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SUPPLEMENT TO THE JULY 1977 REPORT

PRESSURE MITIGATING SYSTEMS TRANSIENT ANALYSIS RESULTS

Prepared by

WESTINGHOUSE ELECTRIC CORPORATION

FOR

THE WESTINGHOUSE OWNERS GROUP ON

REACTOR COOLANT SYSTEM

OVERPRESSURIZATION

September 1977

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- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 6,000 CU.FT.

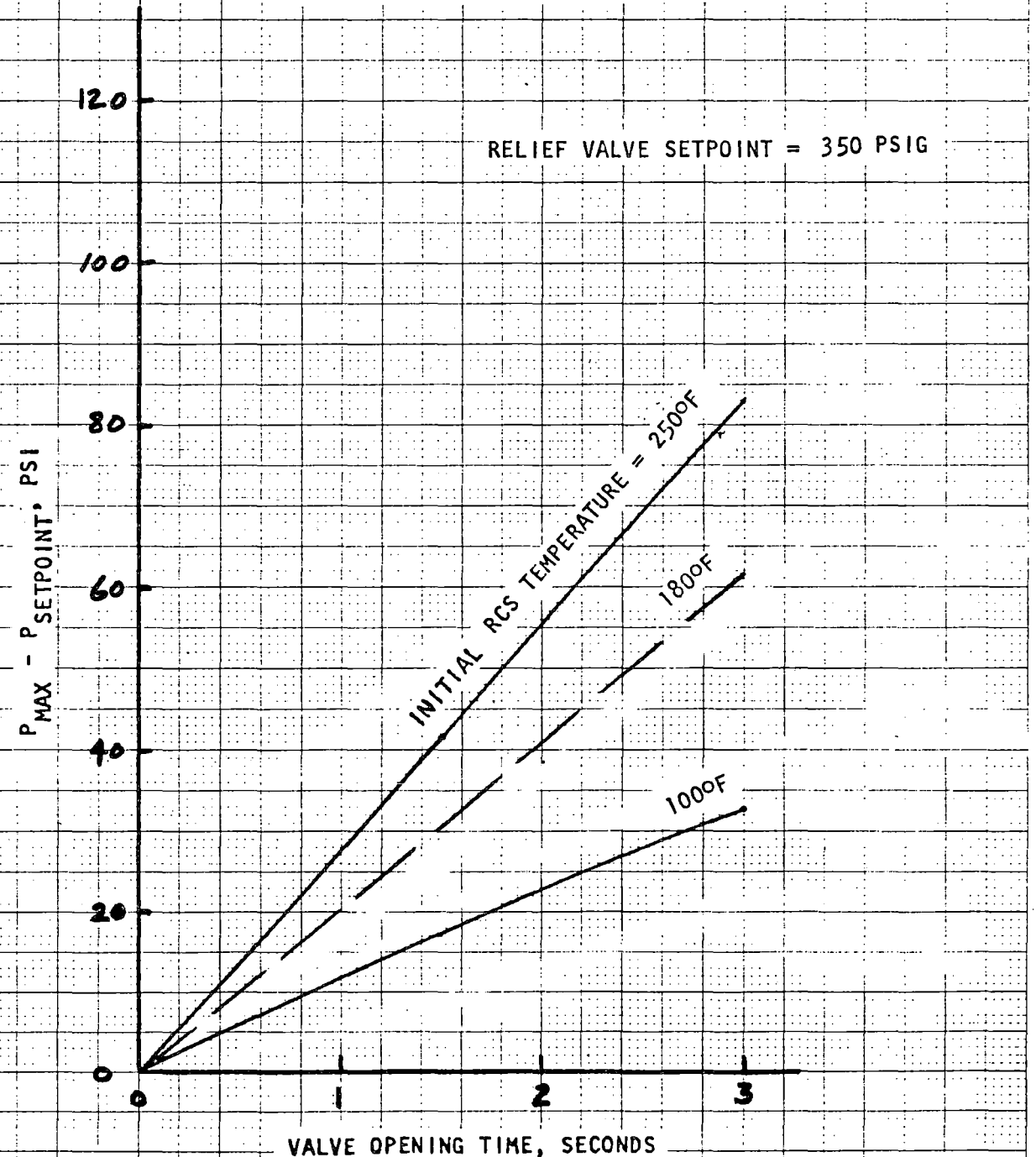
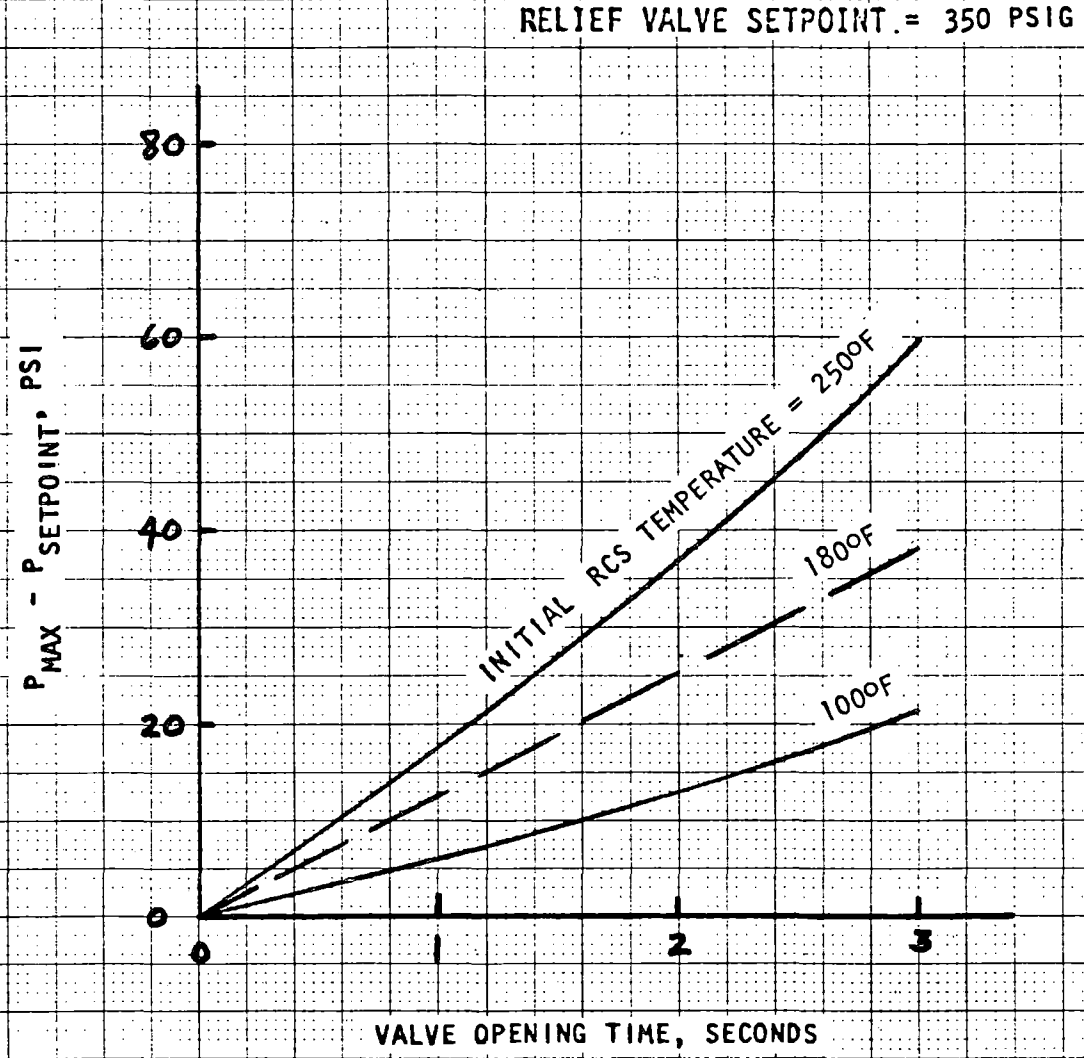


Figure 2

EFFECT OF RELIEF VALVE OPENING TIME ON RCS PRESSURE OVERSHOOT

- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 13000 CU.FT.



EFFECT OF RELIEF VALVE OPENING TIME ON RCS PRESSURE OVERSHOOT

Figure 3

- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 6,000 CU.FT.

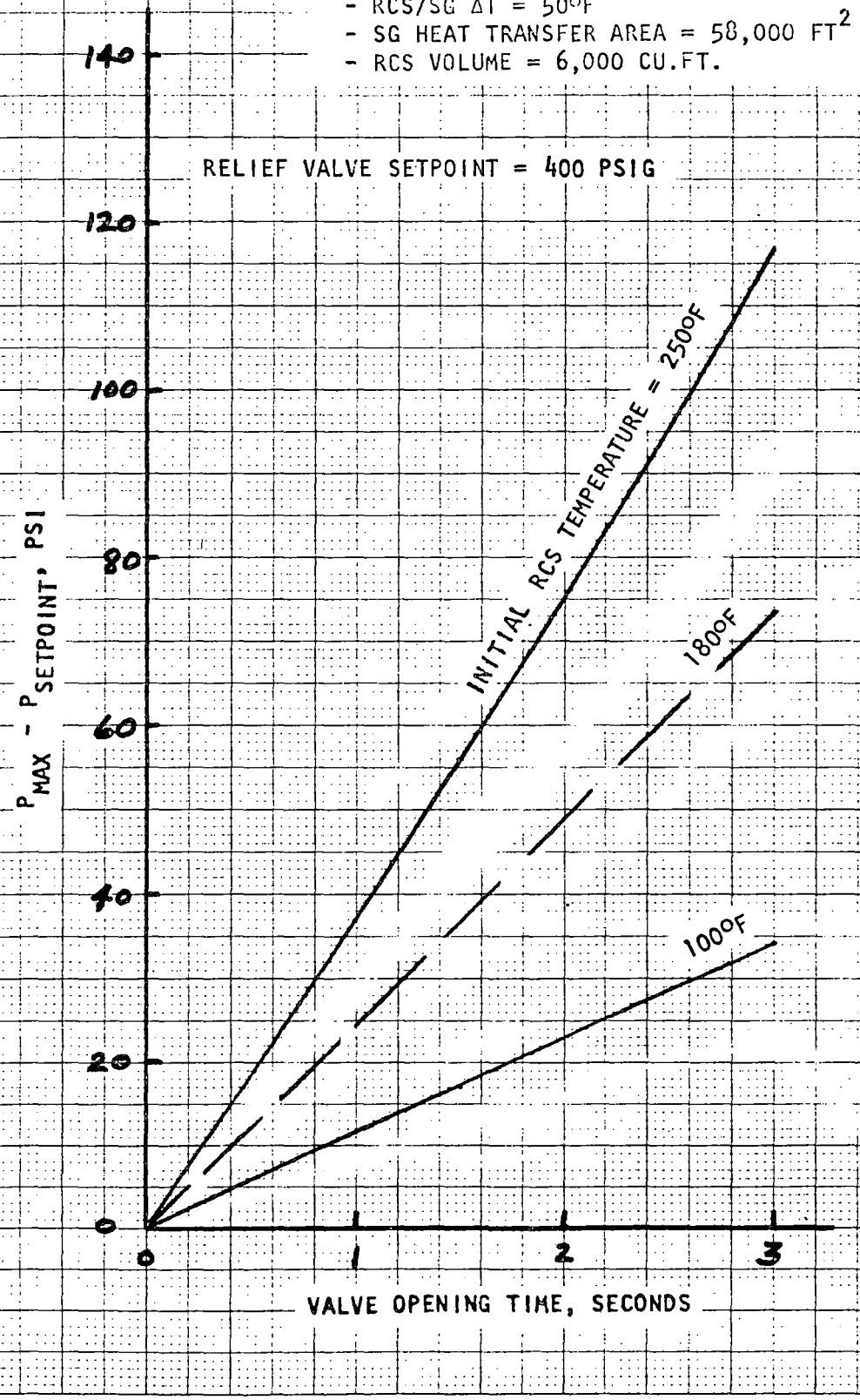


Figure 4

EFFECT OF RELIEF VALVE OPENING TIME ON RCS PRESSURE OVERSHOOT

- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = **13000 CU. FT.**

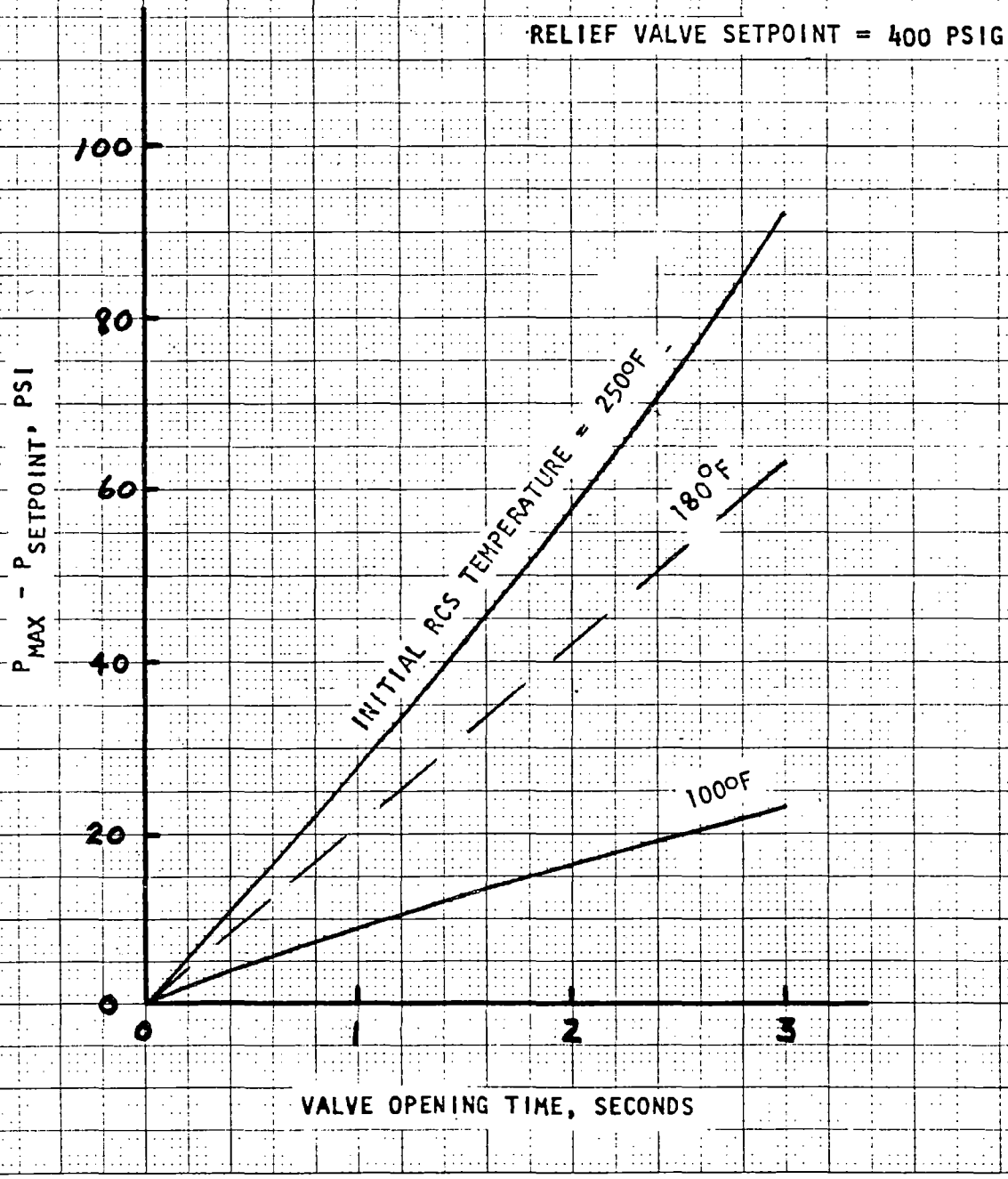


Figure 5

EFFECT OF RELIEF VALVE OPENING TIME ON RCS PRESSURE OVERSHOOT

- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 6,000 CU.FT.

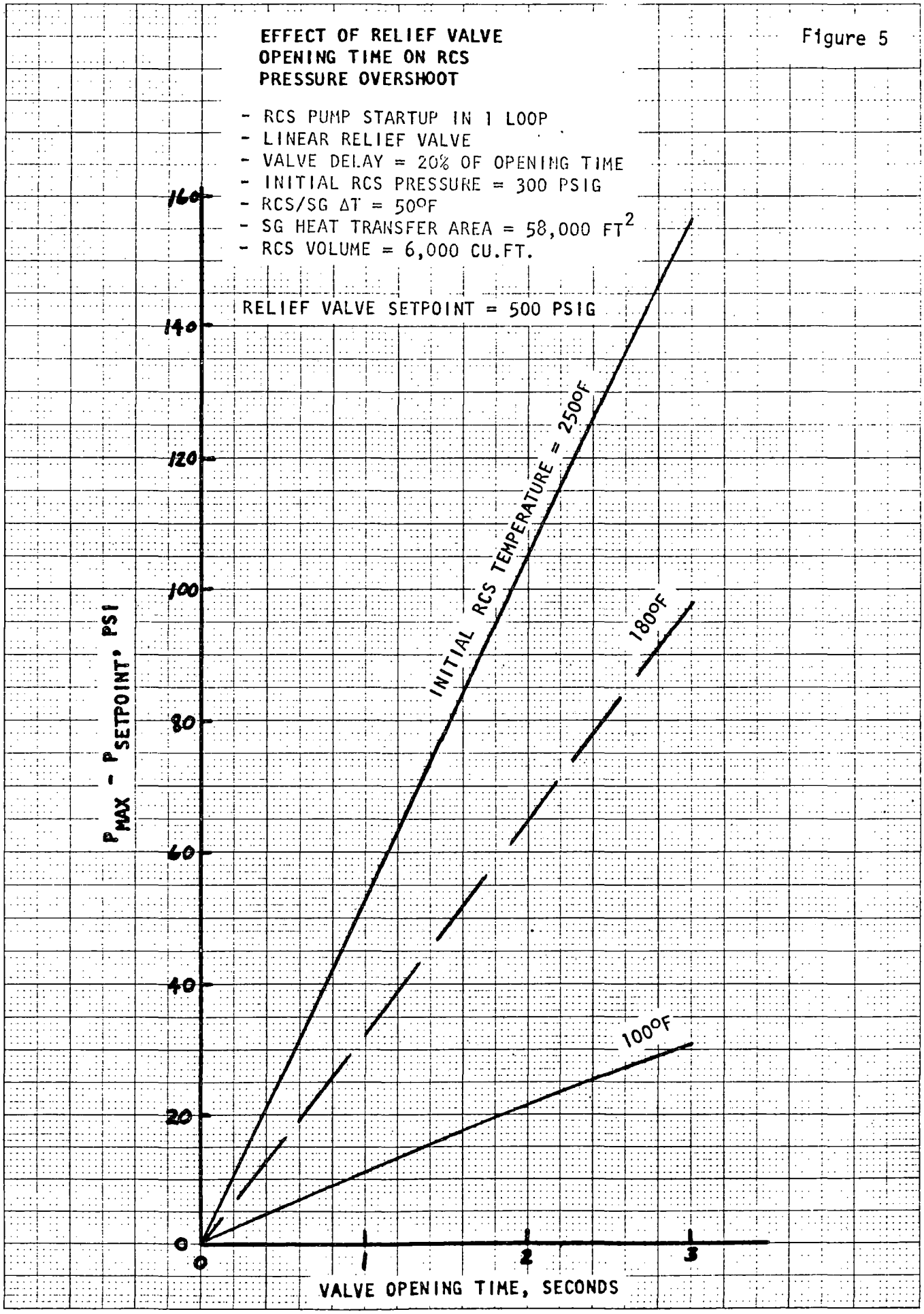
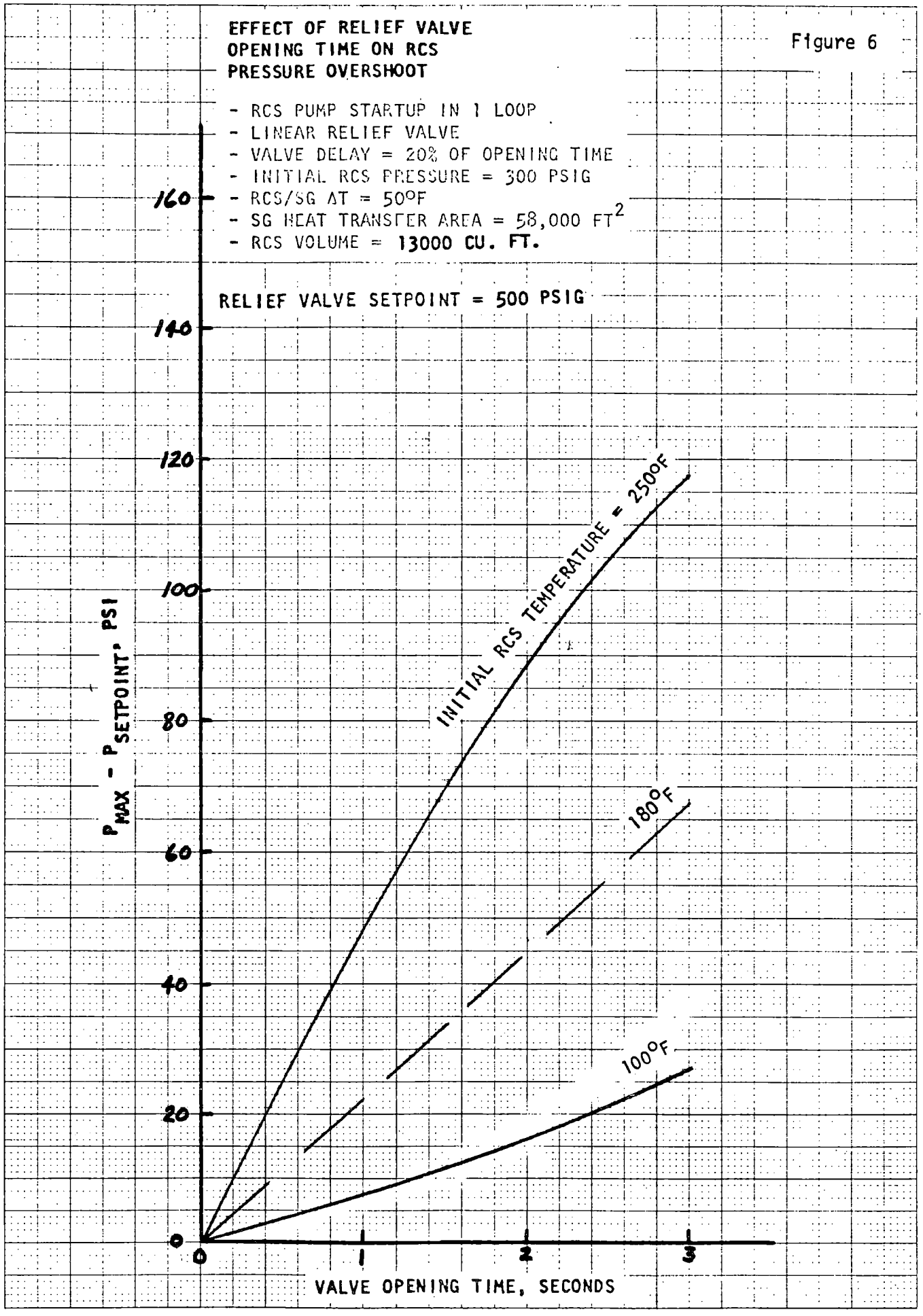


Figure 6


EFFECT OF RELIEF VALVE OPENING TIME ON RCS PRESSURE OVERSHOOT
- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT²
- RCS VOLUME = 13000 CU. FT.
RELIEF VALVE SETPOINT = 500 PSIG
INITIAL RCS TEMPERATURE = 250°F
180°F
100°F
P_MAX - P_SETPOINT, PSI
VALVE OPENING TIME, SECONDS
0
20
40
60
80
100
120
140
160
0
1
2
3

B. SETPOINT OVERSHOOT VARIATION WITH RELIEF VALVE SETPOINT

Figure 7

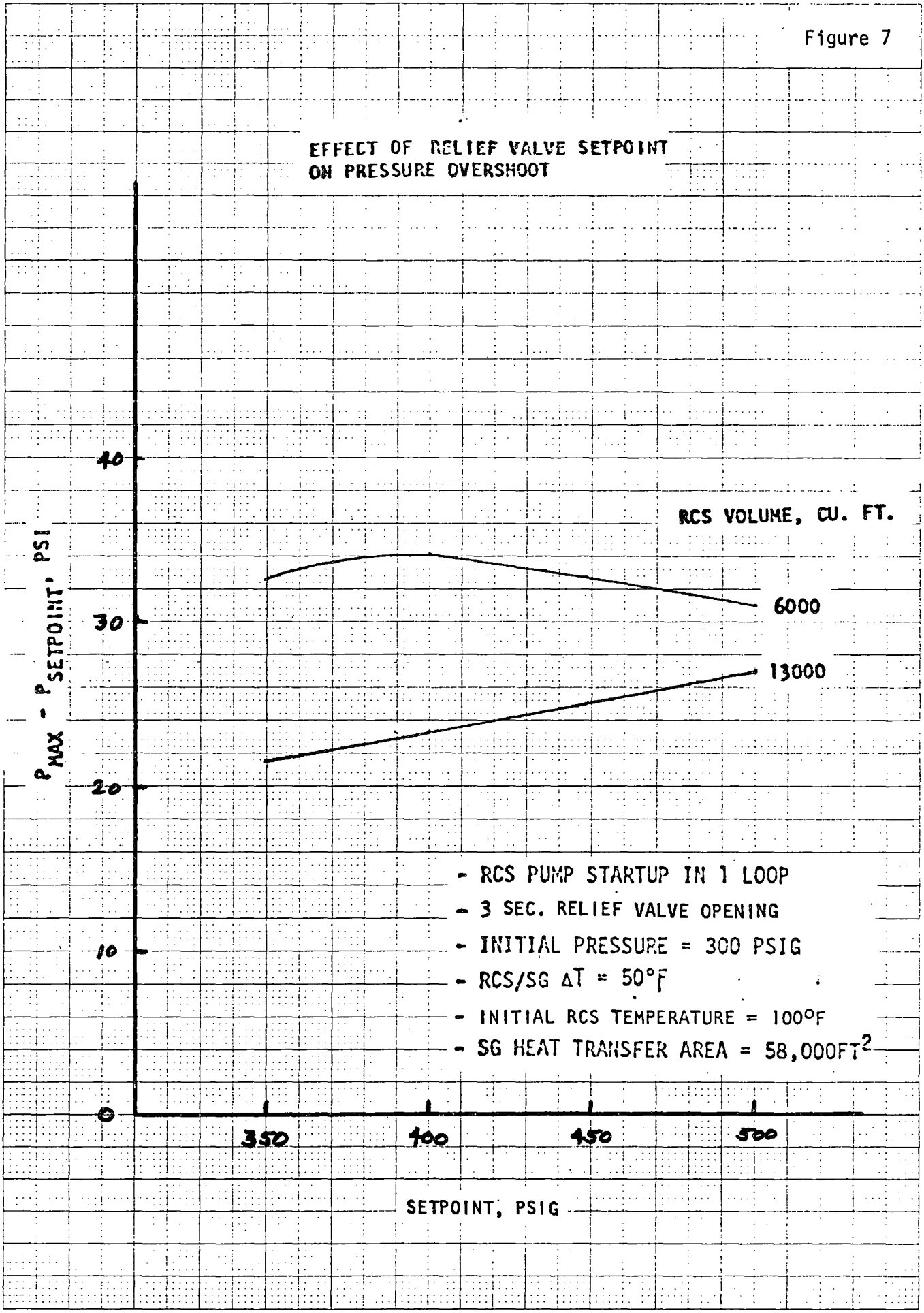

EFFECT OF RELIEF VALVE SETPOINT
ON PRESSURE OVERSHOOT
$P_{MAX} - P_{SETPOINT}$, PSI
40
30
20
10
0
RCS VOLUME, CU. FT.
6000
13000
- RCS PUMP STARTUP IN 1 LOOP
- 3 SEC. RELIEF VALVE OPENING
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- INITIAL RCS TEMPERATURE = 100°F
- SG HEAT TRANSFER AREA = 58,000FT^2
350
400
450
500
SETPOINT, PSIG

Figure 8

EFFECT OF RELIEF VALVE SETPOINT ON PRESSURE OVERSHOOT

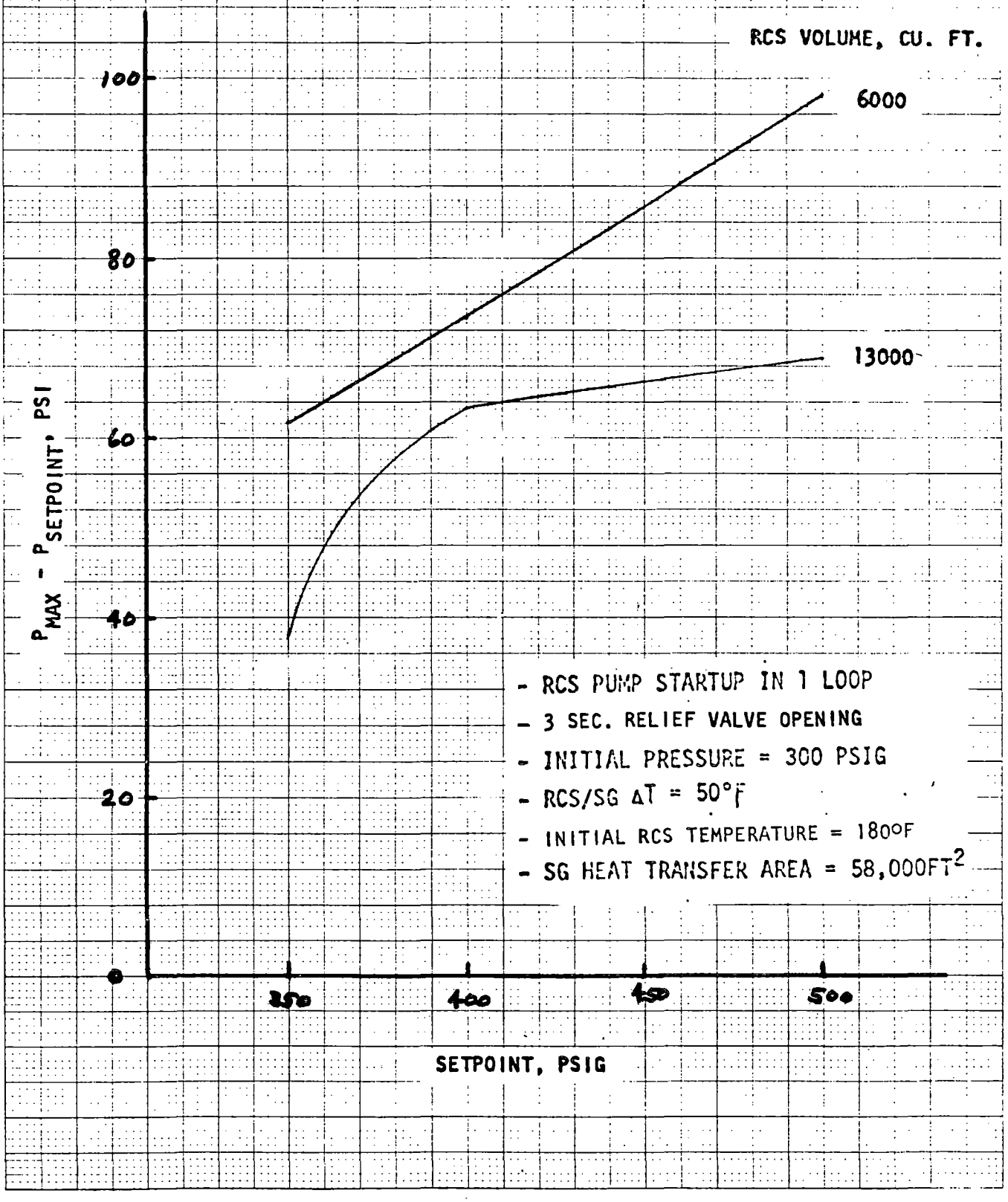


Figure 9

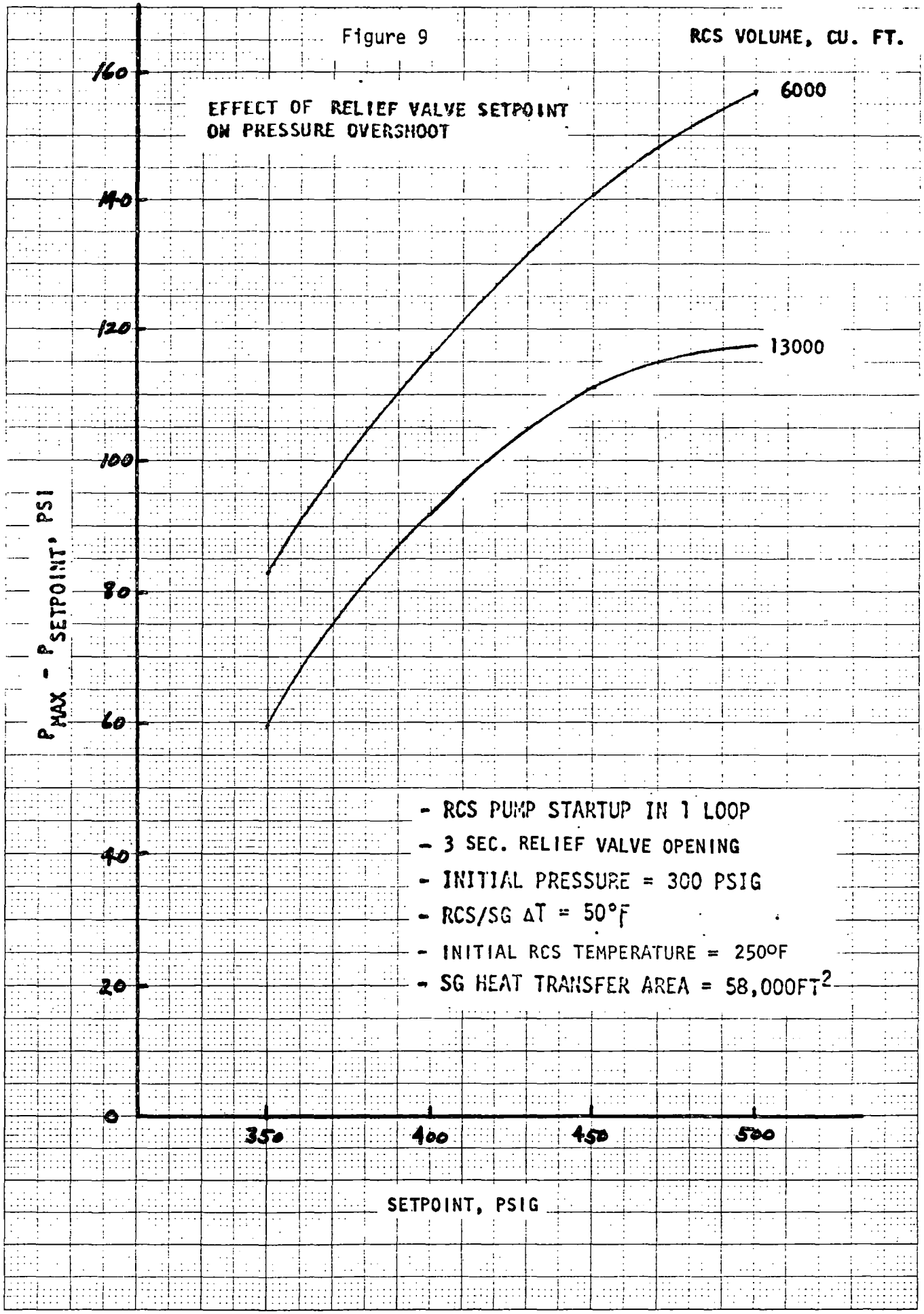

EFFECT OF RELIEF VALVE SETPOINT ON PRESSURE OVERSHOOT
RCS VOLUME, CU. FT.
6000
13000
$P_{MAX} - P_{SETPOINT}$, PSI
160
140
120
100
80
60
40
20
0
350
400
450
500
SETPOINT, PSIG
- RCS PUMP STARTUP IN 1 LOOP
- 3 SEC. RELIEF VALVE OPENING
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- INITIAL RCS TEMPERATURE = 250°F
- SG HEAT TRANSFER AREA = 58,000FT^2

Figure 10

EFFECT OF RELIEF VALVE SETPOINT ON PRESSURE OVERSHOOT

- RCS PUMP STARTUP IN 1 LOOP
- 1.5 SEC. RELIEF VALVE OPENING
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- INITIAL RCS TEMPERATURE = 100°F
- SG HEAT TRANSFER AREA = 58,000FT^2

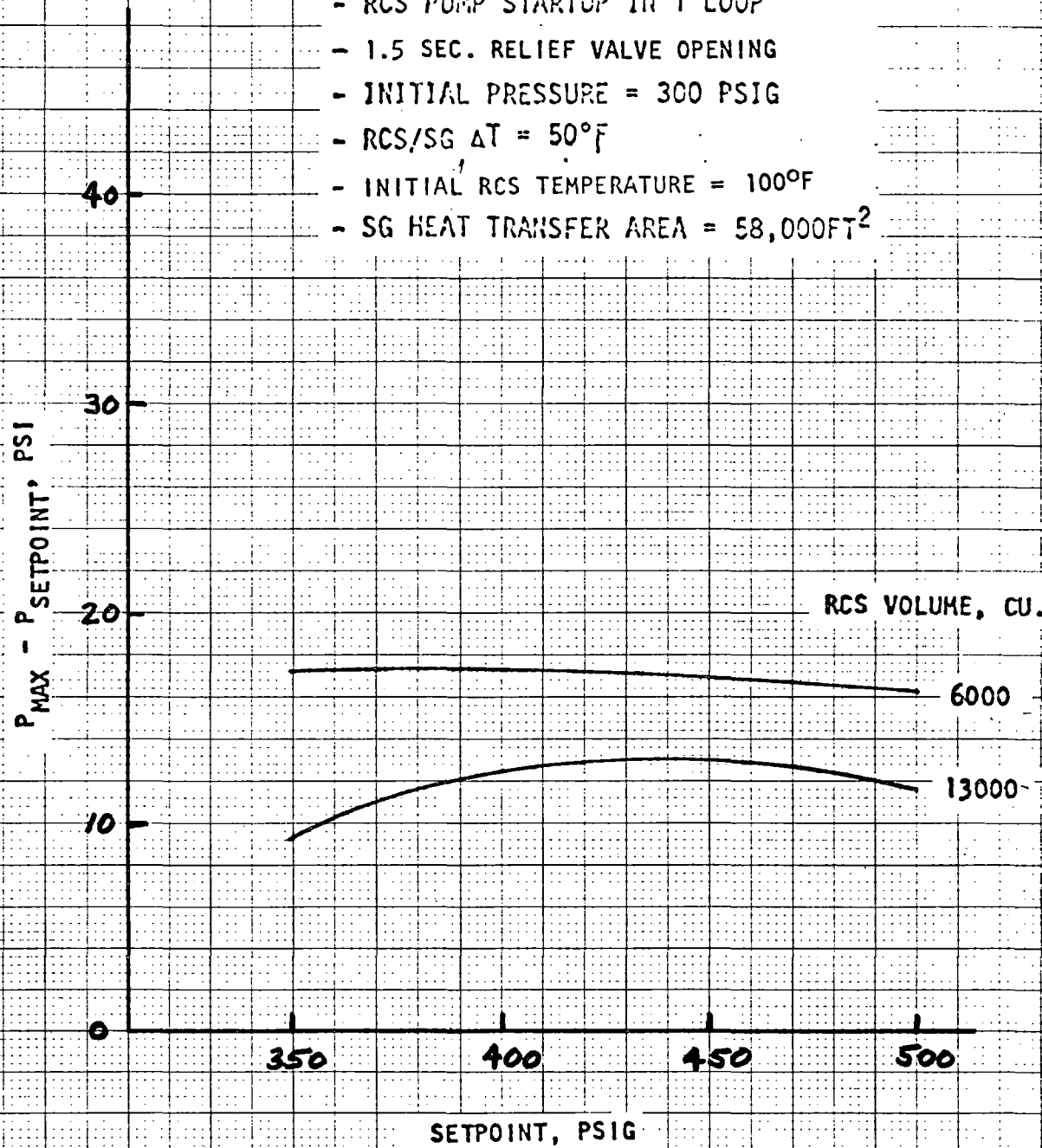
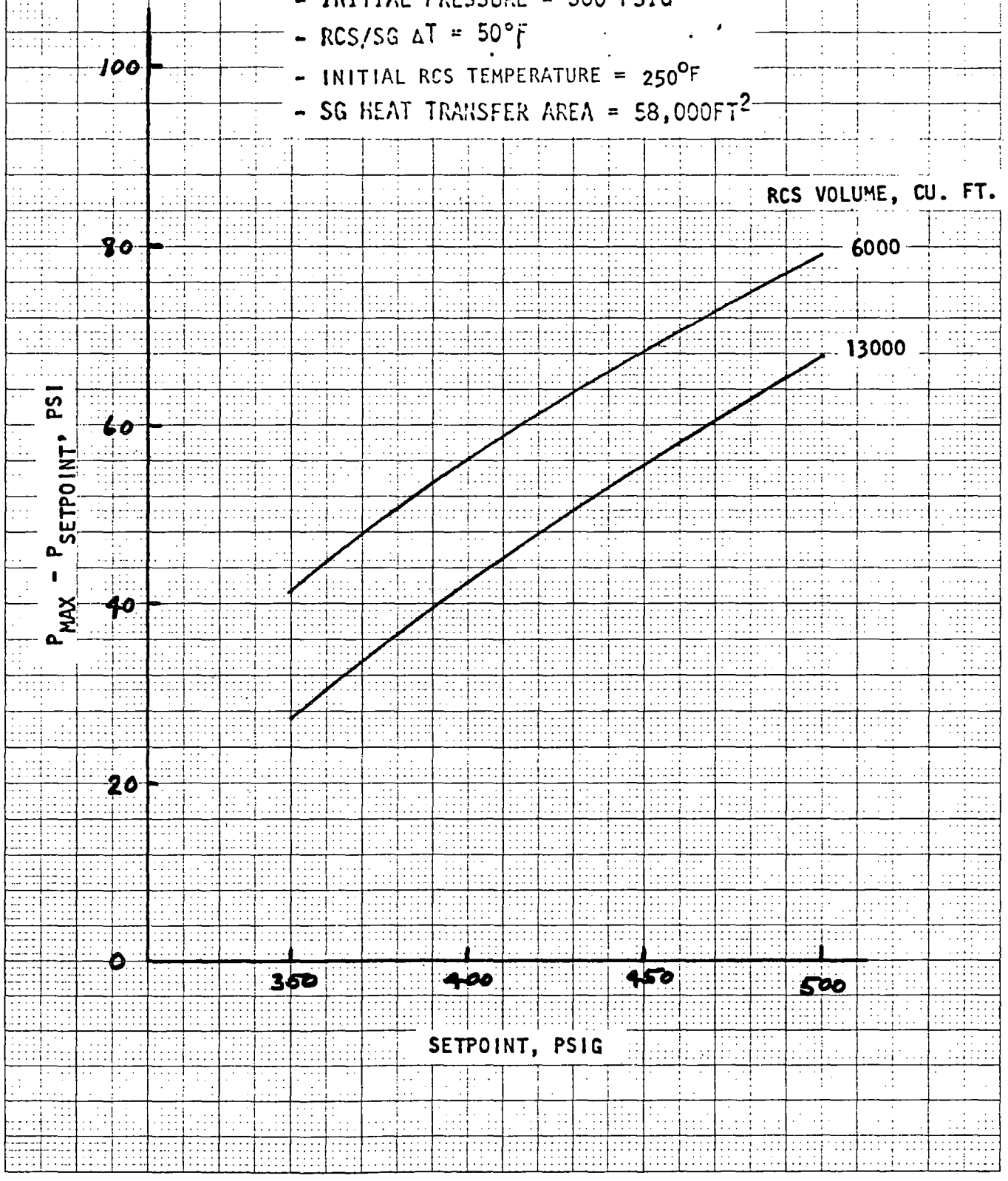


Figure 11

EFFECT OF RELIEF VALVE SETPOINT ON PRESSURE OVERSHOOT

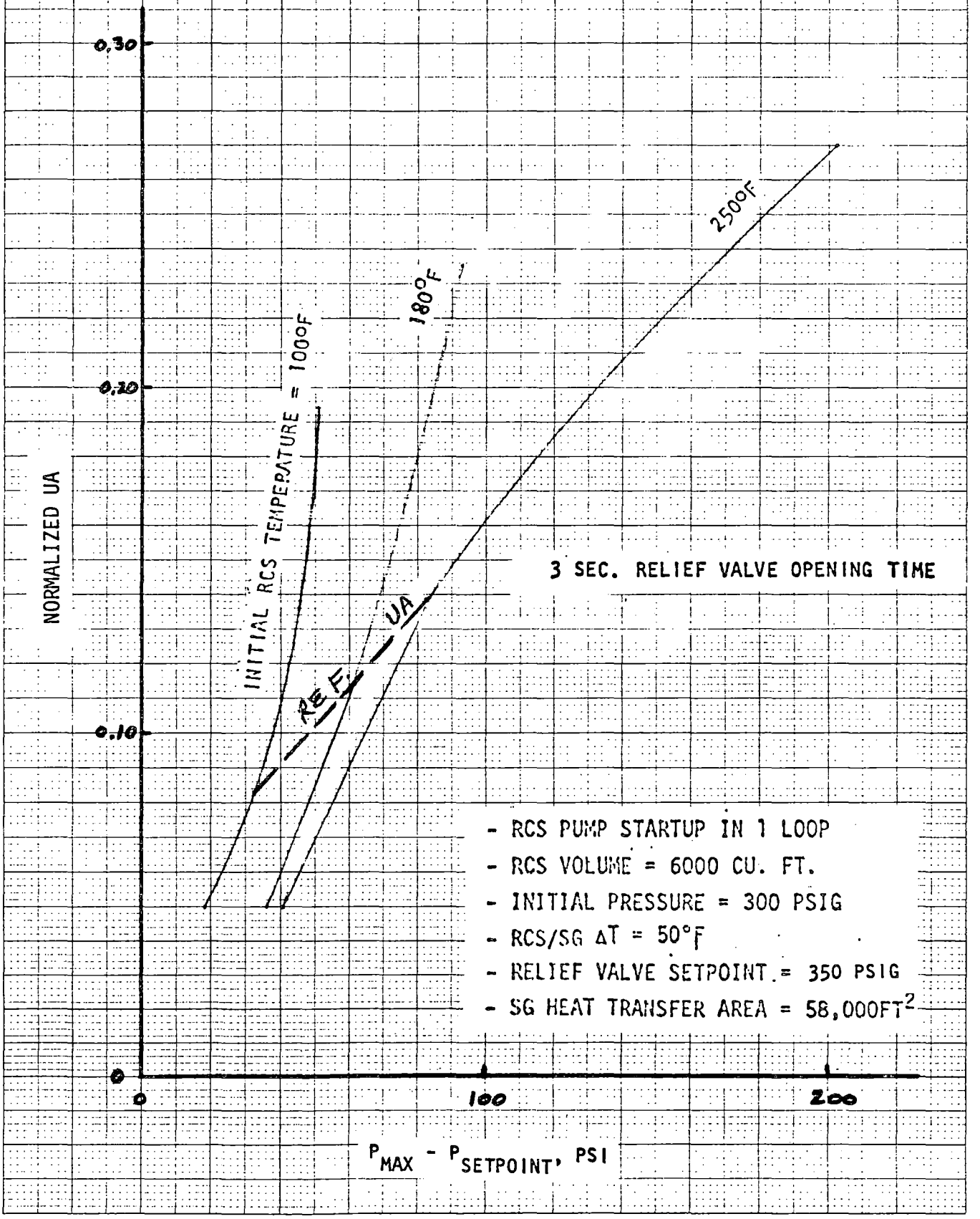
- RCS PUMP STARTUP IN 1 LOOP
- 1.5 SEC. RELIEF VALVE OPENING
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- INITIAL RCS TEMPERATURE = 250°F
- SG HEAT TRANSFER AREA = 58,000FT^2



C. SETPOINT OVERSHOOT VARIATION WITH NORMALIZED STEAM GENERATOR UA

Figure 12

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 13

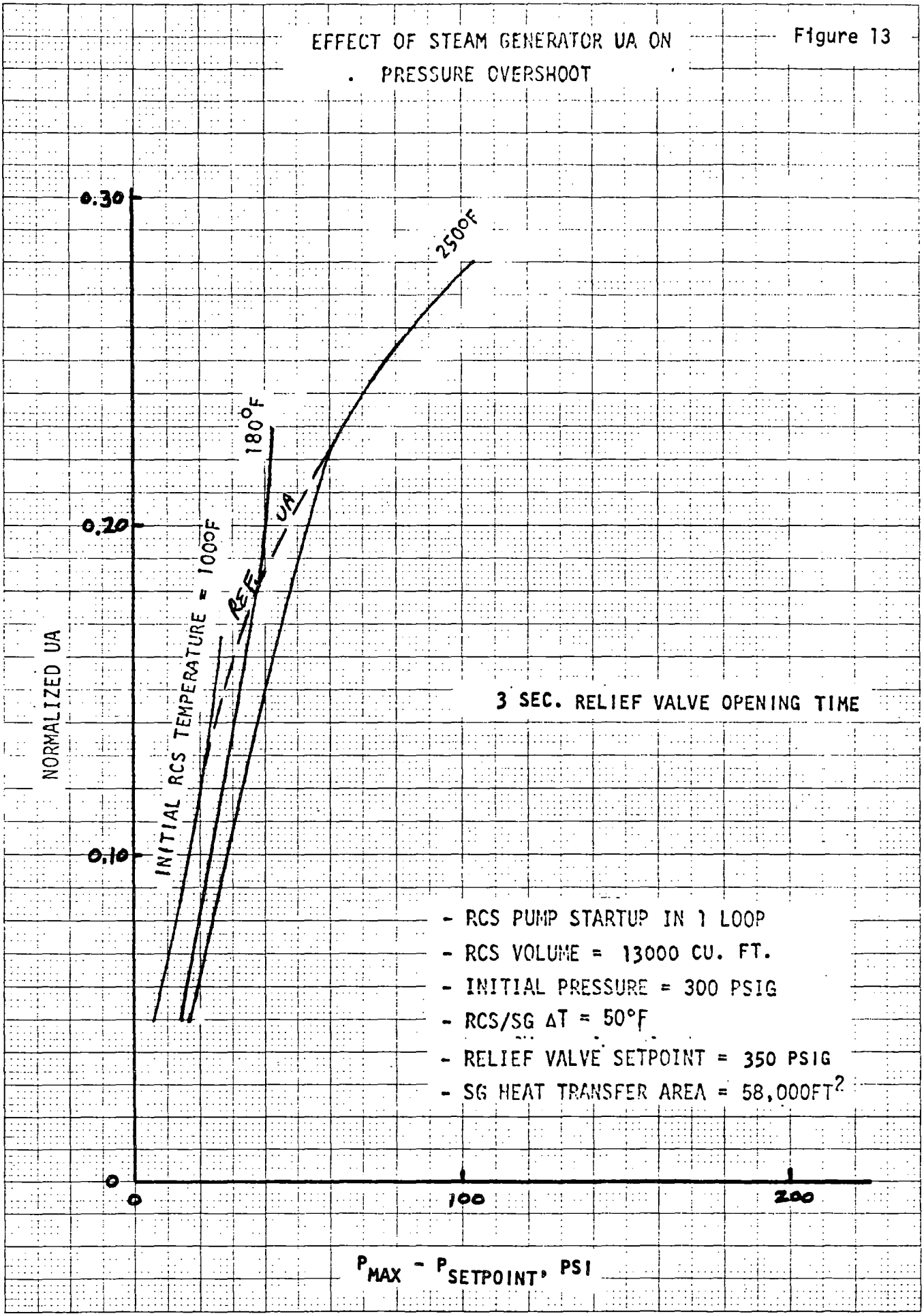
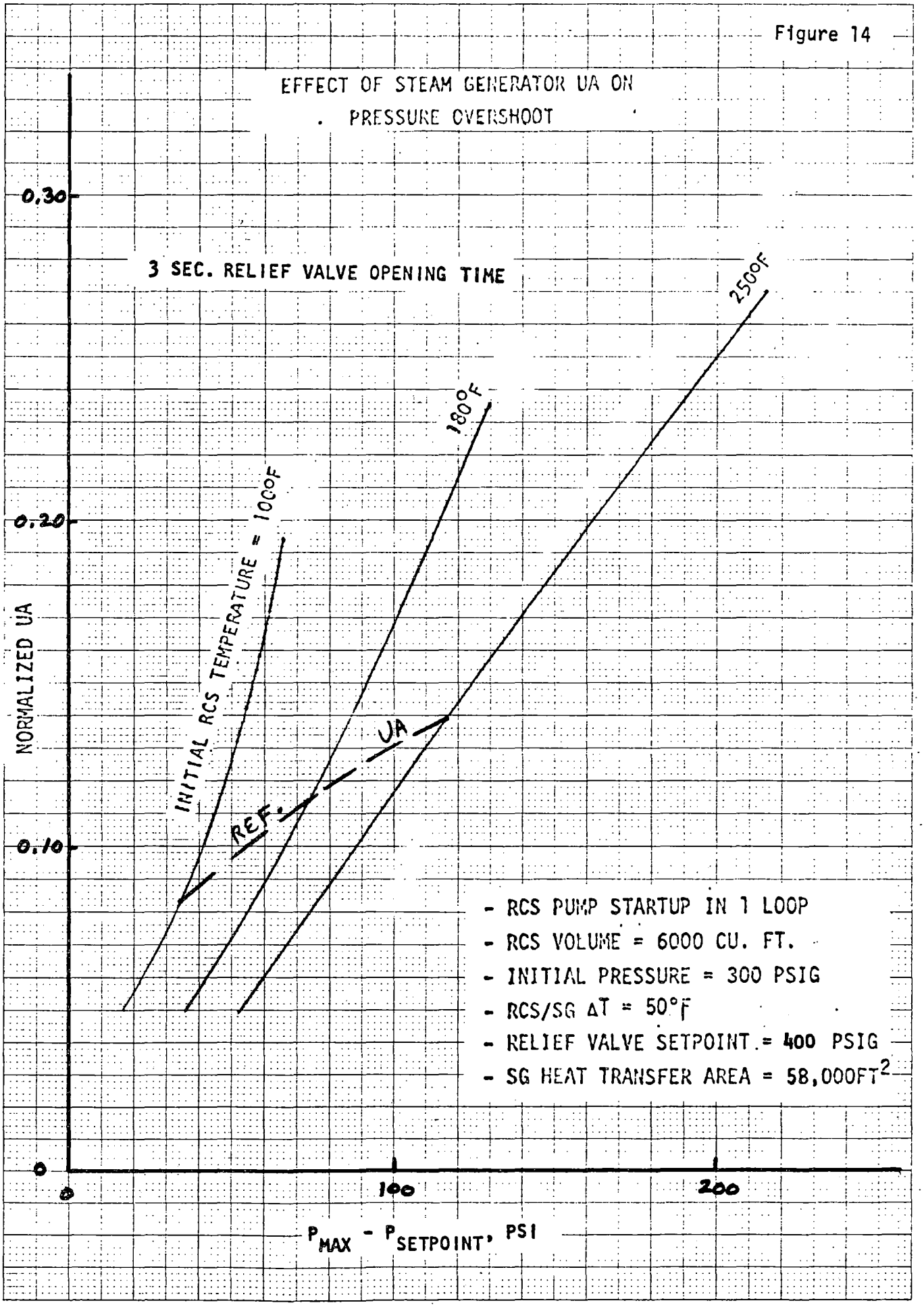

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT
NORMALIZED UA
0.30
0.20
0.10
0
0
100
200
$P_{MAX} - P_{SETPOINT}$, PSI
250°F
180°F
REF. UA
INITIAL RCS TEMPERATURE = 100°F
3 SEC. RELIEF VALVE OPENING TIME
- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 13000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- RELIEF VALVE SETPOINT = 350 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²

Figure 14


EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT
3 SEC. RELIEF VALVE OPENING TIME
NORMALIZED UA
0.30
0.20
0.10
0
0
100
200
$P_{MAX} - P_{SETPOINT}$, PSI
INITIAL RCS TEMPERATURE = 100°F
180°F
250°F
REF.
UA
- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 6000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- RELIEF VALVE SETPOINT = 400 PSIG
- SG HEAT TRANSFER AREA = 58,000FT^2

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

Figure 15

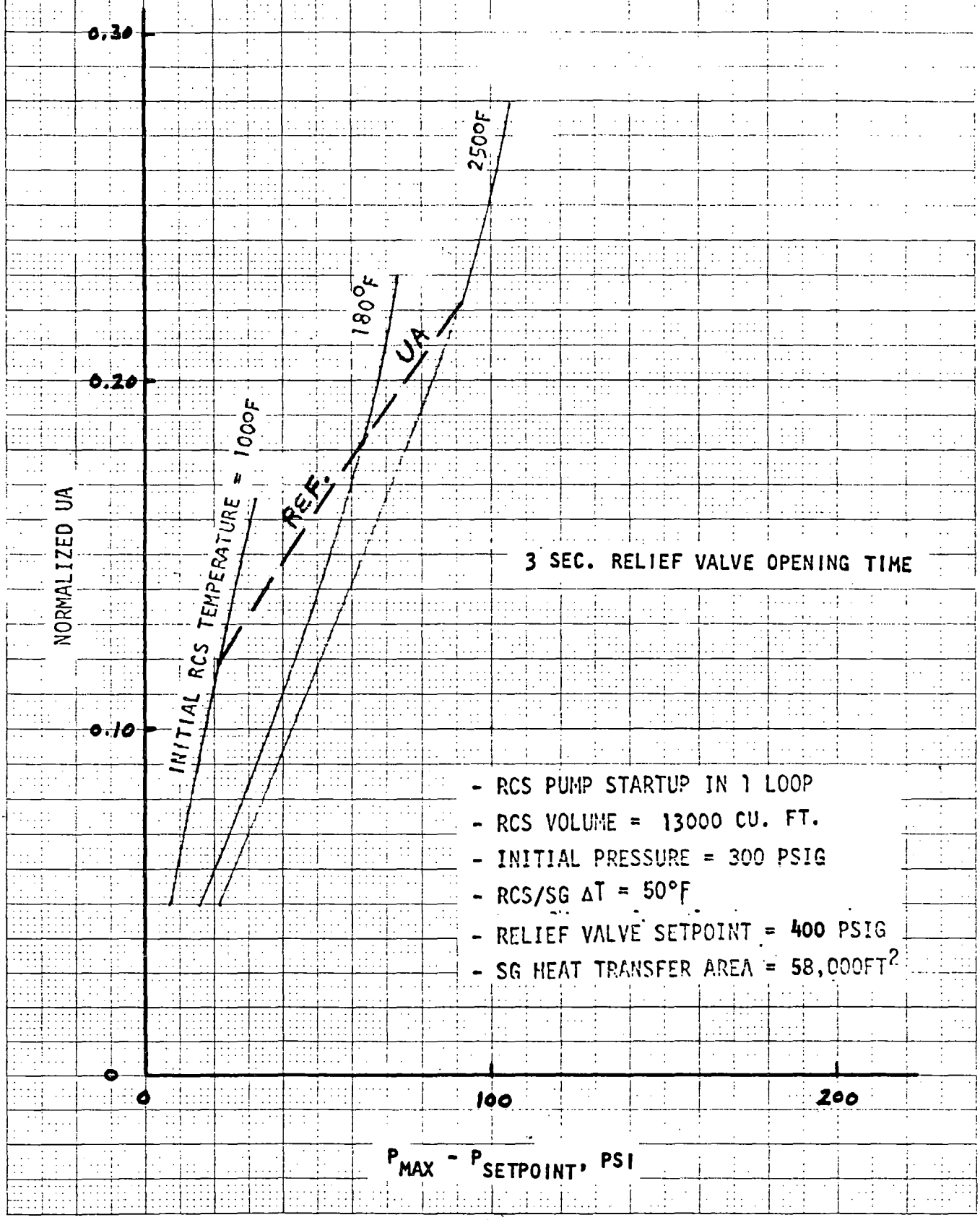


Figure 16

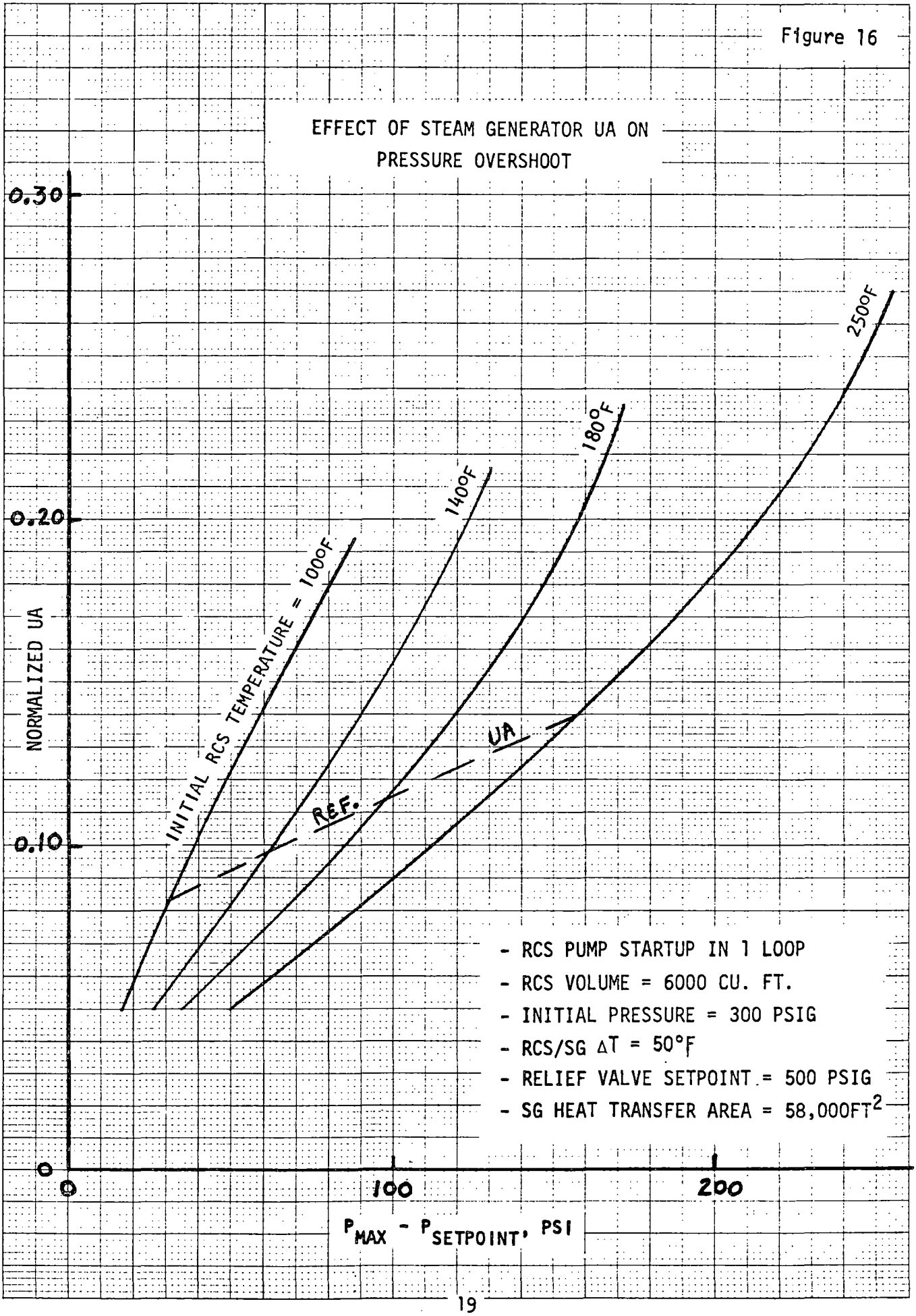

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT
0.30
0.20
0.10
0
NORMALIZED UA
INITIAL RCS TEMPERATURE = 100°F
140°F
180°F
250°F
UA
REF.
- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 6000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- RELIEF VALVE SETPOINT = 500 PSIG
- SG HEAT TRANSFER AREA = 58,000FT2
0
100
200
P MAX - P SETPOINT, PSI

Figure 17

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

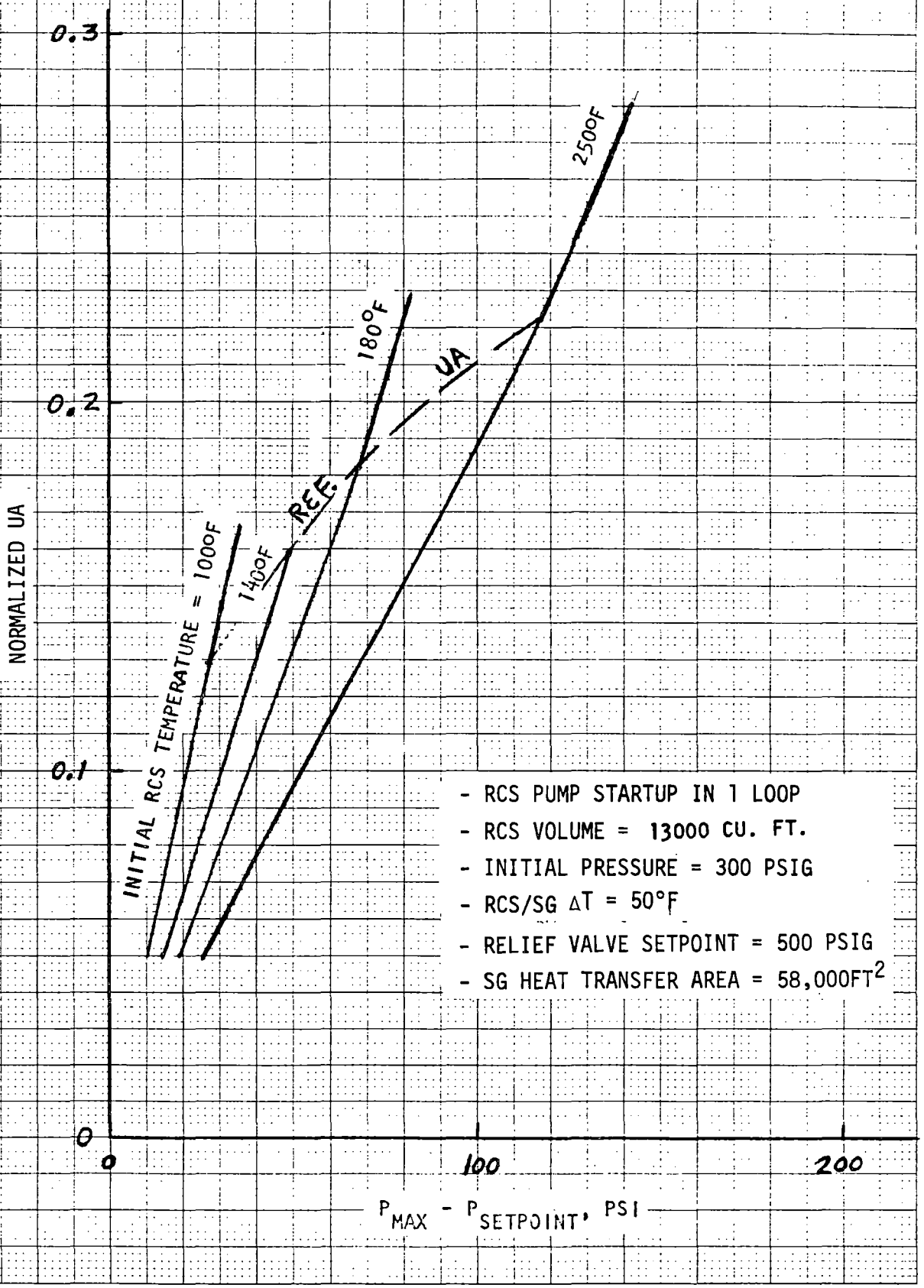


Figure 18

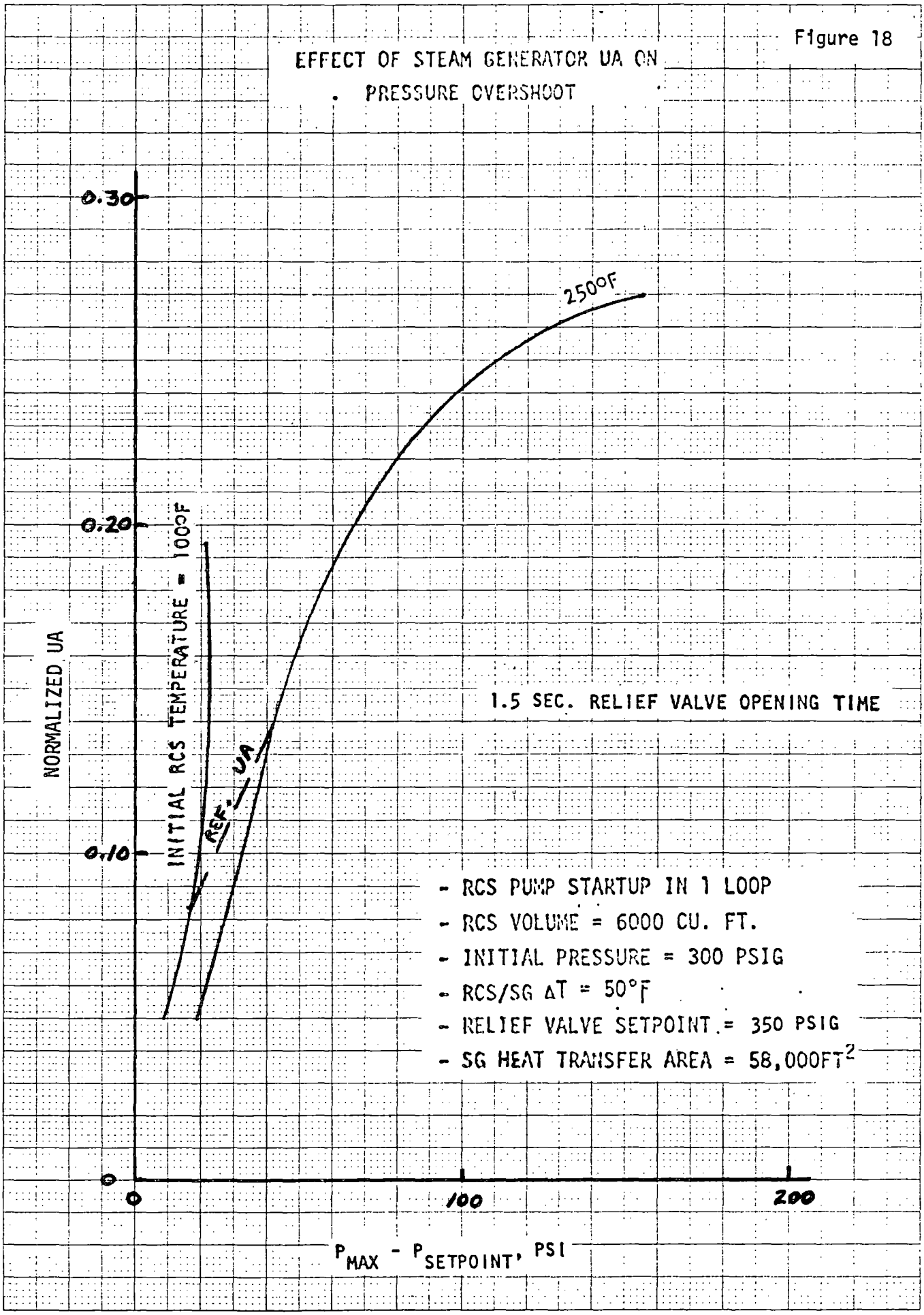

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT
0.30
0.20
0.10
0
NORMALIZED UA
INITIAL RCS TEMPERATURE = 100°F
REF. UA
250°F
1.5 SEC. RELIEF VALVE OPENING TIME
- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 6000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- RELIEF VALVE SETPOINT = 350 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²
0
100
200
P_MAX - P_SETPOINT, PSI

Figure 19

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

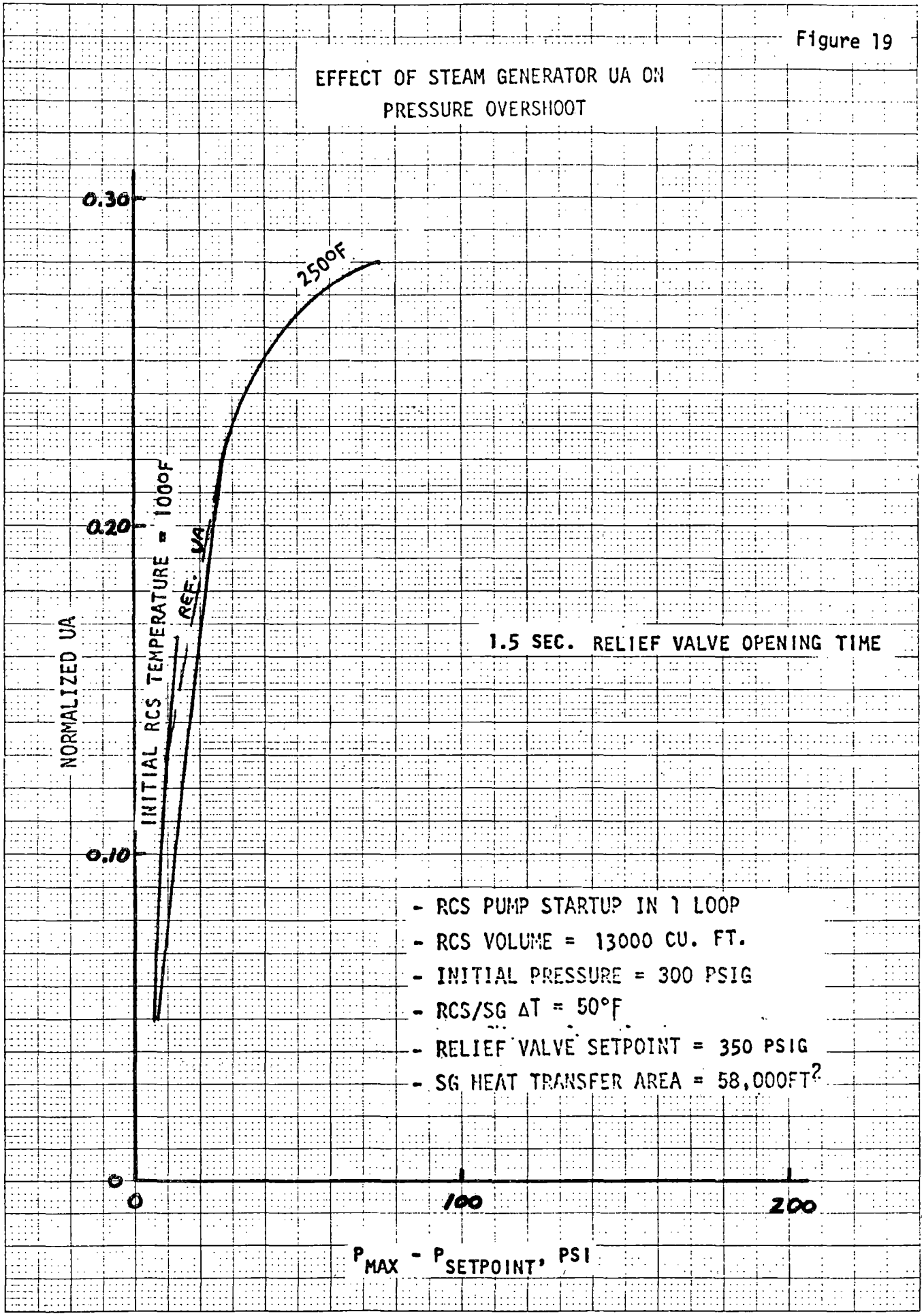


Figure 20

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

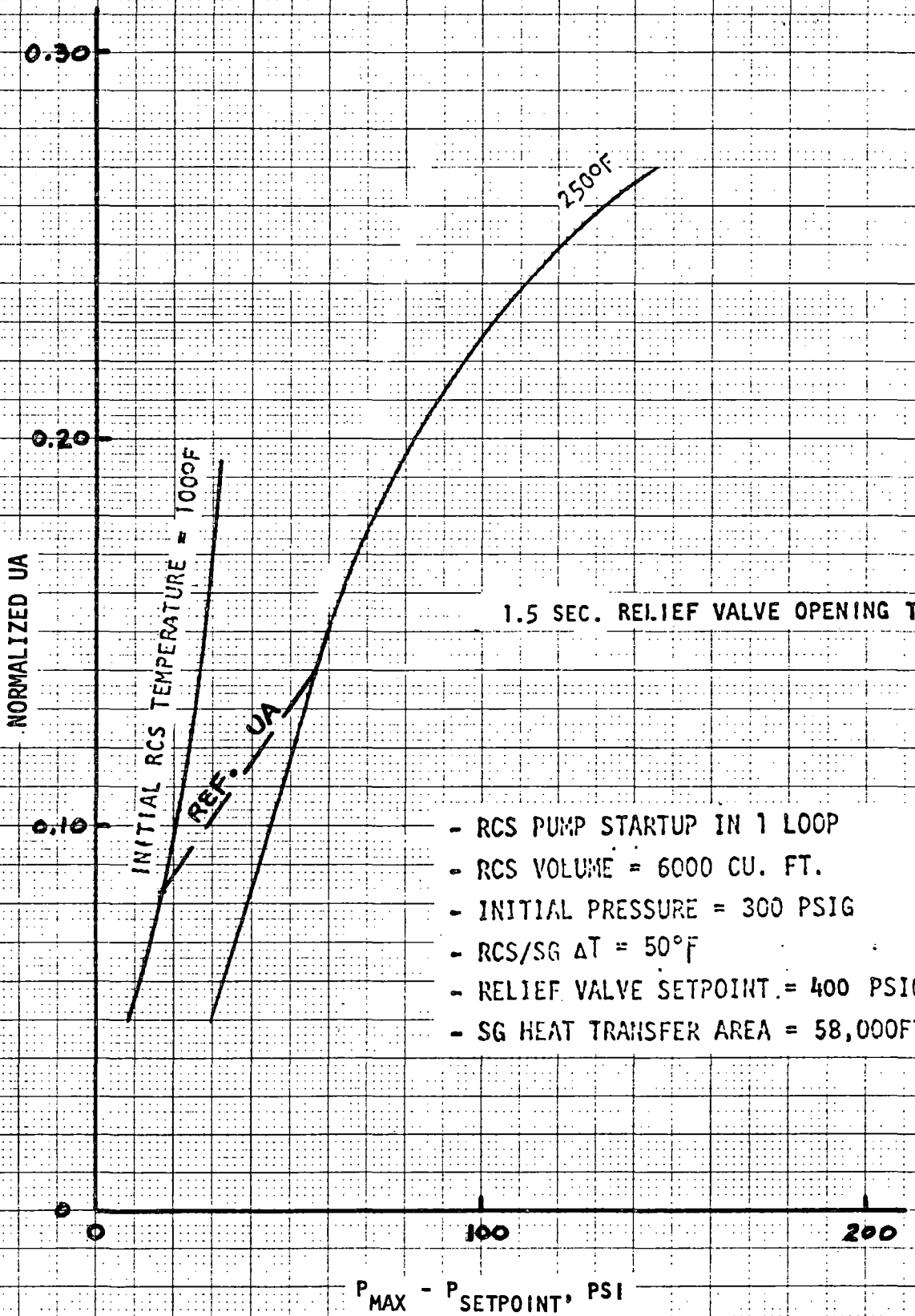
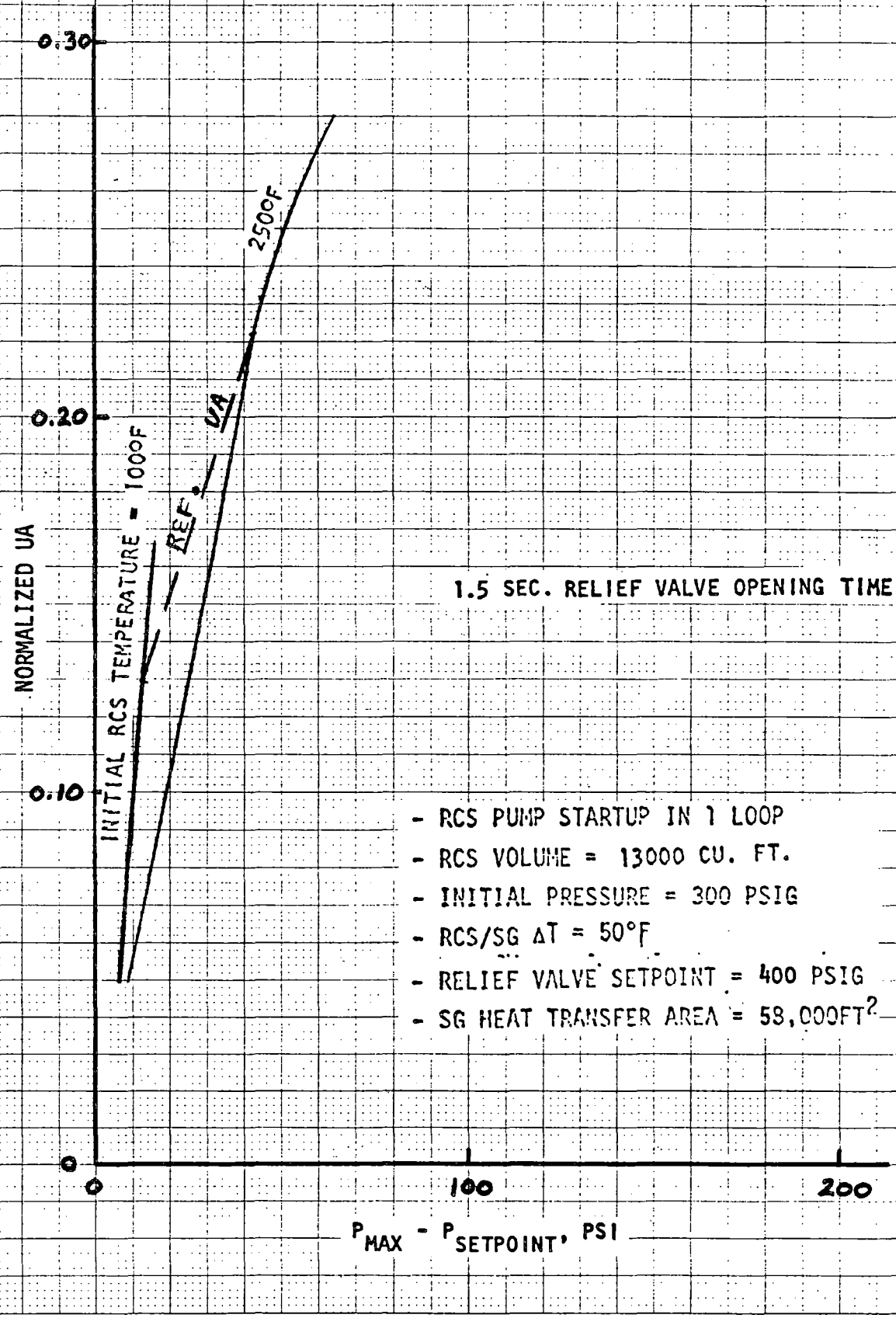


Figure 21

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT



1.5 SEC. RELIEF VALVE OPENING TIME

- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 13000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- RELIEF VALVE SETPOINT = 400 PSIG
- SG HEAT TRANSFER AREA = 58,000FT^2

Figure 22

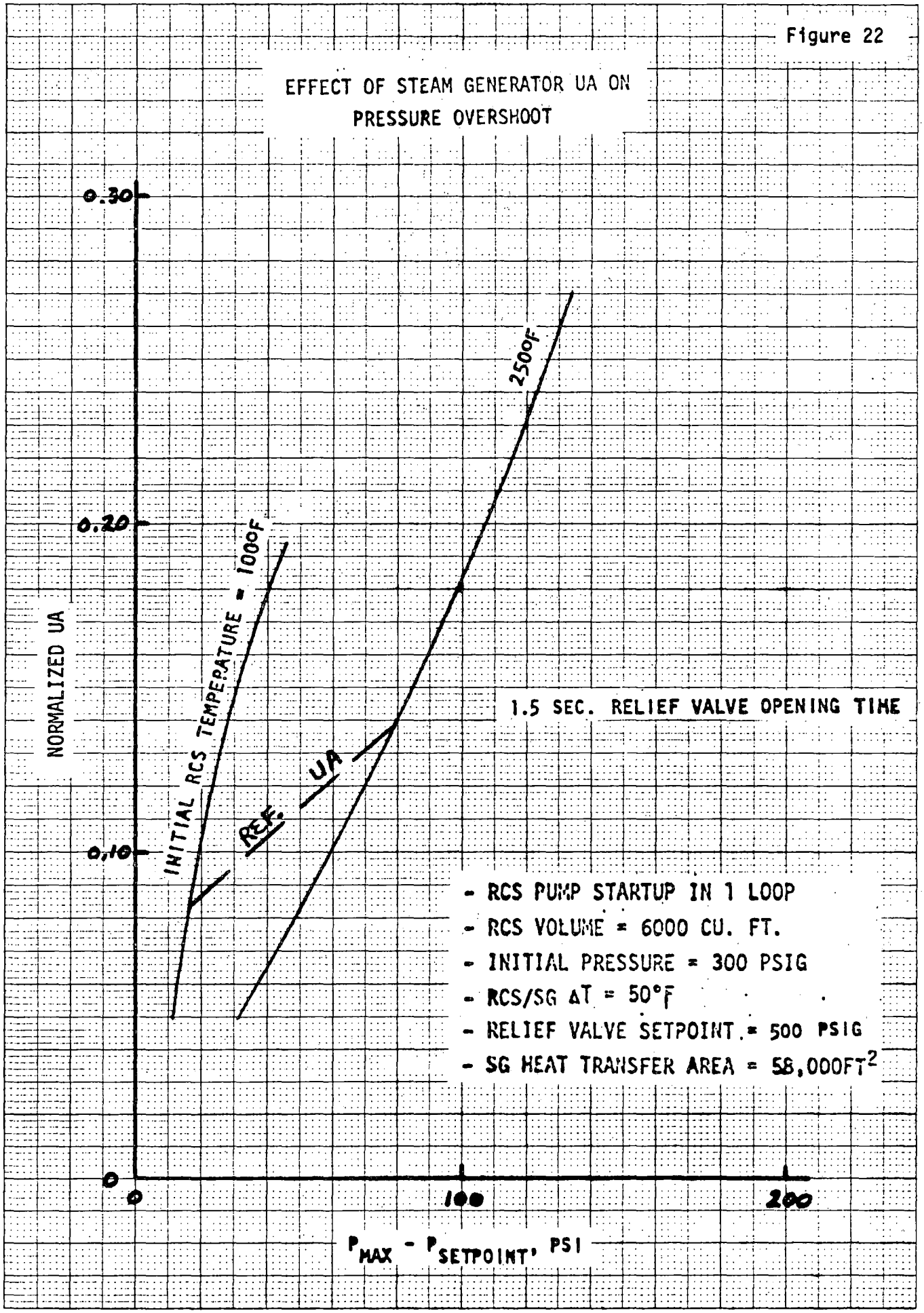
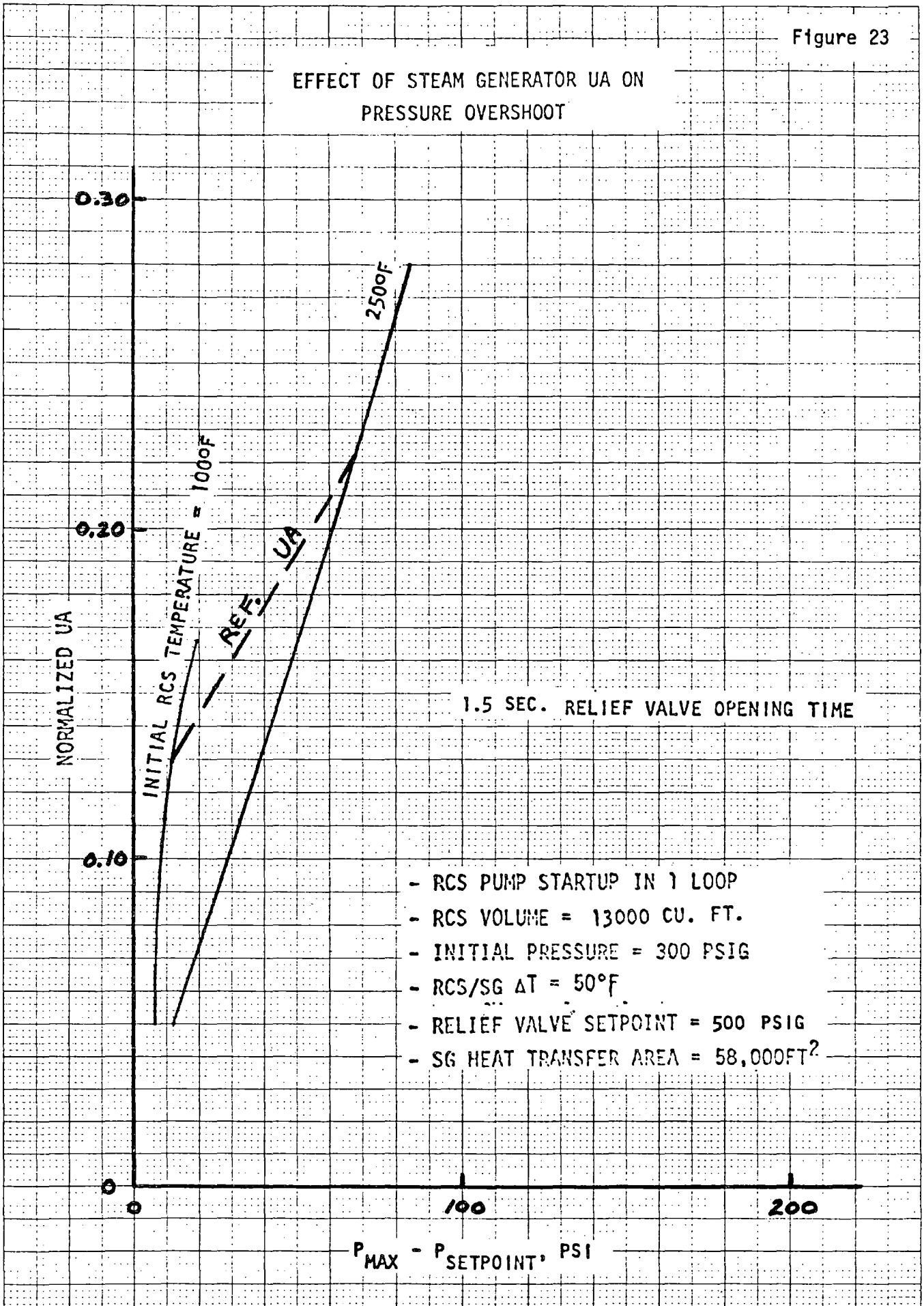

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT
0.30
0.20
0.10
0
0
100
200
NORMALIZED UA
$P_{MAX} - P_{SETPOINT}$, PSI
INITIAL RCS TEMPERATURE = 100°F
REF. UA
250°F
1.5 SEC. RELIEF VALVE OPENING TIME
- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 6000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- RELIEF VALVE SETPOINT = 500 PSIG
- SG HEAT TRANSFER AREA = 58,000FT^2

Figure 23

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



D. SETPOINT OVERSHOOT VARIATION WITH REACTOR COOLANT SYSTEM TEMPERATURE

Figure 24

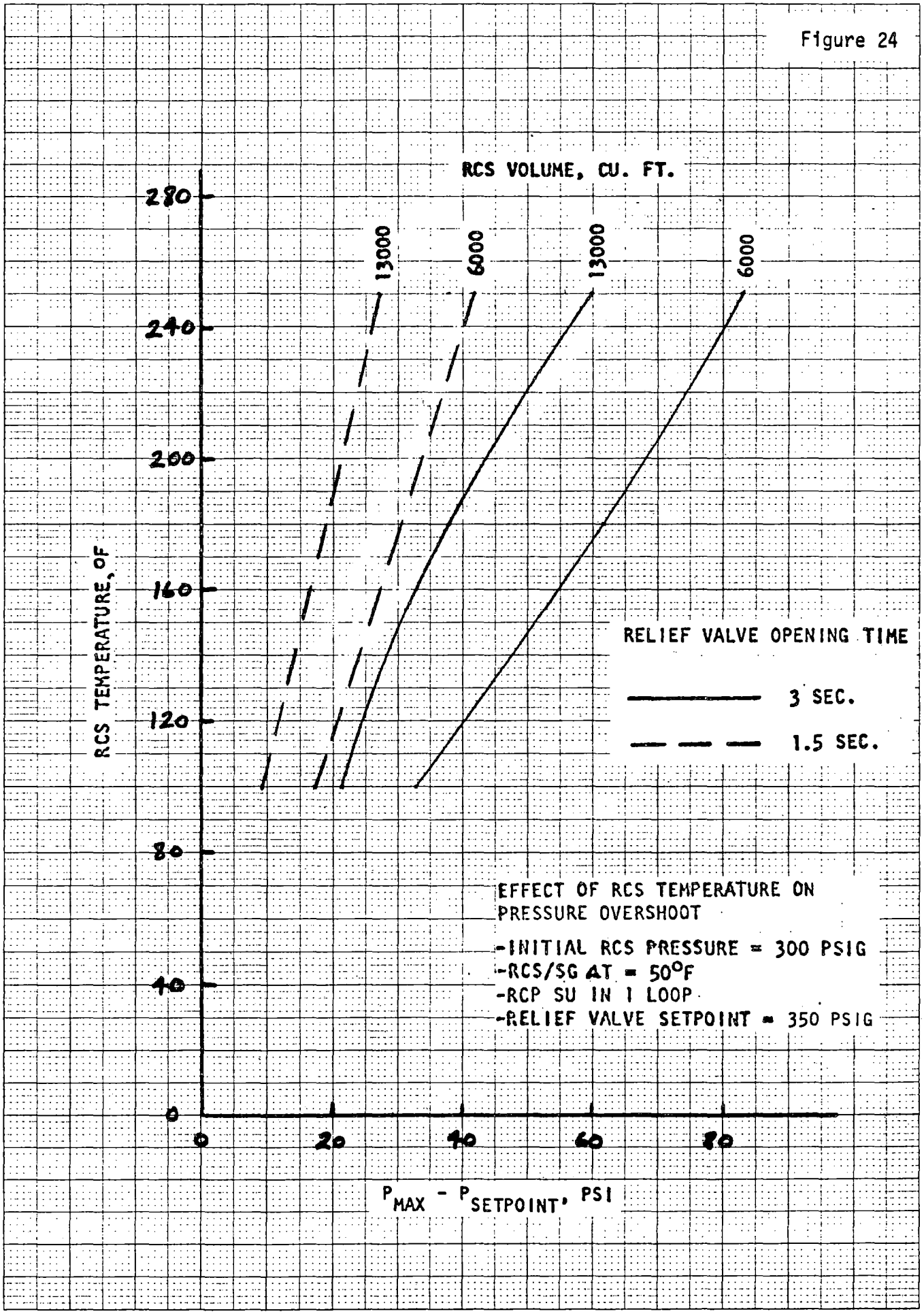

RCS VOLUME, CU. FT.
13000
6000
13000
6000
280
240
200
160
120
80
40
0
RCS TEMPERATURE, OF
RELIEF VALVE OPENING TIME
3 SEC.
1.5 SEC.
EFFECT OF RCS TEMPERATURE ON PRESSURE OVERSHOOT
-INITIAL RCS PRESSURE = 300 PSIG
-RCS/SG ΔT = 50°F
-RCP SU IN 1 LOOP
-RELIEF VALVE SETPOINT = 350 PSIG
0
20
40
60
80
P MAX - P SETPOINT, PSI

Figure 25

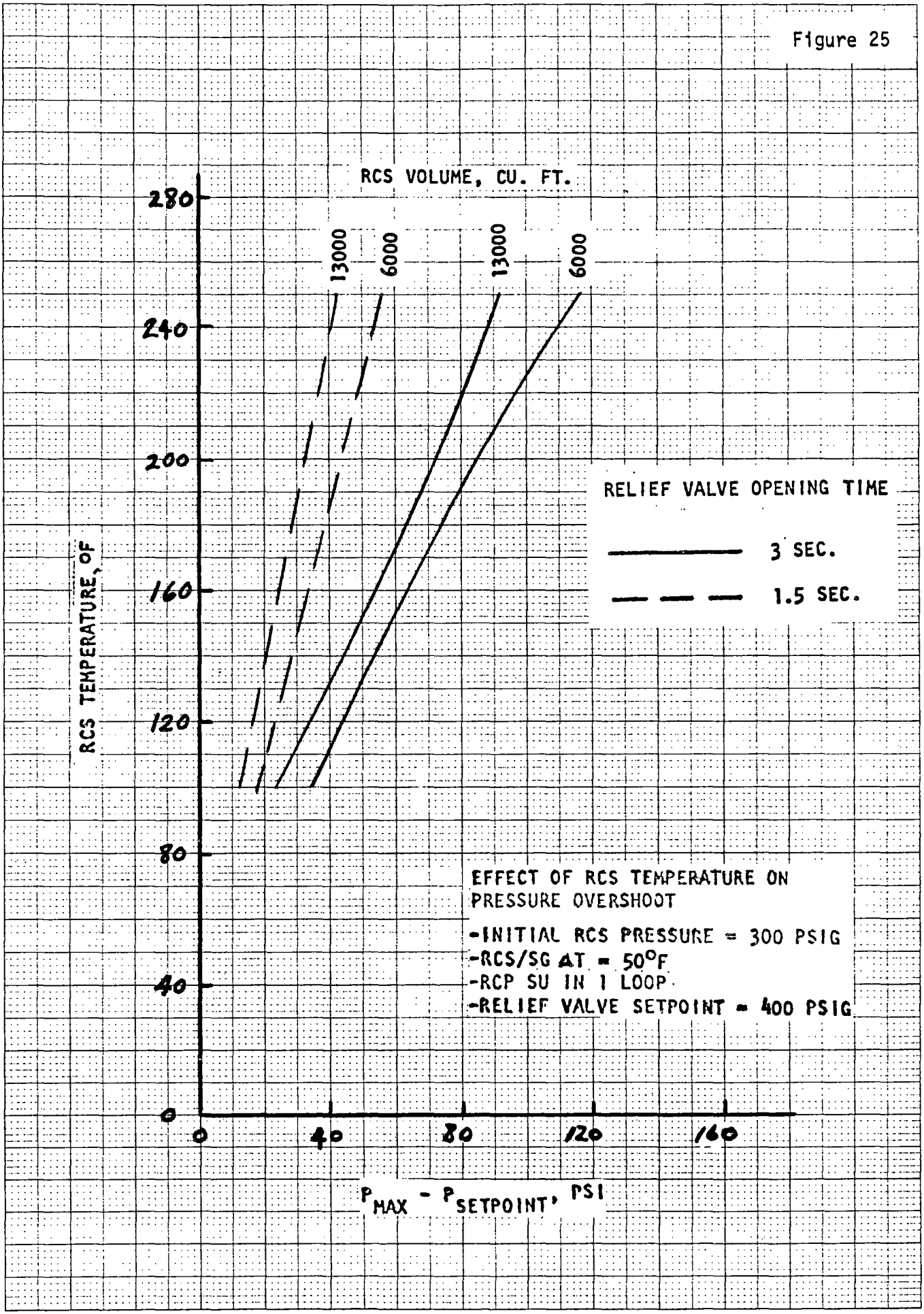
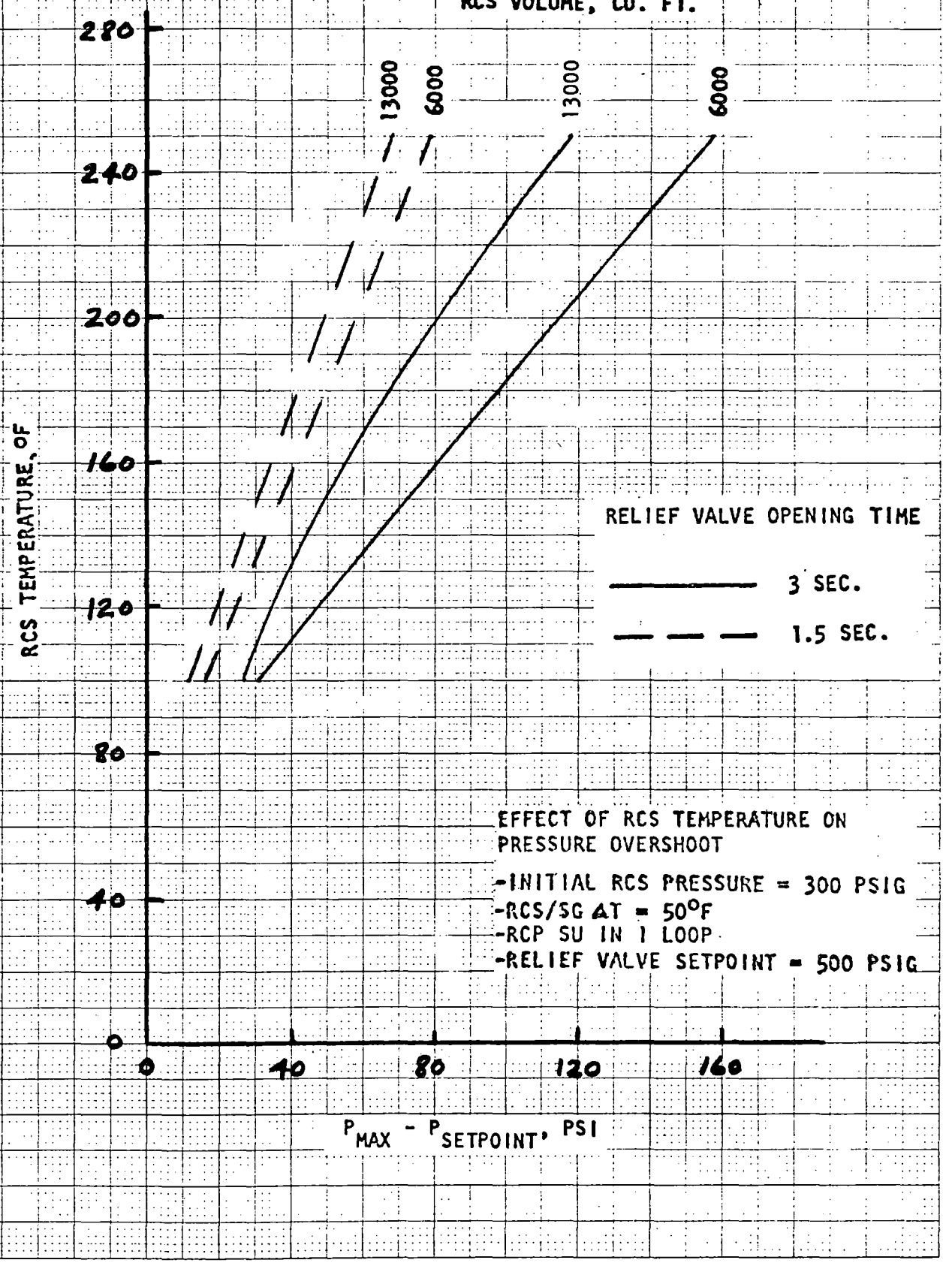

RCS VOLUME, CU. FT.
13000
6000
13000
6000
280
240
200
160
120
80
40
0
RCS TEMPERATURE, °F
RELIEF VALVE OPENING TIME
3 SEC.
1.5 SEC.
EFFECT OF RCS TEMPERATURE ON PRESSURE OVERSHOOT
-INITIAL RCS PRESSURE = 300 PSIG
-RCS/SG ΔT = 50°F
-RCP SU IN 1 LOOP
-RELIEF VALVE SETPOINT = 400 PSIG
0
40
80
120
160
P MAX - P SETPOINT, PSI

Figure 26


RCS VOLUME, CU. FT.
13000
6000
13000
6000
280
240
200
160
120
80
40
0
RCS TEMPERATURE, °F
RELIEF VALVE OPENING TIME
3 SEC.
1.5 SEC.
EFFECT OF RCS TEMPERATURE ON PRESSURE OVERSHOOT
-INITIAL RCS PRESSURE = 300 PSIG
-RCS/SG ΔT = 50°F
-RCP SU IN 1 LOOP
-RELIEF VALVE SETPOINT = 500 PSIG
0
40
80
120
160
P_MAX - P_SETPOINT, PSI

II. INSTRUCTIONAL GUIDE FOR OVERSHOOT DETERMINATION

A. General

The bounding envelope of LOFTRAN RCS Heat Input overpressurization generic results presented in Section I are not generally applicable to any specific plant of the W Owners Group on RCS Overpressurization. To determine a specific relief valve setpoint, a means of interpolating the setpoint overshoot from the generic envelope is required. Depending on the parameters to be interpolated and the correlation envelope available, separate procedures are required to perform the interpolation.

These procedures, similar in format except for the interpolated parameters and figure classification utilized, are developed for six typical heat input examples, listed below.

Example	Parameters to be Interpolated Within Generic Data Envelope	Figure Classification Defining Generic Envelope Correlations
1	Relief Valve Opening Time/ Relief Valve Setpoint	(P_{MAX} vs. $P_{SETPOINT}$)* vs. Valve Opening Time
2	Relief Valve Opening Time/ RCS Volume	(P_{MAX} vs. $P_{SETPOINT}$) vs. Valve Opening Time

*Setpoint overshoot

3	Relief Valve Setpoint/ RCS Volume	(P_{MAX} vs. $P_{SETPOINT}$) vs. Relief Valve Setpoint
4	UA(SG Heat Transfer Area)/ RCS Volume	(P_{MAX} vs. $P_{SETPOINT}$) vs. Normalized UA
5	UA(SG Heat Transfer Area)/ Relief Valve Opening Time	(P_{MAX} vs. $P_{SETPOINT}$) vs. Normalized UA
6	UA(SG Heat Transfer Area)/ Relief Valve Setpoint	(P_{MAX} vs. $P_{SETPOINT}$) vs. Normalized UA

B. Procedures

The procedures developed for the determination of setpoint overshoot are described below for six examples in which specific, typical operating plant parameters are used for interpolation within the operating plant generic data envelope. The results of the sequential application of each step in the procedure to these parameters is noted.

C. Illustrative Examples

1. ILLUSTRATIVE EXAMPLE 1: DETERMINATION OF SETPOINT OVERSHOOT GIVEN RELIEF VALVE SETPOINT AND RELIEF VALVE OPENING TIME WITHIN GENERIC ENVELOPE.

To determine setpoint overshoot for a specific relief valve setpoint (S) and relief valve opening time (Δt) within the generic envelope, the following interpolation procedure and Figures 1 and 3 of Section IA are used.

PARAMETERS FOR HEAT INPUT EXAMPLE 1

Initial RCS Pressure	300 psig
SG Heat Transfer Area	58,000 ft^2
RCS Volume, V_{RCS}	6,000 cu.ft.
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG ΔT	50°F
Relief Valve Opening Time, Δt	2 sec.
Relief Valve Setpoint, S	375 psig

Step	Procedure	Example Application
1	Using Figures C1 and C2 (V_{RCS} = 6000 ft3), determine the setpoint overshoots ΔP_{350} and ΔP_{400} with valve opening time (Δt) equal to 2 seconds and for the initial RCS temperature (T_{RCS}).	For T_{RCS} = 250°F and Δt = 2 seconds, ΔP_{350} = 55.5 psi (Figure C1) and ΔP_{400} = 75.5 psi (Figure C2)
2	For the desired relief valve setpoint, linearly interpolate the setpoint overshoot, ΔP_{375}, from ΔP_{350} and ΔP_{400} using the relationship: $\Delta P_{375} = \Delta P_{350} + \frac{S-350}{400-350} (\Delta P_{400} - \Delta P_{350})$	For S = 375 psig (V_{RCS} = 6000 ft^3), T_{RCS} = 250°F and Δt = 2 seconds, $\Delta P = 55.5 + \frac{375-350}{50} (75.5 - 55.5)$ = 65.5 psi

Figure C1

EFFECT OF RELIEF VALVE OPENING TIME ON RCS PRESSURE OVERSHOOT

- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 6,000 CU.FT.

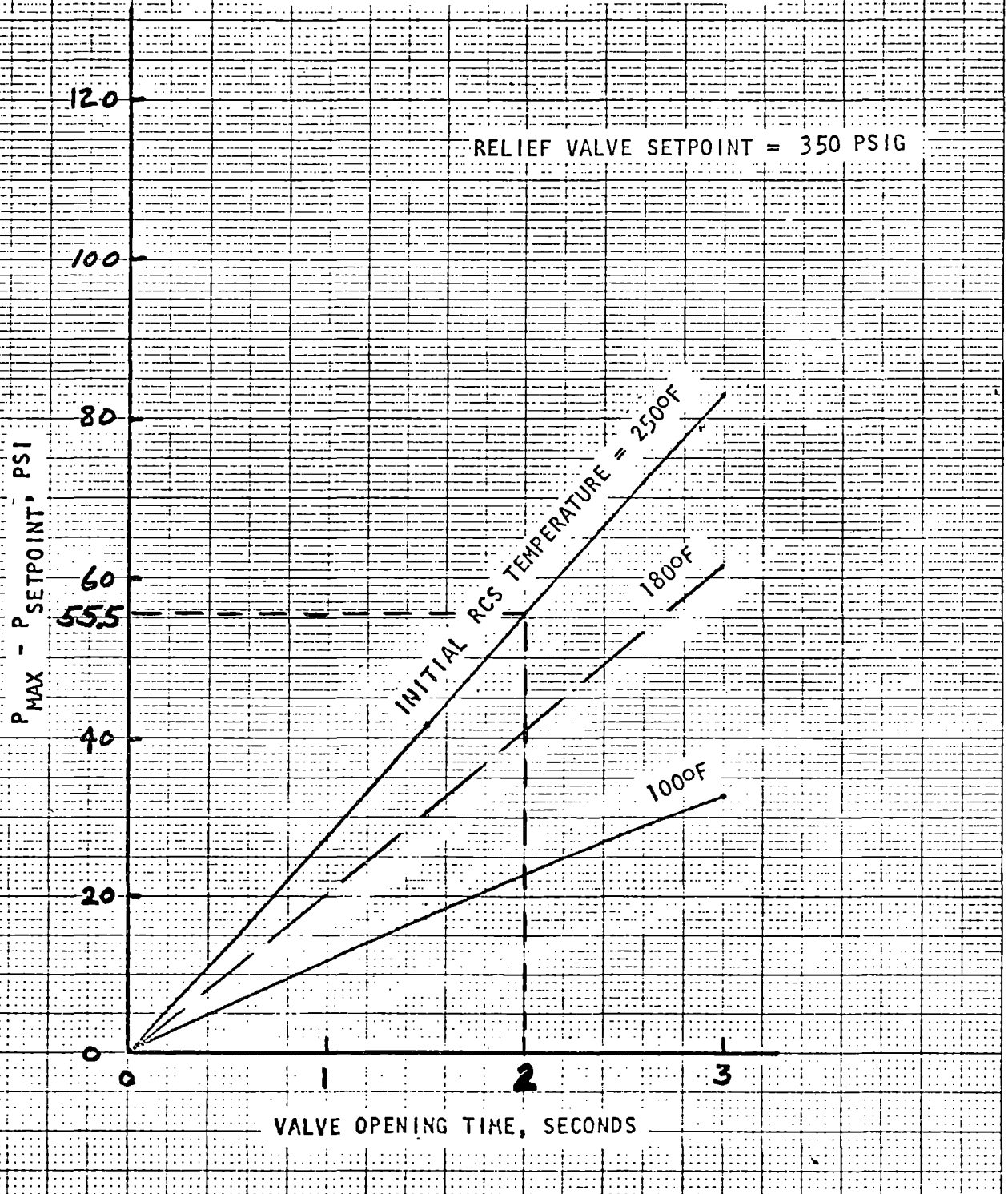
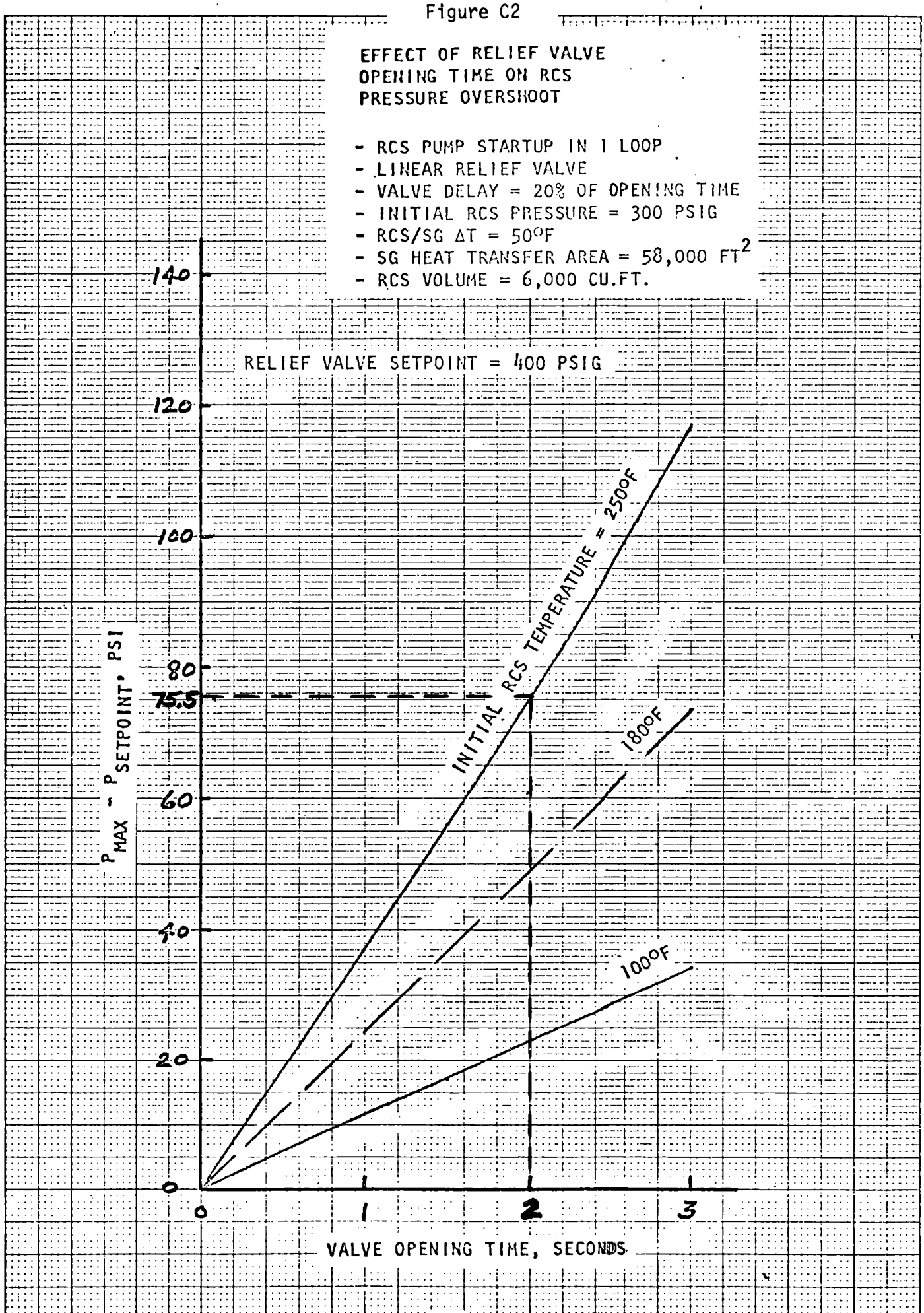


Figure C2


EFFECT OF RELIEF VALVE OPENING TIME ON RCS PRESSURE OVERSHOOT
- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT²
- RCS VOLUME = 6,000 CU.FT.
RELIEF VALVE SETPOINT = 400 PSIG
INITIAL RCS TEMPERATURE = 250°F
180°F
100°F
140
120
100
80
75.5
60
40
20
0
0
1
2
3
P_MAX - P_SETPOINT, PSI
VALVE OPENING TIME, SECONDS

2. ILLUSTRATIVE EXAMPLE 2: DETERMINATION OF SETPOINT OVERSHOOT GIVEN RCS VOLUME AND RELIEF VALVE OPENING TIME WITHIN GENERIC ENVELOPE

The following interpolation procedure is used to determine setpoint overshoot for a specified RCS volume (V_{RCS}) and relief valve opening time (Δt) within the generic envelope. By way of illustration, the following example heat input parameters, utilizing Figures 3 and 4 of Section I.A are used:

PARAMETERS FOR HEAT INPUT EXAMPLE 2

Initial RCS Pressure	300 psig
SG Heat Transfer Area	58,000 ft^2
RCS Volume, V_{RCS}	10,000 cu.ft.
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG ΔT	50°F
Relief Valve Setpoint, S	400 psig
Relief Valve Opening Time, Δt	2 sec.

Step	Procedure	Example Application
1	Using Figures C3 and C4 (S = 400 psig), determine the setpoint overshoots ΔP_{6K} and ΔP_{13K} with valve opening time (Δt) equal to 2 seconds and for the initial RCS temperature (T_{RCS}).	For $T_{RCS} = 250^{o}F$ and $\Delta t = 2$ seconds, $\Delta P_{6K} = \underline{75.5 \text{ psi}}$ (Figure C3) and $\Delta P_{13K} = \underline{57.5 \text{ psi}}$ (Figure C4).
2	For the desired RCS volume, linearly interpolate the setpoint overshoot, ΔP_{10K}, from ΔP_{6K} and ΔP_{13K} using the relationship: $\Delta P_{10K} = \Delta P_{6K} - \frac{V_{RCS} - 6000}{13,000 - 6,000}(\Delta P_{6K} - \Delta P_{13K})$	For V_{RCS} = 10,000 cu.ft. (S = 400 psig), $T_{RCS} = 250^{o}F$ and $\Delta t = 2$ seconds, $\Delta P = 75.5 - \frac{10,000 - 6000}{7000}(75.5 - 57.5)$ $= \underline{65.2 \text{ psi}}$

Figure C3

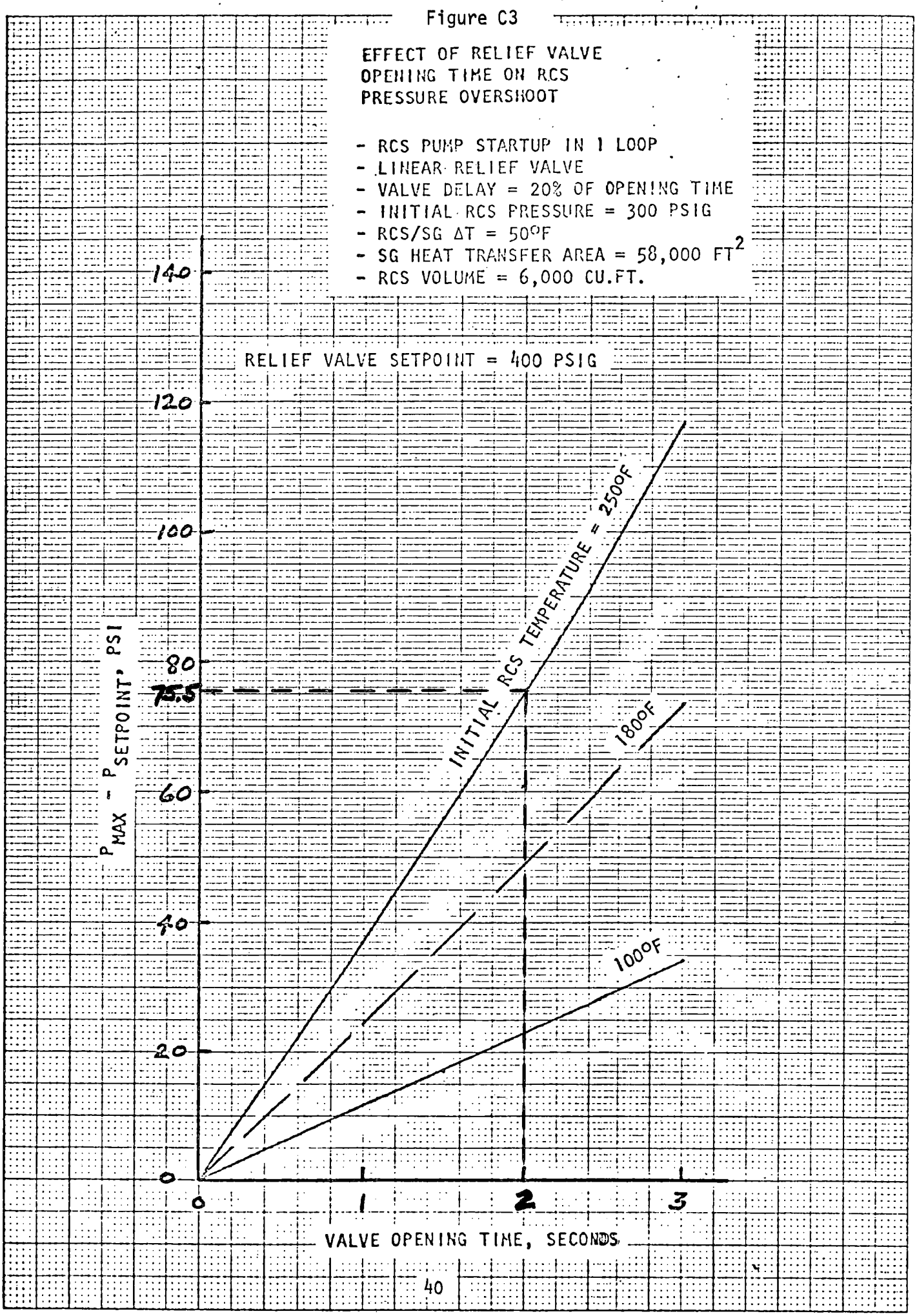
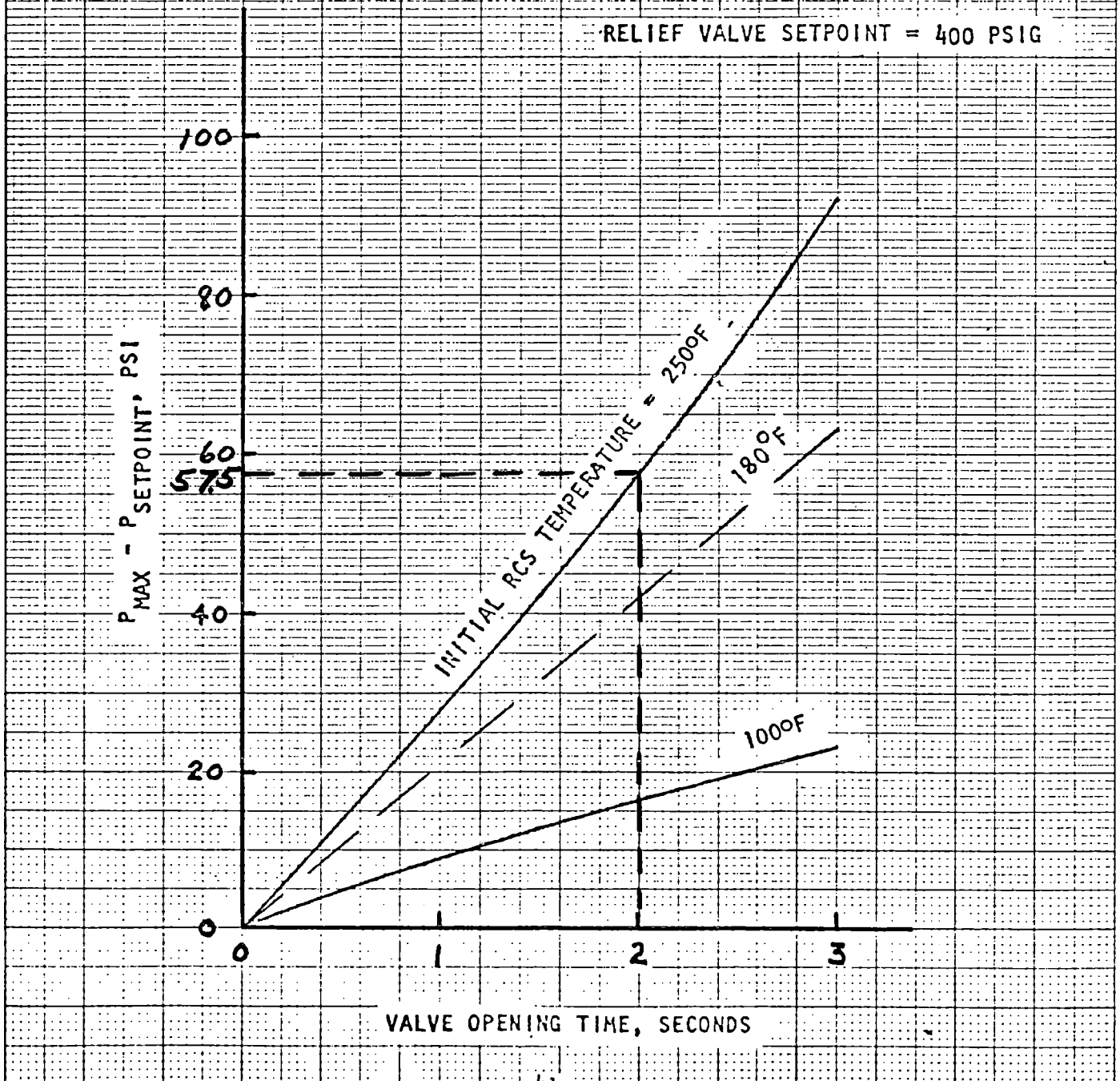

EFFECT OF RELIEF VALVE OPENING TIME ON RCS PRESSURE OVERSHOOT
- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT²
- RCS VOLUME = 6,000 CU.FT.
RELIEF VALVE SETPOINT = 400 PSIG
INITIAL RCS TEMPERATURE = 250°F
180°F
100°F
75.5
140
120
100
80
60
40
20
0
0
1
2
3
P_MAX - P_SETPOINT, PSI
VALVE OPENING TIME, SECONDS

Figure C4

EFFECT OF RELIEF VALVE OPENING TIME ON RCS PRESSURE OVERSHOOT

- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG ΔT = 50°F
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 13000 CU. FT.



3. ILLUSTRATIVE EXAMPLE 3: DETERMINATION OF SETPOINT OVERSHOOT GIVEN RELIEF VALVE SETPOINT AND RCS VOLUME WITHIN GENERIC ENVELOPE

The following interpolative procedure is used to determine setpoint overshoot for a given relief valve setpoint(S) and RCS volume (V_{RCS}) within the generic envelope. By way of illustration, the following example heat input parameters, utilizing Figure 9 of Section IA are specified:

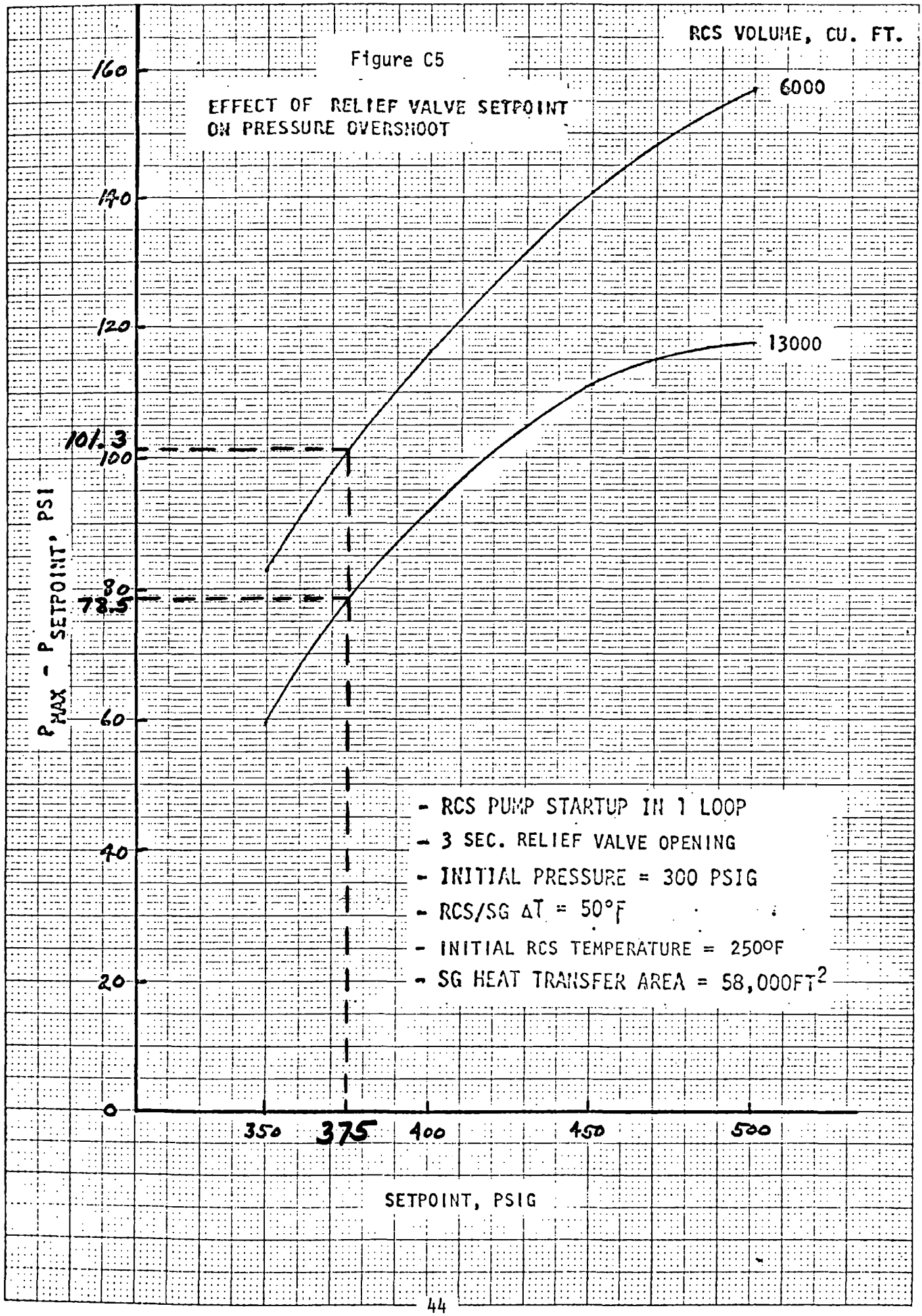
PARAMETERS FOR HEAT INPUT EXAMPLE 3

Initial RCS Pressure	300 psig
SG Heat Transfer Area	58,000 ft^2
RCS Volume, V_{RCS}	10,000 cu.ft.
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG ΔT	50°F
Relief Valve Setpoint, S	375 psig
Relief Valve Opening Time, Δt	3 sec.

Step	Procedure	Example Application
1	For relief valve setpoint(s) equal to 375 psig (Δt = 3 seconds), determine the setpoint overshoots P_{6K} and P_{13K} for the initial RCS temperature (T_{RCS}).	For T_{RCS} = 250°F, P_{6K} = 101.3 psi and P_{13K} = 78.5 psi from Figure C5.
2	For the desired RCS volume, linearly interpolate the setpoint overshoot, P_{10K}, from P_{6K} and P_{13K} using the relationship:	For V_{RCS} = 10,000 cu.ft. (Δt = 3 seconds), and T_{RCS} = 250°F,
	$P_{10K} = P_{6K} - \frac{V_{RCS} - 6000}{13,000 - 6,000} (P_{6K} - P_{13K})$	$P = 101.3 - \frac{10,000 - 6,000}{7000} (101.3 - 78.5)$
		= 88.3 psi

Figure C5

EFFECT OF RELIEF VALVE SETPOINT ON PRESSURE OVERSHOOT



4. ILLUSTRATIVE EXAMPLE 4: DETERMINATION OF SETPOINT OVERSHOOT GIVEN SG TUBE HEAT TRANSFER AREA AND RCS VOLUME WITHIN GENERIC ENVELOPE

For SG tube heat transfer area different from 58,000 ft^2, the determination of setpoint overshoot is made using a slightly modified version of the Heat Input Instructional Guide for Setpoint/Overshoot Determination prescribed in Chapter 4 of the July 1977 Report (Reference 1) and Figures 12 through 23 of Section IA (figures depicting setpoint overshoot variation with normalized steam generator UA). Setpoint overshoots may be obtained for 1.5 sec and 3 sec relief valve opening times (Δt); for relief valve setpoints (S) equal to 350 psig, 400 psig and 500 psig; and for RCS volumes (V_{RCS}) equal to 6000 cu.ft. and 13,000 cu.ft. Setpoint overshoot may also be obtained for Δt, S and V_{RCS} values within these envelopes, depending on the combination of Figures 12 through 23 of Section IA selected. Illustrative Example 4 and subsequent examples will illustrate this interpolative procedure for interpolating Δt, S and V_{RCS}.

Illustration of the use of the modified interpolative procedure of Chapter 4 of Reference 1 is provided below for the determination of setpoint overshoot for a specified SG tube heat transfer

area and RCS volume within the generic envelope. (Illustrative Example 4). Figures 12 and 13 of Section IA are used in the procedure for the following example heat input parameters:

PARAMETERS FOR HEAT INPUT EXAMPLE 4

Initial RCS Pressure	300 psig
SG Heat Transfer Area	29,000 ft^2
RCS Volume, V_{RCS}	10,000 cu.ft.
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG T	50°F
Relief Valve Setpoint, S	350 psig
Relief Valve Opening Time, t	3 sec.

Applying the heat input procedure:

Step	Procedure	Example Application
1	For both the 6000 ft^3 and 13,000 ft^3 RCS volumes (S = 350 psig), obtain the reference normalized UA (UA_{6K} and UA_{13K}) at the initial RCS temperature (T_{RCS}) and relief valve setpoint (S), using Figures C6 and C7.	For T_{RCS} = 250°F and S = 350 psig, UA_{6K} = 0.139 (Figure C6) and UA_{13K} = 0.222 (Figure C7).
2	Determine what fraction, f, of 58,000 ft^2 constitutes the actual steam generator heat transfer area.	29,000 ft^2/58,000 ft^2 = 0.5

Figure C6

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT

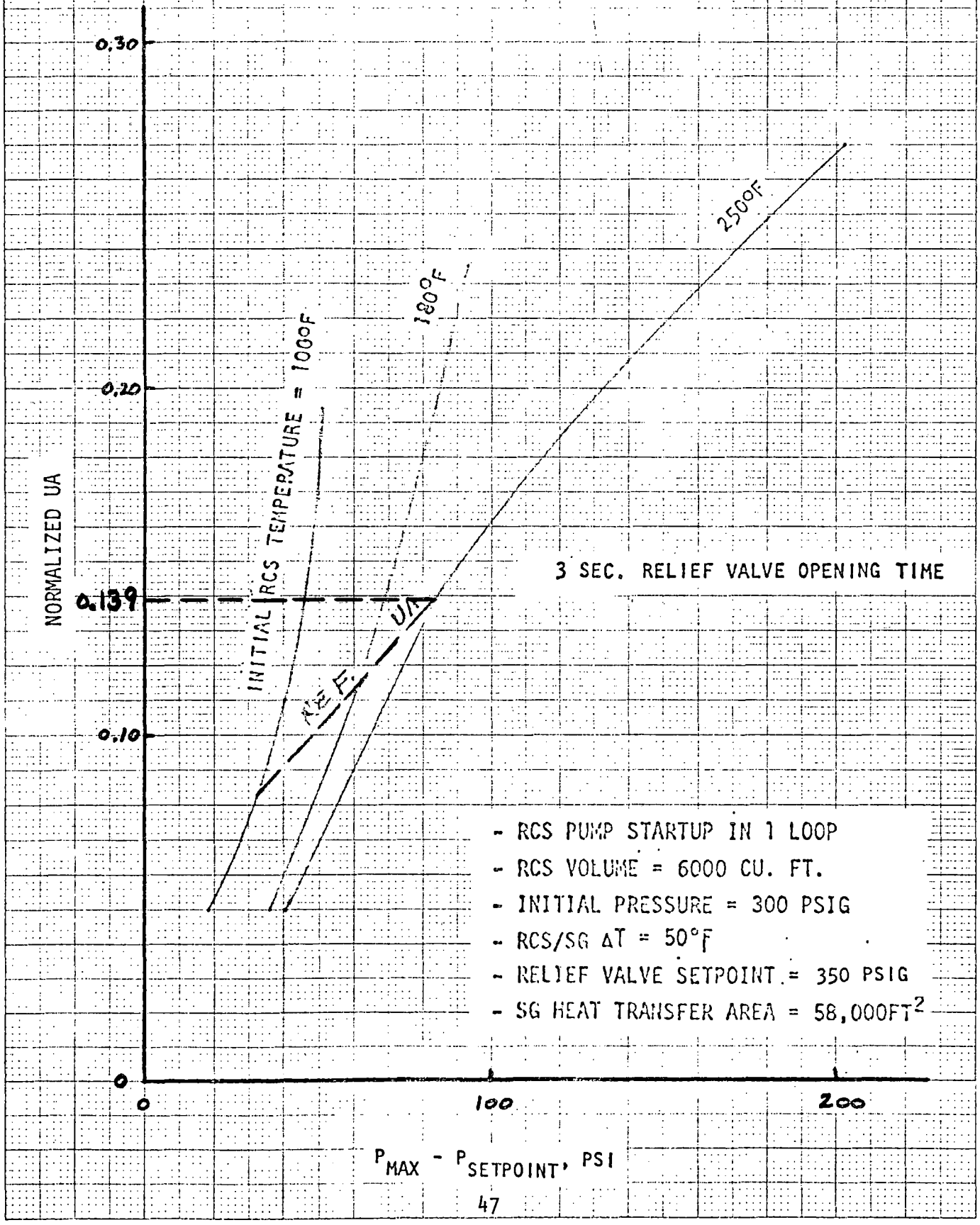
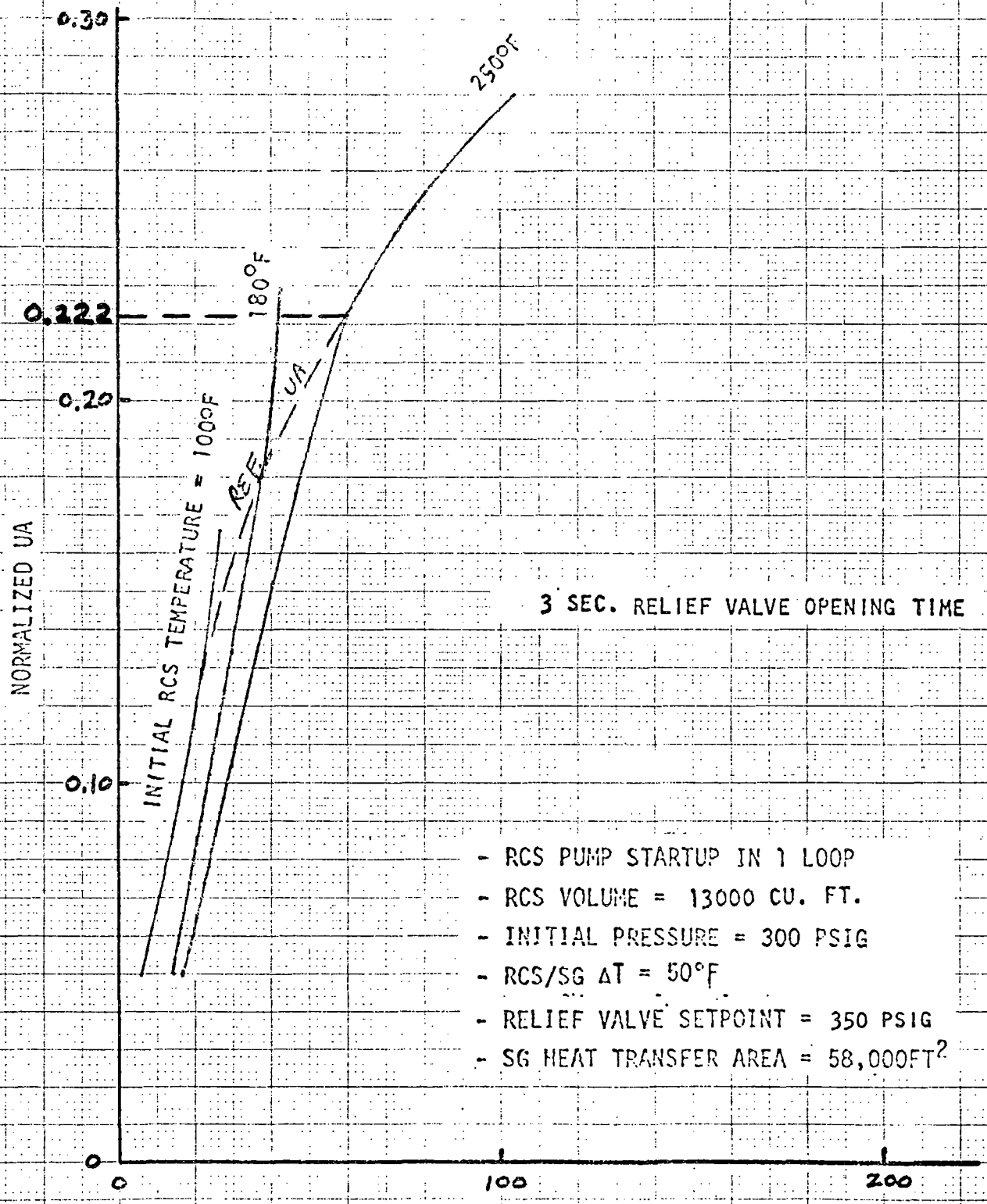


Figure C7

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



Step	Procedure	Example Application
3	Multiply both UA_{6K} and UA_{13K} (from Step 1) by f (from Step 2) to obtain new normalized UA'_{6K} and UA'_{13K} values.	$UA'_{6K} = 0.139 * 0.5 = \underline{0.0695}$ and $UA'_{13K} = 0.222 * 0.5 = \underline{0.111}$.
4	For the same isotherm, T_{RCS}, and for UA'_{6K} and UA'_{13K}, obtain new setpoint overshoots P'_{6K} and P'_{13K} for the 6000 ft^3 and 13,000 ft^3 volumes from Figures C8 and C9.	From Figure C8, for $T_{RCS} = 250^{o}F$, S = 350 psig and $UA'_{6K} = 0.0695$, $P'_{6K} = \underline{50 \text{ psi}}$. From Figure C9 for $T_{RCS} = 250^{o}F$, S = 350 psig and $UA'_{13K} = 0.111$, $P'_{13K} = \underline{31 \text{ psi}}$.
5	For the actual volume, V_{RCS}, linearly interpolate the setpoint overshoot, P'_{VRCS}, for the new steam generator UA from the relationship:	For V_{RCS} = 10,000 cu.ft., P'_{6K} = 50 psi and P'_{13K} = 31 psi,

$$P'_{VRCS} = P'_{6K} - \frac{V_{RCS} - 6000}{7000} (P'_{6K} - P'_{13K})$$

$$P'_{10K} = 50 - \frac{10{,}000 - 6000}{7000} (50 - 31)$$

$$= \underline{39.2 \text{ psi}}$$

Figure C8

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

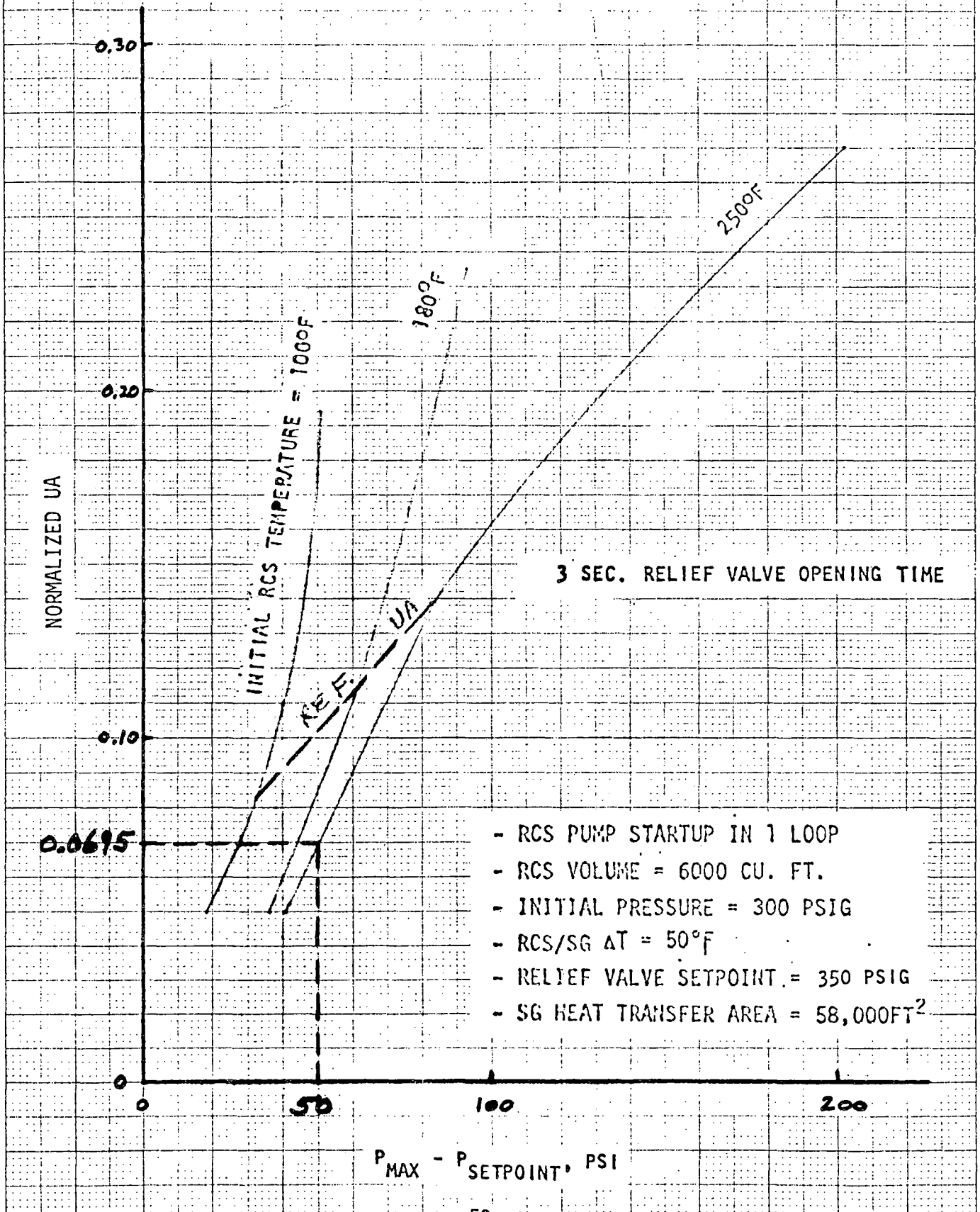
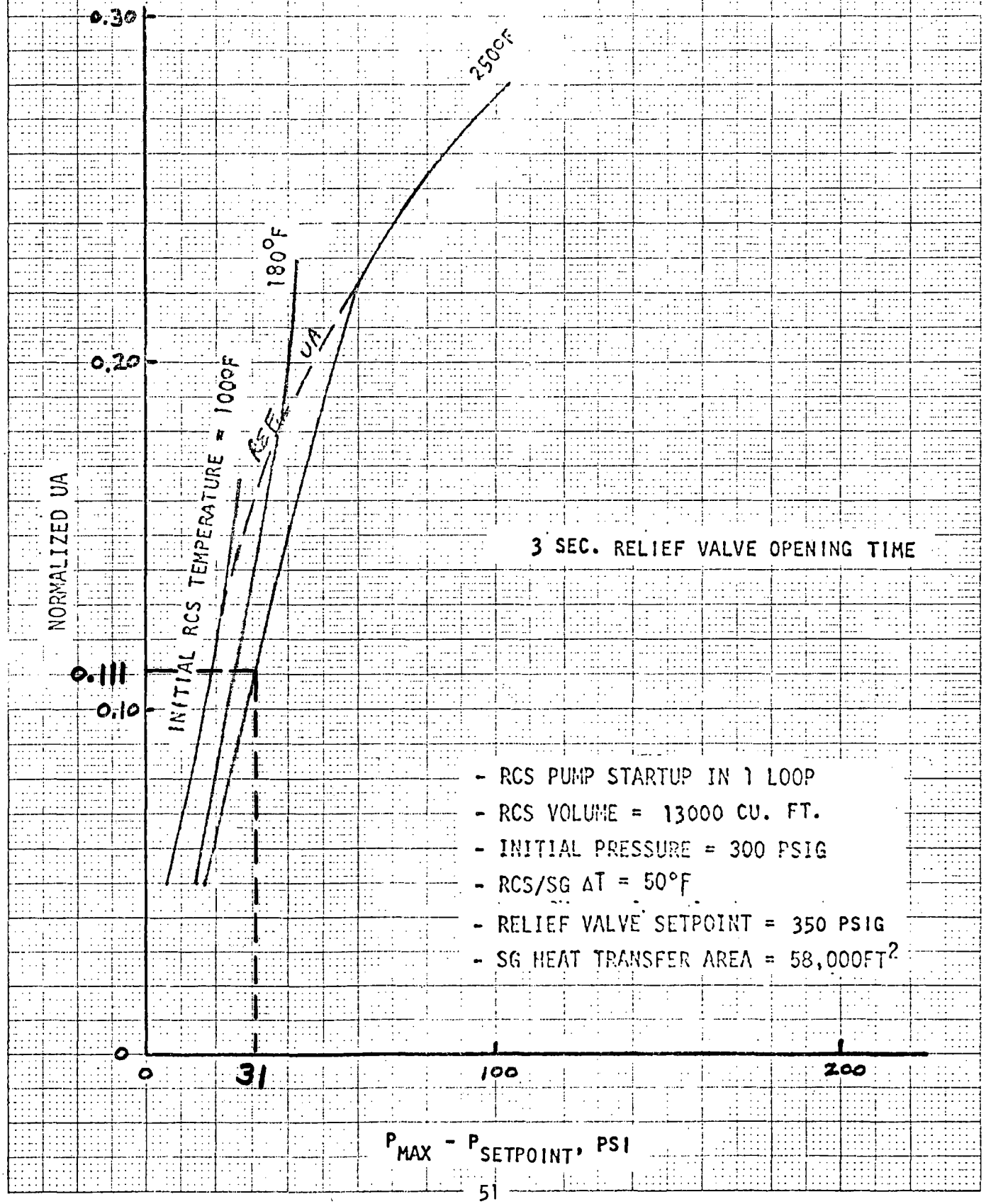


Figure C9

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



5. ILLUSTRATIVE EXAMPLE 5: DETERMINATION OF SETPOINT OVERSHOOT GIVEN SG TUBE HEAT TRANSFER AREA AND RELIEF VALVE OPENING TIME WITHIN GENERIC ENVELOPE.

The interpolative procedure of Example 5 (modified procedure of Reference 1, Chapter 4) is applied below for the determination of setpoint overshoot for a specified SG tube heat transfer area and relief valve opening time within the generic envelope. Figures 12 and 18 of Section IA are used in the procedure for the following example heat input parameters:

PARAMETERS FOR HEAT INPUT EXAMPLE 5

Initial RCS Pressure	300 psig
SG Heat Transfer Area	29,000 ft^2
RCS Volume, V_{RCS}	6,000 cu.ft.
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG T	50°F
Relief Valve Setpoint, S	350 psig
Relief Valve Opening Time, t	2 sec.

Applying the heat input procedure:

Step	Procedure	Example Application
1	For both the 3 second and 1.5 second relief valve opening times, obtain the reference normalized UA (UA_3 and $UA_{1.5}$) for the initial RCS temperature (T_{RCS}) and relief valve setpoint (S), using Figures C10 and C11.	For T_{RCS} = 250°F and S = 350 psig, $UA_3 = UA_{1.5} = \underline{0.139}$ from Figures C10 and C11. (V_{RCS} = 6000 cu.ft.)
2	Determine what fraction, f, of 58,000 ft^2 constitutes the actual steam generator heat transfer area.	29,000 ft^2/58,000 ft^2 = <u>0.5</u>
3	Multiply both UA_3 and $UA_{1.5}$ (from step 1) by f (from Step 2) to obtain new normalized UA_3^1 and $UA_{1.5}^1$ valves.	$UA_3^1 = UA_{1.5}^1 = 0.139 * 0.5$ $= \underline{0.0695}$

Figure C10

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT

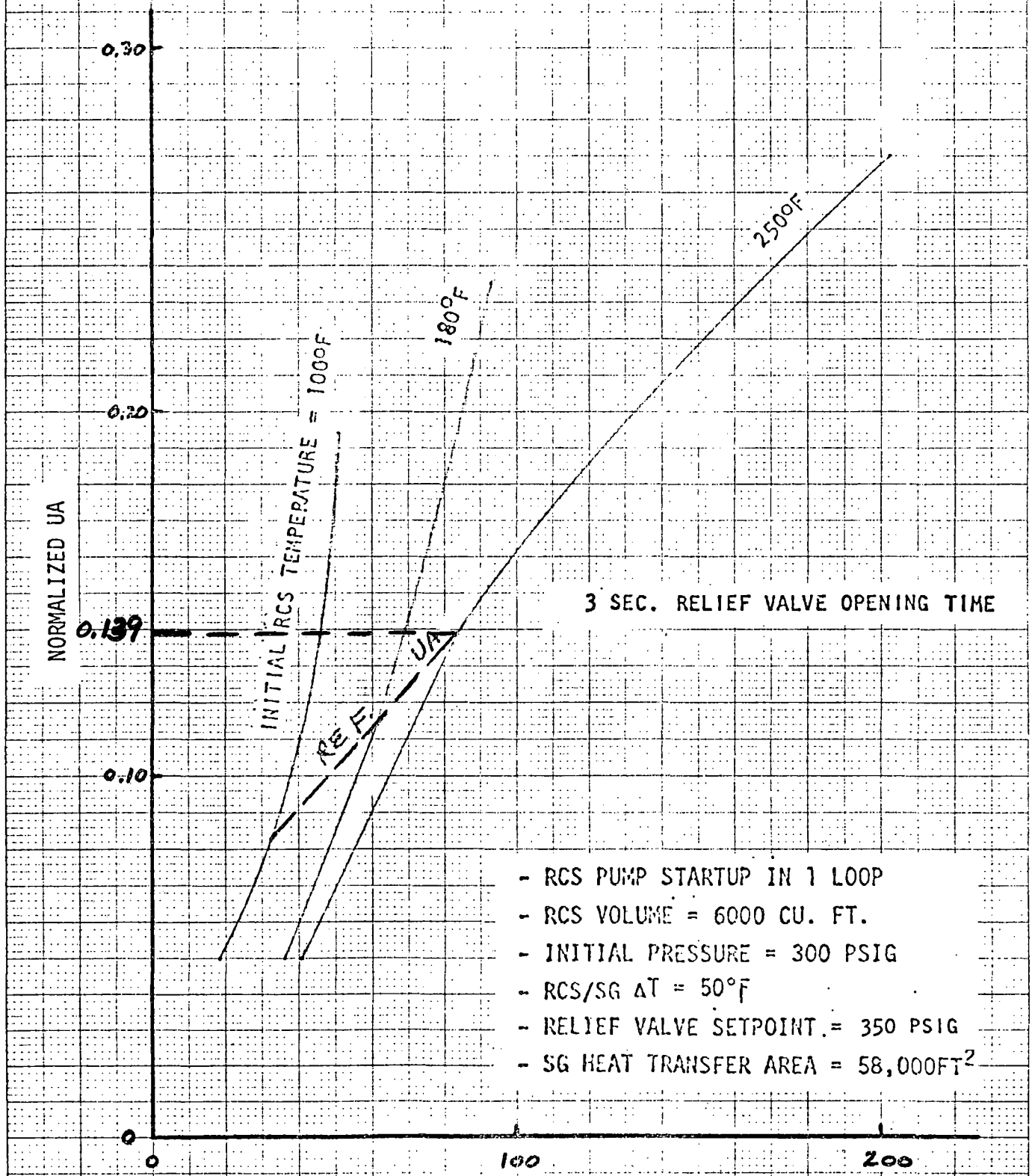
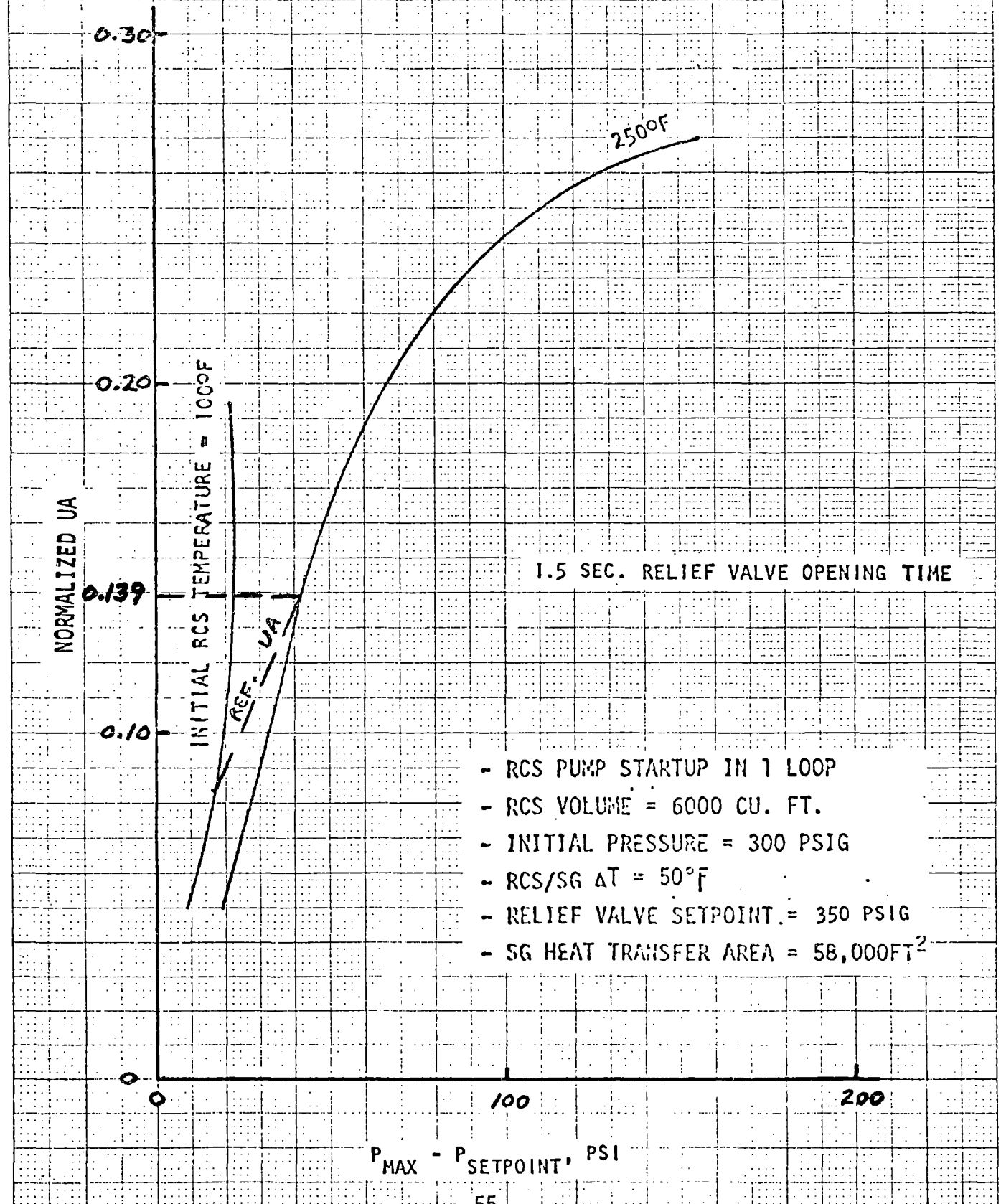


Figure C11

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



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Step	Procedure	Example Application
4	For the same isotherm, T_{RCS}, and for UA_3^1 and $UA_{1.5}^1$ obtain new setpoint overshoots ΔP_3^1 and $P_{1.5}^1$ for the 3 second and 1.5 second relief valve opening times, using Figures C12 and C13.	From Figure C12, for T_{RCS} = 250°F, S = 350 psig and UA_3^1 = 0.0695, P_3^1 = <u>50 psi.</u> From Figure C13, for T_{RCS} = 250°F, S = 350 psig and $UA_{1.5}^1$ = 0.0695, $P_{1.5}^1$ = <u>25 psi</u>
5	For the actual relief valve opening time, t, linearly interpolate the setpoint overshoot, P_t^1, for the new steam generator UA from the relationship: $P_{\Delta t}^1 = P_{1.5}^1 + \frac{t - 1.5}{3 - 1.5} (P_3^1 - P_{1.5}^1)$	For t = 2 seconds, P_3^1 = 50 psi and $P_{1.5}^1$ = 25 psi, $P_2^1 = 25 + \frac{2 - 1.5}{3 - 1.5} (50 - 25)$ = <u>33.4 psi</u>

Figure C12

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

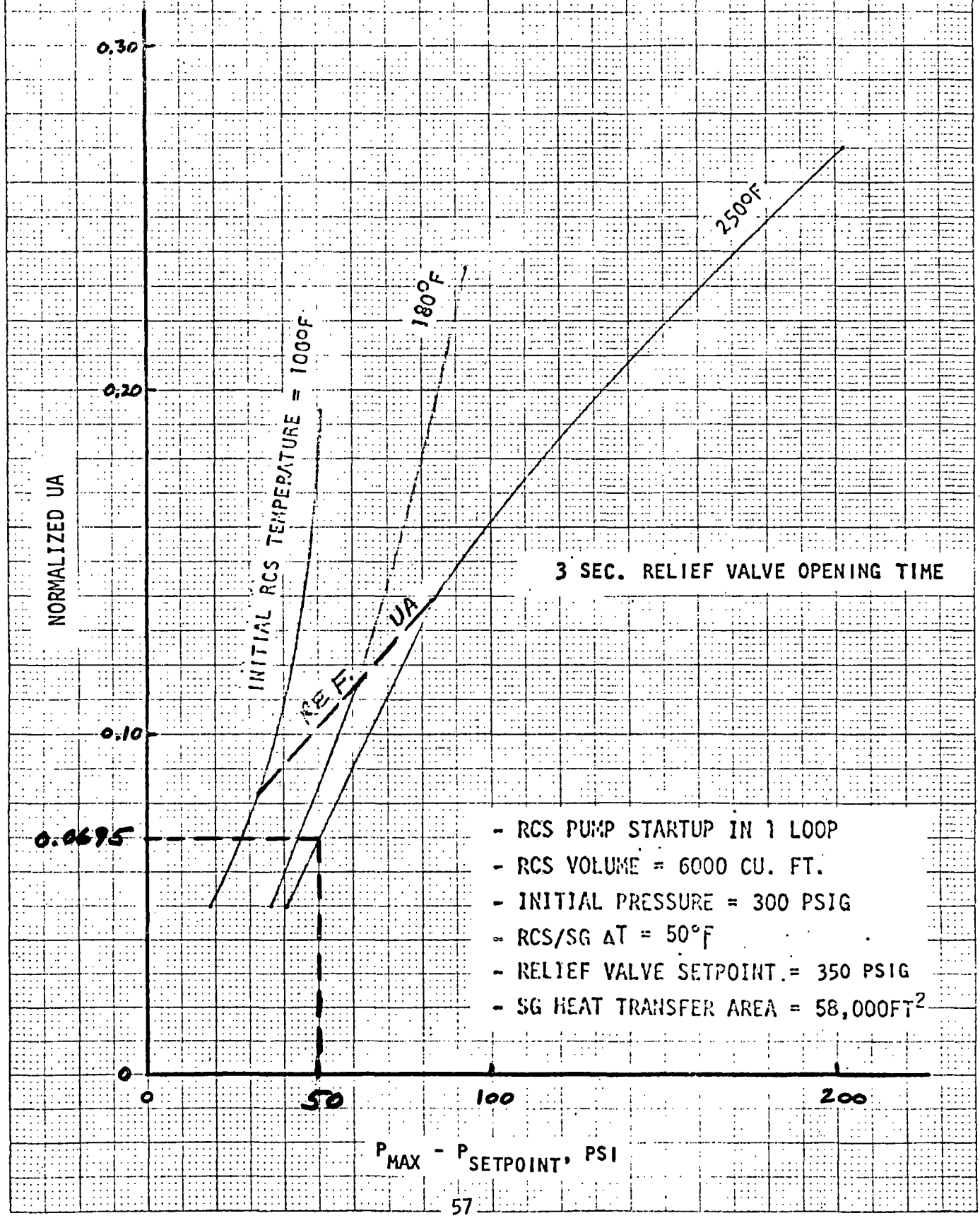
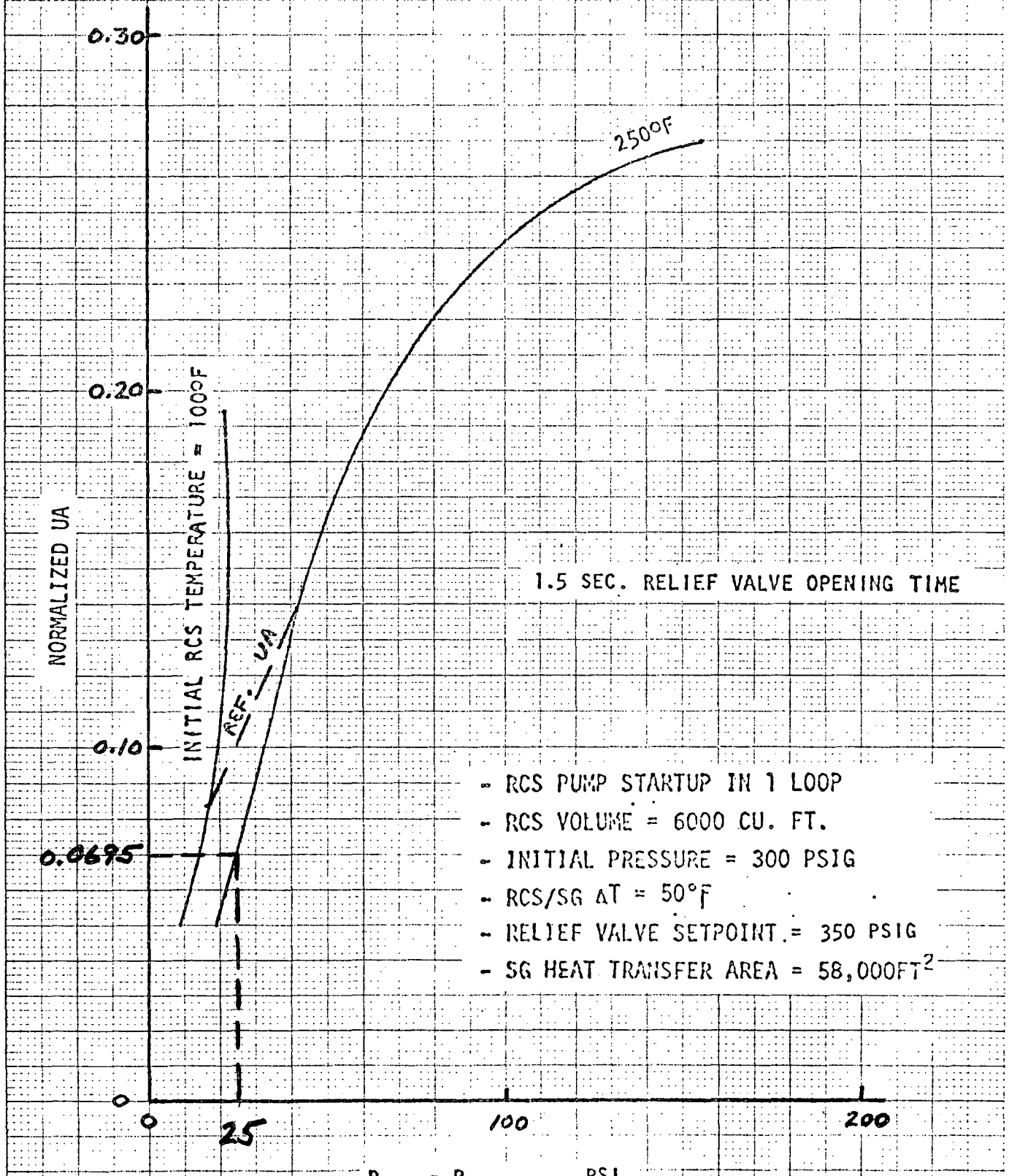


Figure C13

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



6. ILLUSTRATIVE EXAMPLE 6: DETERMINATION OF SETPOINT OVERSHOOT GIVEN SG TUBE HEAT TRANSFER AREA AND RELIEF VALVE SETPOINT WITHIN GENERIC ENVELOPE.

The interpolative procedure of Example 6 (modified procedure of Reference 1, Chapter 4) is applied below for the determination of setpoint overshoot for a specified SG tube heat transfer area and relief valve setpoint within the generic envelope. Figures 12 and 14 of Section IA are used in the procedure for the following example heat input parameters:

PARAMETERS FOR HEAT INPUT EXAMPLE 6

Initial RCS Pressure	300 psig
SG Heat Transfer Area	29,000 ft^2
RCS Volume, V_{RCS}	6,000 cu.ft.
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG ΔT	50°F
Relief Valve Setpoint, S	375 psig
Relief Valve Opening Time, t	3 sec.

Applying the heat input procedure:

Step	Procedure	Example Application
1	For both the 350 psig and 400 psig relief valve setpoints, obtain the reference normalized UA (UA_{350} and UA_{400}) for the initial RCS temperature (T_{RCS}) and relief valve opening time (t), using Figures C14 and C15.	For T_{RCS} = 250°F and t = 3 seconds, $UA_{350} = UA_{400}$ = 0.139 from Figures C14 and C15. (V_{RCS} = 6000 cu.ft.)
2	Determine what fraction, f, of 58,000 ft^2 constitutes the actual steam generator heat transfer area.	29,000 ft^2/58,000 ft^2 = 0.5
3	Multiply both UA_{350} and UA_{400} (from Step 1) by f (from Step 2) to obtain new normalized UA^1_{350} and UA^1_{400} values.	$UA^1_{350} = UA^1_{400}$ = 0.139 * 0.5 = 0.0695

Figure C14

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

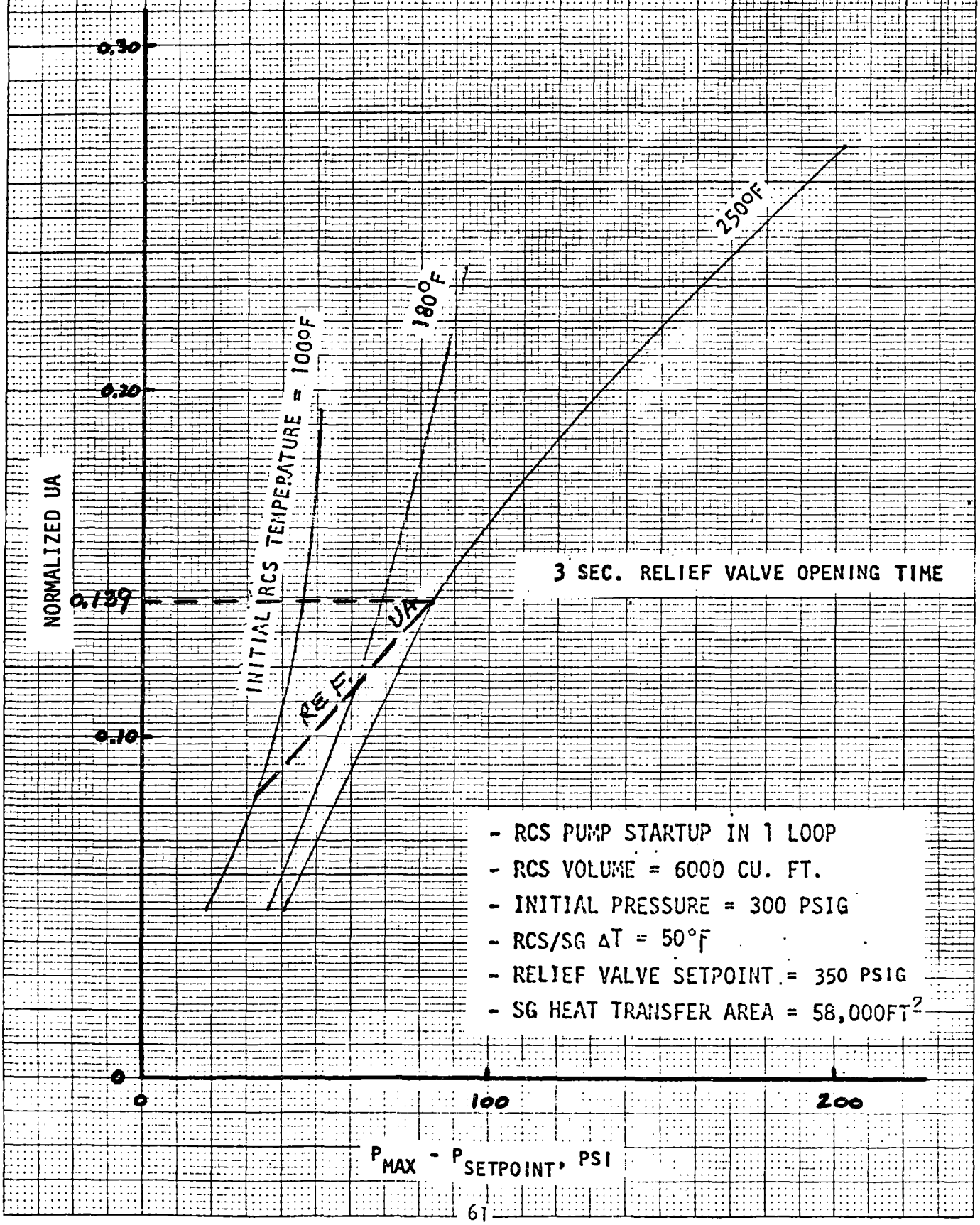
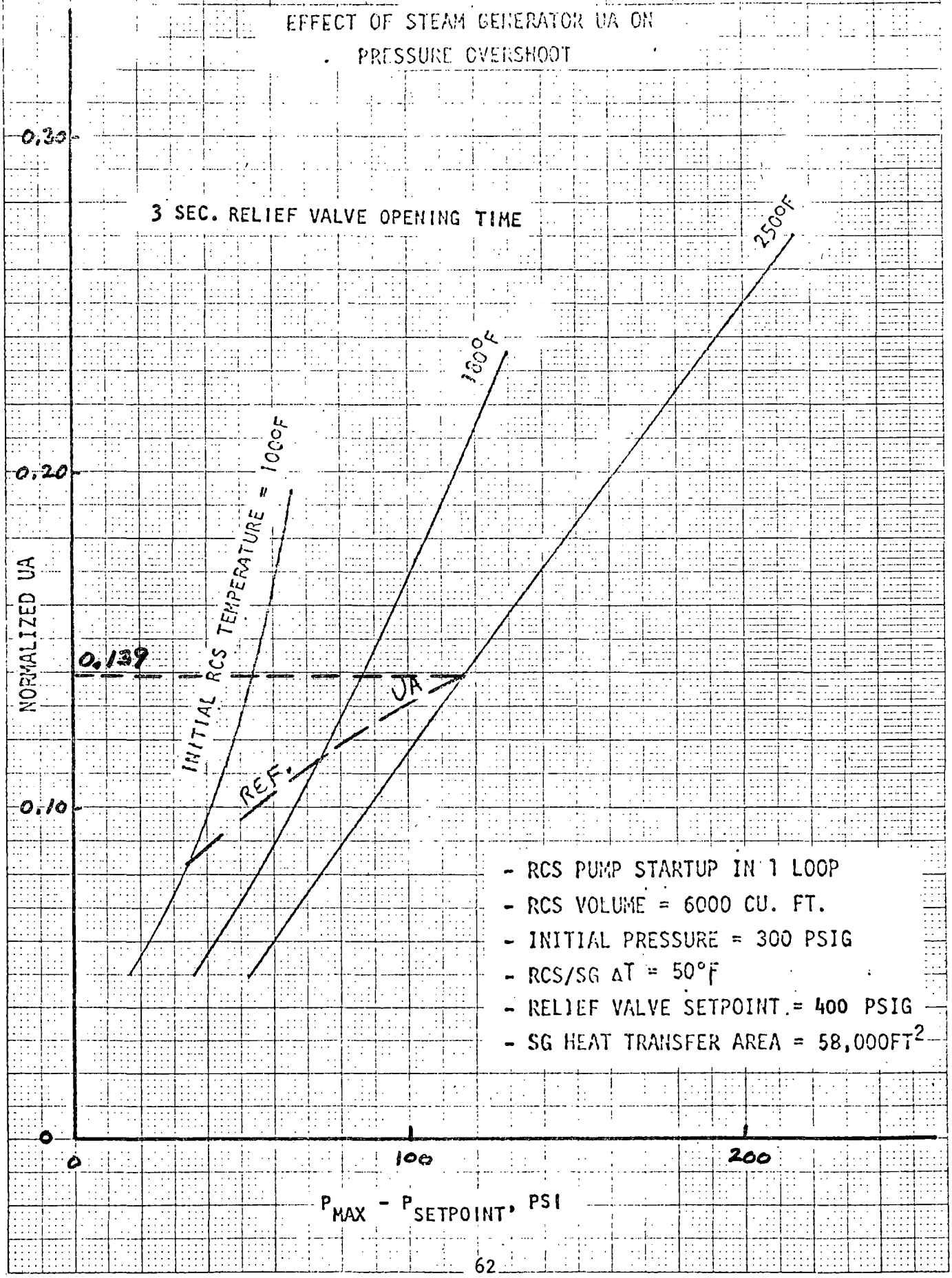


Figure C15

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



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10 X 10 TO ½ INCH 7 X 10 INCHES
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Step	Procedure	Example Application
4	For the same isotherm, T_{RCS}, and for UA^1_{350} and UA^1_{400} obtain new setpoint overshoots, ΔP^1_{350} and ΔP^1_{400} for the 350 psig and 400 psig relief valve setpoints, using Figures C16 and C17.	From Figure C16, for $T_{RCS} = 250^oF$, $\Delta t = 3$ seconds and $UA^1_{350} = 0.0695$, $P^1_{350} = \underline{50 \text{ psi}}$. From Figure C17, for $T_{RCS} = 250^oF$, $\Delta t = 3$ seconds and $UA^1_{400} = 0.0695$, $\Delta P^1_{400} = \underline{66 \text{ psi}}$.
5	For the actual relief valve setpoint, S, linearly interpolate the setpoint overshoot, ΔP^1_S, for the new steam generator UA from the relationship: $\Delta P^1_S = \Delta P^1_{350} + \frac{S - 350}{400 - 350} (\Delta P^1_{400} - \Delta P^1_{350})$	For S = 375 psig, $\Delta P^1_{350} = 50$ psi and $\Delta P^1_{400} = 66$ psi, $\Delta P^1_{375} = 50 + \frac{375 - 350}{400 - 350} (66 - 50) = \underline{58 \text{ psi}}$

Figure C16

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

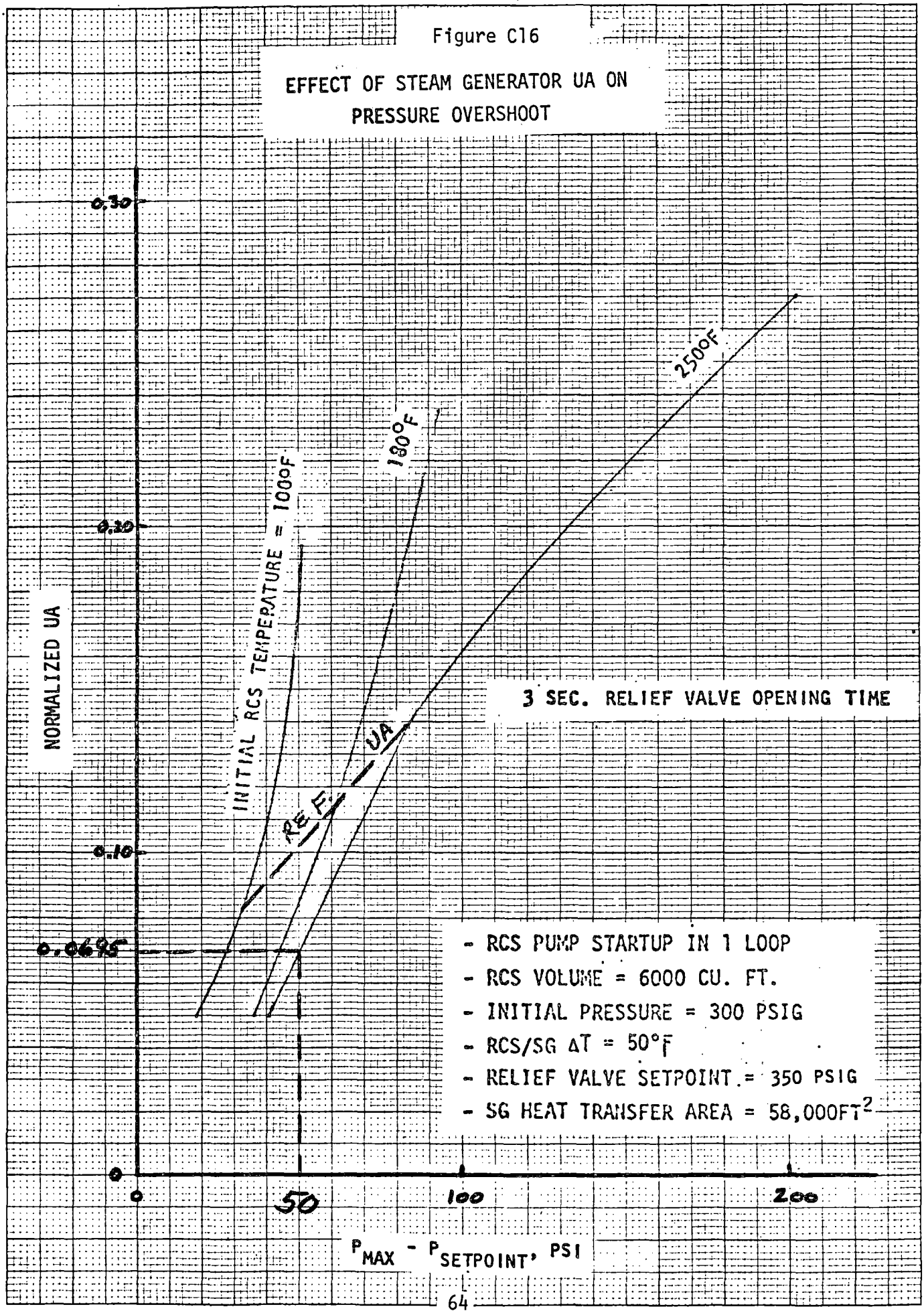
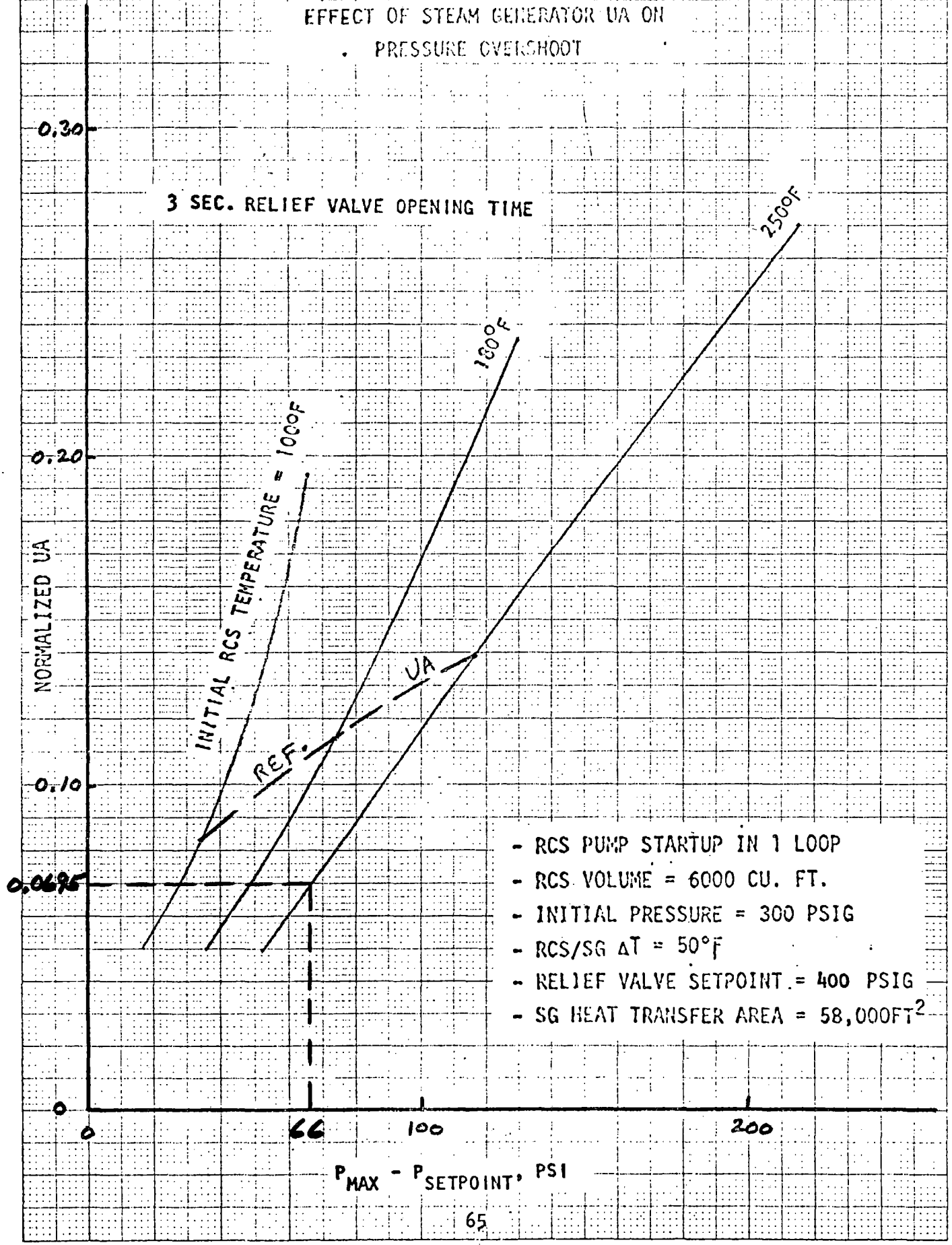


Figure C17

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



REFERENCE

1. "Pressure Mitigating Systems Transient Analysis Results," July 1977. (Westinghouse Report on RCS Solid Water Overpressurization prepared for the W Owners Group on RCS Overpressurization.)

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