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A Division of North American Aviation, Inc.

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GROUP	Sodium Components		LEDGER ACCT.	3621
UNIT	Coolant System Equipment		SUB-ACCT.	4910
APPROVED BY: <i>Leppard</i> (SUPERVISOR)		PROGRAM	HNPF	
OTHER		PROJECT	Sodium Components	
			TWR	5279
			DATE	December 29, 1959
			PAGE	1 OF 6

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SUBJECT:

Prototype Freeze Trap Test

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I STATEMENT OF PROBLEM

In previous freeze-trap designs inadequate cooling capacity has been provided to reject the heat picked up from large hot gas volume vented before liquid sodium reached the trap. The large cooling capacity of the HNPF design was incorporated for that reason. The work described covers the performance evaluation of the liquid cooled freeze trap made according to drawing number 7508-495241 with sodium at 350 and 1000°F,

II SUMMARY OF RESULTS AND RECOMMENDATIONS

The sodium freeze-off function is adequate for all the test conditions encountered. In addition, the freeze-off occurs satisfactorily with the larger clearance provided by a test modification (shown on Figure 1) to provide 0.030 eccentricity to the rotating shaft.

Turning the freeze trap handle is successful in opening the unit for gas venting only when the length of frozen sodium along the shaft is about 3 inches. The latter is the case when 350°F sodium is used. For a seal formed with 1000°F sodium, as many as 15 turns of the trap handle gave no measurable gas venting at pressures up to 30 psi.

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The force required to turn the freeze trap handle varied from 10 to 110 pounds. This force appeared to increase with both length and age of the seal.

On the basis of this testing, the need for the float in the unit has not been proved.

Recommended design changes are: hard surfacing of the inboard shaft journal, using an eccentric shaft, adding an outboard bearing at the handle end (outside the packing), the increasing the clearances in the stuffing box region.

III DESCRIPTION OF EQUIPMENT, METHOD USED, DISCUSSION

The freeze trap is shown schematically in Figure 1. In the sketch the float is shown in the closed position. This is the condition when sodium has risen to a height to fill the freeze trap after venting gas in the system. The purpose of the float is to slow down the flow of sodium through the trap after gas venting has been completed thereby helping the cooling section form a seal. The seal is formed in the relatively thin annulus in the cooled section. In normal operation, no sodium is to pass into the vent line out of the freeze trap. The other features of the unit are utilized for system venting operation subsequent to the first. The rotation of the shaft forces the float to an open position by means of the float cam. During this rotation a gas path was expected to be forced open along the length of the shaft to permit the venting of any gas accumulated in the system.

The freeze trap assembly was installed in the HNPf large valve test loop #2 located in Bldg. 6. The operating shaft was installed level to assure optimum operation of the float valve. An expansion tank ahead of the trap was used to measure sodium level at the test location. Sodium flow rate was approximated by measuring the inert gas flow into the sodium supply tank.

Both the piping and bulk sodium were heated to the test temperature. Cooling water was kept flowing in the cooling jacket at all times. With all valves open, the sodium supply tank was rapidly

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pressurized to obtain a flow rate of about 7.5 cfm. Gas addition was stopped when the sodium level in the expansion tank was above the elevation of the freeze trap. Liquid sodium was maintained at the trap for five minutes. Gas under pressure was then introduced through the expansion tank to check the tightness of the freeze seal thus formed.

With sodium at 350°F, the first seal formed was found to be leaky, however, the formation of the seal a second time resulted in complete shutoff. This seal retained a 10 psi reverse gas pressure adequately. Two turns of the trap shaft were required to obtain a measurable gas flow through the seal. The maximum flow rate was about 0.08 cfm and was influenced only slightly by the system pressure. The later was varied from 5 to 30 psig with a gas flow variation from 0.04 to 0.08 cfm (latter was not linear). Additional turns after the first two did not improve gas flow - if anything they caused a slight decrease.

A seal was formed again and after two turns a venting rate of 0.5 cfm at 30 psi was established. An additional ten turns reduced this rate to 0.4 cfm. The coolant was then turned off and the melt-out heaters (180 watts of G. E. heating cable distributed across the aluminum body) turned on to clear out the seal. During this melt-out the handle was turned once to help in clearing out the sodium from the seal area. The force required increased very sharply until galling caused seizure. A total of 19 turns has been made during this test. Up to the last turn the force had varied, from 15 to 25 pounds.

Removing the shaft from the assembly was quite difficult. Examination of the shaft indicated that the principal area of galling was just ahead of the packing where the nominal clearance was 0.005 inch. Some additional galling was evident on the packing bushing and also on the inner bearing surface adjacent to the cam section. The sodium had penetrated 2½ inches along the shaft during this test.

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The following modifications were made before resumption of testing. The bearing surface nearest the float was cleaned up to remove small burrs. The shaft was turned down eccentrically to provide 0.030 in. relief on one side (opposite to cam). The spring bushing to shaft clearance was increased 0.010 inch. The shaft area below stuffing box was reduced 0.050 in. in diameter.

The same seal forming procedure was used as in the first group of tests (sodium 350°F). As before, gas-tightness was not accomplished until the seal had been formed a second time. With 10 psig gas the unit was tight in the normal direction and indicated a slight leak in the reverse direction (~ 2 cc/min). Turning the freeze trap handle one half turn was effective in venting gas at a rate of 0.5 cfm with a 5 psi differential pressure. Turning the handle a full turn increased the venting rate at the same pressure to 0.9 cfm. It was observed that the flow tended to decrease with time and higher pressure differentials. The force required to turn the handle varied from 10 to 12 pounds. The shaft seized again while turning during the melting operation. After dismantling, galling was noted in the same reduced housing area as before. The shaft diameter reduction had been done one inch away from the correct region. The necked down area was added to the correct location and the unit reassembled. Sodium penetration was $3 \frac{3}{8}$ in. for this test.

The final testing was carried out in a manner similar to the two previous tests except that the sodium was held at 1000°F instead of 350°F. A satisfactory seal was obtained at the first attempt. No gas leakage was measured at 10 psig in either direction. The force required to turn the handle was 21 pounds. No venting occurred. A total of 16 turns resulted in no measurable venting at any test pressure up to 30 psig. Melting out the seal opened the vent satisfactorily. After melting, the force required to turn the shaft was 3 to 5 pounds.

A new seal was formed. Force required to turn handle had increased to 60 pounds. With sodium at 1000°F no venting was possible by turning the handle. The piping temperature was lowered to 350°F.

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but no venting occurred at this new condition. The force required to turn the handle had increased to 110 pounds. After disassembly the shaft was observed to be sodium covered for a distance of 14 inches. Some slight galling was observed on the inboard bearing.

Discussion

The small volume of the test system piping ($\sim 1 \text{ ft}^3$) did not permit testing the ability of the cooling coil to maintain the temperature of the freeze trap when venting hot gas from a system over an extended period. For the test conditions the venting period was approximately 10 seconds. The lower limit of venting rate measurement was 1 cc per minute.

Only the first freeze test was conducted with the float cam position such as to permit operation of the float. All subsequent freeze tests were made with the float held open by the cam. Satisfactory operation of the unit resulted under these conditions. Smoother venting occurs with the float held in the open position. With the float free to close during venting, oscillating gas flow (indicated by the gas flowmeter) was observed at moderate flow rates ($\frac{1}{2}$ cfm). Bobbing of the float in the gas stream is suspected as the cause since holding the float in the open position eliminated the pulsating flow.

It appears that the rotating feature will be useful only during the initial fill period when short seals are formed with relatively cool sodium; at other times melting out must be resorted to. All the major problems encountered during the test were mechanical and associated with the rotating feature of the unit.

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ORIGINAL DESIGN

MODIFICATIONS DURING TEST

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