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SUBJECT: Procedure for Testing Refrigeration System and
Cold Traps--HRT Test VII A

TO: R. Van Winkle

FROM: N. W. Curtis

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To: R. Van Winkle

From: N. W. Curtis

Subject: Procedure for Testing Refrigeration System and Cold Traps
HRT Test VII A

Enclosed is a proposed test procedure covering the refrigeration system and cold traps as requested in the memo from J. W. Hill dated February 29, 1956.

It is felt that sufficient instructions have been included to cover system cleaning, filling, testing, operation and maintenance.

NW Curtis

N. W. Curtis

NWC:be

PROCEDURE FOR TESTING REFRIGERATION SYSTEM AND COLD TRAPS
HRT Test VII A

Purpose

To outline procedures for cleaning, filling, testing and operating the refrigeration system and cold traps.

Introduction

The refrigeration system performs the dual function of supplying refrigerant to the process line freezers and to the cold traps. Two essentially separate systems are used. The primary system with Freon-12 as a coolant consists of a compression-expansion cycle driven by a 15-hp compressor. The secondary system is a circulating Freon-11 system which is in turn cooled by the Freon-12. The F-11 is then circulated through the cold traps and the process line freezers. A warm F-11 supply is provided by means of electric heaters to periodically thaw the cold traps.

Discussion

The primary cooling system consists of a 15-hp single-stage compressor, a water-cooled condenser, and F-12 receiver, drier, oil separator, filter, and a temperature-controlled expansion valve. The F-12 is compressed and cooled and then circulated through the expansion valve and the coils of the F-11 cold storage tank. Operation of the compressor is controlled by the pressure of the compressor suction and discharge lines. Operation of the expansion valve is controlled by the temperature of F-12 leaving the cold storage tank (Fig. 1).

Cold F-11 is circulated at -40°F by a 7-1/2 gpm centrifugal pump through the freezer jackets and the cold traps and back to the cold storage tank. A by-pass stream is circulated through a silica gel drier. Figure 2 is a simplified schematic of the F-11 system.

Hot F-11 (70°F) for defrosting the cold traps is circulated by a 7-1/2 gpm pump through an electrically heated storage tank and through the cold traps. Automatic transfer of the cold traps from the cold F-11 to the hot F-11 will be accomplished every 24 hours.

Care must be taken throughout the filling and testing procedures to keep the refrigeration system in a dry condition. The presence of free water in either the F-11 or F-12 systems could cause corrosive conditions and fouling of heat transfer surfaces. In addition, the water will form ice crystals and circulate with the Freon to stop up strainers and small openings. Silica gel driers have been installed in the F-12 and F-11 hot and cold systems. As soon as they are saturated with moisture the silica gel cartridges should be removed and baked several hours at 350 to 400°F . A sampling procedure will be worked out at a later date to determine their effective life.

Freon-11 at -40°F has a water solubility of 3-5 ppm (Fig. 4) and at 80°F about 90 ppm. An elaborate drying system would be required to maintain moisture concentration of this order. It has been estimated¹ that satisfactory operation of the system will result if the moisture content of the F-11 is maintained below 100 ppm (preferably between 20-60 ppm). In the absence of a suitable test procedure during the startup and initial operating periods, frequent drier cartridge changes will be relied upon for moisture control.

Test Procedure

The F-11 and F-12 systems should be cleaned, leak-tested, and filled in accordance with instructions issued by S. I. Kaplan.²

1. The F-12 compressor should not be operated until the F-11 system has been thoroughly dried. Close all valves at the F-11 supply and return headers. Close valves 752A, 755A, 713A, 761A.
2. Open valves 762A, 763A, 766A, 767A, 754A, 753A, 711A.
3. Check pump lubrication and rotation.
4. Start hot and cold F-11 pumps and allow F-11 to circulate through driers. If cell refrigerant piping is complete, open valves to the cold traps at the supply and return manifolds and allow F-11 to flow through these systems. One cold trap on the core and one on the blanket should be on freeze and the others on thaw. Any moisture trapped in the piping should be removed. It will probably be well to flush piping to the individual freezers in the same manner.
5. Check flow to the driers (L47 and L48).
6. The silica gel driers absorb most of their capacity during the initial period of operation. At the end of four hours stop the pumps, close the drier by-pass valves and replace the drier silica gel cartridges. At the same time remove and clean strainers 711B and 753B.
7. If a sampling procedure has been established, analyze the F-11 for moisture content. It should be less than 100 ppm.
8. With the strainers and driers back in place and the by-pass valves open, start the F-11 hot and cold pumps.
9. Check flow through the driers (L47 and L48).
10. All instrumentation should have been previously checked out as well as compressor lubrication. Open valves 701C, 701A, 710A, 709A, and 705A, and condenser cooling-water valves. Close valve 702A. Partially close pump suction valve 705A.
11. Charge the F-12 oil separator with 34 oz. of refrigeration compressor oil. Also fill the compressor crankcase with oil to the sightglass level.

12. Start the compressor and as soon as pressure in the F-11 cold tank coils reaches normal (PI-P51 approximately 9 psig), open the pump suction valve 705A. Temperature in the F-11 cold tank should stabilize at -40°F and the compressor should shut off. If the instrumentation settings have been properly adjusted the compressor should not cycle excessively.

13. After two hours' running time the F-12 strainer should be removed and cleaned. Before shutting down the compressor check the crankcase oil level and if necessary add oil. Approximately one hour of operation is required to stabilize oil in the crankcase.

14. After 48 hours of running time the drier cartridges in both the F-11 and F-12 systems should be replaced.

15. After the system has reached a stable condition and with two cold traps on the line at no load, record the system temperatures and pressures as shown on the attached data sheet.

Cold Trap Test

The cold traps have been designed³ to cool ten cubic feet per hour of oxygen (measured at standard conditions) plus the entrained liquid from 130°F to -30°F. The traps should be of sufficient capacity to operate for at least 24 hours without defrosting. It should be possible to thaw the traps in three hours and to pre-cool them in another three hours.

A review⁴ of tests conducted by the MIT Practice School indicates that the cold traps should perform satisfactorily during all conditions of operation and it was recommended that no further quantitative tests be conducted. It is felt that these recommendations are valid.

A quantitative test will be made, however, to assure that the cold traps do function. A 24-hr test of the system at about 25% maximum flow can be run in connection with the recombiner tests. Since the length of time to thaw and pre-cool the traps is essentially independent of reactor power level, a determination of these times can be made a part of the same test.

Test Procedure

Test IV A⁵ (Blanket Recombiner) has been specified in detail to test the operation of the recombiner at low flow conditions. The same test can be used to test the cold traps. One 24-hr run should be made with F-11 flowing through the cold trap and with a flow of 2.0 scfm hydrogen and approximately 1.2 scfm oxygen to the recombiner. At the completion of the run the time required to thaw the cold trap and the amount of condensate in the trap should be measured.

1. Check the refrigeration system to assure that all components are functioning properly.

2. Switch the cold traps to manual operation and allow warm F-11 to flow through the trap that is being tested for three hours.

3. Transfer the test trap to freeze position for at least three hours. The F-11 supply and return temperatures should be recorded every 15 minutes. As soon as the trap is pre-cooled and at a stable temperature, the F-11 return temperature should roughly equal the supply temperature.

4. Proceed with the first part of Test IV A (hydrogen flow 2.0 scfm, oxygen flow 1.2 scfm, evaporator pressure 50 psig).

5. At the end of 24 hours shut off the hydrogen, oxygen and evaporator steam.

6. Weigh the condensate tank.

7. Switch the test cold trap to thaw position. Record F-11 supply and return temperatures every 15 minutes for three hours.

8. Weigh the condensate tank to determine the quantity of condensate collected by the cold traps during the duration of the tests.

9. Proceed with Test IV A.

Procedure for Changing Drier Cartridges

1. Open valves 702A, 713A, 761A.

2. Close valves 701A, 701C, 762A, 763A, 766A, 767A.

3. Remove the tops from the drier housings and replace cartridges.

Caution: Freon is toxic and care should be exercised in its handling. Wear safety goggles when opening the system.

4. Restore valves in Steps 2 and 1 in reverse order.

5. Bake old cartridges four hours at 350 to 400°F. Cartridges should be carefully sealed after they are dried. It is suggested that they be sealed in Saran Wrap and then in a can.

Maintenance Procedure

1. Once a month check level in the F-11 hot and cold storage tanks and in the F-12 receiver.

2. Once a month check oil level in compressor crankcase.

3. Every six months check motor lubrication.

4. Once a year replace oil in oil separator.

5. Replace drier cartridges monthly or as indicated by sampling.

6. Clean strainers each time driers are changed.

REFERENCES

1. "Effect of Moisture in the HRT F-11 Circulating Systems for Cold Traps," memorandum from R. C. Robertson to W. R. Gall, Aug. 2, 1955.
2. S. I. Kaplan, "Preparation of HRT Components and Auxiliaries for Initial Startup," Dec. 22, 1955.
3. "HRT Design Request No. 4 - Cold Traps," memorandum from R. B. Briggs and J. W. Hill to W. C. Moore, Apr. 23, 1954.
4. "Testing of the HRT Cold Traps," memorandum from W. D. Burch and B. H. Hamling to R. Van Winkle, Nov. 11, 1955.
5. "HRT Test IV A, Item 35a - Recombiner Condenser," memorandum from H. E. Williamson to R. Van Winkle, Feb. 24, 1956.

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F-11 System

Fig. 1

ORNL-IR-DWG.-13241

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Refrigeration System
Schematic
Fig. 2

ORNL-R-Dwg.-13242

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ORNL-LR-DWG.-
13243

Rate of Drying Freon-12 with Silica Gel

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ORNL-11-1111-1111

Fig. 4

ORNL-LR-Dwg.-13245

Drying Capability of Freon-12 by Silica Gel

Fig. 5

HRT Test VII A
Refrigeration System

1. Two cold traps on "Freeze" at no load
2. Two cold traps on "Thaw" at no load
3. Reactor power = 0

Instrument	No Load Reading	Cold Trap Test-Thaw	Cold Trap Test-Pre-Cool
P51			
P52			
P53			
P54			
L49			
LI-L45			
L-46			
T75K			
T74L			
T74J			
T75L			
T66			
T75J			
Cold Trap 1 Supply			
Cold Trap 1 Return			
Cold Trap 2 Supply			
Cold Trap 2 Return			
No. 3 Supply			
No. 3 Return			
No. 4 Supply			
No. 4 Return			