PROPOSED OUTLINE FOR TEST OF COOLING COIL
PERFORMANCE AT ELEVATED TEMPREATURES AND PRESSURES

AAF

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PROPOSED OUTLINE
FOR TEST OF
COOLING COIL PERFORMANCE AT
ELEVATED TEMPERATURES AND
PRESSURES.

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Prepared for
METROPOLITAN EDISON COMPANY
READING, PENNSYLVANIA

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i. Materials of Construction - identical, 5/8 inch O.D. Copper tube, heavy wall - 0.049 inch, 0.007 inch copper fins spaced 6 per inch, copper headers with schedule 80 steel connections (Test coil uses screwed connections, Full Coil uses ASA flanged connections), cleanable fittings with high temperature O-rings.

During tests, results will be considered valid if performance as given by water side data agrees with performance as given by gas mixture side data. Sufficient test data will be generated to demonstrate reproducibility.

III. DESCRIPTION OF APPARATUS

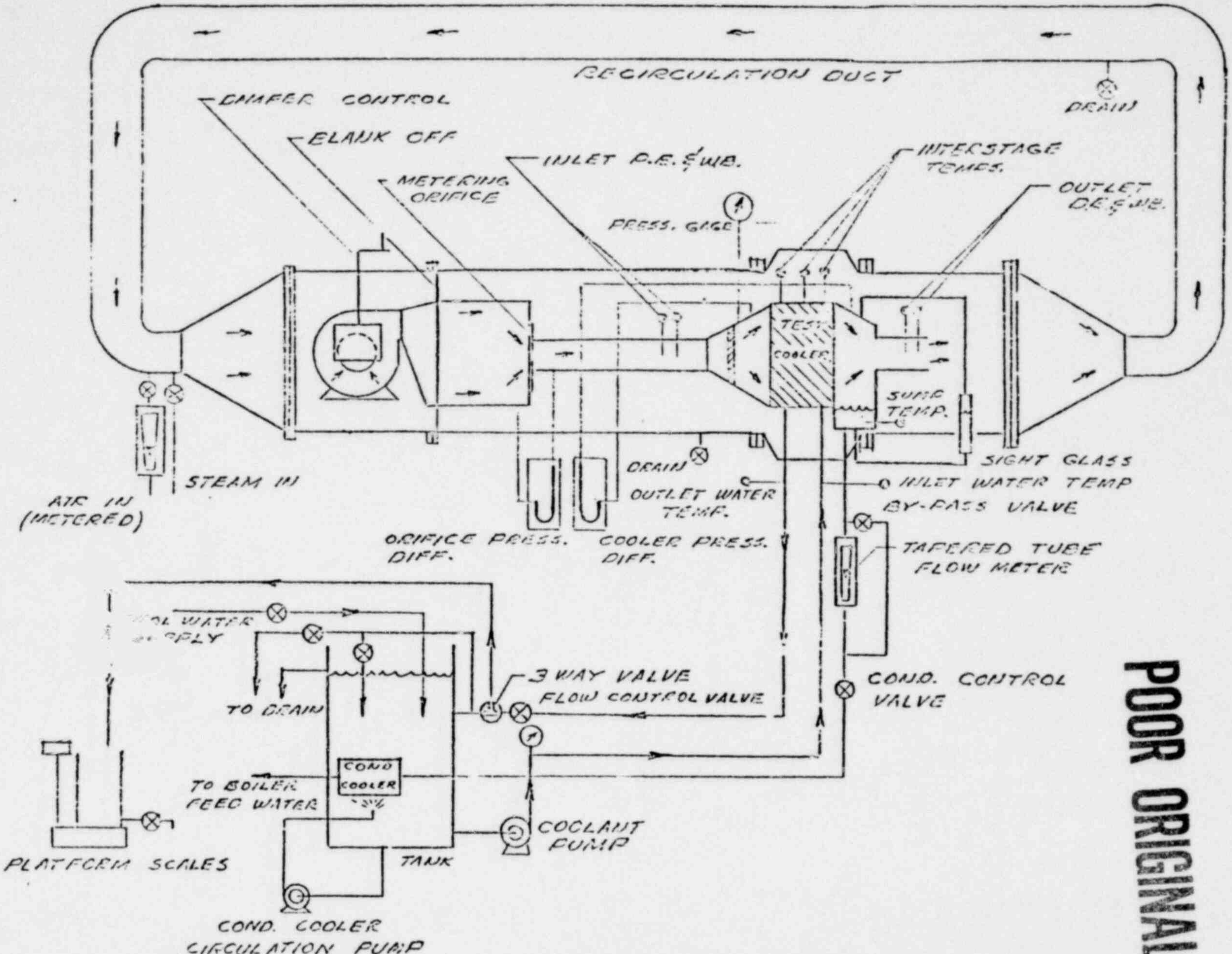
The apparatus used to test this coil has been previously used to test cooling coil performance and can generally be considered to consist of three systems which are the pressure vessel, the test section, and allied instrumentation. A brief description of these systems is given below.

1. Pressure Vessel and Mixture Circulation System. The steam-air mixture will be circulated through a closed loop system by means of a centrifugal blower. (See Figure 1.) On leaving the blower the mixture is completely contained in the duct system of the test section and is expelled from this duct after leaving the coil. This test section, discussed later, is completely surrounded by the 42 inch I.D. insulated shell capable of withstanding the required pressure. The section containing the cooler is slightly larger to accommodate the coil manifold and accompanying piping. After leaving the cooler the mixture enters a transition section and is recirculated back to the fan inlet through the 12 inch I.D. duct provided for this purpose. A large blank-off plate is attached to the fan outlet to prevent the mixture's returning directly to the blower and not being returned through the recirculate duct.

   In order to insure proper mixing, the steam and air are injected upstream of the blower. Compressed air is provided by the normal "plant" air system and the steam is produced by a large (600 bhp) boiler. The mixture flow is controlled by means of a damper on the fan inlet.

2. Containment Cooler Test Section and Water Supply System. The test section will consist of the cooler and all of its attached duct system of the sizes indicated in Figure 1. The cooler will be a 24 x 24 inch section identical in construction to the "full size" unit as shown on AAF Drawing No. MC

   Thermocouples will be placed in these ducts before and after the cooler to indicate the inlet and outlet, wet and dry bulb temperature. A moisture separator pad, of glass matte construction, will be installed to remove any entrained water droplets present.



~SCHEMATIC~

CONTAINMENT COOLER TEST

FIGURE 1.

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Thermocouples will also be placed in the water manifold as close to the coil as is practical to give an accurate indication of the c[illegible]er's performance and minimize any water temperature measurement error.

Because of heat balance inaccuracies encountered in previously run tests, a sheet metal housing will be installed over each end of the coil having the return bends. This will be done to prevent an unmeasurable heat gain by conduction to these parts due to their presence in the hot atmosphere.

Cooling water will be supplied to the coil from a large tank by means of a centrifugal pump. The supply will be arranged to provide water flow through the coil counterflow to the mixture flow. Valves will be provided to regulate the flow and on-line water flow measurement will be used to indicate quantity. The cooler inlet temperature will be maintained through the addition of cold water to the supply. Any excess will overflow into the drain line.

The condensate will be collected in the sump where the temperature will be measured. The flow will be measured by a tapered tube flow meter as it is drained from the system. It will be returned to the boiler feed water system.

3. Containment Cooler Instrumentation. The mixture flow will be measured utilizing the sharp-edged orifice method. The resulting pressure drop will be indicated with a U-tube manometer. The system pressure will be measured by an "instrument" quality Bourdon gage. The absolute pressure is then determined by adding this pressure to the barometric pressure measured in the same area by means of a mercury column barometer. The wet and dry bulb temperatures will be measured by means of thermocouples. The wet bulb thermocouple will be covered with a cotton wick and supplied with water from time to time. All temperatures will be indicated and recorded utilizing a 24 point Esterline-Angus recorder.

   A stop watch will be utilized to assure accurate time measurements when setting and monitoring the coolant flow rate. The coolant circulation measurement loop consists of a collection tank and suitable valving. The water can be diverted to a scales where weight rate of flow is determined without disturbing system operation. The flow will be adjusted by means of a control valve on the downstream side of the cooler.

IV. EXPERIMENTAL PROCEDURE

The following procedure will be used to determine the heat transfer characteristics of the containment cooling coil.

1. The air circulation and water supply system will be started. The steam and air rates will be adjusted, as necessary, to produce the desired condition of temperature, pressure and humidity.

2. The blower damper will be adjusted to give the proper mixture flow.

3. The cooling water flow rate and temperature will be adjusted to give the required conditions.

4. Steps 1, 2 and 3 will be repeated as necessary until stabilized conditions are reached.

5. Data will be recorded utilizing all instrumentation to determine the required temperature, pressure and humidity of the mixture at the inlet and outlet. The temperature and flow rate of the cooling water will be verified. The condensate temperature and flow rate will be recorded.

6. The coil performance can then be determined knowing the cooling water flow rate and its temperature difference. The heat gained by the water system can then be verified by computing the heat lost by the mixture.

A successful test run shall be defined as operation at steady state conditions for a period of fifteen (15) minutes or more. Temperatures, pressures, pressure drops, and flow rates must have reached these steady state levels and damped out excessive oscillations (The control adjustments normally will allow small oscillations while not permitting larger variances). Steady state operation is evidence of the fact that condensate is not building up on the heat transfer surfaces. Any degree of such build-up would rapidly change temperatures and pressure drops due to the very high condensation rates in this type service.

Inasmuch as there are many pieces of data to be observed, as well as a likelihood that any one test run will not be successful in achieving a heat balance (described hereafter), it is impossible to prepublish a rigid test schedule.

During a nominal period of stay of test witnesses (two or three dyas) there will be ample opportunity to evaluate the test procedure, observe data being recorded, and gain a working knowledge of the test equipment. For witnesses to stay through the entire testing portion of the program, will require residency for a much longer period in the event of unplanned shutdowns and rework.

V. CALCULATION PROCEDURE

Upon completion of a test run in which data appears to be sound (as previously defined), a trial heat balance will be made using the water side (or coolant) data against the air side (or mixture) data. If the heat transfer balance is made within reasonable accuracy, the strip chart and all other recorded data shall be appropriately marked with a test identification number for later reference. (Test data for runs which do not balance will not be so coded).

Density and mixture flow rate calculations for the trial heat balance will be carried out in the usual manner, i.e. based on partial pressure laws. Equation (1) defines the density calculation.

$$\rho = \frac{P_a \cdot M_a + P_s \cdot M_s}{10.73(T + 459.7)} \quad (1)$$

where

- ρ = density, lbs/cu.ft.
- P_a = partial pressure of air, psia
- M_a = molecular weight of air (28.97)
- P_s = partial pressure of steam, psia
- M_s = molecular weight of steam (18.)
- T = temperature, F

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Equation (2) defines the volume flow rate calculations at conditions.

$$CFM = 1096.5\, C_d A_o \phi_i \sqrt{\frac{OPD}{\rho}} \quad (2)$$

where

- CFM = volume flow rate, cubic feet per minute
- ϕ_i, C_d = orifice constants, dimensionless (determined through calibration in place)
- A_o = orifice flow area, square feet
- OPD = orifice pressure drop, inches water gage
- ρ = density, lbs/cu.ft.

The experimentally determined performance characteristics of the test coil, once established, will be compared with computer generated test coil performance characteristics. In this manner a direct relationship will be shown between computed results and those that have been measured experimentally. This comparison is made for each of the run conditions and is assumed to remain uniform regardless of coil size. (Past test programs on similar coil configurations bear this out.) In the case of the present test, the computer solution for the full sized (45 inch long) coils involves only accounting for the different length. Applying the 'comparison factor' to computer generated full scale coil data will demonstrate expected performance of the full sized coil bank in service.