SETPOINT PROGRAM DETERMINATION

FOR THE

WESTINGHOUSE COLD OVERPRESSURE MITIGATING SYSTEM

IN THE

WATTS BAR UNIT 1 PLANT

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I. DISCUSSION/BASES

This report documents the development of the power-operated relief valve (PORV) setpoint programs (pressure setpoint vs. reactor coolant system temperature) as determined for the Westinghouse Overpressure Mitigating System (OMS), to be applied during shutdown operation in the Watts Bar Unit 1 Plant. These programs are intended to maintain reactor coolant system pressure within acceptable limits following overpressurization incidents occurring in the Watts Bar Unit 1 Plant during low temperature, water-solid operation. The results of LOFTRAN transient analyses, utilized in the determination of the setpoint program, are also included.

Operating Limits

The PORV setpoint program was developed for this plant, utilizing the algorithm provided in Reference 1. Relief valve operation based on the setpoint program will prevent overpressures produced by valve opening from exceeding the 10CFR50 Appendix G reactor vessel NDT limit and will prevent underpressures produced by valve closure from violating the reactor coolant pump No. 1 Seal minimum pressure requirement. This was accomplished considering both the MI and HI mechanisms and utilizing staggered relief valve operation.

The 10 EFPY heatup and cooldown curves, without margin for instrumentation error, were utilized for the Appendix G limit. Since little change is expected in these curves between 10 EFPY and 32 EFPY, this is consistent with the position delineated in Reference 2, in which 10 EFPY curves are recommended for overpressure studies.

The minimum RCS pressure curve utilized in the setpoint determination is based on system pressure as determined by a wide range pressure instrument in a loop not containing the active reactor coolant pump. This ensures the utilization of a minimum pressure limit curve which will cover this eventuality as well as that case in which the instrument is directly located in the loop with the active pump.

The minimum RCS pressure curve, as calculated from Reference 3, is based upon 63 psi (2 percent) pressure channel trip accuracy as described in Reference 4 and reactor coolant pump No. 1 Seal ΔP equal to 200 psid.

Mass Input Considerations

From the standpoint of determining maximum setpoint overpressure and proximity to Appendix G, the mass input (MI) mechanisms considered in the analysis involved the operation of a single charging pump with inadvertent isolation of letdown flow. Inadvertent actuation of an SI pump was not explicitly analyzed since its operation is to be prevented by the Technical Specifications.

From the standpoint of determining maximum setpoint underpressure and proximity to the RCP number 1 Seal minimum pressure limit, an envelope of mass injection rates was investigated to ensure that the worst case was considered for ultimate setpoint determination. For both the underpressure and overpressure transients, mass injection rates ranging from 40 gpm to 500 gpm were considered, the lower charging rates associated with high pressurizer level operations.

Heat Input Considerations

The heat input (HI) mechanism considered for analysis involved RCS pump startup in one loop with temperature asymmetry in the reactor coolant system, whereby the steam generators were at a higher temperature than the remainder of the system. The magnitude of the temperature difference between the steam generators and the reactor coolant system depends on the previous plant operations which allowed the asymmetry to develop. For this study, it was considered realistic to assume a maximum temperature of 50°F as the design case because much higher differences would be difficult to develop and would be easily recognized by the operator as abnormal conditions requiring special attention.

It should be noted that, while this HI transient was considered in the setpoint program determination, the frequency of occurrence is still sufficiently low that this transient did not need to be considered for conformance to the Appendix G pressure limit*. It was included, principally out of consideration for reactor coolant pump (RCP) No. 1 Seal integrity at low shutdown temperatures, and wherever margin to the Appendix G limit was available at higher temperatures. For the Watts Bar Unit 1 analysis, sufficient margin was available at all temperatures to allow inclusion of this transient in the setpoint determination.

PORV Operation

Staggered operation of the two power-operated relief valves was selected to minimize larger pressure undershoots which could occur with multiple valve operation to compromise reactor coolant pump No. 1 Seal integrity, as well as to restrict the total number of ports for discharge of primary coolant at any given moment to that absolutely necessary for pressure control. For the same reasons, the setpoint program was also selected, where possible, to preclude simultaneous operation of the PORV and the RHR valve(s) in the event that the Residual Heat Removal System would still be activated during the overpressure causative event. The dual setpoints required for staggered operation were determined such that operation of either PORV provides the required relief capacity without causing or requiring operation of the other. This redundancy is an essential factor in allowing the OMS to comply with the single failure criteria design objective.

Wherever possible, setpoints for both PORV's were selected outside the range of potential RHR valve operation (405 to 495 psig), identified by numerical symbol 11 in the algorithm setpoint determination in Section VII. Simultaneous RHR valve-PORV operation is possible at lower temperatures where there is insufficient setpoint pressure margin to accommodate independent PORV and RHR valve operation.

*RESAR 414, Section 5.2.2.10.2, Amendment 16, June 1978; also Reference 2.

Manufacturer's data was used for the development of the Target Rock PORV conservative opening and closing times. Delay times for PORV solenoid actuation (from receipt of signal to start of valve motion) were obtained from the site based upon actual measurements.

The setpoint program includes the effect of time delays associated with transmission of the wide range RCS pressure signal. A conservative value of 0.3 seconds (Reference 4) was utilized in the analyses. In addition, 0.2 seconds (Reference 10) was used as the PORV solenoid actuation delay (time from receipt of signal at solenoid to start of valve motion).

II. SPECIFICATION FOR MASS INPUT TRANSIENTS

Transients Analyzed

A parametric study (Section V) was performed using constant mass injection rates between 40 gpm and 500 gpm. This range was sufficiently extensive to envelope RCS mass injection rates associated with the maximum possible from one charging pump following letdown isolation for the range of setpoints considered.

System/Operating Parameters

A. Temperatures

Reactor Coolant System temperature is equal to 100°F.

B. Reactor Coolant System Volume

The RCS Volume is 11,689 cu. ft. for Watts Bar Units 1 and 2.

C. Initial Reactor Coolant System Pressure

The initial RCS pressure is 300 psig.

There is negligible effect on the relief valve performance and the pressure transient due to initial starting pressure. The mass input transients were conservatively analyzed at 300 psig to assure that the mass input mechanism was always at full performance before the mitigating relief valve was operated.

D. Reactor Coolant System Relief Capability

The transient is analyzed for actuation of one power operated relief valve.

E. Power Operated Relief Valve Characteristics

1. The following mass input rates and pressure setpoints:

   Mass input rates - 40, 100, 300, 500 gpm

   RCS pressure setpoints - 350, 400, 450, 550, 600, 800, 1200, 2500 psig

2. Opening characteristics from Reference 7

3. Opening time = 0.19 seconds (plus 0.2 second solenoid delay)

4. Closing time = 0.67 seconds (plus 0.2 second solenoid delay)

5. C_v = 68 (Reference 7)

F. Mass Injection Flow Capability

1. Normal operation
   Flow into RCS = 120 gpm (per Reference 8)

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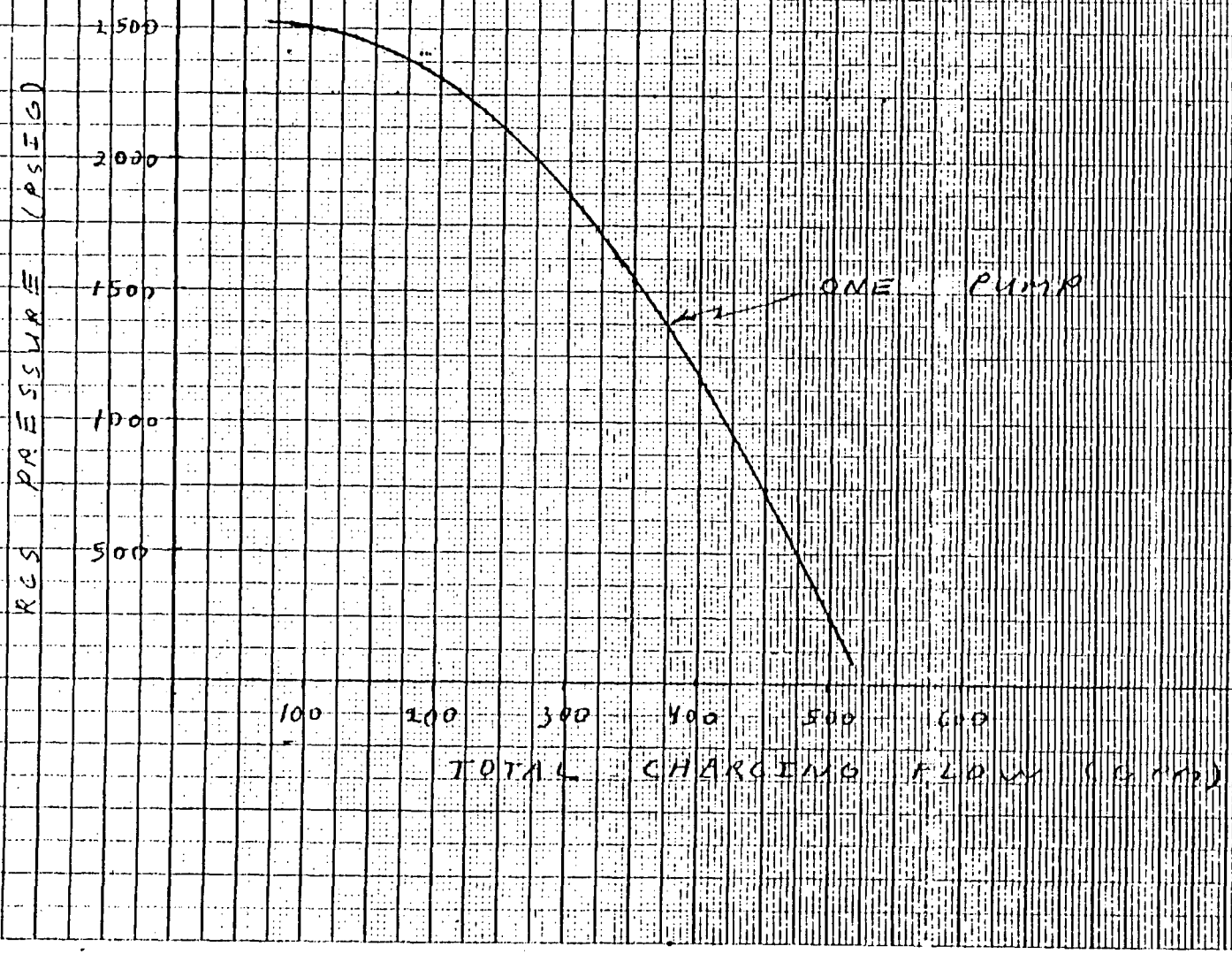
FIGURE 2.1

MAXIMUM CHARGING CAPACITY
VS RCS PRESSURE FOR
WATTS BAR POTTS



2. Infrequent operations (see Figure 2.1)
Flow into RCS at 500 psig RCS pressure:

1 charging pump: up to 474 gpm/Watts Bar Plants

G. Pressure Signal Transmission Characteristics

Time delay to PORV solenoid actuation = 0.3 sec

H. Results Required

Table summarizing the setpoint pressure overshoot, setpoint pressure undershoot, maximum RCS pressure and minimum RCS pressure reached during PORV operation for all transients.

III. SPECIFICATION FOR HEAT INPUT TRANSIENTS

Transient Analyzed

Inadvertent startup of a RCS Pump with temperature asymmetry between the RCS and SG and with the RCS in a water solid condition (Heat Input mechanism producing the worst case overpressurization).

System/Operating Parameters

A. Temperatures

SG - RCS temperature difference = 50°F

Steam generator (heat source) temperatures are 120°F, 150°F, 200°F, 250°F, 300°F, 350°F

B. Reactor Coolant System Volume

The RCS volume is 11,689 cu. ft. for Watts Bar Units 1 and 2.

C. Initial Reactor Coolant System Pressure

The transient is analyzed for 300 psig.

D. Reactor Coolant System Relief Capability

The transient is analyzed for the actuation of one power operated relief valve.

E. Power Operated Relief Valve Characteristics

Opening

1. Twenty-two pressure setpoints as required for algorithm application: (350, 400, 450, 500, 550, 600, 650, 750, 800, 850, 950, 1050, 1150, 1200, 1250, 1350, 1450, 1550, 1750, 1950, 2150, 2500 psig

2. Manufacturer supplied opening characteristic

3. Opening time = 0.19 seconds (with 0.2 second solenoid delay)

4. $C_v = 68$

Closure

1. Twenty-two reset pressures as required for algorithm application: (330, 380, 430, 480, 530, 580, 630, 730, 780, 830, 930, 1030, 1130, 1180, 1230, 1330, 1430, 1530, 1730, 1930, 2130, 2480 psig.

2. Closing characteristic reverse of opening characteristic

3. Closing time = 0.67 seconds (with 0.2 second solenoid delay)

4. $C_v = 68$ (Reference 7)

F. Steam Generator Design Characteristics

SG Tube Heat Transfer Surface Area is 48,000 ft^2/Watts Bar Units 1 and 2
SG Type - Model D3/Watts Bar Units 1 and 2

G. Reactor Coolant Pump Design Characteristics

RCP Type = Model 93A
RCP Motor HP = 7000/Watts Bar Units 1 and 2

H. Pressure Signal Transmission Characteristics

Time delay to PORV solenoid actuation = 0.3 sec

I. Results Required

Table summarizing the setpoint pressure overshoot, setpoint pressure undershoot, maximum RCS pressure and minimum RCS pressure reached during PORV operation for all transients.

IV. SPECIFICATION FOR DETERMINATION OF SETPOINT PROGRAM

A. SETPOINT PROGRAM ALGORITHM

Procedure described in Reference 1, Section 4.

B. TRANSIENTS CONSIDERED

1. Mass Input

All cases described in the specification for mass input transients (Section II).

2. Heat Input

All cases described in the specification for heat input transients (Section III).

C. 10CFR50 APPENDIX G PRESSURE LIMIT

Watts Bar Unit 1

Limits Considered

10EFPY heatup curve without margin for instrument error as shown in Figure 4.1.

10EFPY cooldown curves without margin for instrument error as shown in Figure 4.2.

Curve Utilized

10EFPY heatup curve described in Figure 4.1 (Most limiting for applicability rates given below.

Applicability

Watts Bar Unit 1

Heatup rates up to 60°/hr.

Cooldown rates:

For maximum allowable cooldown rate as a function of RCS temperature, see Figure 4.3.

These rates are consistent with the maximum expected cooldown rate (Reference 6).

FIGURE 4.1
RCS HEATUP LIMITATIONS
WATTS BAR UNIT 1

NOTES:
(1) 10 EFPY OPERATION
(2) HEATUP RATES UP TO 60°F/HR
(3) NO INSTRUMENT ERROR MARGIN

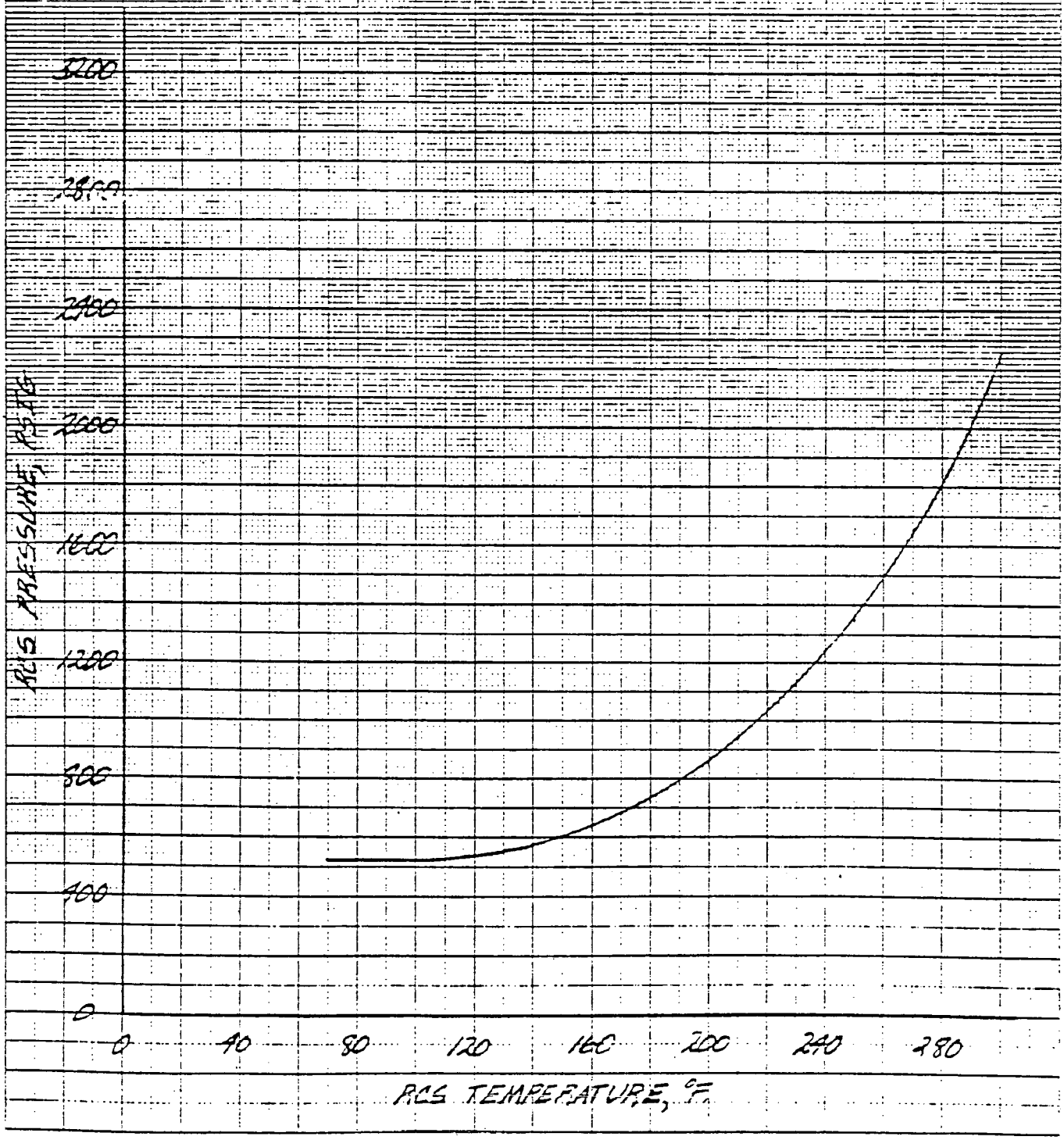


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FIGURE 4.2
RCS COOLDOWN LIMITATIONS
WATTS BAR UNIT 1

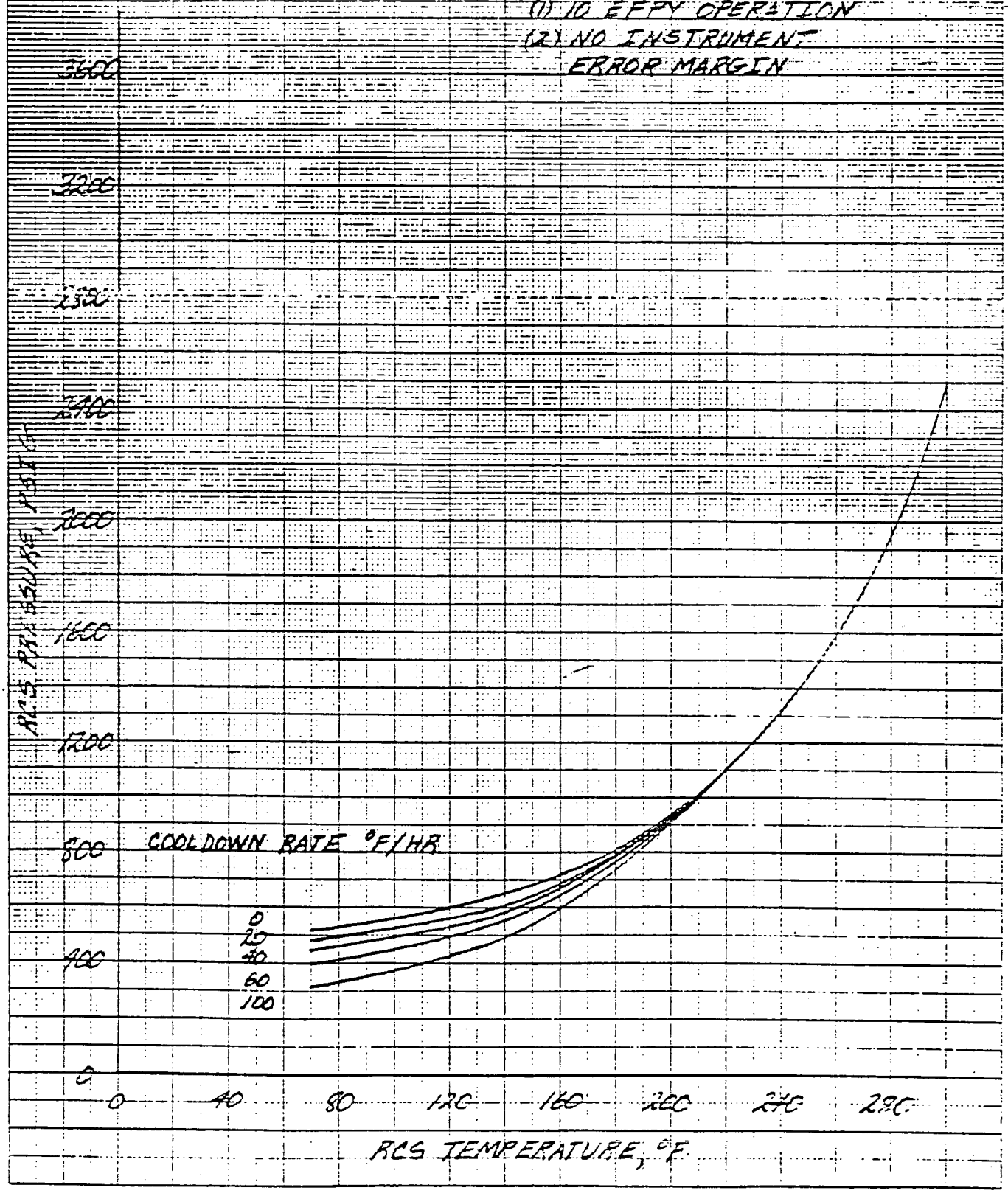

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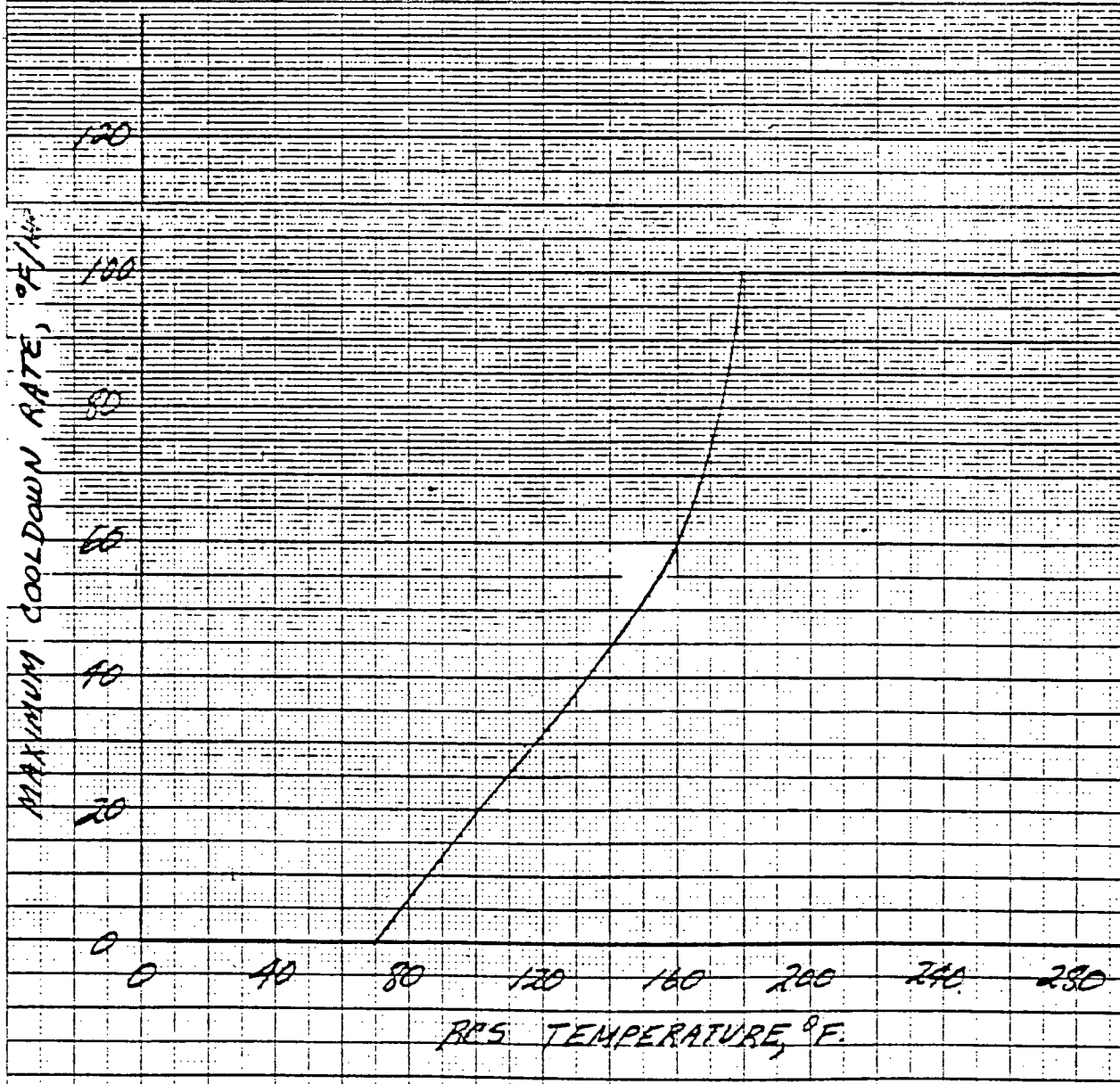
FIGURE 4.3
MAXIMUM ALLOWABLE COOLDOWN RATE
WATTS BAR UNIT 1



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D. REACTOR COOLANT PUMP NO. 1 SEAL PRESSURE LIMIT

1. Curve Utilized

Minimum RCS pressure vs. RCS temperature correlation described in Figure 4.4.

2. Applicability

a. RCP No. 1 Seal ΔP = 200 psid

b. Pressure channel trip accuracy $\leq$ 63 psi (Reference 4)

E. OTHER CONSTRAINTS

1. Staggered PORV Setpoints

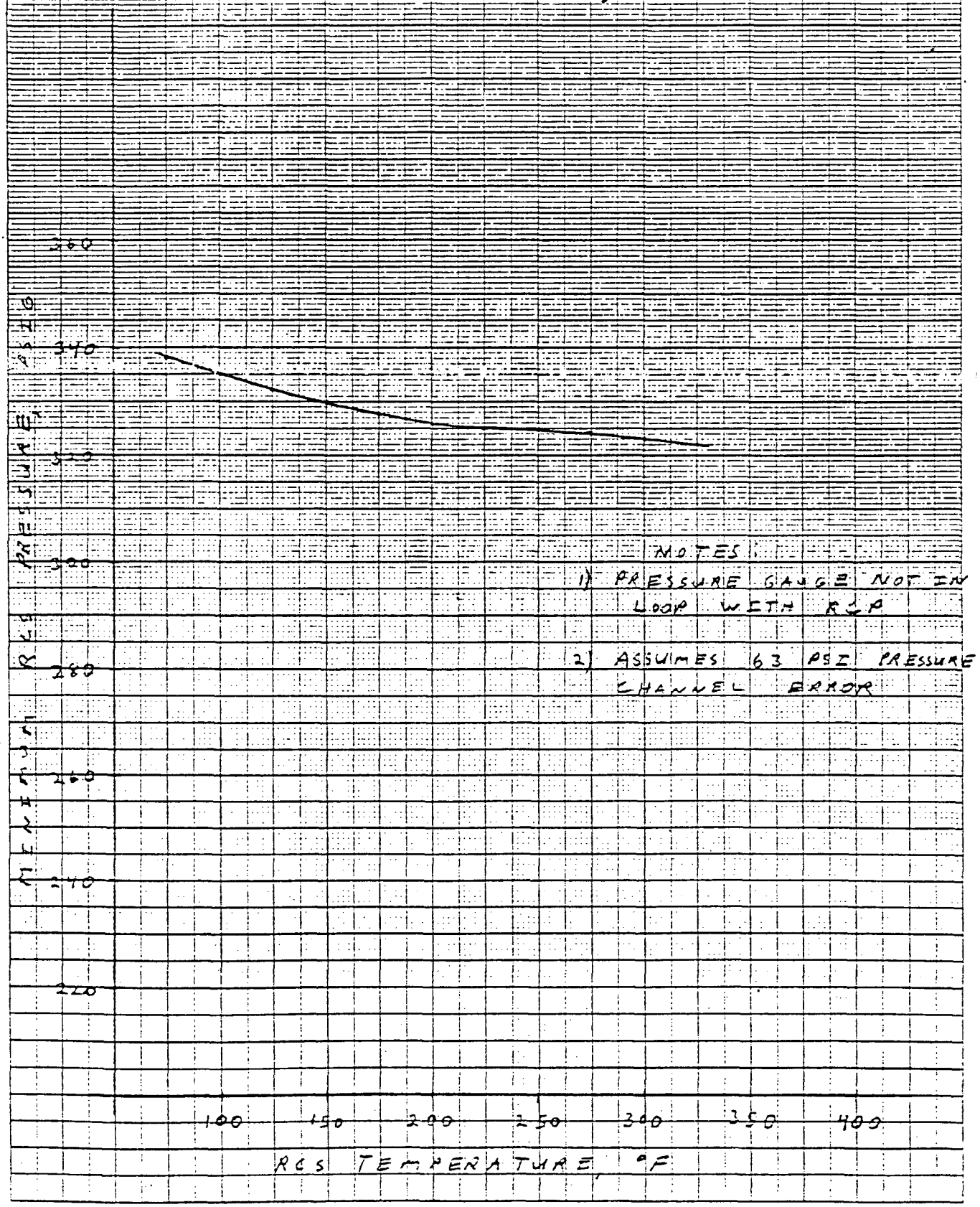
a. Either PORV provides the required relief capacity (single failure of either valve is considered).

b. Higher setpoint of second PORV reduces the likelihood of its operation if first PORV (at lower setpoint) operates.

2. RHRS

Where possible, PORV setpoints are set outside the RHRS operating pressure range (with RHRS valve(s) operating at 450 psig, potential range of RHRS valve operation, including $\pm$ 10 percent tolerance on setpoint is 405 psig to 495 psig) to minimize simultaneous operation of both the PORV and RHRS valve(s).

FIGURE 4.4
WATTS BAR PROJECTS
MINIMUM RCS PRESSURE
FOR STARTING SINGLE
RCS PUMP (RCP)



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3. Plant Operability

The highest possible setpoints were determined, consistent with the limits and constraints described in this section (Section IV), to provide the plant operator with maximum pressure margin for plant operation during shutdown.

4. Thermal Transport

For a heat input transient as described in Section III, it is possible for the temperature RTD to measure a higher temperature than that of the vessel. To account for this effect, it was conservatively assumed that the RTD was measuring a temperature 63°F higher than the vessel temperature (50°F difference between primary and secondary plus 12°F for instrument accuracy).

V. RESULTS OF PARAMETRIC REACTOR COOLANT SYSTEM (CONSTANT) MASS INPUT TRANSIENT ANALYSES FOR 412 PLANT (V_{RCS} = 11,782 CU. FT.)

TABLE 5.1

SUMMARY OF MASS INPUT RESULTS

Mass Input Rate (gpm)	PS PORV Setpoint (psig)	ΔP_{OVER} Setpoint Pressure Overshoot* (psi)	P_{MAX} Peak RCS Pressure (psig)	ΔP_{UNDER} Setpoint Pressure Undershoot** (psi)	P_{MIN} Minimum RCS Pressure (psig)
40	350	2	352	84	266
	400	1	401	89	311
	450	1	451	94	356
	550	1	551	104	446
	600	1	601	110	490
	800	1	801	129	671
	1200	1	1201	154	1046
	2500	1	2501	217	2284

* $P_{MAX} - P_S$
** $P_S - P_{MIN}$

TABLE 5.1 (Con't)

SUMMARY OF MASS INPUT RESULTS

Mass Input Rate (gpm)	PS PORV Setpoint (psig)	ΔP_{OVER} Setpoint Pressure Overshoot* (psi)	P_{MAX} Peak RCS Pressure (psig)	ΔP_{UNDER} Setpoint Pressure Undershoot** (psi)	P_{MIN} Minimum RCS Pressure (psig)
100	350	4	354	81	269
	400	4	404	86	314
	450	4	454	89	367
	550	4	554	101	449
	600	4	604	109	491
	800	4	804	128	672
	1200	4	1204	151	1049
	2500	4	2504	216	2284

* $P_{MAX} - P_S$
** $P_S - P_{MIN}$

TABLE 5.1 (Con't)

SUMMARY OF MASS INPUT RESULTS

Mass Input Rate (gpm)	PS PORV Setpoint (psig)	ΔP_{OVER} Setpoint Pressure Overshoot* (psi)	P_{MAX} Peak RCS Pressure (psig)	ΔP_{UNDER} Setpoint Pressure Undershoot** (psi)	P_{MIN} Minimum RCS Pressure (psig)
300	350	12	362	69	281
	400	12	412	73	327
	450	12	462	80	370
	550	12	562	82	462
	600	11	611	93	507
	800	11	811	114	686
	1200	11	1211	140	1060
	2500	11	2511	202	2298

* $P_{MAX} - P_S$
** $P_S - P_{MIN}$

TABLE 5.1 (Con't)

SUMMARY OF MASS INPUT RESULTS

Mass Input Rate (gpm)	PS PORV Setpoint (psig)	ΔP_{OVER} Setpoint Pressure Overshoot* (psi)	P_{MAX} Peak RCS Pressure (psig)	ΔP_{UNDER} Setpoint Pressure Undershoot** (psi)	P_{MIN} Minimum RCS Pressure (psig)
500	350	21	371	55	295
	400	22	422	60	340
	450	20	470	65	385
	550	21	571	76	474
	600	19	619	85	515
	800	19	819	102	698
	1200	18	1218	123	1075
	2500	20	2520	189	2311

* $P_{MAX} - P_S$
** $P_S - P_{MIN}$

VI. RESULTS OF REACTOR COOLANT SYSTEM HEAT INPUT TRANSIENT ANALYSES FOR 412 PLANT

(SG HEAT TRANSFER AREA = 48,00 SQ FT)

WATTS BAR UNIT 1

TABLE 6.1

SUMMARY OF HEAT INPUT RESULTS

RCS/SG Temperatures (°F/°F)	PS PORV Setpoint (psig)	ΔP_{OVER} Setpoint Pressure Overshoot* (psi)	P_{MAX} Peak RCS Pressure (psig)	ΔP_{UNDER} Setpoint Pressure Undershoot** (psi)	P_{MIN} Minimum RCS Pressure (psig)
70/120	350	7	357	93	257
	400	7	407	97	303
	450	7	457	103	347
	500	7	507	108	392
	550	6	556	113	437
	600	6	606	118	482
	650	6	656	124	526
100/150	350	12	362	85	265
	400	12	412	90	310
	450	11	461	99	351
	500	9	509	101	399
	550	13	563	111	439
	600	10	610	121	479
	650	12	662	128	522

* $P_{MAX} - P_S$
** $P_S - P_{MIN}$

TABLE 6.1

SUMMARY OF HEAT INPUT RESULTS

RCS/SG Temperatures (°F/°F)	PS PORV Setpoint (psig)	ΔP_{OVER} Setpoint Pressure Overshoot* (psi)	P_{MAX} Peak RCS Pressure (psig)	ΔP_{UNDER} Setpoint Pressure Undershoot** (psi)	P_{MIN} Minimum RCS Pressure (psig)
150/120	350	20	370	74	276
	400	21	421	82	318
	450	20	470	89	361
	500	20	520	97	403
	550	21	571	104	446
	600	19	619	106	494
	800	18	818	135	665
200/250	350	30	380	66	284
	450	28	478	82	368
	550	28	578	98	452
	650	29	679	109	541
	750	28	778	121	629
	800	27	927	131	669
	850	25	875	140	710

* $P_{MAX} - P_S$
** $P_S - P_{MIN}$

TABLE 6.1

SUMMARY OF HEAT INPUT RESULTS

RCS/SG Temperatures (°F/°F)	PS PORV Setpoint (psig)	ΔP_{OVER} Setpoint Pressure Overshoot* (psi)	P_{MAX} Peak RCS Pressure (psig)	Δp^{UNDER} Setpoint Pressure Undershoot** (psi)	P_{MIN} Minimum RCS Pressure (psig)
250/300	350	36	386	59	291
	550	35	585	84	466
	750	35	785	113	637
	950	33	983	148	802
	1050	34	1084	161	809
	1250	27	1277	181	1069
	1350	33	1383	195	1155
	1450	28	1478	196	1254
300/350	350	44	394	70	280
	850	39	889	91	739
	1150	36	1186	156	994
	1350	36	1386	172	1178
	1550	30	1580	191	1359
	1750	27	1777	204	1546
	1950	27	1977	216	1734
	2150	26	2176	226	1924

* $P_{MAX} - P_S$
** $P_S - P_{MIN}$

VII. SETPOINT DETERMINATION

A. BASES

Specification delineated in Section IV.

B. LEGEND APPLICABLE TO GRAPHICAL ALGORITHMS

(See Figures 7.2 through 7.7 for Watts Bar Unit 1)

1 - Appendix G minimum allowable pressure

2 - Maximum allowable pressure for RCP No. 1 Seal integrity

3 - Locus of maximum RCS pressures produced by single charging pump/ letdown isolation operation

4 - Locus of maximum RCS pressures produced by HI transients

5 - Locus of minimum RCS pressures produced by all MI transients

6 - Locus of minimum RCS pressures produced by HI transients

7 - Range of potential setpoints based on MI operation

8 - Range of potential setpoints based on HI operation

9 - Range of potential setpoints based on both MI and HI operation

10 - Range of potential RHR valve opening

11 - Range of permissible setpoints

12 - Maximum permissible setpoint

13 - PORV No. 1 (low) setpoint

14 - PORV No. 2 (high) setpoint.

C. DATA UTILIZED

1. Mass Input

a. Parametric Correlations for Reference (412) Plant

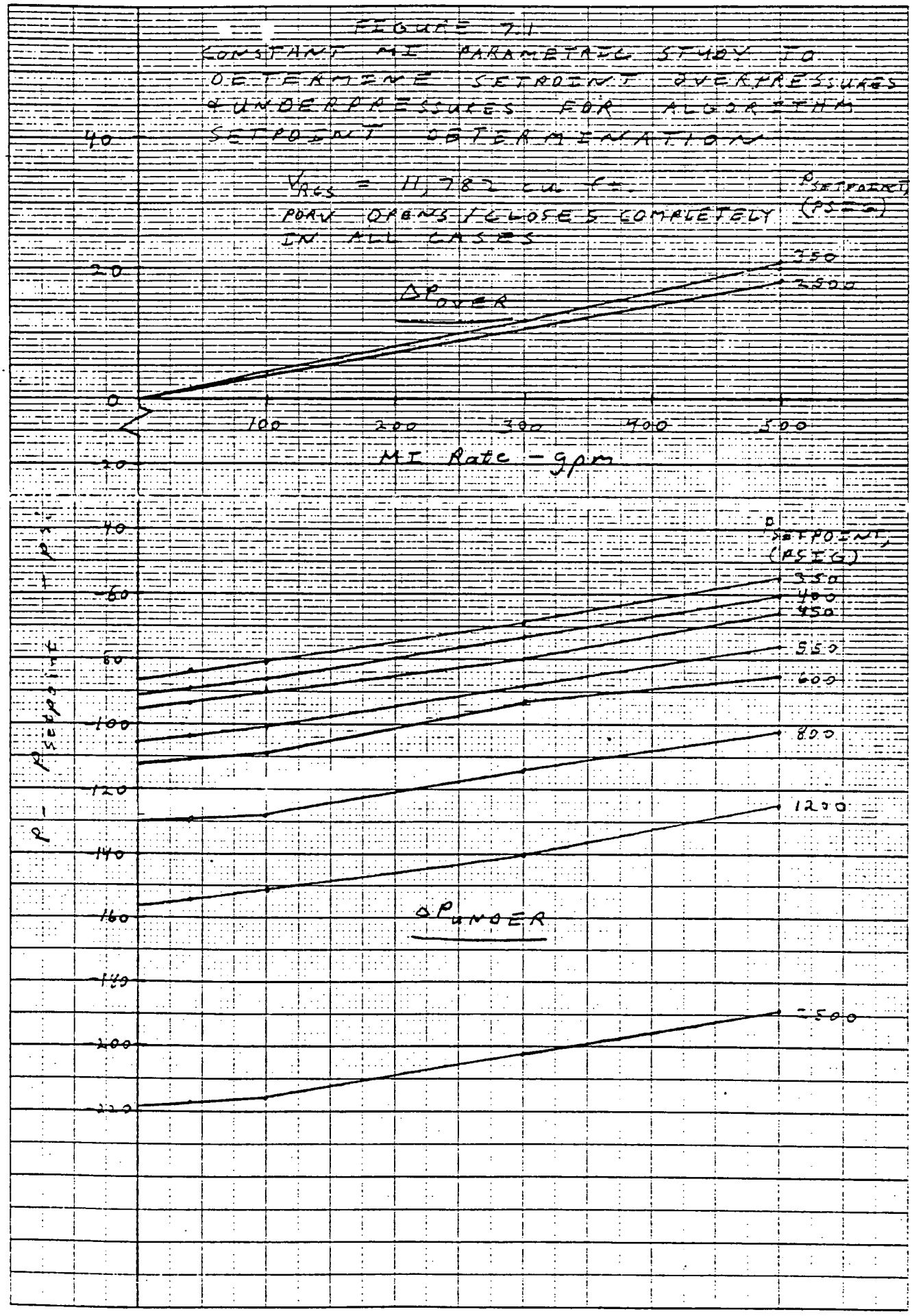
Refer to mass input results of Table 5.1, Section V for a 412 Plant (V_{RCS} = 11,782 ft^3).

(Assumed applicable at all T_{RCS})

The mass input data of Table 5.1, Section V is plotted in Figure 7.1. Setpoint parametric correlations of setpoint overpressure $\Delta P_{OVER} = P_{MAX} - P_{SETPOINT}$ and setpoint underpressure $\Delta P_{UNDER} = P_{SETPOINT} - P_{MIN}$ with (constant) mass input rate were developed to facilitate drawing the locus of maximum RCS pressures produced by MI transients (curve 3 in Figures 7.2 through 7.7) and the locus of minimum RCS pressures produced by the MI transients (curve 5 in Figures 7.2 through 7.7) as a function of setpoint ($P_{SETPOINT}$). As noted in Section II, the range of mass input rates analyzed (40 gpm to 500 gpm) was sufficiently broad to envelope mass injection rates produced by all the letdown isolation mechanisms described in Reference 5.

It should be noted that the ΔP_{UNDER} and ΔP_{OVER} correlations of Figure 7.1 are all monotonic with mass injection rate. This is primarily due to the fast solenoid-actuated valve stroke time in comparison with the generic air valve with a 2 second opening/closing characteristic. Unlike the transients done for the air actuated PORV, the Target Rock valve always opened completely before the valve got a closure signal.

FIGURE 7.1
CONSTANT MI PARAMETRIC STUDY TO DETERMINE SETPOINT OVERPRESSURES & UNDERPRESSURES FOR ALGORITHM SETPOINT DETERMINATION



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K+E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

It should be noted that the maximum ΔP_{UNDER} would be obtained for a charging flow of 0 gpm. This is because with the valve fully open, the depressurization rate is a function of relief flow vs charging flow (for constant RCS pressure). Even though a 0 charging flow would not result in a system pressurization, the conservative ΔP_{UNDER} at this flow rate was used in the calculation of the setpoints.

b. Development of Algorithmic Locus Curves 3 and 5

Table 7.1 summarizes the development of the MI locus Curves 3 and 5 for letdown isolation in Watts Bar Unit 1 with one charging pump operating, utilizing Figure 7.1. The generalized correlations of Figure 7.1 were adjusted to account for specific MI rates as prescribed in Figure 2.1 for one charging pump operation in the development of Curve 3. Curve 5 was developed from Figure 7.1 using the largest ΔP_{UNDER} expected to occur for a prescribed setpoint over the entire MI range (0 gpm to 500 gpm).

2. Heat Input

Refer to heat input results of Table 6.1, Section VI, for the results for the Watts Bar Plant. This data was used directly in determining the ΔP_{OVER} and ΔP_{UNDER} values used for developing curves 4 and 6, respectively, of Figures 7.2 through 7.7.

In developing the PORV setpoint for a given measured RTD temperature, account must be taken of the heat transport effect. If a heat input event were to occur, the cold leg temperature would rapidly rise to that corresponding to the steam generator, while the vessel would still be at the RCS temperature which existed prior to the transient. Therefore, the PORV setpoint must be defined so that it corresponds to the Appendix G limit at the vessel temperature, not the measured RTD temperature. As described in Section III, it was assumed that the RTD was measuring a temperature 63°F higher than the vessel (50°F due to primary to secondary temperature difference plus 13°F instrument error).

TABLE 7.1

ALGORITHM CURVES 3 AND 5 DEVELOPMENT FOR WATTS BAR PROJECT
- 1 CHARGING PUMP/LETDOWN ISOLATION

P_S (PSIG)	MAX MI RATE FROM FIGURE 2.2 (GPM)	$\Delta P_{OVER_{MAX}}$ (PSI) WATTS BAR	$P_{CURVE\ 3}$ OF ALGORITHM (PSIG)	ΔP_{UNDER} (LARGEST, -MARGIN, IF AVAIL.) FROM FIG. 7-1 (PSI)	$P_{CURVE\ 5}$ OF ALGORITHM (PSIG)
350	490	21	371	-86	264
400	490	21	421	-91	309
450	480	20	470	-96	354
550	470	19	569	-106	444
600	465	19	619	-112	488
800	445	18	818	-130	670
1200	400	16	1216	-156	1044
2500	110	4	2504	-219	2281

D. ALGORITHM APPLICATION

(See Figure 7.2 through Figure 7.7)

Figure 7.2 through Figure 7.7 illustrate the application of the algorithm described in Reference 1, Section 4 to Watts Bar Unit 1. Numeric symbols (1) through (9) in each figure summarize the key elements in the application, with (9) representing the range of permissible setpoints based on both MI and HI operations, from which a setpoint can be selected.

The maximum underpressure (ΔP_{UNDER}) utilized for each RCS pressure setpoint in the development of curve 5, the locus from minimum RCS pressure produced by MI transients, is obtained from Figure 7.1. Maximum overpressure (ΔP_{OVER}) selected for each RCS pressure setpoint in the development of curve 3/1cc, the locus of maximum RCS pressures produced by MI transients, is also obtained from Table 7.1. These ΔP_{UNDER} and ΔP_{OVER} values are consistent with all anticipated normal and infrequent modes of mass input (Section II. F), and consider the maximum expected charging rate provided in Figure 2.1.

Algorithm application is extended in symbols (10) through (14) to reflect the specific requirements of Watts Bar Unit 1 as listed in Section IV. E. If the setpoint range over which the RHR valves could be open (10) can be excluded from consideration, the range of permissible setpoints is narrowed to (11) and the plant operability constraint (Section IV. E.3) is applied. If the range of permissible setpoints falls within setpoint range (10), such as is the case at lower RCS temperatures then potential operation of both the PORV and RHR valves must be expected.

Normally, the higher PORV setpoint (14) is determined first, allowing some setpoint margin to the maximum permissible setpoint (where available) for extrapolative/analytical uncertainties in the development or plotting of the analytical results. The lower PORV setpoint (13) would then be determined, based on the constraint minimizing operation of the valve with

the higher setpoint if the valve with the lower setpoint operates (Section IV. E.1). Maximum expected pressure overshoot would be the basis for the difference in the setpoints for the two valves, with overshoot margin added, if available.

Sufficient range of available setpoints (numeral 9) is available for setpoint determination at all RCS temperatures and for all MI and HI events considered consistent with all the requirements and constraints specified in Section IV.

VIII. SETPOINT PROGRAM

The setpoints determined in Section VII for the two relief valves at various RCS temperatures are plotted in Figure 8.1 for Watts Bar Unit 1 together with the Appendix G and RCP No. 1 Seal pressure limits.

For hardware application, the total number of linear segments is limited to a total of 8, which are defined by a total of 9 breakpoints. Linear interpolation is used to calculate valve setpoints between the breakpoints defining the individual line segments. It is important that, in fitting the breakpoints with their linear approximations to the setpoints prescribed by the two curves in Figures 8.1 the limits and constraints delineated in Section IV continue to be observed.

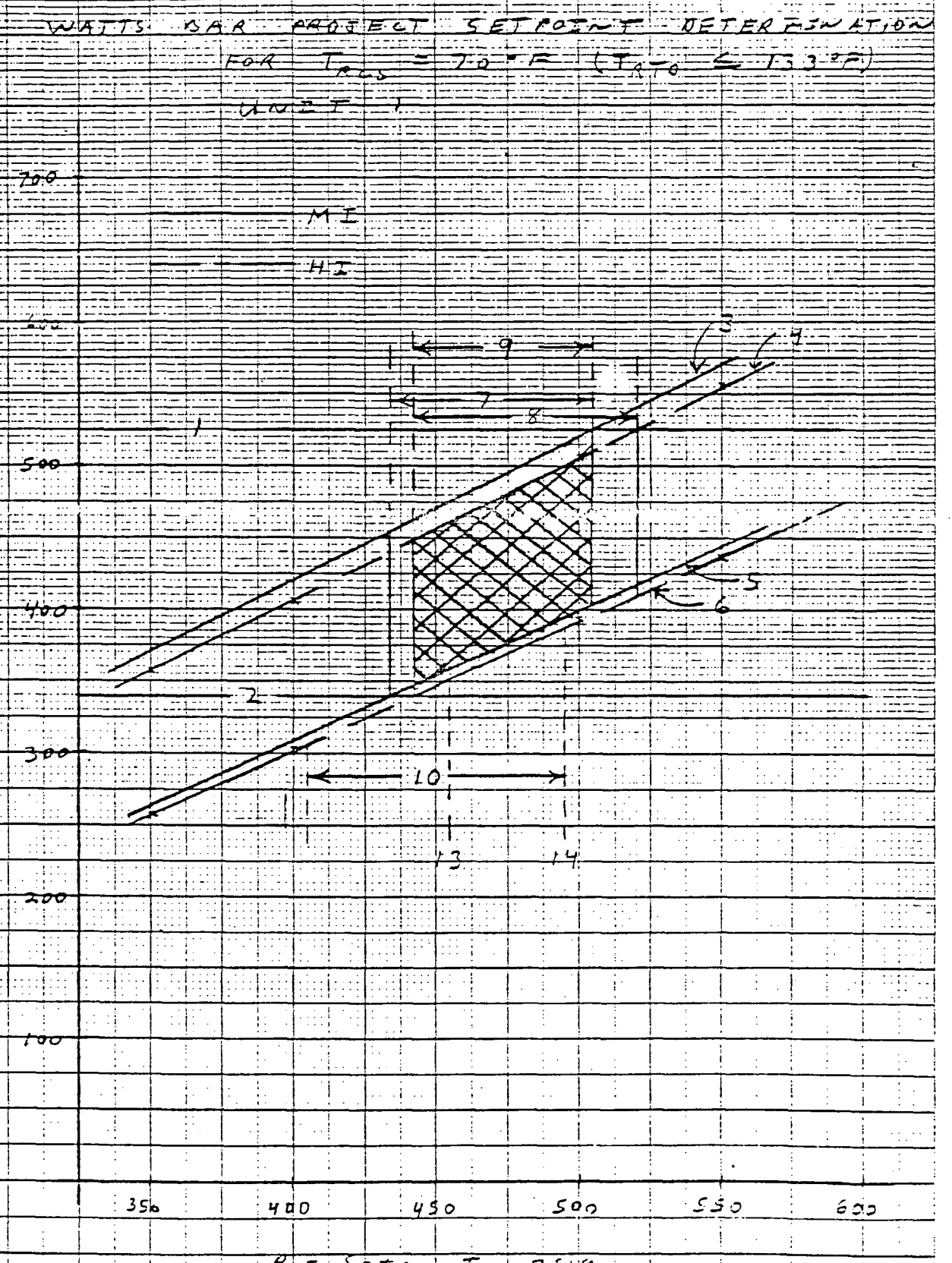
The breakpoints were fitted, subject to these considerations, as shown in Figure 8.1. A listing of the resulting setpoints for the two relief valves is presented in Table 8.1 for Watts Bar Unit 1, together with the corresponding values obtained using the algorithms in Section VII.

FIGURE 7.2

WATTS BAR PROJECT SETPOINT DETERMINATION

FOR T_{RCS} = 70°F (T_{RTO} ≤ 133°F)

UNIT 1



For explanation of numerical symbols, see Section VII.B

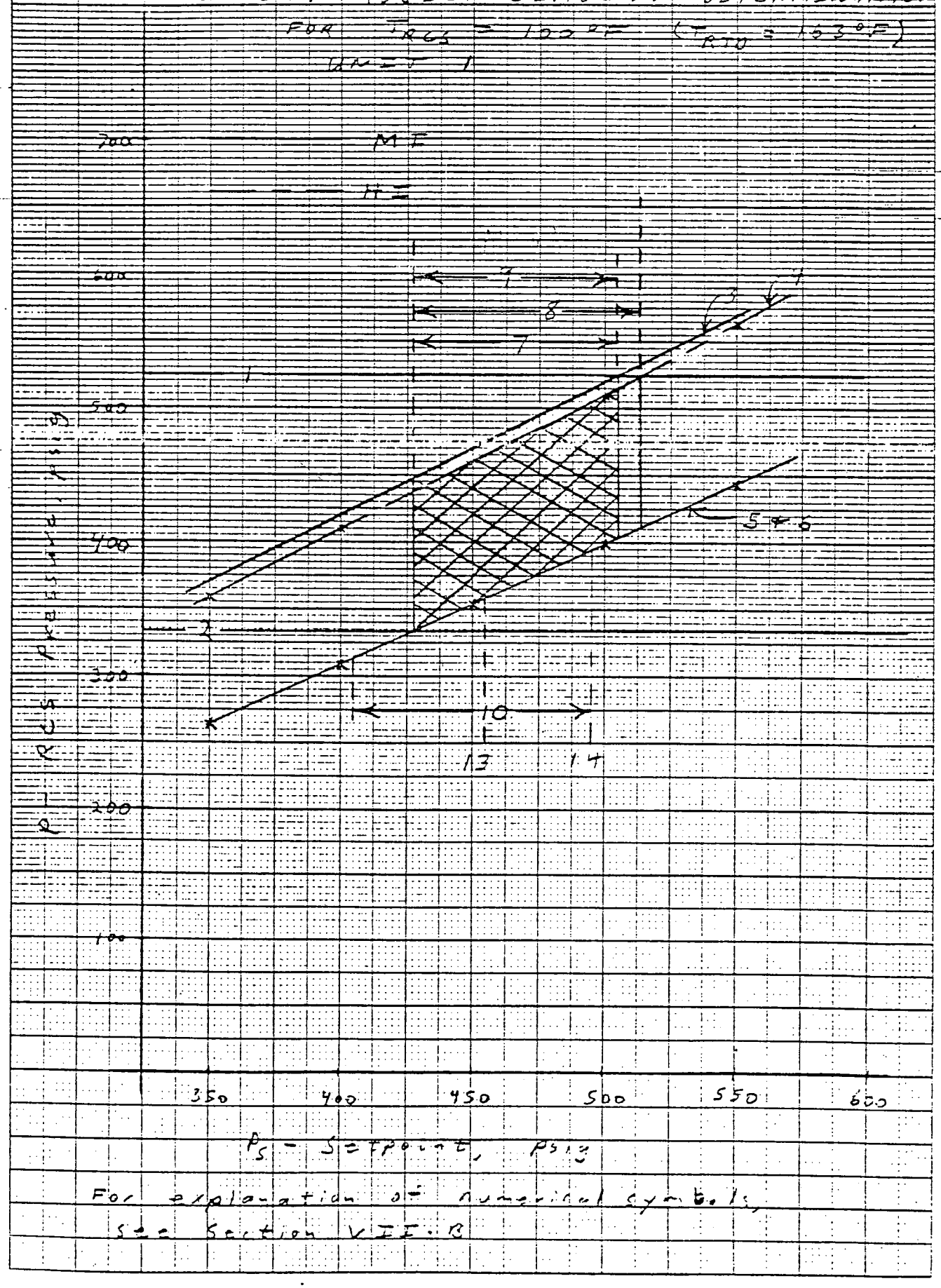
46 1320
K+E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

FIGURE 7.3

WATTS BAR PROJECT SETPOINT DETERMINATION

FOR T_{RCS} = 100°F (T_{RTD} = 103°F)

UNIT 1



For explanation of numerical symbols, see Section VIII.B

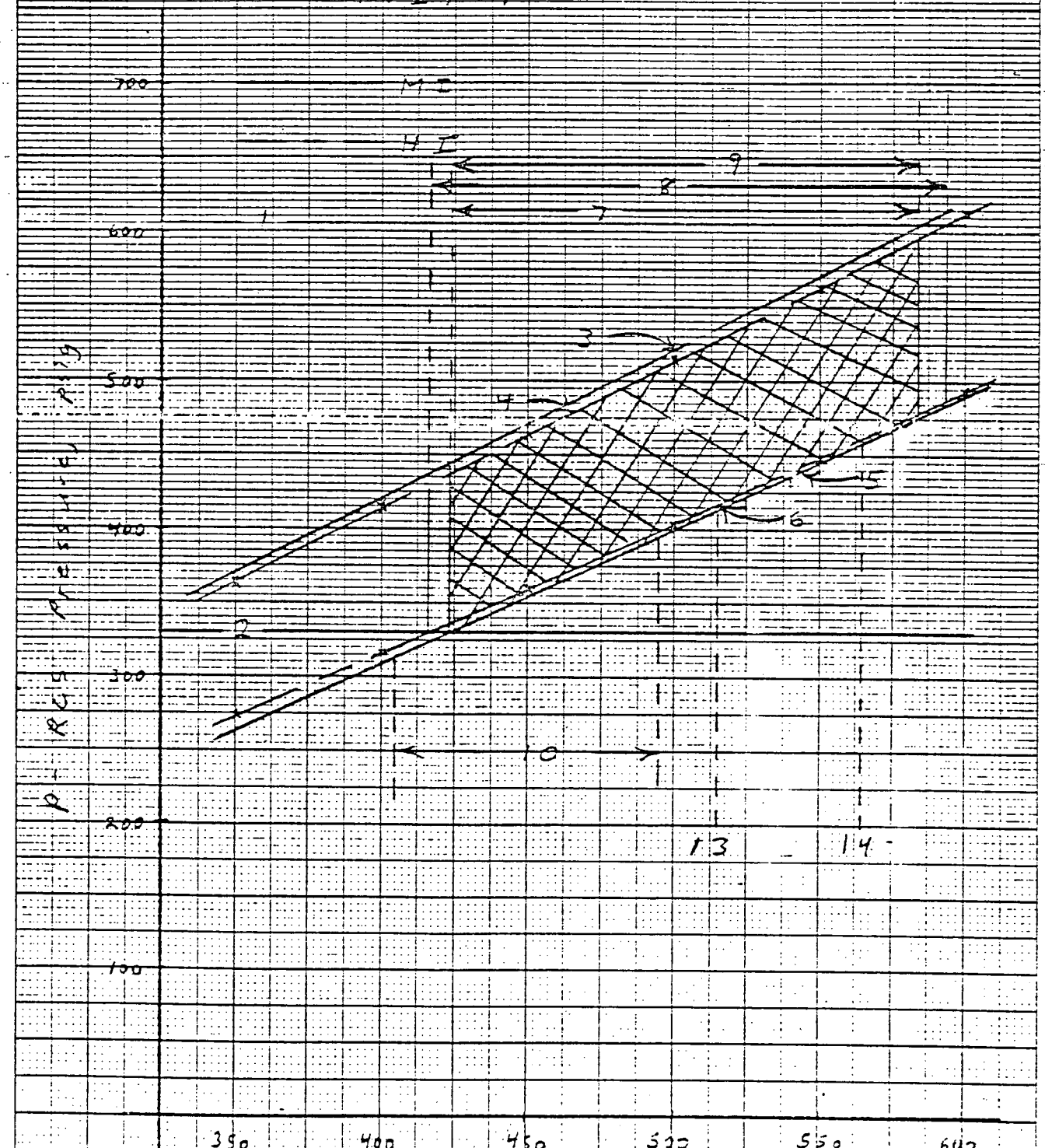
46 1320
K+E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

FIGURE 7.4

WATTS BAR PROJECT SETPOINT DETERMINATION

FOR T_{RCS} = 150°F (T_{RTD} = 212°F)

UNIT 1



For explanation of numerical symbols, see Section VII B

46 1320
K+E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM
KEUFFEL & ESSER CO. MADE IN U.S.A.

461510

FIGURE 7.5

WATTS BAR PROJECT SETPOINT DETERMINATION

FOR UNIT 1

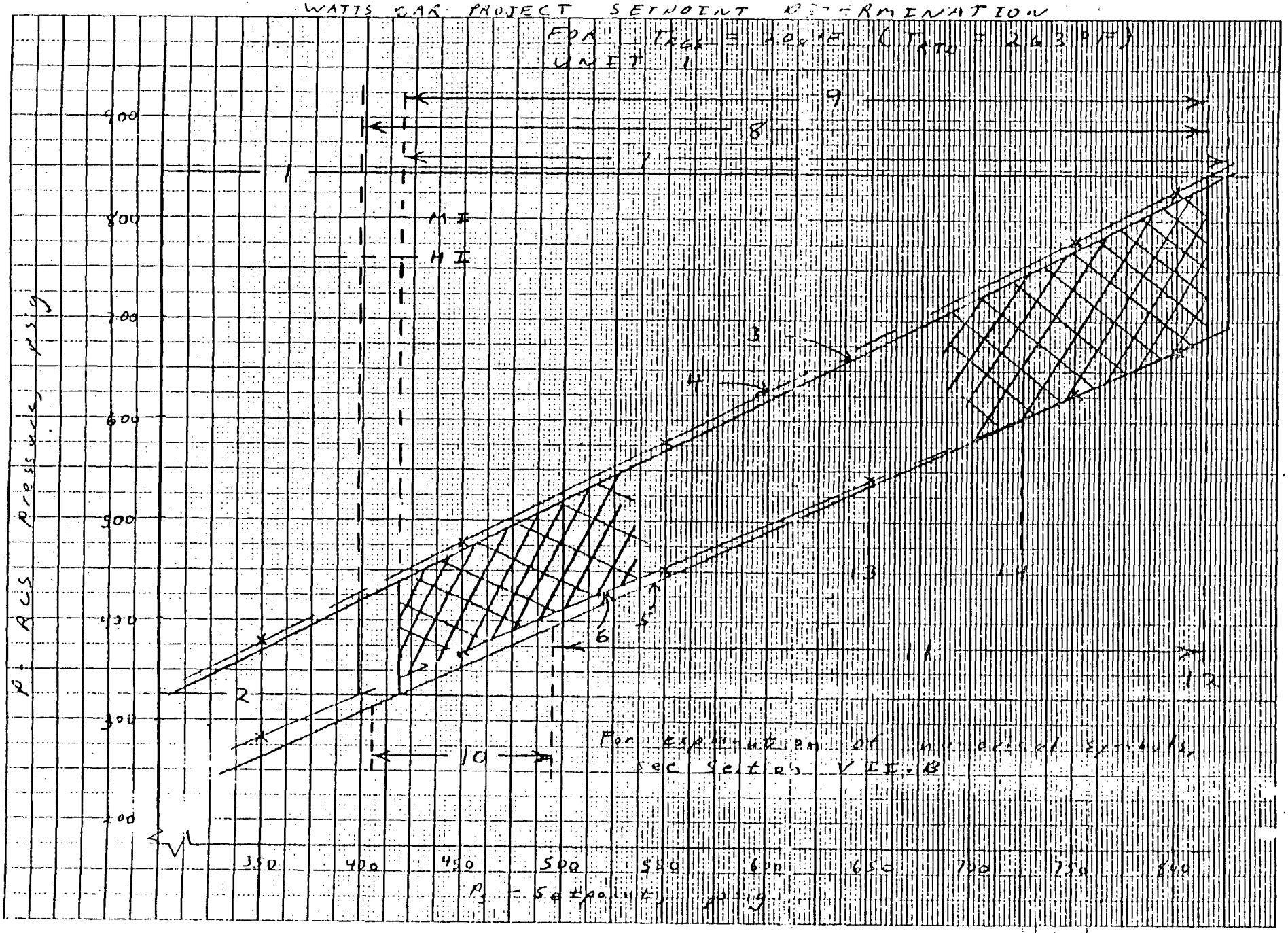
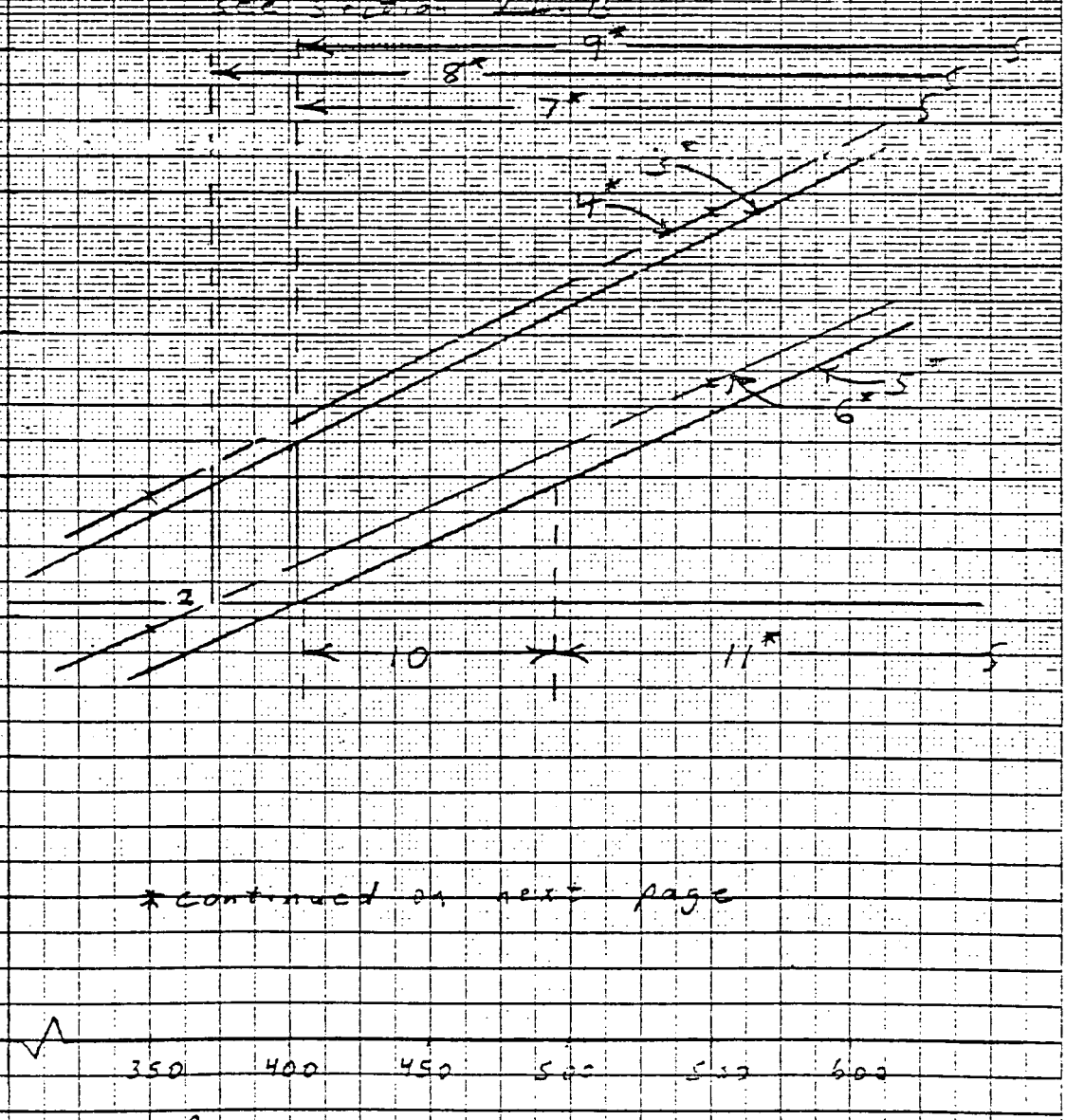


FIGURE 7-6

WATTS ONE PROJECT SETPOINT DETERMINATION

FOR T_{RCS} = 250°F (T_{RTD} = [illegible]°F)

UNIT 1

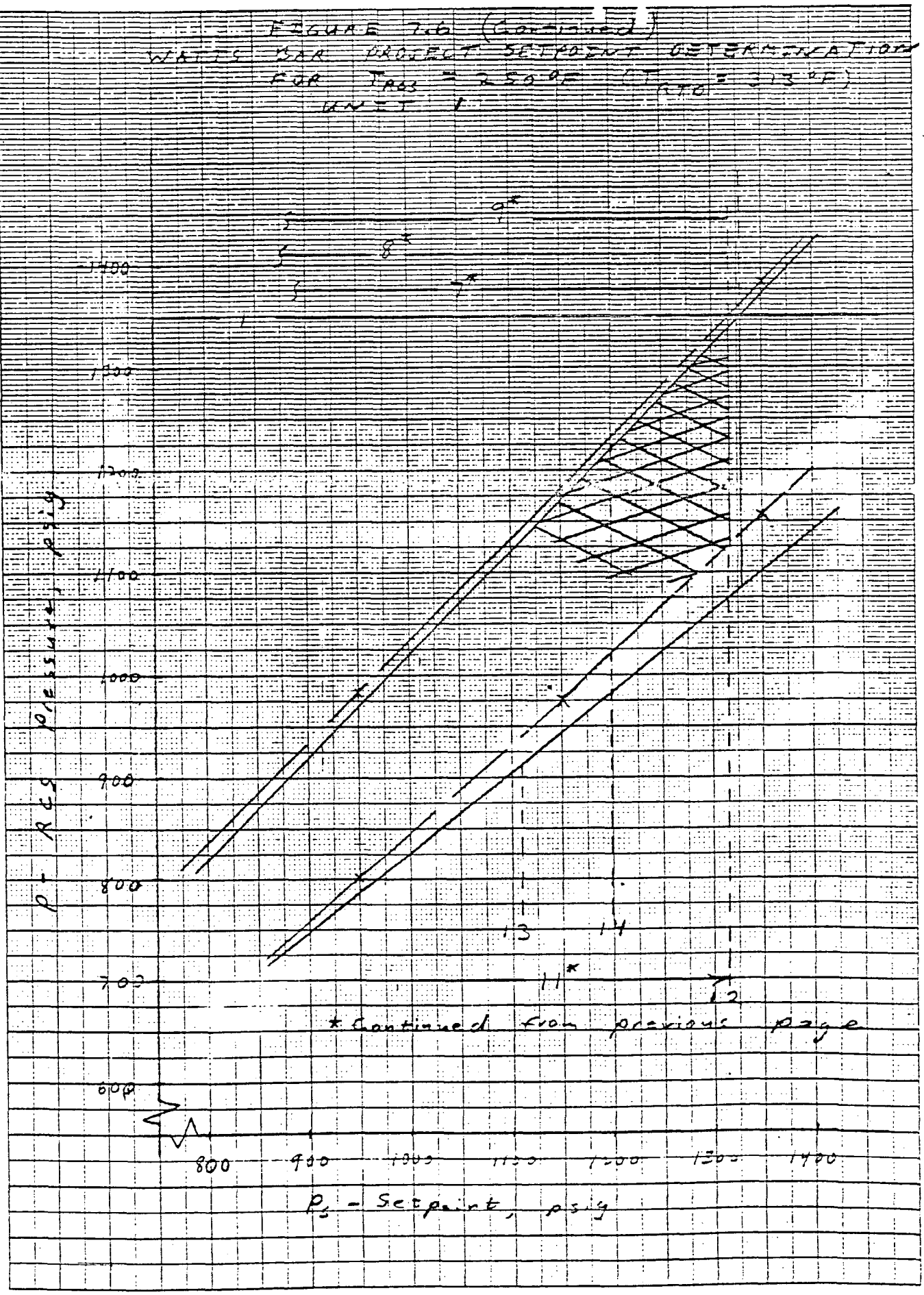


*continued on next page

461510

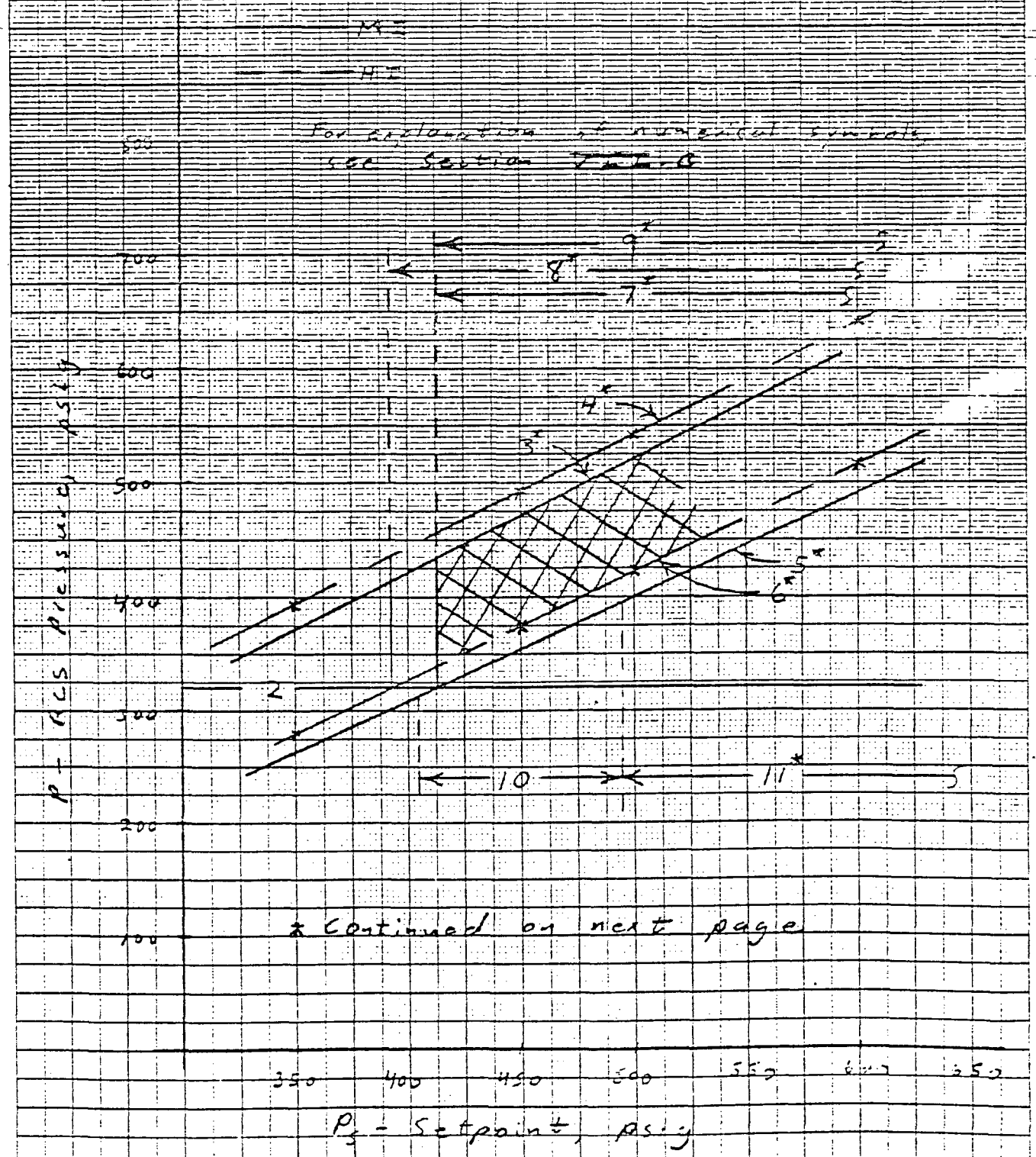
K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM
KEUFFEL & ESSER CO. MADE IN U.S.A.

FIGURE 7.6 (Continued)
WATTS BAR PROJECT SETPOINT DETERMINATION
FOR T_{RCS} = 250°F (T_{RTD} = 313°F)
UNIT 1



461510
K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM.
KEUFFEL & ESSER CO. MADE IN U.S.A.

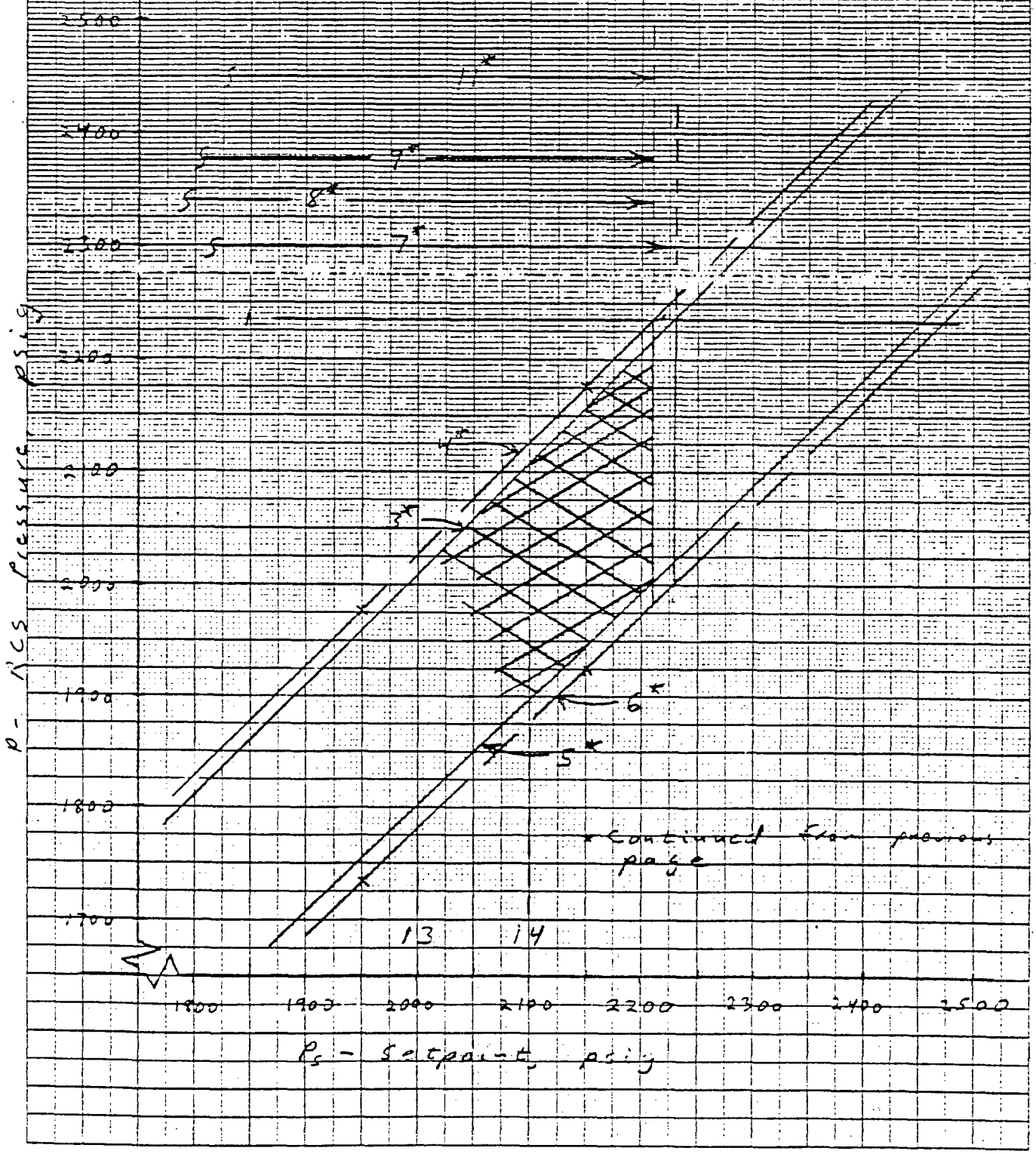
FIGURE 7-7
WATTS BAR PROJECT SETPOINT DETERMINATION
FOR T_{RCS} = 300 °F (T_{RTD} = 363 °F)
UNIT 1



* Continued on next page

461510
K&E 10 X 10 TO THE CENTIMETER 18 X 25 CM KEUFFEL & ESSER CO. MADE IN U.S.A.

FIGURE 7.7 (Continued)
WATTS BAR PROJECT SETPOINT DETERMINATION
FOR T_{RCS} = 300°F (T_{RIO} = 300°F)
UNIT 1



461510
K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM
KEUFFEL & ESSER CO. MADE IN U.S.A.

FIGURE 8.1
WATTS BAR UNIT 1
SETPOINT DETERMINATION
FOR RCS COLD OVERPRESSURIZATION

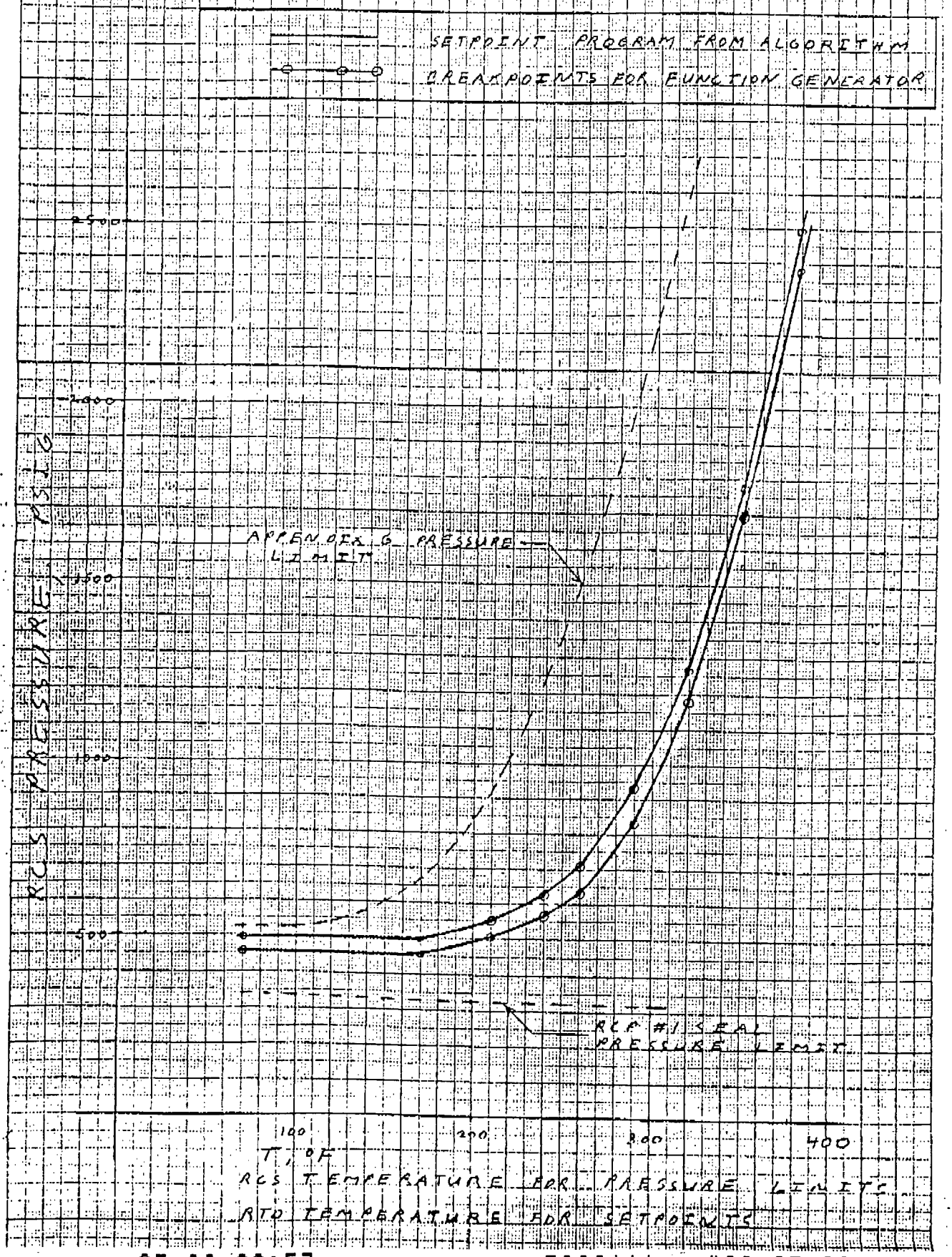


TABLE 8.1

SUMMARY OF SETPOINT DATA FOR WATTS BAR UNIT ONE PLANT

SETPOINT, PSIG

	From Algorithm Application		Function Generator Breakpoints	
T_{RTD}, °F	PORV No. 1	PORV No. 2	PORV No. 1	PORV No. 2
70	455	495	455	495
163	455	495	—	—
170	—	—	455	495
210	—	—	505	550
213	515	565	—	—
240	—	—	565	625
260	—	—	630	705
263	650	725	—	—
290	—	—	835	930
313	1100	1200	—	—
320	—	—	1175	1265
350	—	—	1695	1775
363	2000	2100	—	—
380	—	—	2390	2495

REFERENCES

1. WCAP-9540, July 1979

2. NS-MFSE-1376

3. FSD/RCS-73, 10/8/80

4. FSD/RCS-427, 5/21/82,

5. FSD/SS-TVA/WAT-1086

6. FSD/SS-TVA-1085

7. W-5065, 6/6/83

8. FA-761, 6/27/80

9. FA-935, 11/26/80

10. W-5113, 7/13/83