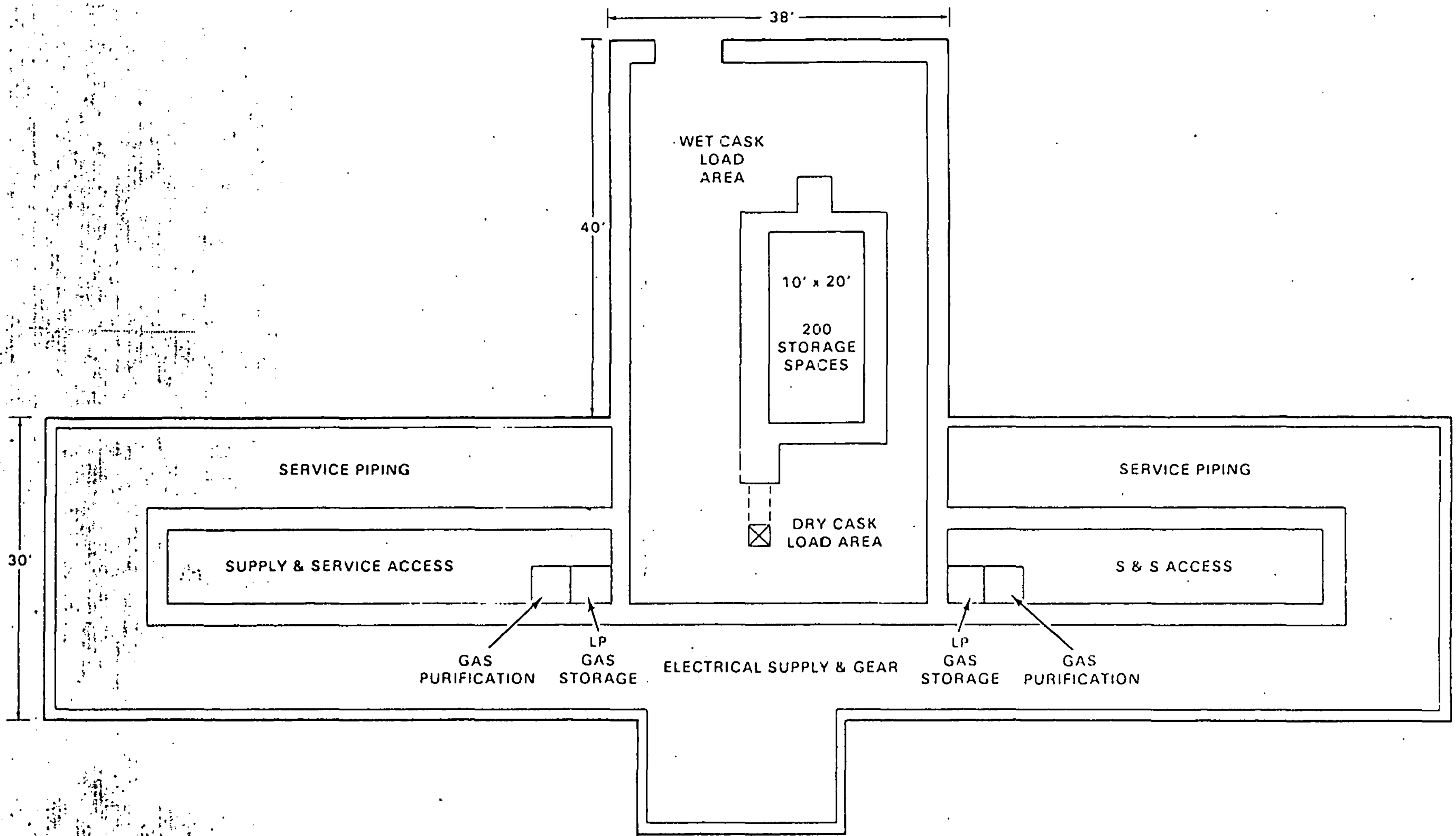
^{85}Kr ENCAPSULATION FACILITY GENERAL ARRANGEMENT UPPER LEVEL



^{85}Kr ENCAPSULATION FACILITY-PROCESS CELL GENERAL ARRANGEMENT



^{85}Kr ENCAPSULATION FACILITY CASE 1-A GENERAL ARRANGEMENT LOWER LEVEL



COST BASES

- 1980 DOLLARS
- FACTORS ADDED FOR NUCLEAR TYPE CONSTRUCTION
- CONSTRUCTION COSTS INCLUDE CONTINGENCY & INTEREST
- NO ANNUAL CAPITAL RECOVERY FACTORS WERE INCLUDED

COST SUMMARY ($K)

	ION IMPLANTATION		500 psi BOTTLES	
	SPUTTERING-BASE CELL	50 YR STORAGE-UNDERWATER	ENCAPSULATION	50 YR AIR STORAGE
FACILITY	4,500		900	
EQUIPMENT				
PROCUREMENT	3,660		240	
INSTALLATION	1,350		115	
TOTAL FIELD COSTS	9,510	17,100[1] 9,700[2]	1,255	73,000[3]
ANNAUL OPERATING COSTS	2,375	450	630	900[4]

(1) BASE CASE

(2) CASE 1-A

(3) FORD BACON & DAVIS - $1979

(4) FORD BACON & DAVIS - $1976

ANNUAL OPERATING COST

ITEM	COST: BASE CASE	COST: CASE 1-A
LABOR	$1,060,000	$940,000
MISCELLANEOUS SERVICE AND MATERIALS*	110,000	95,000
PROCESS MATERIALS	940,000	540,000
ELECTRICITY	265,000	300,000
TOTALS	$2,375,000	$1,875,000

*10% OF LABOR COSTS