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TASK CLOSE OUT DOCUMENT

Task Scope [illegible]

[illegible]

To: M. Levenson
S. Levy
E. Zebroski

Task No. [illegible] Date Complete [illegible]

Reason felt task is complete:

[illegible] on 4/27.

Members of Committee

M. Kolar

J. Kovell

[illegible] Strauss

[illegible]
Signed
Committee Leader

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5/5/79
Kolar
Kendell
Hench

TASK 46 HEAT LOSSES FROM PRIMARY COOLANT SYSTEM

Purpose:

To determine the time at which no external cooling - other than make up and let-down flow-will be required.

Method:

System heat losses were estimated using the cooldown rate of the "B" hot leg during stratification following the pump trip on 4/27. Let-down flow was estimated using measured flow rates for various pressures. Decay heat was extrapolated from B&W curves.

Conclusions:

1) The heat loss with an overage ΔT of 100^{0}F between primary system and containment is about 0.1 M W. + losses through control rod drive penetrations.

2) A let-down flow rate of at least 15gpm has been achieved at pressures from about 1000 down to 300 psig. This flow could remove about 0.1mw.

3) The decay heat will reach 0.2 mw within a year.

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Heat Losses From System - Hot Leg Piping

Assume that loop B cooldown during 4/28 and 4/29 was with zero flow, rejecting heat to the containment

Assume $T_{containment} = 80°F$

With $T_H^B \sim 190°F$ $\quad \Delta T/\Delta t \approx 20°F/35\,hrs = .571\,°F/hr$

$$mc_p \frac{dT}{dt} = UA(T - T_\infty)$$

Pipe Dimensions: $ID = 36\frac{5}{8}"$ $\quad t = 3\frac{1}{8}"$

$\rho_{pipe} = 488\ lbm/ft^3 \quad c_p = .11\ Btu/lbm\text{-}°F$

$$M_{pipe/ft} = \rho A = (488)\pi\left((21.438)^2 - (18.313)^2\right)/144 = 1322.5\ lbm/ft$$

[redacted]

$$UA = \frac{mc_p \frac{dT}{dt}}{T - T_\infty} = \frac{\left[(1322.5)(.11) + (4412)(1)\right](.571)}{190 - 80} = 3.05\ \frac{Btu}{hr\text{-}°F}/ft$$

$$U = \frac{3.05}{\pi(36.625)/12} = \boxed{0.318\ \frac{Btu}{hr\text{-}ft^2\text{-}°F}}$$

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Heat Losses From System - Calculation

Based on estimate of piping heat transfer coefficient, assume this applies to total system, calculate heat loss from piping and major components as function of temperature. From cooldown rate of Z hot leg during stagnation, U piping ~ .32 Btu/hr-ft²-°F (this neglects internal thermal resistance and is based on area of pipe outer surface.

$4\pi r^2$

πD^2

Reactor Vessel -

Diameter - D = 15⅓'

~~Ht (excluding bottom hemisphere)~~ H = 25'

[illegible]

= 2000 ft² UA = 640 Btu/hr-°F

Steam Generator - H excludes both hemi-heads

D = 12' H = 60'

$A = (\pi DH + \pi D^2)2$

= 5430 ft² (2715 ft²/SG) UA = 1740 Btu/hr-°F

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Hot Leg Piping -

L = 138.6' D = 3.5'

$A = \pi DL = 1524\ ft^2$ UA = 488 Btu/hr-°F

Cold Leg Piping

$L = 246.4'$ $D = 2.75'$

$A = \pi D L = 2130\ ft^2$ $UA = 682\ Btu/hr \cdot {}^\circ F$

Pressurizer - [illegible] both hemi[illegible]

$D = 8'$ $H = 37'$

$A = \pi D H + \pi D^2 = 1131\ ft^2$ $UA = 362\ Btu/hr \cdot {}^\circ F$

Q (kwt) 80°F ambient

	UA (Btu/hr·°F)	120	150	200	250	300	350
Reactor Vessel	690	7.5	13.1	22.5	31.9	41.3	
Hot Leg Piping	488	5.7	10.0	17.2	24.3	31.5	
Cold Leg Piping	682	8.0	14.0	24.0	34.0	44.0	
SGs	1740	20.4	35.7	61.2	86.7	112.2	
subtotal	3550	41.6	72.8	124.8	176.8	228.8	
PZR	362	4.2	7.4	12.7	16.0	23.3	
total		45.9	80.2	137.6	194.9	252.2	

note - total heat loss (kwt) vs temp.

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Makeup System Heat Removal Capability

For reference: 1 MW → 948 Btu/sec, assume 30°F ΔT

$$w = \frac{(948\ \text{Btu/sec})(7.48\ \text{gal/ft}^3)(60\ \text{sec/min})}{(30\ \text{Btu/lbm})(62.4\ \text{lbm/ft}^3)} = 340\ \text{gpm/MW}$$

.5 MW → 170 gpm

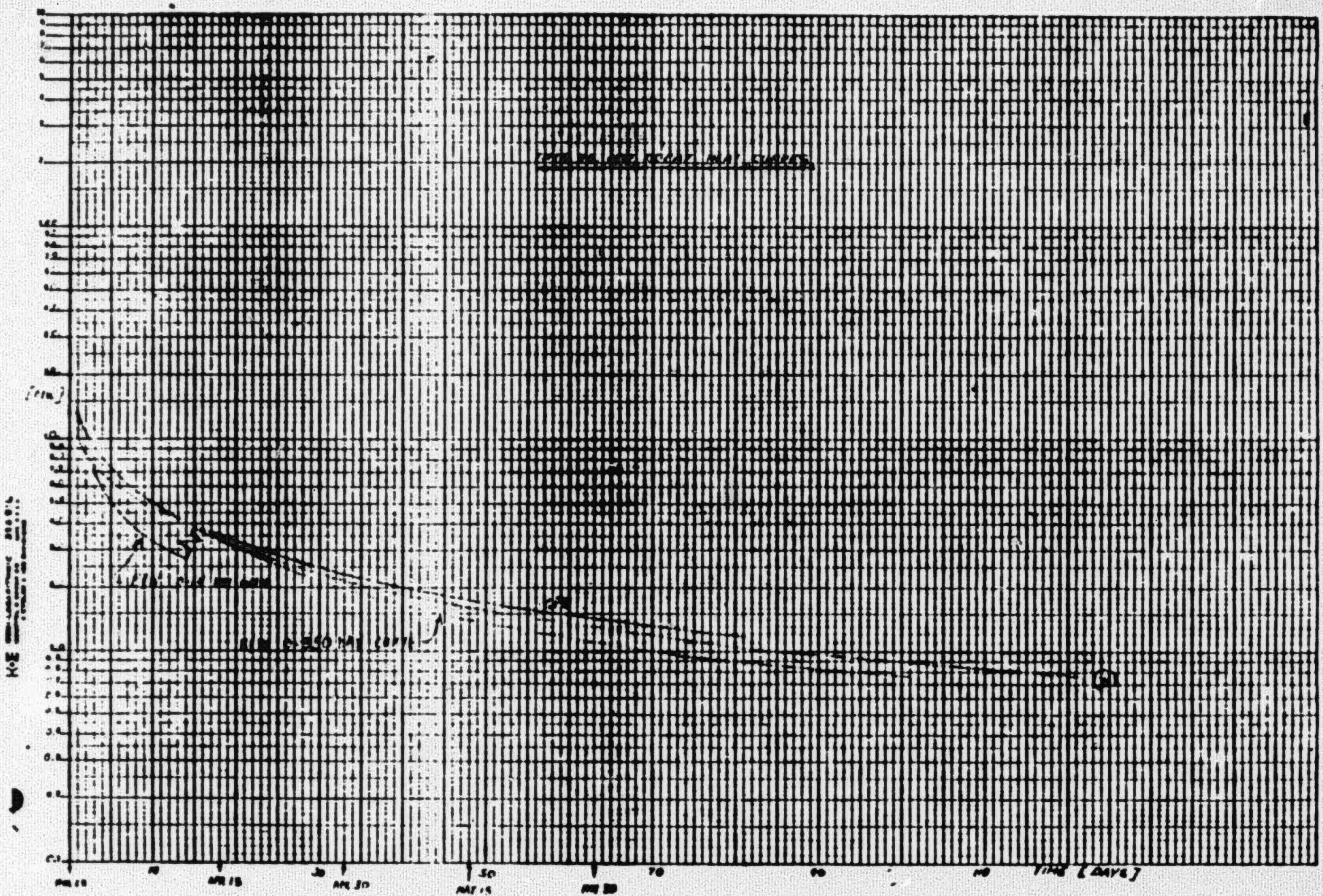
Letdown Flow – assume $w \propto \sqrt{P} \Rightarrow w = 140\sqrt{\frac{P}{2150}} = 3.02\sqrt{P}$

Assume letdown cooler can cool return water to 80°F

P (psig)	w (gpm)	Q (MW)		
		T_{out} = 100°F	T_{out} = 120°F	T_{out} = 140°F
300	52.30	.153	.307	.460
200	42.70	.125	.251	.376
100	30.19	.089	.177	.266
50	21.35	.063	.125	.188

$$Q(\text{MW}) = \frac{w\ \text{g/m} \times (T_{out} - 80)\ \text{Btu/lbm} \times 62.4\ \text{lbm/ft}^3}{7.48\ \text{g/ft}^3 \times 60\ \text{sec/min} \times 948\ \text{Btu/MW-sec}} = 1.467\times10^{-4}\, w\,(T_{out} - 80)$$

Note: This assumes w (gpm) $\propto w_{max}\sqrt{\frac{P}{2150}}$, the dwg indicates bypass piping around the pressure breakdown valve (w/ manual valving). If these valves could be opened, a higher flowrate would be available.



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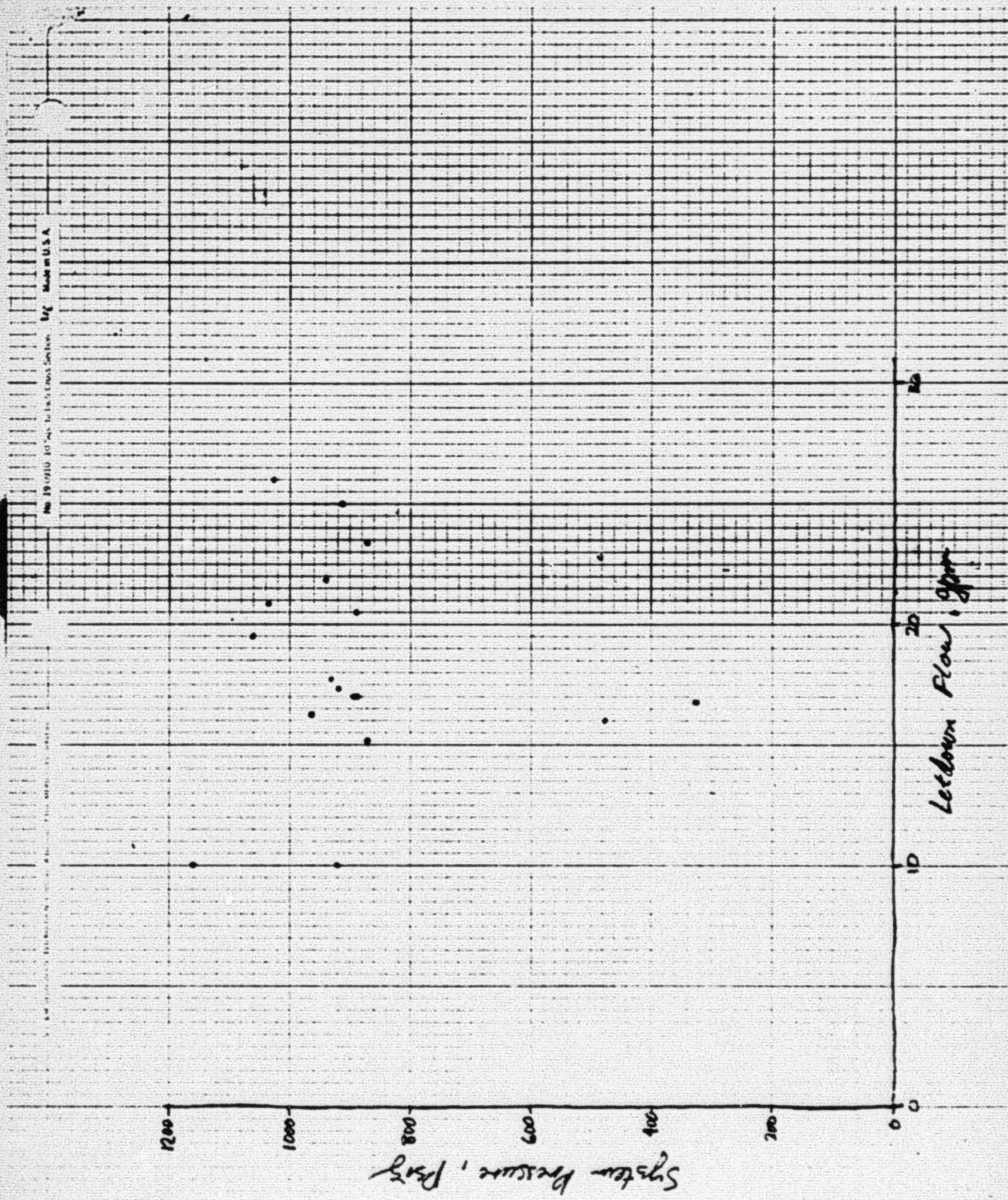
Letdown Flow, gpm
0
10
20
30
System Pressure, Psig
0
200
400
600
800
1000
1200

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