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KAPL-M-EDL-71

General Electric Company
KNOLLS ATOMIC POWER LABORATORY
Schenectady, New York

SIR FREEZE SEAL TEST II

by

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P. A. Benson

Photostat Price \$ 7.80

Microfilm Price \$ 3.30

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.

REACTOR DEVELOPMENT TESTING UNIT

May 25, 1954

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ABSTRACT

Two arrangements of internal components of a freeze seal model were tested in order to determine the hydraulic characteristics.

The internal configuration employing cylindrical knitted mesh packings in the connecting pipes proved the most suitable for the sodium servicing freeze seal, because these packings are more easily fabricated.

CONCLUSION

All tested internal arrangements of components of the freeze seal model functioned satisfactorily. The arrangement with cylindrical knitted mesh packing in the connecting pipes is considered more suitable than the original arrangement because of greater ease of fabrication. The final arrangement is shown in Drawing T-6A9494, page 30.

The test results indicate that more than enough liquid metal will be retained by the freeze seal to form a solidification block. The actual flow rates of gas through the seal during SIR operation are not expected to reach the maximum rate used in this test.

The baffles proved beneficial at the initial surge of gas flow and did not hamper the sustained flow.

The pressure drops across the internal arrangement did not exceed 2.3 psi for 17 gpm of water at room temperature. This was lower than anticipated and within the desired range.

INTRODUCTION

Tests were conducted upon two full-size models of the sodium servicing freeze seal proposed for SIR in order to arrive at an internal configuration that would facilitate freezing of the sodium and establishment of a seal. Two internal arrangements of baffles, bubble splitters, and packings were tested. The hydraulic characteristics of the model were determined, using water as the test medium, to establish that the pressure drop during the flow of the liquid metal is not excessive.

The tests were conducted to determine whether the following requirements would be met by the proposed freeze seal:

1. After the liquid metal system has been filled through the freeze seal, the quantity of liquid metal retained in the seal should be sufficient, upon solidification, to act as a seal to the gas and liquid in the system.
2. After gas is blown through the freeze seal into the system, during servicing operations, the seal should retain sufficient liquid to form a seal.
3. The pressure drop across the liquid metal in the freeze seal should be sufficiently low to assure ease of pumping liquid and gas into the system.

DESCRIPTIONInternal Arrangement No. 1

The internal configuration of the first arrangement tested is shown in Drawing T-7A7882, (labelled "Proposed Plan"), page 9. This design employs, in the chambers, half-cylinder shaped packings of knitted mesh. Since knitted mesh packings of the unusual shape specified were not readily available, stainless-steel wool packings were substituted. Stainless-steel wool packings have approximately the same hydraulic characteristics as knitted mesh packings, but, the former cannot be used in the Mark A liquid-metal system because loose ends could be carried into the system and possibly cause severe damage.

On each side of the seal were two baffles whose function was to split up the bubbles. These are shown in Sketch K-94 (part 2 and 3), page 10. The bubble splitters were spaced $3\frac{1}{2}$ inches apart and the volume between them was tightly packed with approximately 1.1 lb. of stainless-steel wool.

Although this configuration of internal components met the requirements of the test, simplification of the design was desired. The specified packing of unique contour, which consisted of a right circular cylinder bisected through its vertical axis, was quoted by the vendor as extremely difficult to manufacture without loose ends which might be carried into the system.

Internal Arrangement No. 2

Originally, it was planned to test the "Alternate Plan" shown on Drawing T-7A7882 subsequent to testing the "Proposed Plan" (Internal Arrangement No. 1). Since Internal Arrangement No. 1 met the requirements of the test, and since the "Alternate Plan" (Internal Arrangement No. 2) offered no alleviation of the difficulty of fabrication, the latter was not tested.

Internal Arrangement No. 3

The internal configuration of the third arrangement is shown in Sketch EDL-6-53-1, page 11. Two baffles were incorporated as in Internal Arrangement No. 1 and two additional bubble splitters were substituted for the stainless-steel wool packings in each chamber. Two 6-inch lengths of cylindrical packing, supplied by Otto H. York, Inc., were placed inside both the inlet and outlet pipes of the seal.

Subsequently, the two baffles were excluded and an additional test was performed to determine the effect of the baffles upon the sealing characteristics.

Test Equipment

The inlet side of the seal was coupled to an 11-inch straight length of 2-inch pipe. An elbow, a horizontal 2-inch nipple, and another elbow equipped with reducers to a 1/4-inch pipe, directed the inlet flow of liquid and gas upward upon entry, thus reducing any jetting effect that might occur. The 1/4-inch pipe was connected through a tee to the water supply and air supply. A flowrater and a valve were installed on each of these lines to provide control of the flow rate.

The outlet of the seal was coupled, in the same manner as the inlet, to a 13-inch length of 2-inch pipe. This line was then turned by means of two elbows and sent downward into a sink.

Sketch K-95, page 12 shows two hole arrangements of the liquid level indicator shrouds which were incorporated in the various internal arrangements.

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:			
APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS	
		FRACTIONS	DECIMALS
		+	+

T-7A7882
CONT. ON SHEET

TITLE: **MESH PACKED BUBBLE CHAMBER**
FIRST MADE FOR: **MARK B. VAPOR TRAP - FREEZE SEAL**

PROPOSED PLAN
SECTION B-B-B-B

SECTION A-A-A-A-A-A-A-A

ALTERANT PROPOSAL
BAFFLES REMOVED, TWO PLATES & 1/2\"/>

REVISIONS		PRINTS TO	
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

MADE BY: **W. P. C. Co. 1-29-53**
DATE: **April 29, 1953**

APPROVALS: **KAPL**
SCHELECTADY

BY OR DEPT. LOCATION: **T-7A7882**
CONT. ON SHEET

REV NO.
SK 6-53-1
CONT ON SHEET SH NO.

TITLE
SCHEMATIC DIAGRAM OF KNITTED
MESA PACKING ARRANGEMENT
FIRST MADE FOR FREEZE SEAL TEST

KNITTED MESH PACKINGS
6" IN LENGTH EACH

BAFFLES (SK K-94 PARTS 2, 3)

BUBBLE SPLITTERS (SK K-94 PART 1)

REVISIONS	PRINTS TO

MADE BY 198	APPROVALS	DIV	CONT ON SHEET	SH NO.
ISSUED 17/8/53		WORKS		

PROCEDURE

The following test program was performed with the two internal arrangements tested:

1. Determination of the amount of fluid retained by the seal after the system has been filled through it. The seal does not become entirely filled with fluid because of the air trapped in the filling side of the seal.
2. Determination of the quantity of fluid remaining in the seal after gas is blown through the seal for varying durations of time at varying flow rates.
3. Establishment of flow vs pressure-drop curves.

Subsequently Internal Arrangement No. 3 was tested without the two baffles on each section, to substantiate the belief that these baffles were adding little to the over-all effect of the configuration upon the seal characteristics.

Test No. 1

Water entered the seal through the inlet, with the outlet side at atmospheric pressure, at a flow rate of 1 gpm. The fluid level in the outlet section was permitted to rise to 7-3/4 inches. The flow of water was then stopped and both sections of the seal were brought to atmospheric pressure, permitting the fluid to back up into the inlet section. The height of the fluid in both sections, now at the same level, was then recorded. The time required to reach the 7-3/4 inch level at the flow of 1 gpm was used to calculate the volume of water involved.

Test No. 2

Gas was blown through the seal at flow rates varying from 1/2 to 6 cpm. The height of the remaining water was measured at intervals between 1 and 40 minutes for each flow rate. The seal was refilled to the mean level obtained

in Test 1 after each gas flow test before the subsequent flow rate of air was started.

This test was repeated on Internal Arrangement No. 1 with the air entering the opposite side of the seal, in order to determine whether or not the different hole arrangement in the level indicator shrouds changed the results.

Test No. 3

The seal was placed in a closed loop, and the pressure drop across it was measured at varying flow rates up to 17 gpm, to determine the pressure-drop curve.

RESULTS

The performance of both configurations, Internal Arrangements No. 1 and 3, met the requirements of the test satisfactorily. However, Internal Arrangement No. 3 which employed cylindrical mesh packing in the inlet and outlet pipes could be fabricated with greater ease. The final design is shown in Drawing T-6A9494, page 30.

The liquid levels of the freeze seal model, after filling at a rate of 1 gpm until the liquid in one chamber attained a height of 7-3/4 inches, are listed in Table I:

<u>Table I</u>		
<u>Internal Arrangement</u>	<u>Trial</u>	<u>Liquid Level Inches from Bottom</u>
No. 1	1	5-3/16
	2	5-3/16
No. 3	1	4-1/4
	2	4-1/4

The time required to fill Internal Arrangement No. 3 at a rate of 1 gpm was 1 minute, 45 seconds; therefore, 1-3/4 gallon of liquid filled the chamber to capacity. This is not the entire volume of the container, as air is trapped on the filling side of the seal as well as above the exit pipe on the outlet side of the seal.

The liquid level remaining after air had been blown through the seal at varying rates of flow for specified lengths of time are listed in Tables II, III, IV, and V, pages 17 to 20.

The liquid level obtained upon a 1-minute flow of air is slightly less than that which will be experienced in the actual Mark A freeze seal. This is due to the vertical length of the outlet pipe. In the test, this dimension was established as approximately 1 foot. In the Mark A freeze seal, the length will

be greater and therefore less fluid will blow over.

After removal of the two baffles from Internal Arrangement No. 3, the test results indicated that upon gas flow the baffles reduced the initial surge of liquid, but did not affect the amount of liquid lost to entrainment in the gas.

The pressure drop across Internal Arrangements No. 1 or 3 was not high enough to cause any difficulties in the actual Mark A freeze seal. The pressure drops for water for each seal model are shown in Tables VI, VII, and VIII, pages 21 to 23.

The pressure drops for all the arrangements tested are plotted against flow in Figures 5 to 10, pages 24 to 29.

TABLE II

WATER LEVEL AFTER GAS FLOW

Internal Arrangement 1. Liquid Level Indicator Well No. 1 in Inlet, No. 2 in Outlet

Flow Rator Reading - mm		Air Flow	Water Level - Inches from Bottom							
Required	Actual	cfm	start	1 min.	3 min.	6 min.	10 min.	15 min.	25 min	40 min.
31.5	30.5, 31.0	1/2	5 3/16	4 1/8	3 7/8	3 13/16	3 13/16	3 3/4	3 3/4	3 3/4
39.5	39.0, 40.0	1	5 3/16	3 7/8	3 3/4	3 1/4	3	3	3	3
47.5	47.5	1 1/2	5 3/16	3	3	2 15/16	2 15/16	2 15/16	2 15/16	2 15/16
56.0	56.0	2	5 3/16	3	3	2 15/16	2 15/16	2 7/8	2 13/16	2 1/2 After Setting
64.2	64.2, 65.0	2 1/2	5 3/16	2 3/8	2 3/8	2 3/8	2 3/8	2 1/8	2 1/8	2 1/16
72.2	72.0, 72.2	3	5 3/16	2	2	2	2	1 15/16*	2	2
88.0	88.0, 89.0	4	5 3/16	1 3/4	1 5/8	1 9/16	1 5/8	1 5/8	1 5/8	1 9/16
103.0	103.0	5	5 3/16	1 1/2	1 7/16	1 7/16	1 7/16	1 7/16	1 7/16	1 3/8
118.0	118.0	6	5 3/16	1 3/16	1 3/16	1 1/8	1 1/8	1 1/8	1 1/16	1 (45 min.)

*Stopped Overnight

TABLE III

WATER LEVEL AFTER GAS FLOW

Internal Arrangement 1. Liquid Level Indicator Well No. 2 in Inlet, No. 1 in Outlet

Flow Rator Reading - mm		Air Flow cfm	Water Level - Inches from Bottom							
Required	Actual		start	1 min.	3 min.	6 min.	10 min.	15 min.	25 min.	40 min.
31.5	31.0, 32.0	1/2	5 3/16	3 31/32						
39.5	39.0, 40.0	1	5 3/16	3 3/16	3 5/32	3 5/32	3 5/32	3 5/32	3 5/32	3 5/32
47.5	47.0, 48.0	1 1/2	5 3/16	3 3/16						
56.0	56.0	2	5 3/16	2 3/4	2 11/16	2 11/16	2 11/16	2 21/32	2 9/16	2 9/16
64.2	64.0, 65.0	2 1/2	5 3/16	2 3/8						
72.2	72.0, 73.0	3	5 3/16	2 1/4	2	2	2	2	2	1 31/32
88.0	88.0	4	5 3/16	1 15/16	1 29/32	1 29/32	1 29/32	1 7/8	1 7/8	1 29/32*
103.0	103.0	5	5 3/16	1 3/4	1 3/4	1 3/4	1 5/8	1 5/8	1 5/8	1 5/8
118.0	114.0**	5.7	5 3/16	1 19/32	1 5/8	1 5/8	1 19/32	1 19/32	1 19/32	1 1/2

*Stopped overnight before measurement was taken

** Maximum air flow

TABLE IV

WATER LEVEL AFTER GAS FLOW

Internal Arrangement 2. With Baffles

Flow Rator Reading - mm			Air Flow	Water Level - Inches from Bottom							
Des.	Max.	Min.	cfm	start	1 min.	3 min.	6 min.	10 min.	15 min.	25 min.	40 min.
31.5	32.5	30.5	1/2	4 1/4	4 1/16	3 31/32	3 15/16 ⁺	4	3 31/32	3 31/32	4
39.5	+0.5	-0.5	1	4 1/4	3 3/4	3 3/4	3 3/4	3 3/4	3 3/4	3 3/4	3 9/16*
47.5	+0.5	-0.5	1 1/2	4 1/4	3 5/16	3 5/16	3 1/4 ⁺	3 5/16	3 9/32	3 5/16	3 5/16
56.0	+0.5	-0.5	2	4 1/4	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/32
64.2	+0.5	-0.5	2 1/2	4 1/4	2 13/16 ⁺	2 7/8 ⁻	2 7/8 ⁻	2 7/8 ⁻	2 27/32	2 13/16	2 25/32
72.2	+0.5	-0.5	3	4 1/4	2 5/8	2 5/8	2 5/8	2 5/8	2 5/8	2 5/8	2 9/16
88.0	+0.5	-0.5	4	4 1/4	2 1/8	2 1/32	2	2	2	1 15/16	1 7/8
Max. **					1 3/4	1 3/4	1 23/32	1 1/2	1 1/2	1 1/2	1 1/2

*Baffle interfered with measurements

**Air Flows: Max. 103.5 mm

Min. 97.0 mm

Avg. 99.2 mm

TABLE V

WATER LEVEL AFTER GAS FLOW

Internal Arrangement 2. Baffles Removed

Flow Rator Reading - mm			Air Flow		Water Level - Inches from Bottom							
Des.	Max.	Min.			start	1 min.	3 min.	6 min.	10 min.	15 min.	25 min.	40 min.
39.5	+0.5	-0.5	1		4 1/4	3 13/16	3 3/4	3 3/4	3 23/32	3 23/32	3 11/16	3 21/32
56.0	+0.5	-0.5	2			3 1/8	3 1/8	3 3/32	3 1/16	3 1/16	3 1/32	3 1/32
72.2	+0.5	-0.5	3	*		2 5/8	2 5/6	---	---	---	---	2 1/4
88.0	+0.5	-0.5	4			1 15/16	2 1/32	2	1 7/8	1 27/32	1 3/4	1 25/32
Max.		104.0	5.05			1 17/32	1 1/2**	1 15/32	1 15/32	1 5/16	1 9/32 ⁺	1 9/32

*Bubble splitter interfered with liquid height measurement

**Flowrator dropped to 100.0 mm, 4.8 cfm

TABLE VI

PRESSURE DROP

Internal Arrangement 1.
H₂O Temperature — 29°C
Room Temperature — 31°C

Flow Rator Reading-gpm	Flow Corrected gpm	Manometer Reading In. CC/4			Pressure Drop psi
		Left	Right	Total	
2	2.04	1.2	0.1	1.3	.027
4	4.00	2.05	1.0	3.05	.063
6	5.81	3.1	2.1	5.2	.108
8	7.73	4.35	3.5	7.85	.163
10	9.57	5.8	5.1	10.9	.227
12	11.48	7.4	6.95	14.35	.298
14	13.33	9.3	9.1	18.4	.383
16	15.22	11.2	11.3	22.5	.468
18	17.1	13.15	13.6	26.75	.556

TABLE VII

PRESSURE DROP

Internal Arrangement 2.

Room Temperature - 26°C

Flow - gpm	Δ P Across Chambers Only			Δ P Across Model (Including Packings)		
	inch CC/4		psi	inch CC/4		psi
	Left	Right		Left	Right	
2.04	0.55	0.75	0.00042	-2.15	-4.5	0.050
4.00	0.4	0.9	0.0106	0.8	-7.3	0.171
5.81	0.1	1.2	0.0232	4.25	-10.9	0.320
7.73	-0.35	1.65	0.0423	9.2	-16.05	0.534
9.57	-0.85	2.25	0.0655	14.75	-22.1	0.778
				<u>cm C₂H₂Br₄</u>		
11.48	-1.6	3.1	0.0993	19.1	-20.5	1.10
13.35	-2.4	3.9	0.133	25.2	-26.4	1.43
15.21	-3.3	4.9	0.173	32.1	-33.3	1.82
17.10	-4.3	5.9	0.216	39.3	-40.5	2.22

TABLE VIII

PRESSURE DROP

Internal Arrangement 2. All Packing Removed

Room Temperature - 26°C

Flow gpm	ΔP			
		inch CC/4		psi
	Left	Right	Total	
2.04	-0.4	0.9	0.5	0.011
4.00	-0.05	1.3	0.8	0.017
5.81	-0.65	2.1	2.75	0.0581
7.73	-1.7	3.2	4.9	.104
9.57	-2.85	4.45	7.3	.154
11.48	-4.5	6.15	10.65	.225
13.35	-6.5	8.25	14.75	.312
15.21	-8.6	10.3	18.9	.399
17.10	-11.0	12.8	23.8	.502

HEIGHT OF REMAINING FLUID (H₂O) IN CHAMBERS VS TIME AT VARIOUS AIR FLOW RATES

INTERNAL ARRANGEMENT No. 1

Level Indicator Shrouds as
per Table II

HEIGHT OF REMAINING FLUID (H₂O) IN CHAMBERS VS AIR FLOW CFM AT 20 MIN. PERIOD

INTERNAL ARRANGEMENT No. 1

Level Indicator Shrouds
as per Table II

HEIGHT OF REMAINING FLUID FROM BOTTOM

50

40

30

20

10

0

1.0

2.0

3.0

4.0

5.0

6.0

7.0

AIR FLOW CFM

PAB 7/30/53
PB-102

HEIGHT OF REMAINING FLUID (H₂O) VS TIME AT VARIOUS AIR FLOW RATES INTERNAL ARRANGEMENT No. 1

Level Indicator Shrouds
as per Table III

HEIGHT OF REMAINING FLUID IN CHAMBERS VS AIR FLOW RATES CFM AT 20 MIN. PERIOD INTERNAL ARRANGEMENT No. 1

Level Indicator Shrouds
as per Table III

WATER LEVEL - INCHES FROM BOTTOM

AIR FLOW CFM

FB-104

826 026

PRESSURE DROP PSI VS FLOW GPM
INTERNAL ARRANGEMENT No. 3

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:			
APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS	ANGLES
		FRACTIONS	DECIMALS

T-6A9994
COUNT SHEET
REV. NO. 1
DATE: 7-23-52

TWO-WAY VENT (TYPE I)
FREEZING SEAL
FIRST MADE FOR LIQUID METAL SERVICE CONNECTIONS

REV. NO.	NAME	MATERIAL
1	2	FREEZING CHAMBER
1	3	COVER
2	4	CONNECTING PIPE
2	5	BOTTOM COVER
2	6	BUBBLE SPLITTER
2	7	BUBBLE SPLITTER
2	8	BAFFLE PLATE
2	9	BAFFLE PLATE
2	10	TOP PLATE
2	11	LIQ. LEVEL IND.
3	12	SPACER
2	13	CONNECTING PIPE
2	14	PIPE
2	15	COVER
2	16	PLATE
2	17	THERMOCOUPLE WELL
1	18	HEATER HOUSING
1	19	HEATER UNIT
1	20	ELBOW
1	21	PIPE
1	22	ELBOW
1	23	PIPE
1	24	REDUCER
1	25	PIPE
1	26	GASKET
4	27	BOLT, HEX. HD.
4	28	NUT, HEX.
1	29	OUTER PIPE
1	30	HEATING & COOLING MESH

REDUCED SCALE VIEW AT 'A'

DESIGN LAYOUT
NOT TO BE USED FOR FABRICATION

NOTES—
ESTIMATED WEIGHT WITHOUT INSULATION & TANK
HEATERS = 170 LBS.
ALL WELD PREPARATIONS BY VENDOR
ALL TOLERANCES ARE ± 1/32 UNLESS OTHERWISE SPECIFIED
APPROX. OVERALL DIMENSIONS—
HEIGHT = 22 1/2", WIDTH = 10 1/2", LENGTH WITH WATER CONNECTIONS = 22 1/2",
LENGTH WITHOUT WATER CONNECTIONS = 17 1/2"

REVISIONS	PRINTS TO
1. Deleted P.T. 18 TWO	216
2. Added P.T. 29	SIR
3. 30 CHANGED TO	
4. LUBRICATION	