TASK CLOSE OUT DOCUMENT

Task Scope _NATURAL CIRCULATION — DEGRADED_
CORE GEOMETRY — CALCULATION OF
TEMPERATURES

To: M. Levenson
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Task No. _39_   Date Complete _4 /21_

Reason felt task is complete:

Preliminary temperatures calculated

Members of Committee

Referred at EPRI under
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W. Lowenstein for S. Levy
Signed
Committee Leader

<u>NATURAL CIRCULATION/DEGRADED CORE EXPERIMENT</u>

OBJECTIVE: To ascertain the efficiency of cooling by free convection within degraded core.

ASSUMPTION: (1) Fuel has collected in layers over central core region at grid spacer elevations. (15 inches apart)

(2) Heat generation rate of 1.5×10^{-3} of nominal full power (2732 MW).

(3) Total blockage of central core region (annular bypass of scaled dimensions)

   a) 3/4 blockage
   b) 7/8 blockage

SOLUTION: (1) Use Volume Scaling (i.e. KW/ft^3 water)

(2) Q_{core} = 4.1 MW

Q_{layer} = 450 KW (9 layers) $\Big\}$ Target TMI

$\dfrac{Q_{layer}}{V_{layer}}$ = 5.3 $\dfrac{KW}{ft^3}$

Test Vessel I.D.	= 9 inches
Test Pressure	= Atmospheric
Plate to Wall Gap	= 0.300 in. (3/4 Blocked)
Plate to Wall Gap	= 0.150 in. (7/8 blocked)
Target Test Model Q	= 0.23 KW/layer
Spacing between layers	= 1.25 inches

Test Model

Q_{layer} = 0.21 KW/layer

Q_{layer} = 0.40 KW/layer $\Big\}$ Achieved

Q_{layer} = 0.67 KW/layer

RESULTS: (1) Boiling <u>not</u> observed anywhere during free convection.

(2) Threshold of local boiling (top layer) only observed when inlet flow reduced by use of valve.

(3) See Figure attached for actual results.
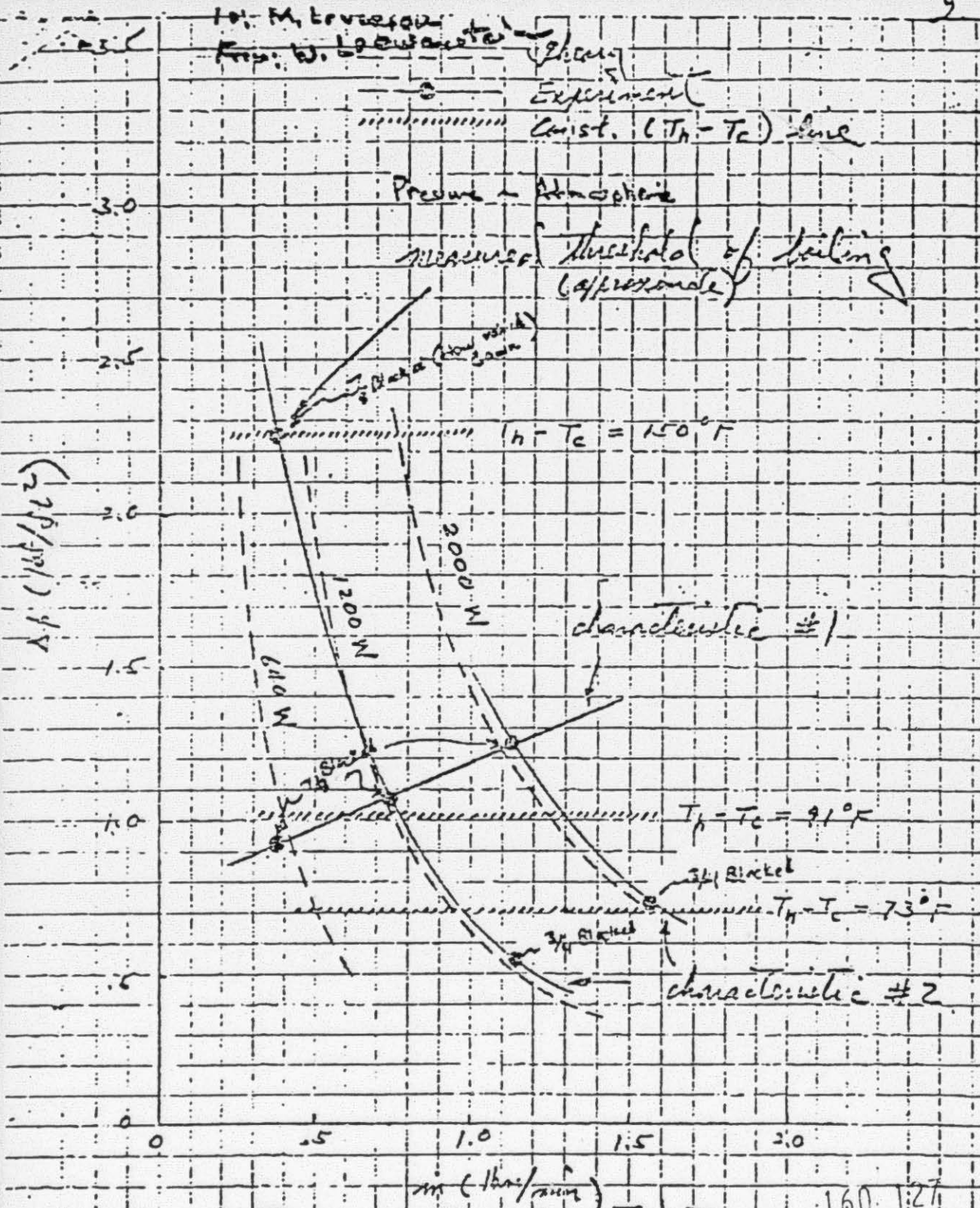
160 126

To: M. Levenson
Fro: W. Loewenstein

Theory
Experiment
Const. $(T_h - T_c)$ line

Pressure ~ Atmospheric

measured threshold of boiling (approximate)

$T_h - T_c = 150°F$

characteristic #1

$T_p - T_c = 91°F$

3/4 Blocked

$T_H - T_c = 73°F$

3/4 Blocked

characteristic #2

1200 W

2000 W

600 W

Δp (lbf/ft²)

$\dot{m}$ (lbm/min)

160 127

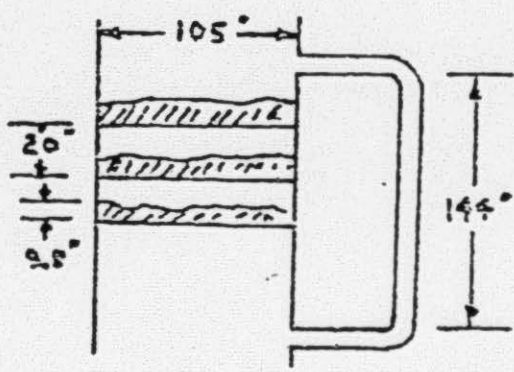Fig. 2 System Characteristics

Free Convection Heat Transfer Calculations

Through "Porous" Media

A. Calculate four cases:

1. System pressure = 900 psi
   Inlet temperature = 280°F and 350°F

2. System pressure is atmospheric
   Inlet temperature = 170°F and 200°F

Assumptions:

1. Power ≈ 0.2% of 2500MW ≈ 6MW
2. Core divided into 8 regions defined by spacers.
3. Region with porous medium has diameter of 105 in.
4. Porous medium is defined by cylinders of .4" diameter spaced with a pitch to diameter ratio of 1.065 in a staggered grid. This gives a porosity of 20%. For heat transfer area the ends of the cylinders are ignored.
5. Assume 3 "trays" of porous material, in following geometry.

Results:

1. The heat transfer rate required in the porous medium is 306 BTU/hr ft² to carry away the heat generated. (If a temperature difference of 100°F is

Results (cont.):

assumed between the fluid and the surface, the heat transfer coefficient
required is about 3 $BTU/hrft^2$ which is typical of free convection in
air.)

2. At a pressure of 900 psi, free convection provides more than enough flow
    at inlet temperatures of $280^{\circ}F$ and $350^{\circ}F$ to prevent the water from
    reaching saturation. The heat transfer coefficient is of order
    250 $BTU/hr\ ft^{2\ \circ}F$ and the temperature rise approximately $1^{\circ}F$.

3. At atmospheric pressure with inlet temperature of $170^{\circ}F$ or higher, free
    convection does not provide enough flow to allow water to remain sub-
    cooled. Hence local boiling will result.

4. Calculations using CHF correlations for beds consisting of 300 to 800
    micron particles show that at atmospheric conditions CHF will pro-
    bably be reached. However, due to the low power generation the temperature
    rise will not be significant.