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FILLING INSTRUCTIONS FOR THE PRATT & WHITNEY FORCED CONVECTION LIQUID METAL INPILE LOOP EXPERIMENT (PW-19)

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Table of Contents

Filling Instructions For The Pratt & Whitney Forced Convection Liquid Metal Inpile Loop Experiment (PW-19)

Written by: P. T. Heyl

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J. R. Miller
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Introduction

This manual describes the apparatus and procedures which will be used to fill the liquid metal system of the Pratt and Whitney Forced Convection Liquid Metal Inpile Loop. The liquid metal to be used is a mixture containing 56 percent sodium and 44 percent potassium which is a liquid at room temperature. This will necessitate filling the experiment at the Engineering Test Reactor Site to prevent liquid metal contamination of the pump motor located at the upper end of the experiment.

In order to simplify the filling procedure at the reactor site two containers will be shipped from CANEL each of which contains exactly enough liquid metal to fill the experiment to the prescribed level. A fill dolly incorporating a purified helium system and an evacuation system will also be provided at the reactor site. This apparatus will be used to evacuate and purge the experiment prior to making the liquid metal transfer from the shipping container. After completing the liquid metal transfer, the liquid metal fill tube will be crimped, cut, and seal welded. The liquid metal and helium systems will then be pressurized through the helium fill tubes which will also be crimped, cut, and seal welded. Each tube seal weld will be inspected after completion of the weld by mass spectrometer leak check and dye penetrant fault detection.

Description of Apparatus

The fill dolly to be used at the Engineering Test Reactor Site will incorporate the following components: a loop volume container, heater assembly, helium scrubber and dryer, liquid metal flow indicator, helium supply, mechanical vacuum pump, diffusion pump, Philips gage, G. E. molecular vacuum gage, powerstats, instrumentation, and the valves and tubing required for the operation of the liquid metal, vacuum, and helium systems.

The applicable Pratt and Whitney drawings are included in the following tabulation.

Title	Drawing Number
"Electric and Piping Schematic L M Fill Dolly, Inpile Loop ETR"	CLD-10126-3-5
"Frame, Inpile L M Fill Dolly (ETR Unit)"	CR-100920
"Layout, L M Fill Dolly (ETR Unit)"	CLR-10126-1
"Stand For Removable Fill Dolly Frame Inpile L M Fill Dolly ETR Unit"	CD-101027
"Stand Loop Prep Demountable and Portable ETR Inpile Loop"	CLR-10129-9

The loop volume container (Pratt and Whitney drawing CD-100767) consists of two cylindrical sections. The lower section is 6 inches high with an I.D. of 6 inches, and the upper section is 15 inches high with a 2 inch I.D. The top and bottom of the lower section slope approximately 75° with the longitudinal centerline of the container. This loop volume container configuration was chosen for three reasons. The top and bottom of the lower section were inclined with the container center line

to prevent the possibility of trapping any gas during charging and to insure complete transfer of the NaK at the time the experiment is filled. An inside diameter of approximately 2 inches was selected for the upper section to provide an adequate filling liquid level tolerance in the loop volume container while maintaining 0.030 inch tolerance on the NaK level in the experiment. A lower section of larger diameter was used in order to decrease the overall height of the container to a convenient value. The loop volume container will be shipped to the Engineering Test Reactor Site equipped with a dump line welded to the bottom of the lower section and a gas blanket line welded to the top of the upper section. Both lines will be supplied with bellows valves and capped with "Swagelok" fittings.

The heater assembly will be made up of four clam shell type heaters totaling 3500 watts which will surround the lower eight inches of the loop volume container and provide sufficient heat to remelt its contents (solid sodium may be present if the container has experienced temperatures lower than 65F during shipping or storage).

Purified helium will be supplied to the fill unit from a two bottle source through a scrubber system. The gas will be bubbled through a 15 inch packed column scrubber, containing 316 stainless steel mesh and NaK at 450F, to remove contaminants. It will then be passed through a cooled 15 inch vapor trap dryer, containing 316 stainless steel mesh, to entrain any NaK carried over in the helium from the scrubber. The scrubber will be heated with clam shell type heaters and the vapor trap dryer will be cooled with flowing air. Pratt and Whitney drawings CD-100832 and CD-100819 respectively show the scrubber and dryer in detail.

A vacuum system has been incorporated in the fill unit to provide a means of adequately purging the experiment and transfer lines prior to transferring the NaK to the experiment. This system will include both a mechanical vacuum pump and a diffusion pump in order to decrease the time required to evacuate the helium and NaK regions of the experiment.

Special stainless steel liquid metal bellows valves will be used on the loop volume container dump and gas blanket lines and on the purge bypass to the fill line since these valves are subject to liquid metal contamination.

"Hoke" diaphram type valves will be used in the helium blanket system.

A mercury bubbler will be used on the fill rig vent line to prevent back diffusion of air when the experiment is vented. The column above the bubbler will be 30 inches long so that mercury cannot be drawn into the experiment or fill rig under any conditions.

The following instrumentation will be provided on the fill dolly: Two pyrovanes and two powerstats for the control of the loop volume container and helium scrubber heaters, probe lights for the vapor traps and fill line flow indicator, a G. E. molecular and a Philips vacuum gage to provide static and pumping pressure readings during evacuation of the experiment, and pressure gages indicating the helium pressures at the helium supply, loop volume container, and fill rig vent line.

Experiment Filling Procedure

1.0 General

The PW-19 inpile loop liquid metal fill dolly was designed with emphasis on

safety. The procedure to be followed in its use should present no hazard to personnel or possibility of a miss-fill if the filling instructions are carefully followed. Pratt and Whitney CANEL Health and Safety Procedure C5.05 and Bulletin E .02 entitled "Alkali (liquid) Metal Test Rigs and Experiments" and "Immediate First aid for Alkali (liquid) Metal Burns" respectively, as well as the entire filling procedure should be carefully studied before proceeding with an actual fill.

2.0 Preliminary Preparation

2.1 Fill Dolly Preparation

2.11 Mechanical Vacuum Pump

Check the oil level in the mechanical vacuum pump. Add only Welch "Duo-Seal" pump oil to the pump reservoir.

2.12 Diffusion Pump

The diffusion pump boiler must be removed and filled to the prescribed level with "Octoil" vacuum pump fluid. While the boiler is off, the jet assembly should be inspected. Any coked oil or gum should be removed from the jet assembly before reassembling the pump.

Two precautions must be observed in the operation of the diffusion pump.

1. The pump must not be operated with an inlet pressure exceeding 0.2 mm of Hg. Introduction of air above this pressure will cause coking of the pump oil in the boiler and jet assembly.

2. The pump must not be isolated from the roughing pump for a period of more than 15 minutes while the boiler is being heated. Isolation of the pump for a longer period may result in coking of the pump oil due to termination of refluxing caused by rising pressure. It may be necessary, therefore, to periodically rough the diffusion pump during one or more of the purging procedures covered in this manual. This can be accomplished, with valves VV-3 and VV-4 closed, by lowering the pressure between valve VV-2 and the mechanical pump to 0.02 mm of Hg, opening valve VV-2, roughing the diffusion pump to 0.02 mm of Hg, and then closing valve VV-2.

2.13 Mercury Bubbler

The reservoir of the mercury bubbler must be filled with fresh triple distilled mercury to a point approximately one inch above the bottom end of the system bleed tube.

2.14 Scrubber Installation

The scrubber must be installed in the helium system between the supply bottles and the drier as shown on figure 1 and drawings CLD-10126-3-5 and CLR-10126-1. Particular attention must be given to the connection of the inlet scrubber line. While this connection is being made there must be a substantial flow of helium from the helium bottle to minimize the amount of oxygen that will remain in the system. The identity of the inlet

scrubber line must be double checked. If the scrubber outlet line is connected to the helium supply the liquid metal in the scrubber will be transferred to the dryer when helium flow is started. After both scrubber connections have been made and tightened the helium pressure at the scrubber inlet valve should be set between 10 and 15 psig. Both scrubber valves must remain closed.

2.15 Loop Volume Container Installation

Weigh the loop volume container to an accuracy of 0.15 pounds and record the weight. Position and bolt the loop volume container mounting brackets to the rack provided for them on the fill dolly. The helium blanket line must then be connected into the fill dolly helium system as shown on figures 1 and 2 and on drawings CLD-10126-3-5 and CLR-10126-1. The dump line "Swagelok" plug must be left in place. The loop volume container inlet gas valve and dump valve must remain closed.

2.16 System Leak Check and Purge

Connect a two foot length of 0.500 inch I.D. neoprene vacuum hose between the mechanical vacuum pump header and the LX-2 vapor trap outlet fitting using the 0.625 inch O.D. tube by 0.250 inch "Swagelok" adapter provided. Check the "Swagelok" connections between valve HV-5 and the LX-3 vapor trap. If these components are not connected, a 0.250 inch O.D. copper or plastic line must be connected between them. Refer to figure 2. Open valves VV-1, HV-3, HV-5, and HV-6. Close valves HV-2, HV-4 and HV-9. Valves LMV-1, HV-1, HV-7 and HV-8 on the loop volume container and scrubber units must remain closed. Plug the fill dolly power cable into a 480 volt a-c power receptacle. Start the mechanical vacuum pump and G. E. Molecular gage and continue pumping until the G. E. gage indicates a pressure of approximately 0.02 mm of Hg. Close valve VV-1. The pressure in the system should not rise more than 0.05 mm of Hg in 50 to 60 seconds if there are no leaks present in the system.

Set the inlet helium pressure at 10 psig and slowly open valve HV-8. Crack valve HV-7 and slowly bleed helium into the system. The bleed must be slow enough to maintain a positive pressure at the helium regulator pressure gage to prevent ingassing. When the system pressure reaches 10 psig open valve HV-9 and crack valve HV-4. Maintain a slow bleed for several minutes. Close valves HV-4, HV-7 and HV-9 and open valve VV-1. Pump the system down to 0.02 mm of Hg. Close valve VV-1 and crack valve HV-7 (maintain a positive inlet gage pressure). Pressurize the system to 10 psig. Repeat the latter purge cycle. Turn the mechanical vaccum pump off and maintain a 10 psig helium blanket on the system.

2.17 Loop Volume Container Helium Blanket Check

Close valve, HV-5 and open valves, HV-3 and HV-9. Bleed the helium pressure at gage HP-3, down to zero by cracking valve HV-4. Close valves HV-3, HV-4, and HV-9 and check valves HV-1 and HV-2 which should be closed. Crack valve HV-1 and read the loop volume container blanket pressure on gage HP-3. If a net positive pressure is observed on gage HP-3 contamination of the liquid metal in the loop volume container has not occurred. Close valve HV-1.

2.2 Loop Volume Container Liquid Metal Remelt

Set the loop volume container heater pyrovane control set point at 400F. If the pyrovane does not indicate ambient temperature test the continuity of the circuit to the loop volume container thermocouple and repair this thermocouple if necessary. Turn the loop volume container heater circuit "On" and raise the loop volume container powerstat setting to 20 percent. After the temperature in the loop volume container stabilizes, raise the powerstat in increments of 5 percent until the pyrovane cuts the heater power out. Maintain the liquid metal at 400F for a period of 24 hours. Periodically agitate the loop volume container by slowly rolling the fill dolly back and forth. At the end of the 24 hour period turn the loop volume container heater powerstat to zero and turn the heater power "Off".

2.3 Fill Dolly Relocation

The removable portion of the fill dolly, enclosed by the dotted line in figure 1, must be relocated on the second deck of the experiment preparation stand (refer to Pratt & Whitney drawing CLR-10129-9 entitled "Stand-Loop Prep Demountable and Portable ETR Inpile Loop") where it will be supported on an adjustable frame (refer to Pratt & Whitney drawing CD-101027 entitled "Stand For Removable Fill Dolly Frame, Inpile Liquid Metal Fill Dolly, ETR Unit"). The terminology used to identify the removable portion of the fill dolly throughout the remainder of this manual will be "fill rig". Before relocating the fill rig the PW-19 experiment must be positioned in the experiment preparation stand. The procedures to be followed in mounting the experiment in this stand are described in section I of CNLM-1181 entitled "Installation and Removal Procedure for the Pratt and Whitney Forced Convection Liquid Metal Inpile Loop Experiment (PW-19)".

2.31 Relocation Procedure

A) Close valves HV-3, HV-5 and HV-6.

B) Disconnect the 0.250 inch O.D. tubing between valves HV-5 and the LX-2 vapor trap (installed in accordance with section 2.16).

C) Disconnect the vacuum hose adapter from the LX-2 vapor trap outlet (installed in accordance with section 2.16).

D) Disconnect the three fill rig power cables from the fill dolly outlets; coil and attach them to the cable bracket provided on the fill rig.

E) Attach the lifting harness (stored on the fill dolly helium bottle rack) to the lifting lugs on the fill rig frame.

F) Move the fill dolly, fill rig support stand (drawing CD-101027), and the experiment preparation stand (drawing CLR-10129-9) to an area which has access to a crane or hoist.

G) Attach the crane hook to the fill rig lifting harness and take up the slack in the cable. Note: The Philips gage is not to be transfered with the fill rig. It must be carried to the fill rig after the latter has been positioned on the experiment preparation stand.

H) Lift the fill rig free of the fill dolly and while still supported by the crane position it near the fill rig support stand (drawing CD-101027).

I) Remove the two corner connecting angles (item 13 drawing CD-101027) from the fill rig support stand (drawing CD-101027).

Note: These connecting angles must be relocated on the fill rig frame where they will be bolted to the lower section of item 6 (refer to drawing CR-100920, two locations).

J) Lower the fill rig into position in the fill rig support stand (drawing CD-101027). Be sure that the two suspension members (item 20 drawing CR-100920) straddle the versabar channel support (item 3 drawing CD-101027).

K) Bolt the two corner connecting angles which were removed from the fill rig support stand in step I, to the vertical versabar supports (item 6 drawing CR-100920) of the fill rig frame. When bolted in place, these angles must have sufficient clearance so that they will slide freely up and down the vertical versabar members of the fill rig support stand (item 7 drawing CD-101027).

L) Raise the fill rig and its support stand to the first deck of the experiment preparation stand and position it so that the holes in the plywood decking line up with the holes in the versabar runners of the fill rig support stand (refer to sections A-A and B-B of drawing CLR-10129-9).

Note: These holes must be drilled when the fill rig and fill rig support stand are positioned on the experiment preparation stand for the first time at the reactor site. The size and location of the holes will be determined at this time by the Pratt and Whitney project co-ordinator.

Loosely bolt the support stand in place and then disconnect the lifting harness from the fill rig frame and bolt it to its storage location on the fill dolly.

M) Connect the mechanical pump vacuum header to the vacuum manifold near the diffusion pump discharge (points A to B fig 1) using the 25 foot long 0.500 inch I.D. neoprene vacuum hose and hose clamps provided.

N) Connect the fill dolly helium system to the fill rig helium system by connecting new 0.250 inch O.D. copper tubing between valve HV-5 and the LX-3 vapor trap (points C and D fig 1).

O) Connect the three fill rig power cables to their respective receptacles on the fill dolly.

P) Connect the vacuum header to the vacuum manifold at the flange joint (item 44 drawing CLR-10126-1) and connect the vacuum manifold vapor trap to the vacuum header using the preformed 0.250 inch O.D. stainless steel tubing and "Swagelok" fittings provided.

Note: If necessary adjust the clearance between the fill rig and the experiment to obtain mounting clearance for the vacuum header.

2.4 Helium and Liquid Metal Fill Line Connections

The loop volume container drain line and the experiment liquid metal fill tube (part number T-1009594) and helium fill tube (part number T-1009608) must be connected to the fill rig as follows. Refer to Pratt and Whitney drawing T-1013200 entitled "Inpile Loop, Assembly Of".

A) Position the bottom of the 0.187 inch I.D. "Swagelok" fitting at the end of the vacuum header approximately 9½ inches above the T-1000422 tube which houses the experiment fill lines at the top end of the experiment. Vertical adjustment of the vacuum header is made by raising or lowering the fill rig in its support stand by means of the two thumb screws provided (item 19 drawing CD-101027). Horizontal adjustment of the header must be made by moving the fill rig support stand.

Note: If sufficient horizontal support stand travel cannot be obtained using the existing bolt holes in the preparation stand plywood decking new holes must be drilled which will give the required adjustment.

B. The 0.187 inch O.D. helium fill tube (part number T-1009608) must be cut so that it extends between 9 and 9½ inches above the end of the T-1000422 tube which houses the two fill lines at the top of the experiment. This cut is to be made with a tube cutter and is not to be deburred.

Note: Before making the cut the surface of the tube which will be positioned in the vacuum header "Swagelok" must be polished, using fine emery cloth in a direction perpendicular to the axis of the tube, to remove any axial surface scratches which might cause the "Swagelok" ferrules to leak. When the cut is made, care must be exercised to insure that foreign material is not introduced into the system through the tube.

C. Position the 0.187 inch I.D. vacuum header "Swagelok" fitting over the 0.187 inch O.D. helium fill tube by lowering the fill rig. Tighten the "Swagelok" fitting.

D. Thread the 0.125 inch O.D. liquid metal fill tube (part number T-1009594) from the experiment to the fill rig liquid metal flow indicator (item 6 drawing CLR-10126-1, point E fig 1) positioning the tube so that it rises vertically for approximately 5 inches above the end of the T-1000422 tube and then runs toward the bottom of the flow indicator with a slight upward pitch. The tube must be cut and bent to fit the bottom flow indicator "Swagelok" fitting and must include enough excess length to permit recutting if the first "Swagelok" connection leaks. The cut must be made with a tube cutter. After the tube has been cut, the following method must be used to deburr the inside diameter of the tube. Face the end of the tube downward and apply 10 pounds of helium pressure to the experiment through valves HV-8, HV-7, HV-6, HV-5, HV-3 and the 0.187 inch O.D. helium fill tube to provide gas flow through the end of the liquid metal fill tube which is to be deburred. Using a fine file, cut the end of the tube back far enough to remove the burr.

The outside diameter of the tube, near the end, must be polished with fine emery cloth, in a direction perpendicular to the axis of the tube, to remove any surface defects which could cause the ferrules in the flow indicator "Swagelok" to leak. Helium flow through the tube must be maintained

while it is being polished to prevent foreign matter from entering the system. After the preparation of this tube has been completed, valve HV-3 must be closed. The fill tube must next be positioned in the bottom flow indicator Swagelok fitting and the "Swagelok" nut tightened.

E) Remove the "Swagelok" plug from the loop volume container dump valve outlet. This valve, LMV-1, has remained closed throughout the experiment filling preparations and must remain fully closed when the "Swagelok" cap is removed. Connect the loop volume container dump line to the fill rig liquid metal transfer line as shown in figure 1.

2.5 Complete System Leak Check

The complete system must be leak checked using a helium sensitive mass spectrometer leak detector with a minimum input sensitivity of 1×10^{-6} atmospheric cc/sec.

2.51 Leak Check Procedure

A) Valves LMV-1, HV-1, HV-4, HV-6, VV-2 and VV-4 must be closed.

B) Valves VV-1, VV-3, HV-2, HV-3, HV-5, HV-7, HV-8, HV-9 and HV-10 or HV-11 must be open.

C) Turn the mechanical vacuum pump and G.E. molecular gage "On" and pump the system down to 0.1 mm of Hg.

D) Close valve VV-3, set the helium pressure regulator at the helium supply at 10 psig, and slowly bleed helium into the system by cracking valve HV-6. The gas flow into the system must be controlled so that a net positive pressure at the helium supply is maintained. When the system pressure reaches 10 psig the supply pressure must be slowly increased until the system pressure reaches 30 psig.

E) Leak check the complete system. Each fitting and connection in the system must be thoroughly scanned with the leak detector sampling probe.

NOTE: In order to detect a leak using this leak check method the sampling probe must pass directly above the leak point, consequently greater attention must be given to this method than would be necessary if the system could be evacuated and bathed in helium. Leaks which occur at a tube to "Swagelok" connection must be repaired by replacement of the tubing and ferrules if the leak cannot be stopped by tightening the fitting. Leaks which occur at a brazed or soldered joint may be repaired by resoldering the joint using lead tin solder.

2.6 Experiment Purging Procedure

The experiment must be purged in accordance with the following procedure before it can be filled.

A) Valves LMV-1, VV-4, HV-1, HV-2, HV-4, HV-6 and HV-9 must be closed.

B) Valves VV-1, VV-2, VV-3, HV-3, HV-5, HV-7, HV-8 and HV-10 or HV-11 must be open.

C) Start the mechanical vacuum pump and G.E. molecular gage and pump the system down to 0.02 mm of Hg. Turn the scrubber heater "On" and set the scrubber pyrovane set point at 450F. Set the scrubber heater powerstat at 45 percent and permit the internal scrubber temperature to reach 450F. Turn the dryer blower "On."

D) Turn on the diffusion pump blower, diffusion pump heater, and Philips gage (refer to section 2.12 of this manual for diffusion pump operational precautions).

E) Close valves VV-2, VV-3, and HV-3 and open valve HV-2. Crack valve HV-6 and slowly bring the system pressure up to 10 psig while maintaining a positive inlet helium pressure at the helium supply. Open valve HV-9 and crack valve HV-4. Bleed helium slowly through the bubbler for 30-40 seconds.

F) Close valves HV-2, HV-4, HV-6 and HV-9 and open valve VV-3. Pump the system down to 0.02 mm of Hg. Open valves VV-2 and VV-4 and close valve VV-3. Continue to pump the system down until the pressure at the Philips gage drops below 5×10^{-4} mm of Hg. Close valve VV-4 and read the system equalizing pressure on the Philips gage. Continue to pump the system down until the equalizing pressure does not rise above 5×10^{-3} mm of Hg within two minutes after closing valve VV-4.

G) Close valves VV-2, VV-3 and VV-4 and open valve HV-2. Crack valve HV-6 and slowly bring the system pressure up to 10 psig while maintaining a positive inlet helium pressure at the helium supply.

H) Purge the experiment by repeating steps F and G in sequence until four full cycles have been completed.

I) Turn the diffusion pump heater power "Off" (valves VV-3 and VV-4 must be closed, valves VV-1 and VV-2 must be open, and the mechanical vacuum pump must be operating). Continue operation of the diffusion pump blower until the diffusion pump boiler reaches room temperature. Turn the two vacuum gages and mechanical vacuum pump "Off." Maintain the system under a positive helium blanket pressure of 10 psig.

3.0 Experiment Liquid Metal Filling Procedure

The following procedure must be used to transfer the liquid metal from the loop volume container into the inpile loop.

3.1 Preliminary Preparation

Valves LMV-1, VV-1, VV-2, VV-3, VV-4, HV-2 and HV-4 must be closed. Valves HV-1, HV-3, HV-5, HV-6, HV-7, HV-8, HV-9 and HV-10 or HV-11 must be open. The system helium blanket pressure must be set at 10 psig and the liquid metal flow indicator probe circuit must be turned on and tested by shorting the probe to ground.

3.2 Liquid Metal Transfer

Close valve HV-3, open valve LMV-1. Crack valve HV-4 and slowly bleed helium out of the system through the bubbler. A pressure differential of approximately

8 psi will develop between gages HP-2 and HP-3 and the liquid metal flow indicator probe light will go "On" indicating that liquid metal flow to the experiment has started. The indicated pressure on gage HP-2 must be closely watched during the liquid metal transfer. This pressure will rise to approximately 10 psig when the liquid metal transfer has been completed. The flow indicator probe light will extinguish at this time confirming completion of the transfer. Open valve HV-2, close valves HV-1 and LMV-1, and continue a slow purge through valve HV-4 and the mercury bubbler. Tap the T-1009594 fill tube lightly between the flow indicator and the T-1000241 tube to free any droplets of NaK remaining in the tube from the liquid metal transfer. Close valve HV-4.

4.0 Experiment Liquid Metal and Helium Fill Tube Sealing Procedure

4.1 Equipment

4.11 Welding Process (Manual Tugsten Arc Inert Gas Shielded)

A. P. & H. Model D C 302 or Miller Model SR 300X rectifier welder or an approved equivalent. The operating ranges of these machines are as follows:

Low Range	3 to 80 amps.
Medium Range	12 to 240 amps.
High Range	115 to 405 amps.

The welding machine used must have controls for high frequency, gas flow, and water flow, and must be equipped with a remote rheostat type foot switch control.

B. Linde HW9 gas cooled torch with a No. 4 ceramic cup or approved equivalent.

C. 1/16 inch diameter 2 percent thoriated tungsten electrode.

D. A crimping tool, a pair of bolt cutters, and a 400F Tempelstik, to be furnished by Pratt and Whitney.

4.12 Brazing Process (Manual Oxy-acetelyene Torch Braze)

A. Victor J-28 oxy-acetelyene torch or equivalent.

B. No. 0 and No. 2 tips.

C. Handy and Harmon "Handy Flux" or approved equivalent.

D. AMS 4770, 1/32 inch diameter silver brazing alloy.

4.13 Leak Check Machine

A. Consolidated Electrodynamics, Inc. helium mass spectrometer or equivalent.

Input sensitivity to be 1×10^{-6} atmospheric cc/sec or better (class B

requirement). Reference: CPS 200, revision 7/11/58 entitled, "Procedure for Leak Detection by Mass Spectrometer."

4.2 Welding and Brazing Procedure for Sealing the T-1009594 and T-1009608 Fill Tubes.

The part numbers which are given in the following procedures refer to Pratt and Whitney drawings T-1013200, sheet 1 or T-1013282, sheet 1 unless otherwise designated.

A. Set the fill dolly helium blanket pressure at 10 psig using the helium supply regulator. Valves HV-2, HV-5, HV-6, HV-7, HV-8, HV-9 and HV-10 or HV-11 should be open and all other valves in the system should be closed. Before proceding, have all of the equipment and tools required to perform operations B, C, and D on hand and ready for use. Crack valve HV-4 and bleed helium through the liquid metal fill tube part T-1009594 to purge it of liquid metal. Close valve HV-4 and maintain the 10 psig helium blanket on the fill rig and experiment.

B. Using the crimping tool, crimp the 1/8 inch diameter fill tube, part number T-1009594, at a point not greater than 1 inch above the end of the fill tube housing tube, part number T-1000421.

C. Again using the crimping tool, crimp and hold the 1/8 inch diameter fill tube, part number T-1009594, at a point 1/2 inch or less above the end of the fill tube housing tube, part number T-1000421. The crimping tool is to be held securely on the liquid metal fill tube during the following cutting and welding operation.

D. Using the bolt cutters, cut the liquid metal fill tube through the center of the top crimp, clean the cut surface with acetone, and weld the stub end using 20 amps and 15 cfh gas flow through the torch. Use high frequency start, increase the current to 20 amps with the rheostat foot switch and decay to 3 amps on completion of the weld. After the weld is completed and the current has been turned off, the welding torch must be held in position for an additional period of 30 seconds. The 15 cfh inert gas flow through the torch will provide the weld area with inert gas coverage to prevent oxidation. Continue to hold the crimping tool securely in place on the liquid metal fill tube until all of the preliminary leak check preparations have been completed in step F of this section. Open valve HV-3 and close valve HV-2 to maintain the helium blanket pressure on the experiment.

E. Measure the position of the liquid metal fill tube stub to insure that it is not more than 1 inch above the end of the fill tube housing part number T-1000421.

F. Pressurize the experiment with helium through the 3/16 inch diameter helium fill tube, part number T-1009608, to 81 psig on pressure gage HP-3 by raising the helium supply pressure at the helium bottle pressure regulator. Leak check and dye check the liquid metal fill tube stub weld using the following procedures:

1 Position the leak dectector probe directly above the liquid metal fill tube stub weld.

2 Release the pressure exerted by the crimping tool on the lower crimp but hold the tool in the crimping position.

3 Leak check the stub weld (refer to section 4.13). If a leak is detected recrimp the tube, wire brush and clean the stub weld, and reweld the stub (refer to operation D of section 4.2). If the stub weld or repaired stub weld does not leak proceed to sequence 4.

4 Heat the weld, and area $\frac{1}{4}$ to $\frac{1}{2}$ inch below it, to a temperature of 400F using a torch. This temperature is to be determined with the use of a 400F "Templestick" supplied by Pratt and Whitney. Thoroughly leak check the stub weld while it is at this temperature (if a leak is detected refer to sequence 3 of this section for stub weld repair).

5 Dye check the liquid metal fill tube stub weld using the dye check kit provided by Pratt and Whitney for this purpose. Weld faults indicated by the dye check should be filed out. The crimping tool must be held securely on the lower crimp during any reworking of the stub weld and a complete leak check should be made following any reworking of this weld in accordance with the procedure outlined in the preceding sequences.

G. Maintain the internal helium pressure of the experiment at 81 psig and repeat steps B through E of section 4.2 on the 3/16 inch O.D. helium fill tube, part number T-1009608. Leak check and dye check the helium fill tube stub weld following the procedure outlined for the liquid metal fill tube leak check and dye check in operation F of section 4.2, sequence 1 through 5.

Note: The experiment will have been prescurized to 81 psig prior to cutting and welding this tube.

Close valve HV-3 as soon after welding the T-1009608 tube as possible. Reset the fill dolly regulated helium pressure at 10 psig.

H. Prepare the T-1000464 cap and T-1000421 tube for brazing by removing all foreign material with acetone (reference drawing T-1013282 section F-F).

I. Fabricate an AMS 4770 1/32 inch O.D. brazing alloy ring to fit the shoulder on the T-1000464 cap (reference drawing T-1013282 section F-F). Thoroughly clean the formed braze ring with acetone.

J. Place the braze ring on the shoulder of the T-1000464 cap, and apply Handy and Harmon "Handy Flux" to the braze area of the T-1000464 cap, T-1000421 tube, and entire braze ring. The mating surfaces to be brazed must be thoroughly fluxed. Assemble the T-1000464 cap and brazing ring on the T-1000421 tube and flux the exterior surfaces for a distance of 1/2 inch on each side of the braze joint.

K. Prepare and regulate the brazing equipment. Use a No. "0" tip which will permit rapid and even heating. Light the torch and adjust it for a soft, slightly reducing flame. Start heating the T-1000421 tube and T-1000464 cap assembly for a distance of about 1/2 inch to 1 inch from the joint. Heat the assembly evenly in order to obtain a uniform expansion and to distribute the heat uniformly to the inner surfaces. Sweep the flame

steadily back and forth while going around the tube. Avoid overheating in local areas. The object of the heating operation is to bring both the cap and tube to a uniform temperature of 1270F, the temperature at which the braze ring will melt and flow freely. After the braze ring has melted, it may be necessary to apply a little pressure to the top of the cap in order to close the gap left by the melting braze ring. Cool the brazed cap and tube assembly slowly by occasionally fanning it with the torch until it has cooled to a "black heat", i.e. all color has disappeared. After the parts have reached "black heat", wet a swab with water and apply it to the joint in order to crack and remove the braze flux. Remove all flux from the outside of the assembly.

L. Connect the 1/4 inch diameter buffer region helium fill tube (part number T-1013491) to the 1/4 diameter "Swagelok", fitting located on the top of the fill rig vacuum header. Using a 1/4 inch tube bender, bend the helium fill tube through 90° in the direction of the vacuum header at a point 6 inches above the inlet air tube "Swagelok" fitting, (part number T-1000435.) Make a second 90° bend in the T-1013491 tube to position the free end of this tube adjacent to the 1/4 diameter vacuum header "Swagelok" fitting. Using a tube cutter, cut the T-1013491 tube to fit the vacuum header "Swagelok." Before making the cut polish the surface of the tube, which will be positioned inside of the "Swagelok", with fine emery cloth in a direction perpendicular to the axis of the tube to remove axial surface scratches. Position the T-1013491 tube in the vacuum header "Swagelok" and tighten the "Swagelok" nut. Remove the T1009608 tube stub from the 3/16 "Swagelok" fitting on the bottom side of the vacuum header. Cap the fitting with a "Swagelok" plug. Pressurize the helium buffer region of the experiment using the following procedure:

1. Valves HV-1, HV-2, 1MV-1, HV-4, HV-6, HV-9 and VV-4 must be closed.

2. Valves VV-1, VV-2, VV-3, HV-3, HV-5, HV-7, HV-8, and HV-10 or HV-11 must be open.

3. Start the vacuum pump and G.E. Molecular Gage and pump the system down to 0.02 mm of Hg.

4. Close valve VV-3, crack valve HV-6, and slowly bring the system pressure up to 10 psig while maintaining a positive inlet helium pressure at the helium supply.

5. Raise the system pressure to 50 psig by adjusting the set point of the helium supply pressure regulator on the fill dolly.

M. Thoroughly leak check the braze of the T-1000464 cap performed in operation J of section 4.2 in accordance with instructions presented in section 2.5, step E. Repair the braze joint if necessary.

N. Prepare the T-1013709 cap and T-1000422 tube for brazing by removing all foreign material with acetone, (drawing T1013282, section F-F). The parts must be cleaned thoroughly.

O. Fabricate a braze ring to fit the shoulder of the T-1013709 cap using

AMS 4770 1/32 inch diameter braze alloy wire. Thoroughly clean the braze ring with acetone. Position the braze ring on the shoulder of the T-1013709 cap and apply Handy and Harmon "Handy Flux" to the shoulder of the T-1013709 cap, braze ring, and shoulder on the T-1000422 tube. The mating surfaces to be brazed must be thoroughly fluxed. Assemble the T-1013709 cap and braze ring on the T-1000422 tube and flux the exterior surfaces for a distance of 1/2 inch on each side of the braze joint.

P. Prepare and regulate the brazing equipment. Use a No. 2 tip which will permit rapid and even heating. Light the torch and adjust it for a soft slightly reducing flame. Start heating the tube and cap assembly for a distance of about 1/2 inch to 1 inch on either side of the braze joint. Heat the assembly evenly to obtain uniform expansion and even distribution of heat. Sweep the flame steadily back and forth while going around the tube. Avoid overheating local areas. The object of the heating operation is to bring both the cap and tube to a uniform temperature of 1270F, the temperature at which the braze ring will melt and flow freely. After the braze ring has melted it may be necessary to apply a little pressure to the top of the cap in order to close the gap left by the melting braze ring. Cool the brazed cap and tube assembly slowly by occasionally fanning it with the torch until it has cooled to "black heat", i.e. all color has disappeared. After the parts have reached "black heat", wet a swab with water and apply it to the joint in order to crack and remove the braze flux. Remove all flux from the outside of the assembly.

Q. Cap the exit air tube part number T-1014054 with the modified "Swagelok" exit air tube cap (part number T-1010769). Connect the inlet air tube reducer (part number T-1010775) to the end of the inlet air tube (part number T-1013853). Refer to drawing TLJ-100293, sheet 6. Obtain a helium bottle equipped with a pressure regulator which will regulate up to 50 psig and position the bottle near the base of the experiment preparation stand. Connect 1/4 inch diameter copper tubing (or a suitable substitute such as 1/4 inch diameter dacron tubing) between the helium supply and the T-1010775 inlet air tube reducer. A tee fitting connected to a valve must be inserted in this interconnecting tube to provide a method of bleeding pressurized helium from the experiment air system. Pressurize the experiment air system to 50 psig. Lower the helium bottle pressure regulator setting to 0 psig. Bleed the helium out of the experiment air system using the valve provided for this purpose. Close the bleed valve and again pressurize the experiment air system to 50 psig with helium.

R. Thoroughly leak check the T1013709 cap and T1000422 tube braze performed in operation P of section 4.2 in accordance with the instructions presented in section 2.5, step E. Repair the braze joint if necessary.

4.3 Welding Procedure for Sealing the T-1013491 Fill Tube

The part numbers given in the following procedure refer to Pratt and Whitney drawing number T-1013200, sheet 1 or T-1013282, sheet 1 unless otherwise designated.

A. Purge the helium buffer region of the experiment using the following procedure:

1. Valves HV-1, HV-2, LMV-1, HV-3, HV-4, HV-9 and VV-4 must be closed.

2. Valves VV-1, VV-2, VV-3, HV-5, HV-6, HV-7, HV-8 and HV-10 or HV-11 must be open.

3. Start the vacuum pump and G.E. Molecular Gage and pump the system down to 0.02 mm of Hg.

4. Turn on the diffusion pump blower, diffusion pump heater, and Philips gage. Note: Refer to section 2.12 of this manual for diffusion pump operational precautions.

5. Close valves VV-2 and VV-3, crack valve HV-3, and slowly bring the system pressure up to 10 psig while maintaining a positive inlet helium pressure at the helium supply.

6. Close valve HV-3 and open valve VV-3. Pump the system down to 0.02 mm of Hg. Open valves VV-2 and VV-4, close valve VV-3, and continue to pump the system down until the Philips gage reads below 5×10^{-4} mm of Hg. Close valve VV-4 and read the system equalizing pressure on the Philips gage. Continue to pump the system down until the equalizing pressure does not exceed 5×10^{-3} mm of Hg within two minutes after closing valve VV-4.

7. Purge the helium buffer region of the experiment by repeating sequences 5 and 6 until four purge cycles have been completed. Repeat sequence 5 and raise the buffer region helium pressure to 36 psig on gage HP-3 by raising the helium supply pressure regulator set point. Before proceeding, have all the tools and equipment necessary to perform operations B through D of section 4.3 on hand and ready for use.

B. Using the crimping tool, crimp the T-1013491 1/4 inch diameter helium fill tube at a point 2 inches above the end of the T-1000242 support.

C. Crimp and hold the T-1013491 1/4 inch diameter helium fill tube at a point 1/2 inch below the crimp made in the previous operation. The crimping tool must be held securely on the second crimp during the following cutting and welding operation and until preparations are completed to leak check the weld. Close valve HV-3 as soon after cutting the T-1013491 tube as possible.

D. Using the bolt cutters cut the top crimp in the center and thoroughly clean the helium fill tube stub with acetone. Weld the helium fill tube stub using 20 amps and 15 cfh gas flow through the torch. Use high frequency start, increase to 20 amps with the rheostat foot switch and decay to 3 amps on completion of the weld. After the weld has been completed and the current has been turned off hold the torch on the weld area for a minimum period of 30 seconds. The 15 cfh gas flow through the torch will provide the weld with inert gas coverage which will prevent oxidation.

E. Leak check the helium fill tube stub weld using the following procedure:

1. Position the leak detector probe directly above the helium fill tube stub weld.

2. Release the pressure exerted by the crimping tool on the lower crimp but continue to hold the tool in the crimping position.

3. Leak check the stub weld (refer to section 4.13). If a leak is detected recrimp the tube, wire brush and clean the stub weld, and reweld the stub (refer to operation D of section 4.3). If the stub weld or repaired stub weld does not leak proceed to sequence 4.

4. Heat the weld and area 1/4 to 1/2 inch below it to a temperature of 400F using a torch. This temperature is to be determined with the use of a 400F "Templestik" supplied by Pratt and Whitney. Thoroughly leak check the stub weld while it is at this temperature. (If a leak is detected refer to sequence 3 of this section for stub weld repair).

5. Dye check the helium fill tube stub weld using the dye check kit provided by Pratt and Whitney for this purpose. Weld faults indicated by the dye check should be filed out. The crimping tool must be held securely on the lower crimp during any reworking procedure on the stub weld and a complete leak check should be made following any reworking of the weld in accordance with the procedures outlined in the preceding sequences.

F. Bend the helium fill tube stub down and around the exit air line part number T-1014054 positioning the stub so that no portion of the helium fill tube protrudes above the top of the T-1000424 support.

5.0 Fill Dolly Reassembly

5.1 Preliminary Preparation

A. Turn the scrubber heater power and dryer blower "Off."

B. Crack valve HV-3 and lower the system helium blanket pressure to 10 psig at the helium supply pressure regulator. Close valve HV-3.

C. Close all valves in the system.

D. Disconnect the dump line connection at valve LMV-1 and replace the dump line with a 1/4 inch "Swagelok" plug. Disconnect the loop volume container gas blanket line at valve HV-1 and replace this line with a "Swagelok" plug. Disconnect and replace the 1/4 inch stainless steel tubing and "Swagelok" tee between valves HV-2 and LMV-1. NOTE: No connection is made at valve LMV-1. Replace the flow indicator and liquid metal transfer line between the indicator and the "Swagelok" tee previously referred to. The tubing and flow indicator removed in this sequence may contain traces of liquid metal. A steel container (such as a bread pan) should be placed under the "Swagelok" connections of these items as they are removed. A 1/2 inch layer of Met-L-X must be spread across the bottom of the container and a 50 pound can of Met-L-X must be open and available as a safety precaution in the event of a liquid metal fire. As each "Swagelok" connection is broken, the exposed surfaces must be sealed with "Swagelok" caps or plugs. The required "Swagelok" fittings, flow indicator, and preformed tubing required in this sequence will be supplied by Pratt and Whitney.

E. Disconnect the 1/4 inch copper tubing between valve HV-5 and the LX-3 vapor trap. Disconnect the 0.500 inch I.D. Neoprene Vacuum hose between the mechanical pump vacuum header and the fill rig vacuum header discharge (points A and B fig 1). This hose must be coiled and stored for future use.

F. Disconnect the Philips gage sensing head cable from the Philips gage and tape the cable to the vacuum header. Disconnect the Philips gage power cable and transfer the gage to the floor.

G. Disconnect the 1/4 inch stainless steel helium supply tube from the fill rig vacuum header at the "Swagelok" fitting on the header. Disconnect the vacuum header from the vacuum manifold at the flange joint and cover both exposed flange surfaces with protective covers. Store the vacuum header for future use. Note: The vacuum header must be handled with extreme care to avoid injury to the Philips gage sensing head.

H. Disconnect the three fill rig power cables from the fill dolly, and coil and attach them to the front face of the fill rig.

5.2 Reassembly Procedure

A. Attach the fill rig lifting harness to the lifting lugs on the fill rig. Using a crane or hoist, take up the slack in the lifting harness. Remove the bolts which hold the fill rig support stand (drawing CD-101027) to the plywood decking of the experiment preparation stand (drawing CLR 10129-9). Hoist the fill rig and fill rig support stand clear of the experiment preparation stand. Lower the fill rig and support stand to the floor but continue to support the weight of the fill rig with the crane. Remove the two corner connecting angles (item 13 drawing CD-101027) which were relocated on the fill rig in step I of section 3.21 of this manual. Lift the support stand free of the fill rig and replace the corner connecting angles on the support stand. Store the support stand for future use.

B. Relocate the fill rig in the fill dolly (refer to drawing CLR-10126-1).

C. Remove the loop volume container from the fill rig and re-weigh it to an accuracy of 0.15 pounds. Note: The loop volume container must be equipped with the same hardware at this weighing as it was when originally weighed in section 2.15 of this manual. Subtract the empty weight from the full weight and verify that a complete transfer of the liquid metal has been made. Bolt the loop volume container into the special shipping container provided by Pratt and Whitney and place the contaminated flow indicator and tubing, removed from the fill rig in step D of section 5.1 of this manual, in the shipping container with the loop volume container. Note: The tubing must be bent in order to fit it into the shipping container. Replace the vermiculite packing around the loop volume container and nail the shipping container cover in place. The shipping container must be labeled in accordance with ICC regulations and a steel strap must be affixed around the container to prevent the top and/or bottom covers from working loose during shipping.

D. Relocate the Philips gage on the shelf provided for it on the fill rig (now located on the fill dolly).

Appendix A

Pratt and Whitney CANEL Health and Safety Procedures and Bulletins

Title	Reference No.
"Alkali (Liquid) Metal Test Rigs and Experiments	C5.05
"Immediate First Aid For Alkali (Liquid) Metal Burns"	E.02

PRATT & WHITNEY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION
CANEL HEALTH & SAFETY–PROCEDURE

SUBJECT: ALKALI (LIQUID) METAL TEST RIGS AND EXPERIMENTS	TOPIC SAFETY

I. GENERAL

A. This instruction outlines the policy to be observed and the procedures to be followed for the protection of personnel as well as the plant and community property relative to the use of alkali metals in the liquid state.

B. For information concerning first aid for injured employees, see the Health and Safety Bulletin E.02, "Immediate First Aid for Alkali (Liquid) Metal Burns". For general background information on liquid metals see: "Liquid Metals Handbook, NAVEXOS P-733 (Rev.), June 1952, and "Liquid Metals Handbook - Sodium-NaK, Supplement", TID 5277, July 1, 1955.

C. This procedure voids all previous memos written at CANEL on the subject of liquid metal safety.

D. The wide variety of test, development and experimental work carried out with liquid metals at CANEL makes it highly impractical to cover all situations with detailed specifications and methods. This procedure cannot and must not be used as a substitute for judgment at the planning, design and operation stages.

E. This instruction covers two categories of the aspects of liquid metal work at CANEL.

1. Requirements for all alkali (liquid) metal work. These are the aspects which past experience has shown to be necessary and standard for all liquid metal work.

2. Factors which must be given prime consideration. These are the aspects where past experience has shown that standardization is impractical, yet prime consideration must be given for all liquid metal work.

F. The responsibilities of the following are outlined:

1. Test Engineering
2. Plant Engineering
3. Design Engineering
4. Experimental Operations
5. Health and Safety

II. POLICY

A. Work with alkali (liquid) metals shall be planned, designed and carried out in a manner which minimizes the injury potential to employees and the risk of property damage and shall be consistent with good judgment, practicality, and the value of the results to be obtained.

B. Personnel protective clothing and equipment shall be made available to employees, but it shall not be considered as a substitute for employee education and training, good judgment, safe working conditions, safe design of equipment and intelligent employee conduct.

III. PROCEDURES

A. REQUIREMENTS FOR ALL ALKALI (LIQUID) METAL WORK

To minimize the injury potential to employees, the following procedures or rules shall apply to all test rigs, laboratory tests or small engineering development tests, etc. which involve alkali (liquid) metals.

1. A fireproof structure (may be portable or fixed) designed to adequately enclose the work must be provided for all liquid metal which is to be subjected to pressure. The probability of spraying or splashing of liquid metal on personnel, combustible building materials or other rigs and equipment must be kept to a minimum. An effort must be made to anticipate all possibilities in order to design for minimum probability of such spraying or splashing. Many rigs with only one pound will require fireproof structure for enclosures. For example, most all apparatus containing one pound or more of lithium under pressure should be given careful consideration for enclosures with fireproof structures. However, all apparatus containing five pounds or more under pressure must be enclosed by a fireproof structure adequate to prevent spraying or splashing of liquid metal on personnel, combustible building materials, etc.

2. All areas occupied by personnel and all passageways which may be used by pedestrians or vehicles shall be adequately protected by fixed or portable fireproof shields to eliminate any reasonable probability of spraying or splashing of liquid metal on personnel, combustible materials or other rigs and equipment.

3. Where rigs or experiments are enclosed by a structure, the controls shall be located outside the enclosure except for those where such engineering designs cannot be accomplished. Where portable shields are used, the controls shall be located in such a manner that the operator is shielded from possible liquid metal spraying or splashing.

4. Where rigs or experiments are not enclosed by a structure, the rig or experimental area shall have a positive identification such as a chain guard or equivalent. When operations are in progress, the chain guard (or equivalent) shall be in place. All liquid metal work in progress shall be identified by a sign which reads "CAUTION - LIQUID METAL TEST IN OPERATION".

5. Where possible, metal drip pans or pan capable of holding the entire liquid metal contents of the rig or apparatus shall be placed below the rig or apparatus in such a manner that a failure of the system will result in the liquid metal being contained in the pan (s). They must prevent the possibility of liquid metal reaching a concrete floor. For larger rigs (above 100 lb. inventory) other methods, such as sloped steel-covered floors and sump pits, will have to be used instead of pans.

6. Where a dump valve is employed on a rig or other apparatus, it shall be of an automatic fail-safe design with override operation available from the control panel.

7. Oil and water systems shall be isolated from liquid metal systems, where possible.

8. At all times during the operation of a test rig or experiment, a qualified operator must be available and, if possible, in the immediate area.

9. When, for any reason, a rig or other apparatus containing liquid metal at elevated temperatures and/or pressure requires inspection, repair, or adjustment by an employee inside the enclosure or beyond the protective shields, the individual or individuals (e.g., the decision may involve both the test engineer and the test foreman and/or laboratory supervisor) responsible for the operation of the test must decide whether the operation be stopped before the work is performed. The decision must weigh the degree of risk involved to the employees against the practicality, economy, timing and effects of the shutdown. If entry without shutdown is decided upon, the following conditions must be met:

a. The individual (s) responsible for the operation must approve the entry. Such entries and the time of stay are to be kept to the very minimum necessary to perform only those jobs where the risk is compatible with the necessity and value of the work.

b. The pressure on the system shall be reduced to the lowest practical pressure.

c. The employee entering and an emergency observer must wear the following protective clothing:

Eye Protection - Chippers goggles (H&S Identification No. 1.03.00) for full eye protection (or equivalent approved by Health and Safety).

Head and Face Protection - Face shield (H&S Identification No. 4.01.15) provides full face, head and neck protection.

Body Protection - Loose fitting coveralls of flame and chemical resistant material (H&S Identification No. 4.01.00) and chrome leather coat (H&S Identification No. 4.01.18 or No. 4.01.19 for medium and large respectively).

Hand and Forearm - Chrome leather glove with long gauntlet (H&S Identification No. 4.01.20). Long asbestos gloves (H&S Identification No. 4.01.22) may be worn over the leather gloves.

Foot Protection - Heavy leather safety shoes and leather shoe laces (H&S Identification No. 4.02.01) with chrome leather leggings (H&S Identification No. 4.01.21).

NOTE: Protective clothing will not give complete protection against prolonged exposure to the high temperature liquid metals. It is intended solely to give the person involved sufficient time to get out of contact with the metal without incurring major injuries. The only purpose of the emergency observer is to remove or guide the worker to safety in the event of an accident.

10. Work with rigs or apparatus containing alkali (liquid) metal not under pressure or only blanket pressure requires the following protective clothing:

Eye Protection - The minimum requirement is the regular type of safety glasses. More complete protection may be specified for specific work.

Head and Face Protection - No minimum requirement. Specific protection may be required for specific work.

Body Protection - Flame-resistant coveralls or lab coats, loose fitting (H&S identification Nos. 4.01.00 and 4.01.07). Coveralls are preferred and should be the normal attire rather than lab coats.

Hand and Arm Protection - When working with tools or equipment, wear gloves to prevent injury from slippage or breakage (H&S identification No. 2.01.03, 2.01.04 by size or 2.01.07). Chrome leather gloves with long gauntlets must be worn when handling equipment containing alkali (liquid) metal (H&S Identification No. 4.01.20). Exceptions will be considered by Health and Safety for laboratory use involving very small quantities.

Foot Protection - No minimum requirement. However, Health and Safety may require heavy leather safety shoes and leather shoe laces (H&S Identification No. 4.03.01) if work for the individual is frequent or of long duration or if deemed necessary because of the aspects of the specific work performed.

NOTE: Liquid metal emergency boards are outfitted with emergency protective clothing.

11. Safety inspections must be made prior to the initial filling and operation of any rig, test or experiment. The test engineer (or equivalent) must notify Health and Safety when the apparatus is to be ready for inspection. Where high pressures are involved or the presence of water, the inspection will be performed by a group with representatives from Health and Safety, Test Engineering, Plant Engineering and Experimental Operations.

12. The test area foreman or supervisor responsible for an area shall be notified before any work is performed (on rigs or other apparatus which contain alkali metal or a residue thereof) by service groups or others not under his supervision (i.e., electricians, pipe fitters, welders, etc.). He will then tag the rig or apparatus with a "CAUTION - ALKALI METAL" tag, H&S-8 (Figure 1, 8 1/2" x 11", yellow background with red letters) describing the contents and present state of the apparatus. Tags must be posted in a location where they may be read safely.

    Examples of descriptions:

    "This rig has been drained but contains residual NaK in a liquid state", or

    "This rig has been cleaned and is free of all alkali metal", or

    "This rig contains liquid sodium at high temperature and under pressure".

    Before other groups or individuals work on any rig or apparatus which contains alkali metal or the residue thereof, they shall require that a "CAUTION - ALKALI METAL" tag be attached to the apparatus, stating the contents and the state of the apparatus at the time they are to perform the work thereon. It shall be the test foreman's or the supervisor's responsibility to be certain that other groups who work on the rigs understand what is written on the tags.

    It is also the responsibility of the test foreman or supervisor to see that all work on the apparatus containing alkali (liquid) metal is performed safely. For example, the application of pressure to a rig by a welder must be approved by that test foreman or supervisor.

13. All filling disconnections and connections necessary for filling operations for liquid metal metal apparatus shall be performed by the Liquid Metal Transfer Group or Experimental Operations.

14. Electrical conduits or lines which are vital to the operation of the rig must be shielded to prevent their contact with liquid metal in the event of a failure in the rig or apparatus.

15. All possible sources of water should be considered. Where such sources are possible, efforts such as calking of the lower edges of partitions, raised sills, shields, etc. should be employed.

16. All employees working with alkali metals must know the hazards involved, emergency procedures, and how to use respiratory protection, fire fighting and first aid materials.

B. FACTORS WHICH MUST BE GIVEN PRIME CONSIDERATION

During the planning and design of rigs or other apparatus containing alkali metals and at the time of inspection prior to operation, the following factors must be considered:

1. Emergency ventilation - The smoke from a fire can seriously hamper fire fighting and/or rescue activities and is corrosive. The presence of expensive and delicate instruments or equipment in areas where the smoke from a fire could cause damage is undesirable. (Example: Chemistry laboratories where a microbalance is used.)

2. Control panels - If it is possible for the control panels to be splashed with liquid metal or damaged by the oxide smoke, some means of protection should be employed.

3. Water piping - Water piping in liquid metal test areas should be used only where no other alternative can be arranged. Such water piping, if permitted, shall be of welded construction and protected from mechanical damage. Consideration shall be given to the need for a device to prevent water from splashing in the event of a leak. Sheet metal ducts encasing the water pipes and drained to a safe location may be a solution. The location of the water cutoff for emergencies should be considered. Emergency cutoff valves should be considered for power failures.

4. Emergency dump valve - Consideration should be given to the installation of a second emergency dump valve for those rigs requiring dump valves and which contain over 25 pounds of liquid metal. The second valve, if decided upon, shall be a manually operated valve with a positive mechanical drive arranged so that the valve can be opened from the control panel.

5. Location of the apparatus - Since the oxide dust from alkali metal fires is caustic, consideration should be given to expensive and delicate instruments or equipment which might be damaged in the event of a fire.

6. Emergencies - An emergency board as described by drawing CLD-10109 should be within quick access to all major alkali metal areas. Where small alkali metal operations are carried out, make certain that proper and adequate respiratory protection and fire-fighting and first aid materials are available for immediate use.

IV. RESPONSIBILITIES

A. Test Engineering

The test engineer (including those of equal status but with different job titles) shall be responsible for:

1. Including in the planning of all alkali metal work all the requirements and factors of prime consideration outlined in this procedure as well as other factors which may become obvious in order to conform to the policy as stated.

2. Advising Health and Safety of major plans which may necessitate a deviation from this procedure or which may require additional types or quantities of protective clothing. (Briefing Health and Safety during the design stage may save delays at the time of inspection.)

3. Notifying Health and Safety when the apparatus is to be ready for inspection and prior to filling, giving as much lead time as possible.

4. Deciding when it is desirable to have work done on an operating apparatus under pressure and/or at high temperatures.

5. (Where the actual work is being performed by the test engineer, chemist, etc. and not by Experimental Operations) tagging the apparatus with a "CAUTION - ALKALI METAL" tag prior to any work being performed by any individual not under his supervision, and removing the tag when it is no longer applicable.

B. Plant Engineering and Design Engineering

Plant Engineering and Design Engineering shall be responsible for:

1. Including in the design of the rigs and their stands for alkali metal work all the requirements and factors of prime consideration outlined in this procedure as well as other factors, such as the choice of rig location within a building, which may become obvious in order to conform to the policy as stated.

C. Experimental Operations

Where the actual test is carried out by Experimental Operations, the test area foreman shall be responsible for:

1. Seeing that all operations are carried out safely and in accordance with this procedure.

2. Deciding whether work requested on an operating apparatus under pressure and/or at high temperature may be safely carried out.

3. Tagging the apparatus with a "CAUTION - ALKALI METAL" tag prior to any work being performed by any individual not under his supervision and removing the tag when it is no longer applicable.

4. Seeing that each liquid metal test being conducted by Experimental Operations is identified as "CAUTION - LIQUID METAL TEST IN OPERATION" when the test is in progress.

5. Filling all liquid metal apparatus and making all filling connections and filling disconnections to such apparatus. (Liquid Metal Transfer Group)

6. Seeing that all work on apparatus containing alkali metals and under the supervision of Experimental Operations is planned and carried out safely. This includes work performed on or in the immediate vicinity of such apparatus by other groups or individuals such as electricians, welders, pipe fitters, etc.

D. Health and Safety

The safety engineer or industrial hygienist assigned to the area involved shall:

1. Inspect all test or experimental apparatus prior to their operation with alkali metal and prepare an inspection report for Test Supervision, Test Engineering and Plant Engineering.

2. Arrange for a group inspection when the size, pressure and temperature of the test so indicates.

3. Supply the "CAUTION - ALKALI METAL" tags upon request.

Figure 1

CAUTION

ALKALI METAL

BEFORE WORKING ON THIS APPARATUS, READ THE FOLLOWING DESCRIPTION OF THE CONTENTS.

Continue on back if needed

Contents described by _____ _____
Signature Date

H&S-8 (3/58)

PWA CONNECTICUT AIRCRAFT NUCLEAR ENGINE LABORATORY

HEALTH & SAFETY BULLETIN

SUBJECT: IMMEDIATE FIRST AID FOR ALKALI (LIQUID) METAL BURNS

I. GENERAL

Alkali metals - sodium, lithium, potassium and NaK - possess many properties which make them hazardous for certain applications. Yet, experience has shown that proper precautions permit their safe use even at high temperatures and pressures. The use of the terminology "Liquid Metals" has become more commonly used than "Alkali Metals". They are called "Alkali Metals" because they form strong alkalies with water and can be reduced from these alkalies. Only one of the alkali metals listed above, NaK, is a liquid at room temperature. The other metals - sodium, lithium and potassium - are solids at room temperature.

II. ALKALI METAL - SKIN REACTION

Every precaution must be taken to avoid skin and eye contact with alkali metals in any form. Of greatest concern from the personnel protection standpoint is the reaction of alkali metals with the skin and eyes, causing thermal and/or alkali burns. A thermal burn, resulting from the contact of hot metal and skin, is like any other thermal burn and requires only conventional treatment. In the case of alkali burns, however, treatment is much more difficult, since the hydroxide penetrates the tissues and must be neutralized or removed before healing can be accomplished. Alkali metal burns are self-cauterizing and are rarely accompanied by bleeding.[1]

III. ALKALI METAL - THROAT AND LUNGS REACTION

The possibility of a reaction between alkali metals and the throat and lungs is generally limited to contact of oxide smoke from a fire or caustic mist from an alkali metal-water reaction. Contact of sodium oxide smoke or hydroxide mist with the throat and lungs is very irritating and generally cannot be tolerated due to the stinging and coughing caused by the smoke. There is no recognized local or systemic form of acute or chronic toxicity resulting from sodium or sodium oxide smoke. Any injury to the throat or lungs resulting from contact with sodium or sodium oxide would be due to thermal or alkali burns and not to any toxicity of the fumes, metals, or smoke.[1]

IV. ALKALI METAL - WATER REACTION

Sodium and NaK react violently with water, generating hydrogen and sufficient heat to ignite the hydrogen in the presence of air. Since the heat and hydrogen generated by the reaction often result in explosions, areas in which sodium or NaK is handled should be as free as practicable of sprinkler systems, water pipes, and steam lines.

In the absence of air, the reaction between sodium and water results in a rapid generation of hydrogen which must be vented to prevent a build up of excessive pressures. Wherever such a possibility exists, as in a steam generator, provisions must be made to isolate the bulk of the sodium and/or water and vent the hydrogen produced by the reaction.[1]

V. ACCIDENTS RESULTING IN INJURIES TO PERSONNEL - IMMEDIATE FIRST AID

A. The first action to be taken in all cases is to flood the affected area with MINERAL OIL. Mineral oil may also be used for the eyes.

B. The next action is to call Health and Safety - Medical Station, Ext. 3172 at CANEL and Ext. 751 at Podunk. (When emergency phones are installed, please use them.)

Give the following information:

1. Nature of the accident.
2. Extent of the injury.
3. Location of the injured person.
4. What has or is being done to the injured person.

If you should happen to be the only person around or cannot attract the attention of another person to notify Health & Safety, then it will be necessary for you to leave the injured person long enough to call Health & Safety.

Ref. 1: "Liquid-Metals Handbook, Sodium-NaK Supplement - TID 5277, July 1, 1955"

DATE ISSUED	SUPERSEDES	DATED	TO BE REVIEWED BEFORE	PAGE	NUMBER
June 14, 1957	Original	Original	June 14, 1958	1 OF 2	E.02

C. Check the front, back and sides of the patient to be sure there are no unnoticed spots where the alkali metal is in contact with the skin or clothing.

D. If alkali metal is on the clothing, the clothing should be removed.

E. If it is suspected that alkali metal is in contact with the skin underneath the clothing, the clothing should be removed.

F. Use the spatula or pointed forceps to remove the metal. DO NOT BRUSH or WIPE away the metal.

G. Keep applying mineral oil and attempting to remove metal until the nurse arrives.

H. If the eyes are affected, mineral oil should be used to flush out the eyes. If necessary, the eye should be forced open by another individual. DO NOT ATTEMPT TO REMOVE METAL FROM EYES. KEEP FLUSHING WITH MINERAL OIL UNTIL MEDICAL PERSONNEL ARRIVE.

I. Shock may accompany any serious injury. All serious injuries should be given first aid for shock in addition to the treatment being given for the specific injury. First Aid treatment for shock consists of keeping the injured person warm, quiet and lying down.

J. Mineral Oil is available in large 55-gallon drums. These drums are painted white and have a gravity flow system. They are needed when there is a majority of the person's body covered with alkali metal. Smaller bottles are available on the emergency boards and at the rig entrance. Spatulas and tweezers are also available at these locations.

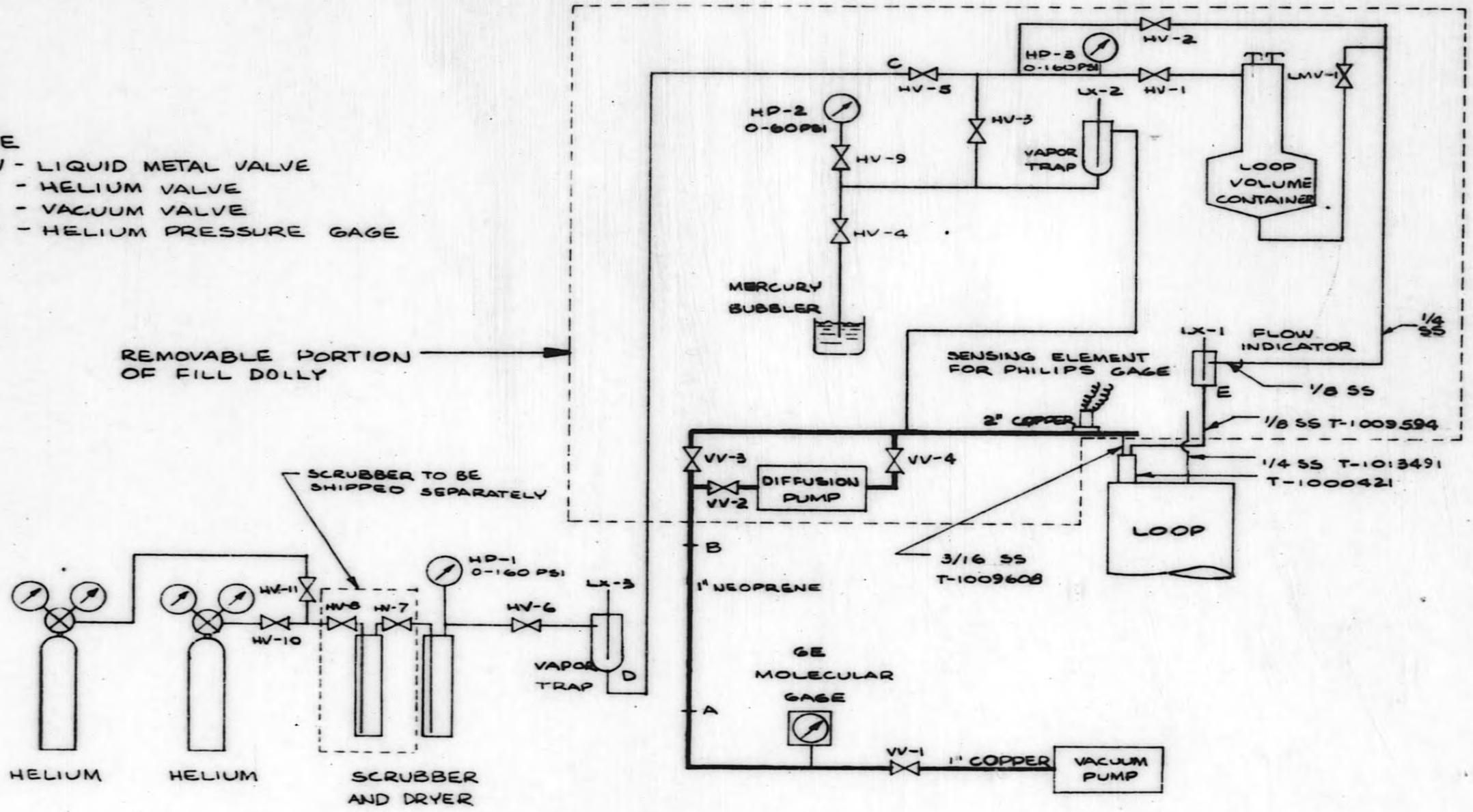
The best first aid you can give a person is to help him remember to be cauticus and to wear his protective clothing. In particular, remind him to wear his safety glasses. Aid him to prevent injuries. Keeping this in mind, the eye you save may be your own.

Appendix B

Figure(s)

Title	No.
"Piping Schematic, ETR Inpile Loop Liquid Metal Fill Rig"	Fig. 1
"Piping Schematic (Showing Preliminary Connections) ETR Inpile Loop Liquid Metal Fill Rig"	Fig. 2

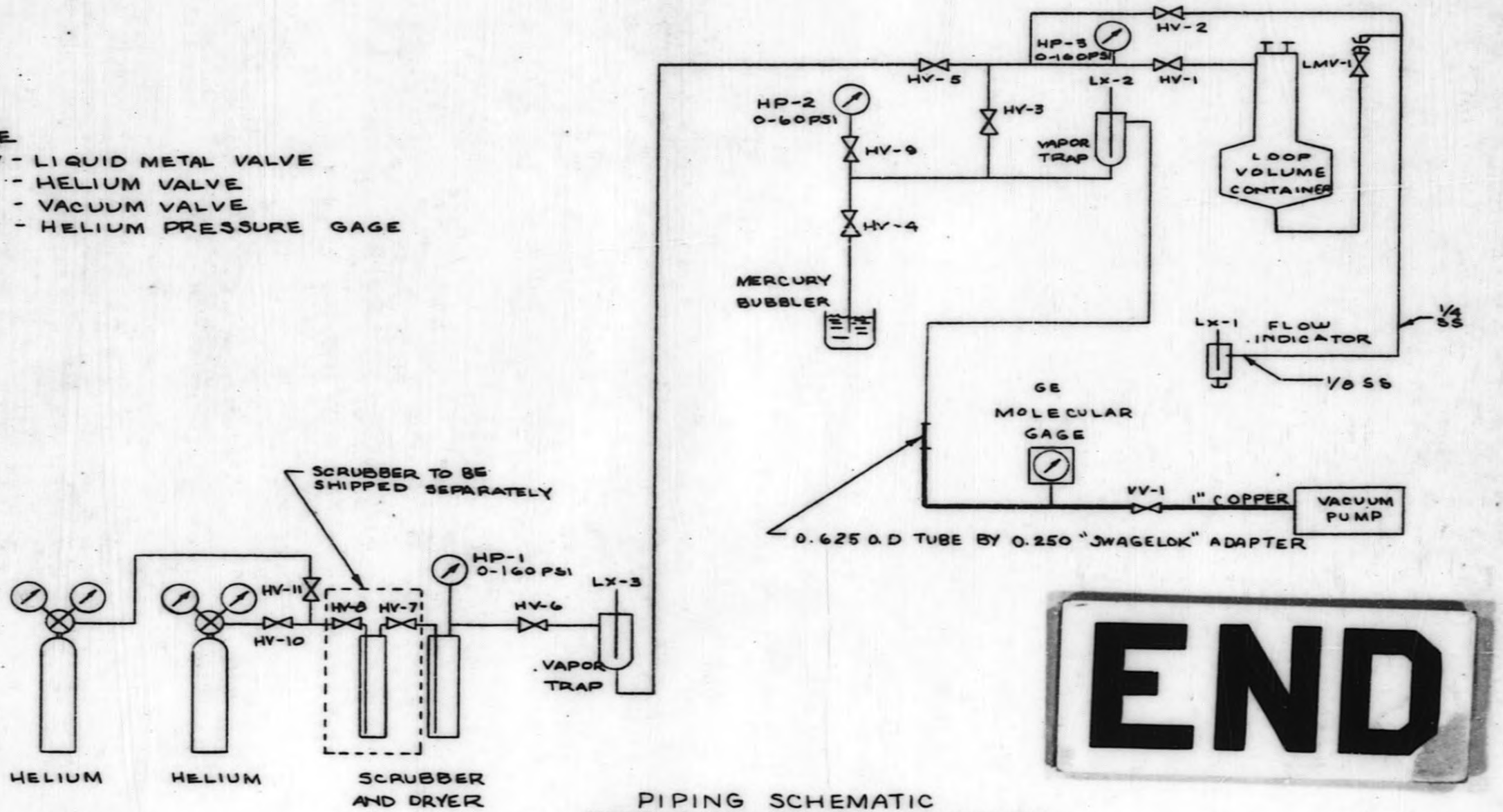
CODE
LMV - LIQUID METAL VALVE
HV - HELIUM VALVE
VV - VACUUM VALVE
HD - HELIUM PRESSURE GAGE



PIPING SCHEMATIC
ETR INPILE LOOP LIQUID METAL FILL DOLLY
CNLM 1192 FIGURE 1.

CODE

LMV - LIQUID METAL VALVE
HV - HELIUM VALVE
VV - VACUUM VALVE
HP - HELIUM PRESSURE GAGE



END

PIPING SCHEMATIC
(SHOWING PRELIMINARY CONNECTIONS)
ETR INPILE LOOP LIQUID METAL FILL RIG
CNLM-1192 FIGURE 2