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SUBJECT: Air-Cooled Condenser--Steam System
HRT Engineering Test Procedure V 5

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COPY

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AIR-COOLED CONDENSER
STEAM SYSTEM
HRT Engineering Test Procedure V 5

1.0 Objective

The Fluor Fin-Fan air-cooled condenser installed to "kill" all steam in excess of the 2 Mw which can be fed to the turbo-generator will be tested to determine its performance under low and high load conditions. Cooling capability and steadiness of operation particularly under low load conditions where the condenser must operate with much of the cooling surface flooded by condensate will be determined.

2.0 General Description

The Fluor Fin-Fan cooler will be tested initially for cooling capability and operability using 250 psi plant steam. However, plant steam cannot be supplied in quantities sufficient to test the unit at normal or high load conditions, so final testing will have to be deferred until the reactor is producing power.

The 250-psi plant steam will be admitted to the steam killer through the package boiler valve manifold, and the condensate from the steam killer will be discharged into the deaerator as shown in the attached flowsheet, Fig. 1. The air-cooled condenser will be isolated from the rest of the system by valving.

Data will be obtained on the inlet steam conditions, flow rate, condensate discharge conditions, and ambient air conditions in 200-Kw steps, starting with a heat load of 200 Kw and progressing to the maximum that can be supplied with the 250 psi plant steam. The steam killer will be observed for steadiness of operation, fan vibration, and general operability. The tests will be extended to determine the capacity of the system at high heat loads when reactor steam is available. However, the initial data will be used to predict capability at higher heat loads.

The speed of the fan motor and pitch of the fan blades will be varied only if it is apparent that doing so will improve the operation of the steam killer. In order to conserve time they should not be adjusted for low load conditions until the behavior at loads approaching the maximum obtainable with building steam is determined. If possible, a minimum heat load for good operation at the existing pitch and high speed should be determined. If time is available the significance of these two parameters should be determined by trial of both motor speeds and two or three fan blade pitches.

3.0 Apparatus Required

3.1 The following is a list of all the instruments required to run the preliminary tests on the steam killer:

AIR COOLED CONDENSER TEST FLOWSHEET

FIGURE 1

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Smaller orifice for FE-518
HIC-536 for HCV-536
FE-518A and 518B
FI-518A and 518B
PI-659
TE-576 and 577
Pressure gauge--in line 345B at steam killer
Anemometer
Calorimeter
Thermometer

4.0 Procedure

4.1 Precautions to be taken prior to and during operation of the steam killer.

- 1.0 Check to see that the gear drive unit has sufficient clean oil for operation. Correct oil level is indicated on the unit.
- 2.0 Check the weep holes in the fan blades to make sure they are open and will drain condensate from inside the blades.
- 3.0 Check the lubrication schedule to see if the motor and coupling have been lubricated.
- 4.0 Immediately after starting the fan, check the unit for any vibrations or noises that might indicate trouble.
- 5.0 If the motor fails to run, check the vibrator switch to see if the ball is properly set on the cup assembly.

4.2 Startup

- 1.0 Check to see that the instruments listed in Section 3.1 are installed and ready for operation.
- 2.0 Make the following valve check:

Closed

325A	V-339A	V-306A	V-345C
313A	V-340A	V-364A	V-317A
314A	V-319A	V-312A	V-355A
344A	V-319B	V-316A	V-365A
HCV-536 (set air supply to 0 lb)			
HCV-537 (set air supply to 0 lb)			
HCV-541 (set air supply to 0 lb)			

Open

363A (deaerator vent orifice valve)
345B (pressure gauge)
V-311A V-345A V-371 V-344B V-344C
Set PV-557 for maximum discharge pressure.

3.0 Open the blowdown valve 798A in the line teeing off line 306 between V-318A and V-306A and drain the system. After draining, crack V-319A and blow down the steam supply line. Close the blowdown valve.

4.0 Just crack HCV-536A and open V-319A.

5.0 Start the motor drive for the steam killer fan. If motor and fan operation is satisfactory, begin the testing procedure.

4.3 Testing Procedure

1.0 Using the anemometer, take several air velocity readings over the steam killer.

2.0 Open HCV-536 until the flow rate to the steam killer is about 700 lb/hr as indicated by FI-518A. A 700 lb/hr flow rate is approximately equal to 200 Kw. Note: The instrument department will supply the necessary meter factors and curves to determine flow rates for various upstream pressures.

3.0 Allow the system to come to equilibrium and begin recording the following readings on the data sheet every 10 minutes for 1 hour:

Pressure at the orifice - PI-657

Temperature at the orifice - TE-574

Percent of range - FI-518A

Inlet steam pressure - PI-659

Inlet steam temperature - TE-576

Quality - Calorimeter connected to the inlet steam line. It will only be necessary to determine the steam quality once during each 1-hour test.

Condensate pressure - Pressure gauge attached to line 345 at V-345B

Condensate temperature - TE-577

Air Temperature - Ambient temperature

Steam killer heat load - Total Btu/hr

4.0 After one hour of steady operation increase the flow rate 700 lb/hr and again allow the system to come to equilibrium.

5.0 Begin taking data again every 10 minutes for 1 hour.

6.0 Repeat steps 3 and 4 until the maximum flow to the steam killer is reached.

6.

Ambient Air Temperature:

[illegible]

Signed

Calculations:

Design heat transfer coefficient based on outside area.¹

$$\text{Heat exchanged at } 353^{\circ}\text{F} = 30,500,000 \text{ Btu/hr}$$

$$\text{Heat transfer surface} = 13,700 \text{ ft}^2$$

$$\text{Air flow at } 65^{\circ}\text{F} = 181,000 \text{ cfm}$$

$$\text{Air temperature} = 65^{\circ}\text{F}$$

$$q = UA\Delta T_m$$

$$q = \text{heat transferred, Btu/hr}$$

$$U = \text{overall heat transfer coefficient, Btu/hr-ft}^2\text{-}^{\circ}\text{F}$$

$$A = \text{area for heat transfer, ft}^2$$

$$\Delta T_m = \text{logarithmic mean temperature difference, } ^{\circ}\text{F}$$

$$\Delta T_m = \frac{[T_{\text{steam}} - T_{\text{inlet air}}] - [T_{\text{steam}} - T_{\text{outlet air}}]}{\ln \frac{[T_{\text{steam}} - T_{\text{inlet air}}]}{[T_{\text{steam}} - T_{\text{outlet air}}]}}$$

$$T_{\text{outlet air}} = T_{\text{inlet air}} + \frac{q}{\text{airflow} \times \text{density} \times C_p}$$

$$C_p \text{ air at 1 atm} = 0.237 \text{ Btu/lb-}^{\circ}\text{F}$$

$$T_{\text{outlet air}} = 65^{\circ}\text{F} + \frac{30,500,000}{60(181,000)(0.237)(0.076 \text{ lb/ft}^3)}$$

$$T_{\text{outlet air}} = 65^{\circ}\text{F} + 156^{\circ}\text{F} = 221^{\circ}\text{F}$$

$$\Delta T_m = \frac{(353 - 65) - (353 - 221)}{\ln \frac{353 - 65}{353 - 221}} = \frac{288 - 132}{\ln \frac{288}{132}} = \frac{156}{0.779}$$

$$\Delta T_m = 200^{\circ}\text{F}$$

$$U = \frac{30,500,000}{(13,700)(200)} = \frac{30,500,000}{2,740,000} = 11.1 \text{ Btu/hr-ft}^2\text{-}^{\circ}\text{F}$$

¹HRT Steam System Design Report, KD-1327, March 8, 1955.

Calculation of actual overall heat transfer coefficient:

$$U_{\text{actual}} = \frac{q \text{ (From Test)}}{13,700 \Delta T_m \text{ (From Test)}}$$

As in previous calculation determine outlet air temperature by calculations based on measured heat transfer, ambient air temperature and air flow rate to compare with measured outlet air temperature.

$$T_{\text{outlet air}} = \text{ambient air temperature} + \frac{\text{heat transferred (Btu/hr)}}{1.08 \text{ (air flow ft}^3\text{/min)}}$$

Calculate ΔT_m

$$\Delta T_m = \frac{[\text{steam temp. (test) - ambient air temp.}] - [\text{steam temp. (test) - outlet Air Temp.}]}{\ln \frac{[\text{steam temp. (test) - ambient air temp.}]}{[\text{steam temp. - outlet air temp.}]}}$$

Performance ratio (P.R.)

$$P.R. = \frac{\text{actual overall heat transfer coefficient}}{\text{design overall heat transfer coefficient}}$$

$$P.R. = \frac{U_{\text{actual}}}{11.1}$$

Design Specifications: (JS-HRT-5)

Tube Side

Steam flow rate	35,000 lb/hr
Steam pressure at inlet	140 psia
Enthalpy of steam at inlet	1196.0 Btu/lb referred to saturated liquid 32°F
Water pressure at outlet	To be specified by seller but not less than 100 psia.
Sub-cooling required	None

Air Side

Design dry bulb temperature	65°F
Altitude of installation	900 ft

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