

WC 1223-03-00

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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6. ILLUSTRATIVE EXAMPLE 6:

59

DETERMINATION OF SETPOINT OVERSHOOT GIVEN SG

TUBE HEAT TRANSFER AREA AND RELIEF VALVE

SETPOINT WITHIN GENERIC ENVELOPE

REFERENCE

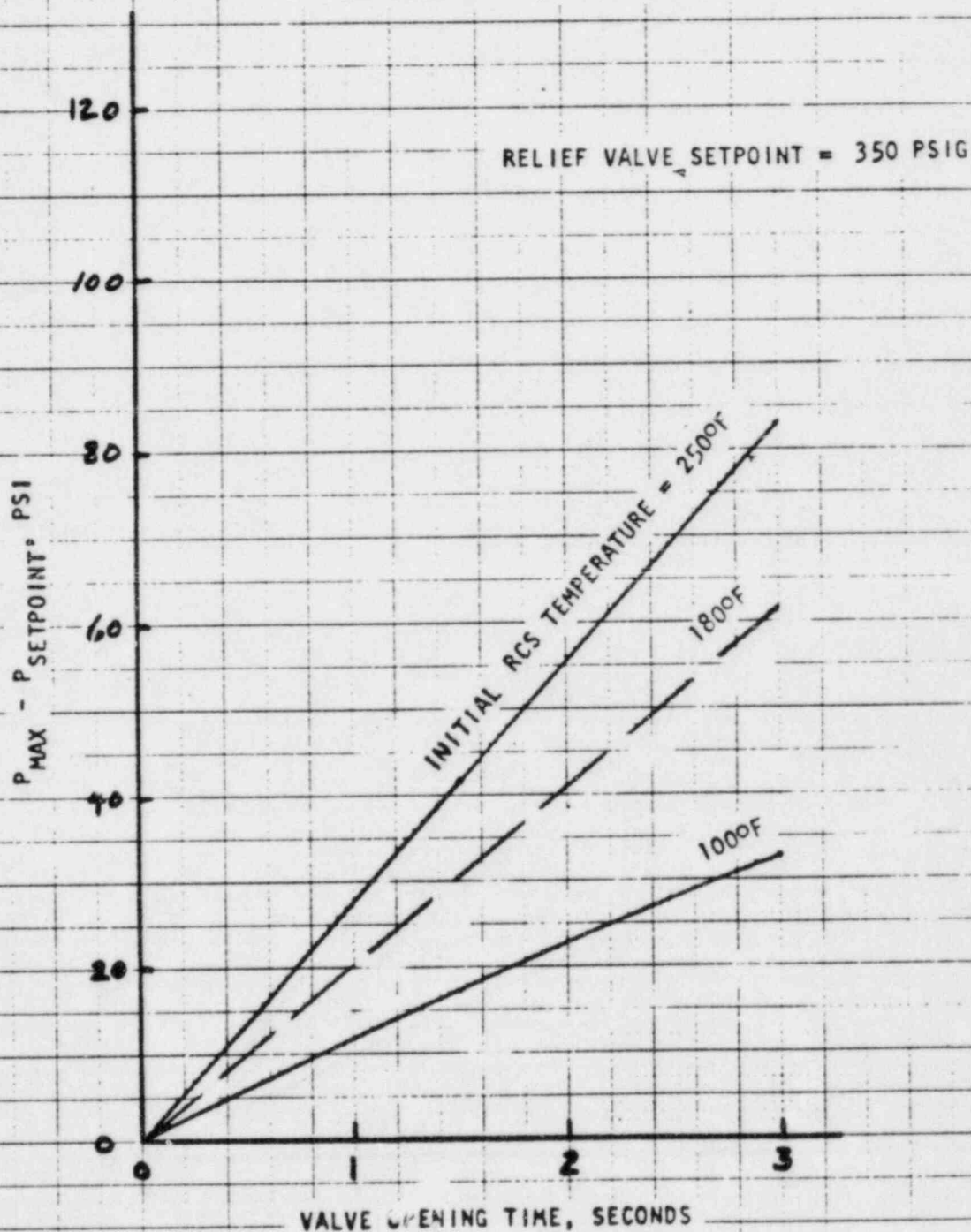
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I. SUPPLEMENTARY LOFTRAN HEAT INPUT RESULTS

A. SETPOINT OVERSHOOT VARIATION WITH
RELIEF VALVE OPENING TIME

**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 $\Delta T = 50^{\circ}F$
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 6,000 CU.FT.



46 1320

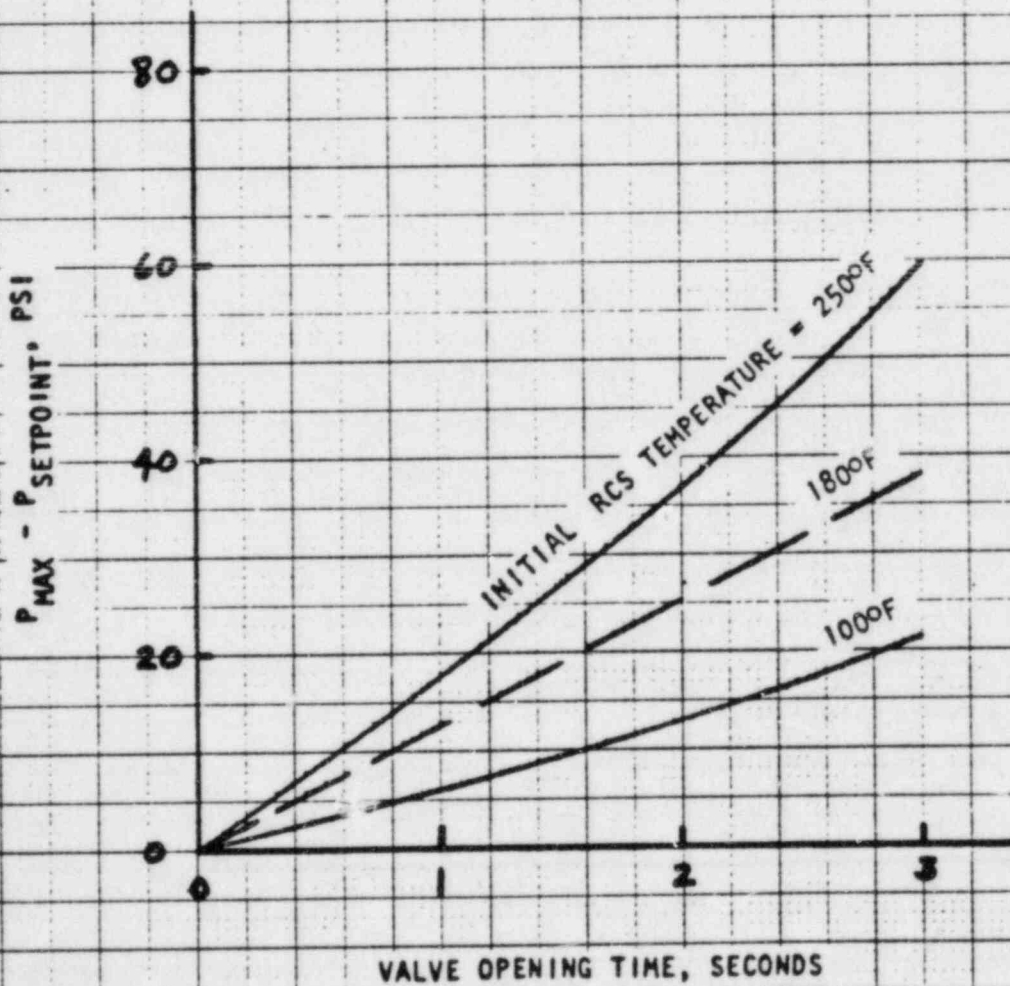
K-E 10 X 10 TO 1/2 INCH 7 X 10 INCH
KEUFFEL & ESSER CO. MADE IN U.S.A.


Figure 2

**EFFECT OF RELIEF VALVE
OPENING TIME ON RCS
PRESSURE OVERTHOOT**

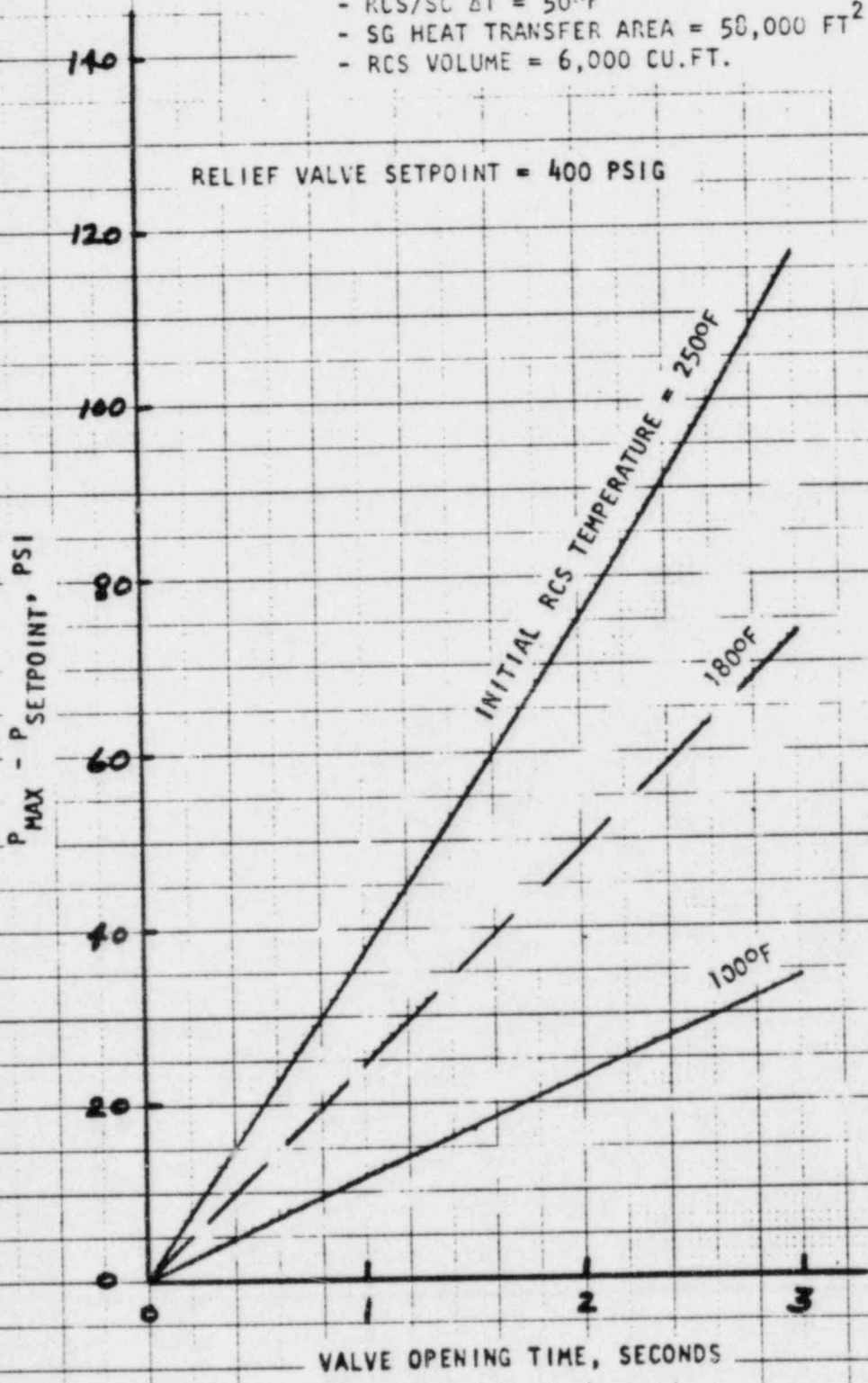
- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^{\circ}F$
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 13000 CU.FT.

RELIEF VALVE SETPOINT = 350 PSIG




1223-03-00 Figure 3
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 $\Delta T = 50^\circ F$
- SG HEAT TRANSFER AREA = 50,000 FT²
- RCS VOLUME = 6,000 CU.FT.



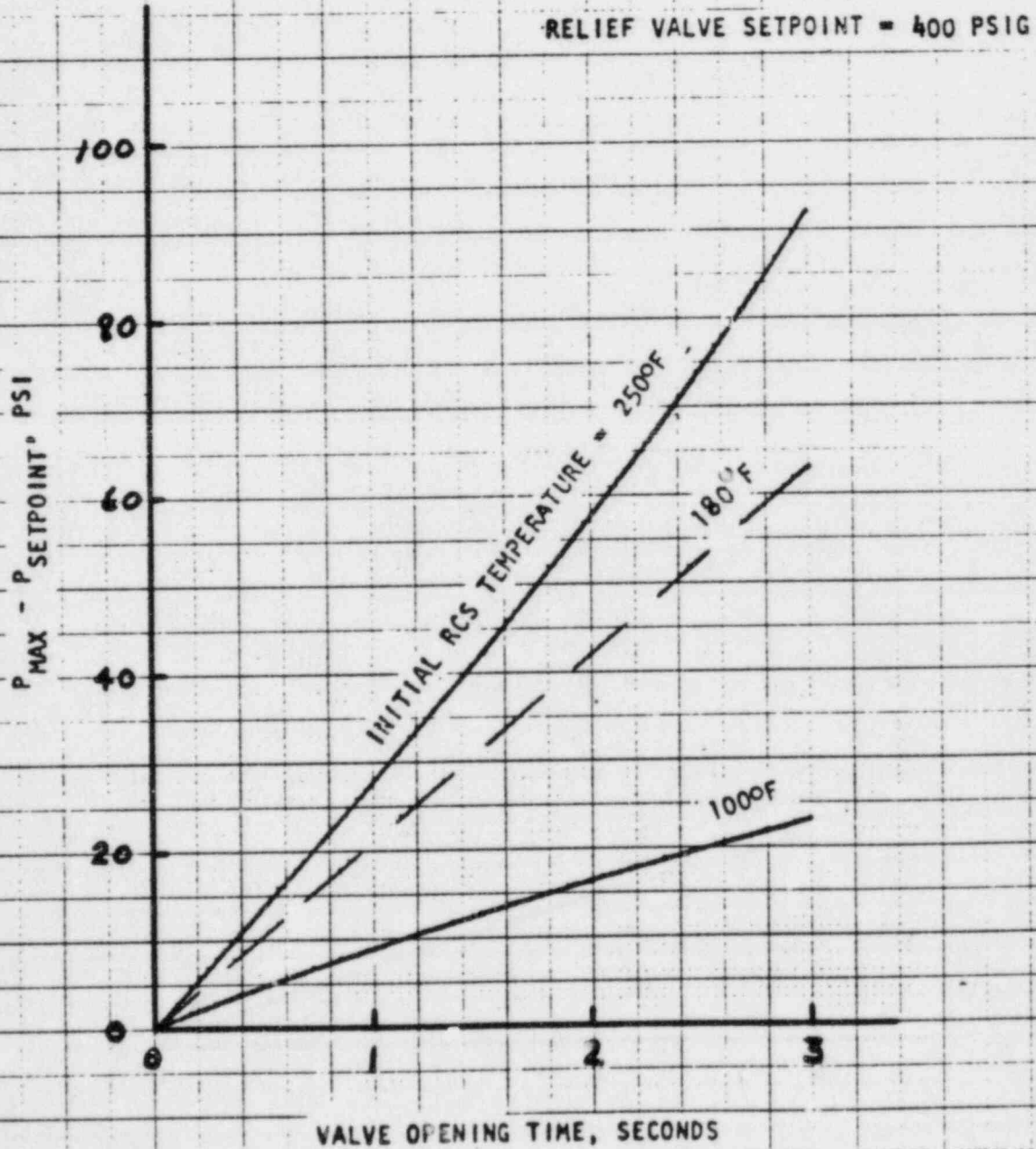
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K&E
10 X 10 TO 7/8 INCH 7 X 10 INCH
HEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 4

**EFFECT OF RELIEF VALVE
OPENING TIME ON RCS
PRESSURE OVERSHOOT**

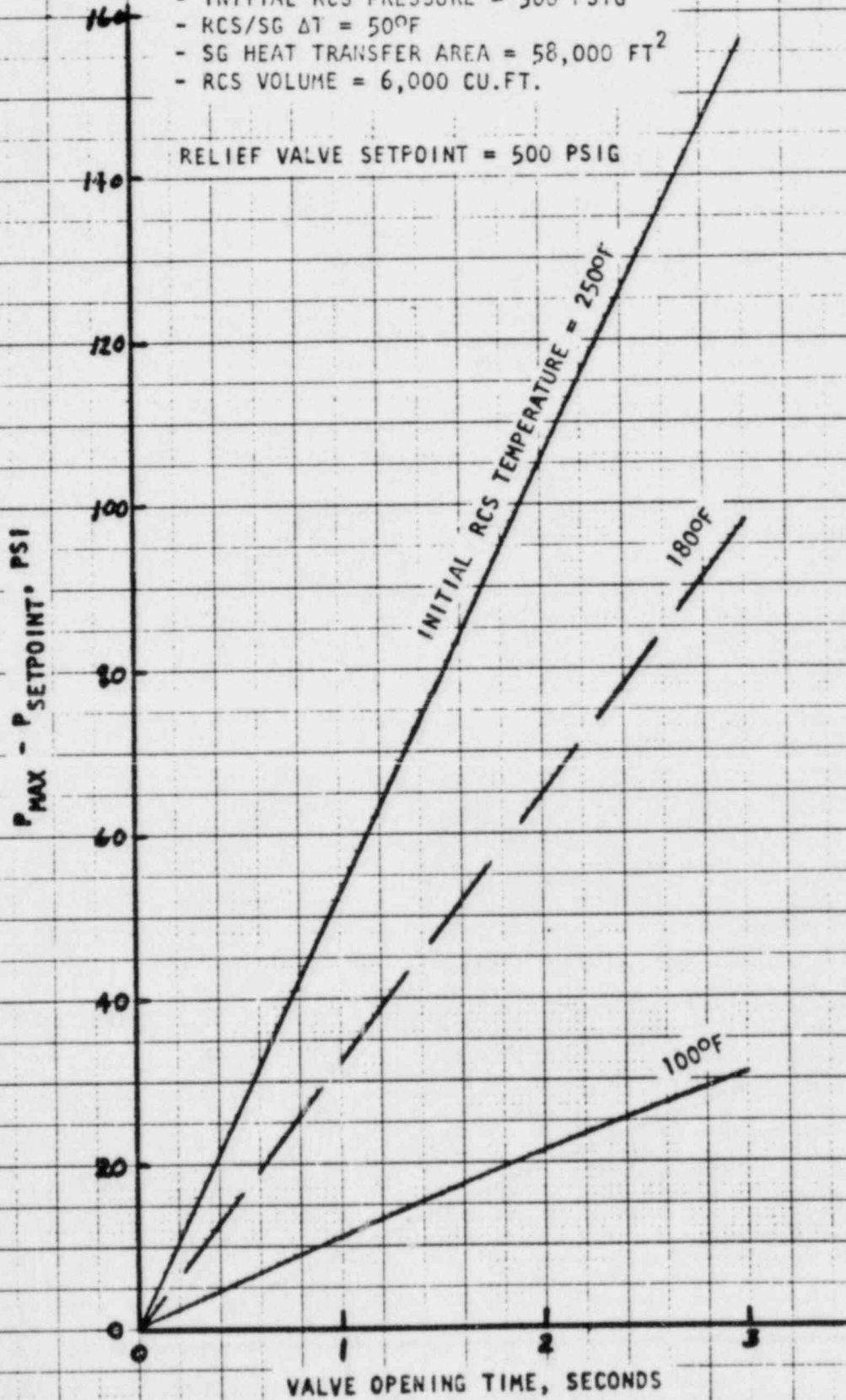
- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^{\circ}F$
- SG HEAT TRANSFER AREA = 58,000 FT²
- RCS VOLUME = 13000 CU. FT.



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 $\Delta T = 50^\circ F$
- SG HEAT TRANSFER AREA = 58,000 FT²
- RCS VOLUME = 6,000 CU.FT.

RELIEF VALVE SETPOINT = 500 PSIG

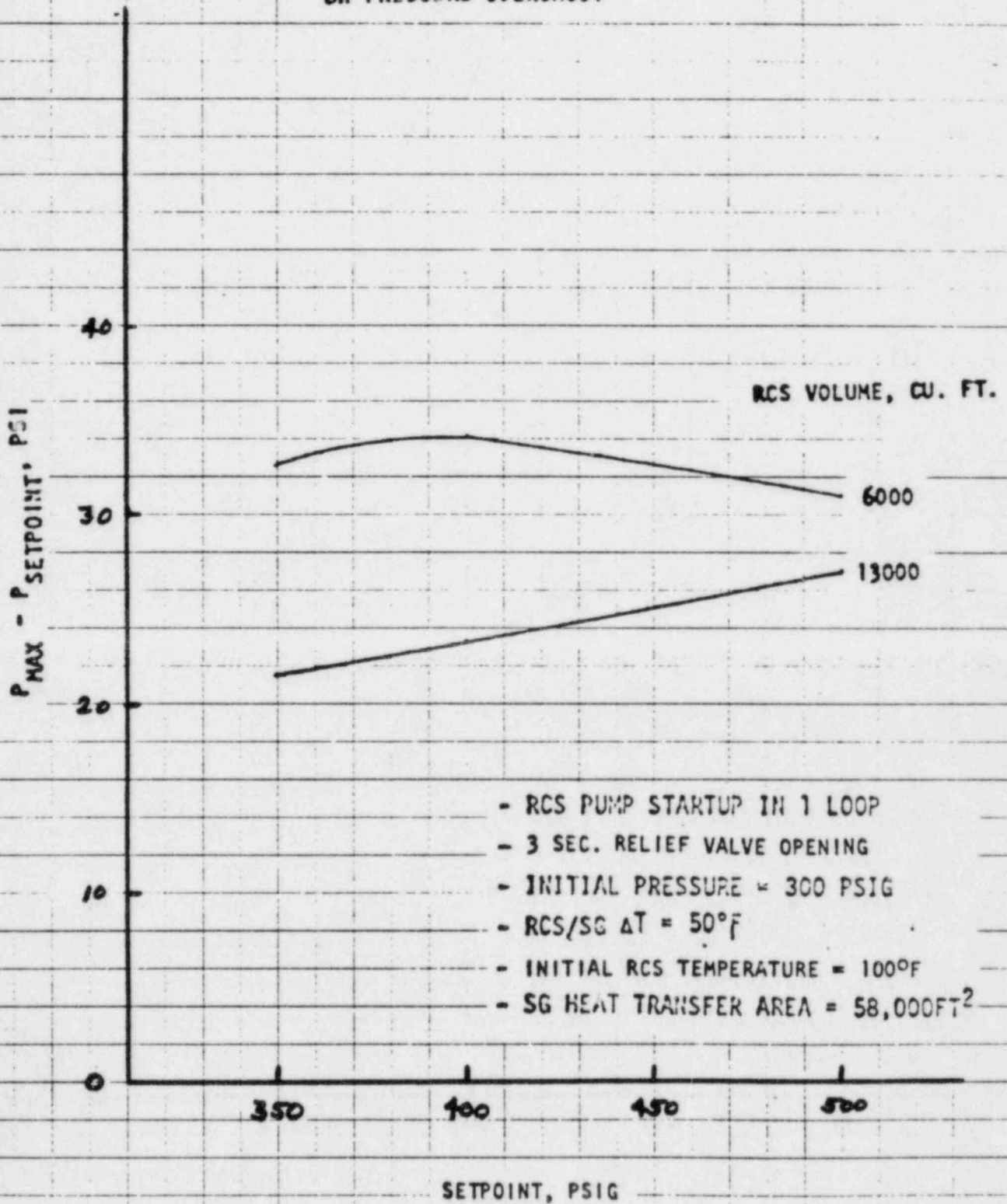


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K-E 10 X 10 TO 1/2 INCH 7 X 11 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

B. SETPOINT OVERSHOOT VARIATION WITH
RELIEF VALVE SETPOINT

EFFECT OF RELIEF VALVE SETPOINT
ON PRESSURE OVERSHOOT



- 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 = 58,000FT²

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K-Σ 10 X 10 TO 1/2 INCH 7 X 10 INH 111'S
HEUFFEL & ESSEFF CO. MADE IN U.S.A.

Figure 8

EFFECT OF RELIEF VALVE SETPOINT
ON PRESSURE OVERSHOOT

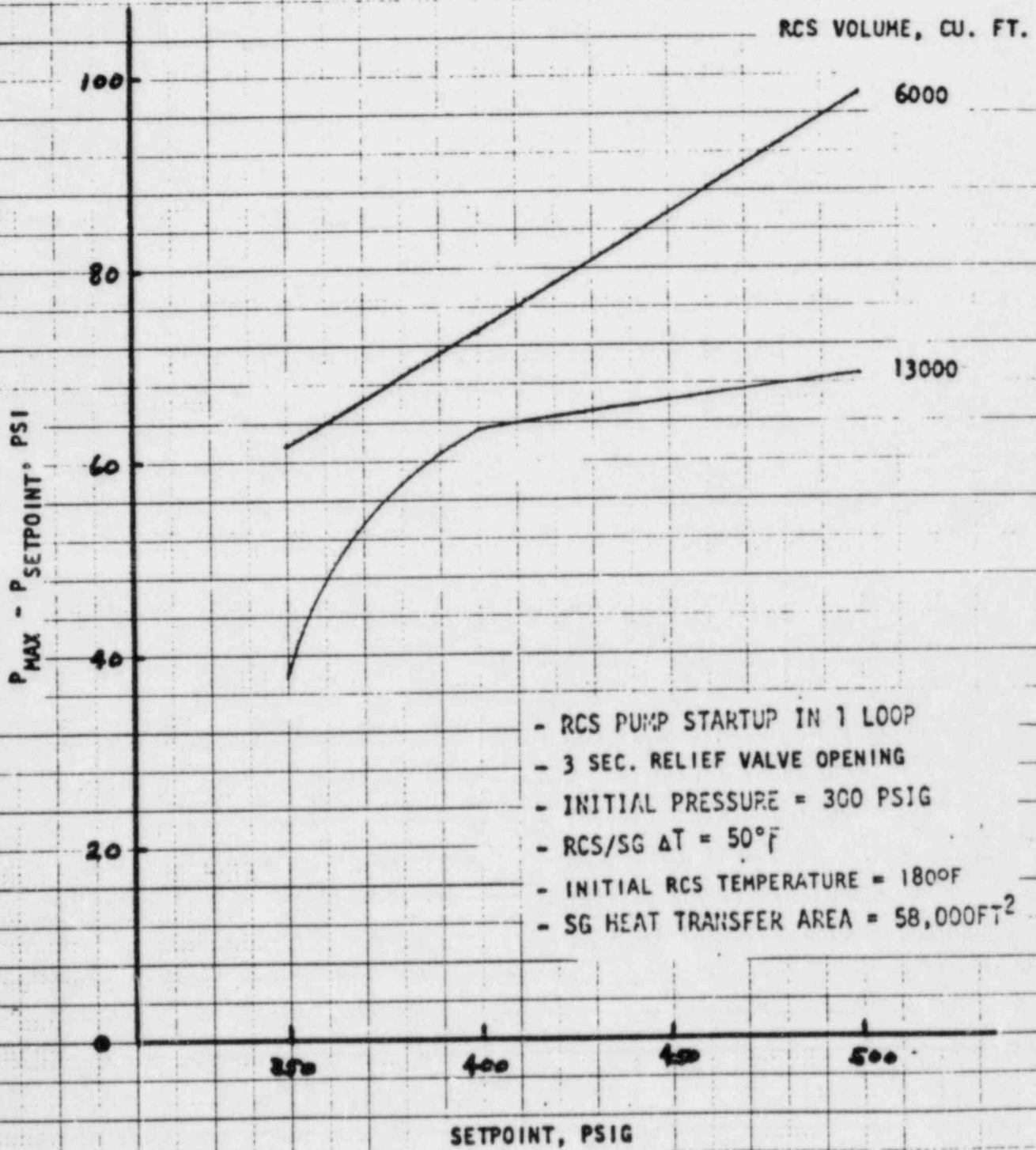
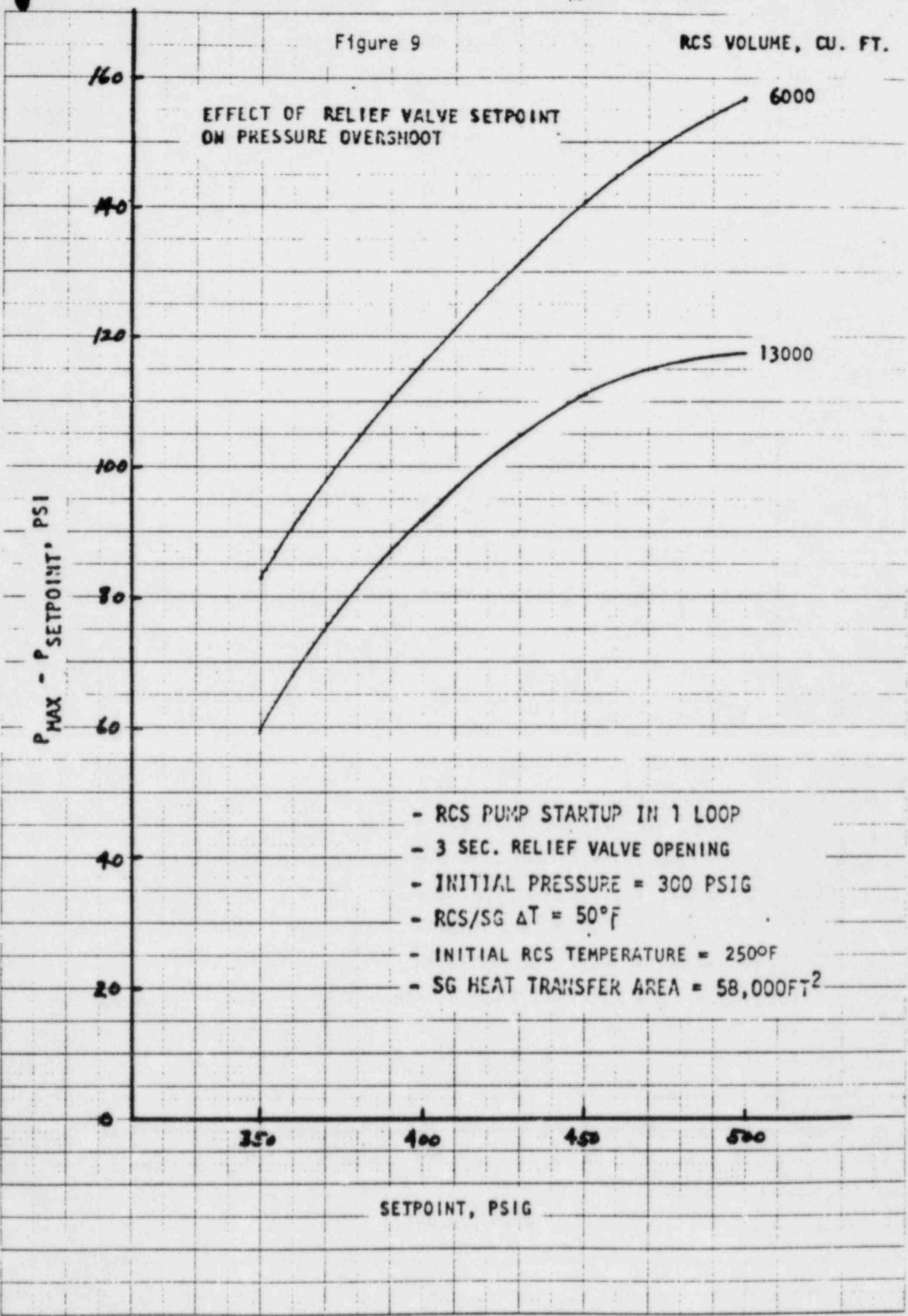


Figure 9

RCS VOLUME, CU. FT.

EFFECT OF RELIEF VALVE SETPOINT ON PRESSURE OVERSHOOT



- 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 = 58,000FT²

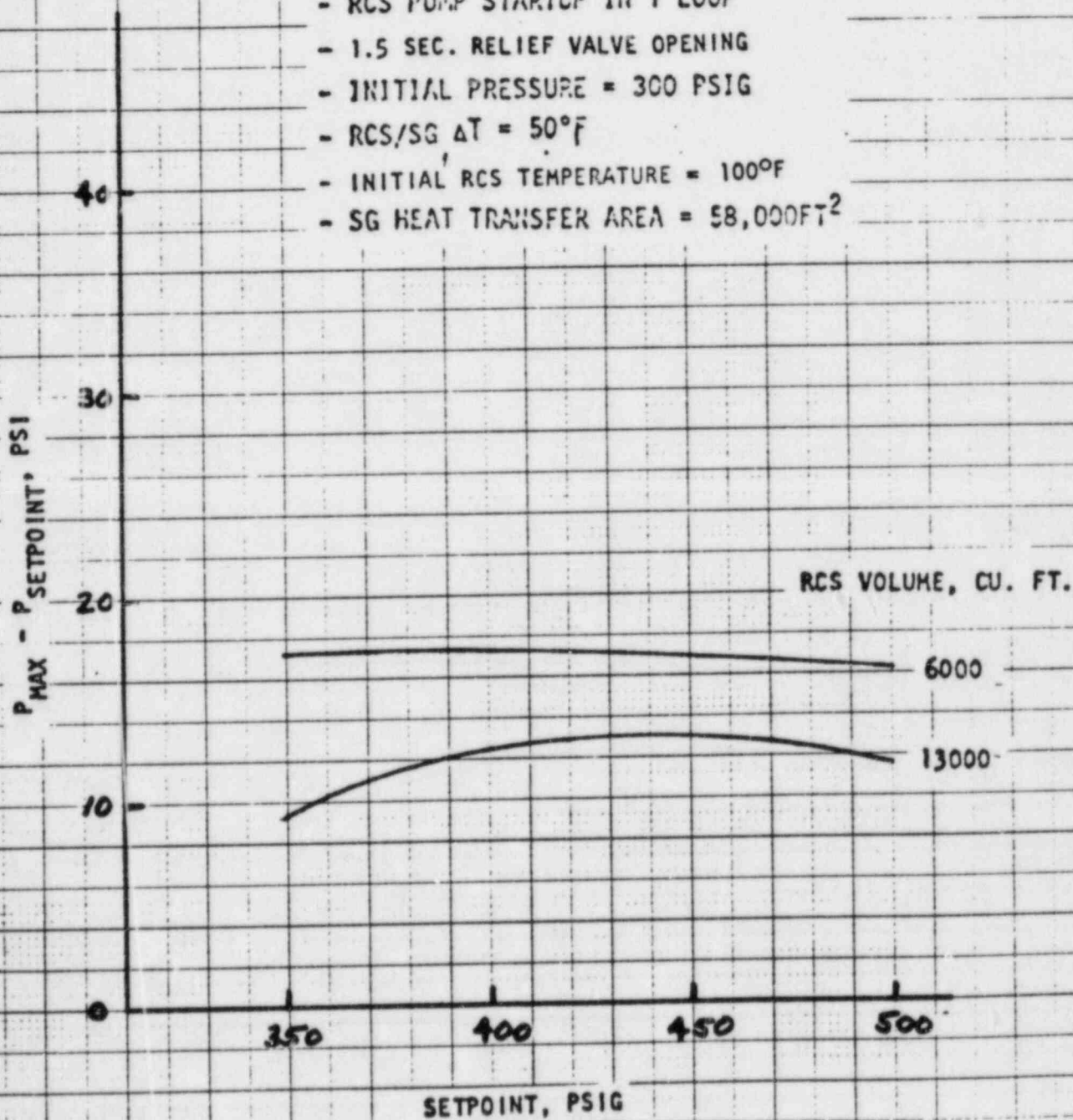
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K-E 10 X 10 TO 1/2 INCH 7 X 10 INCHES NEUFEL & ESSER CO. MADE IN U.S.A.

Figure 10

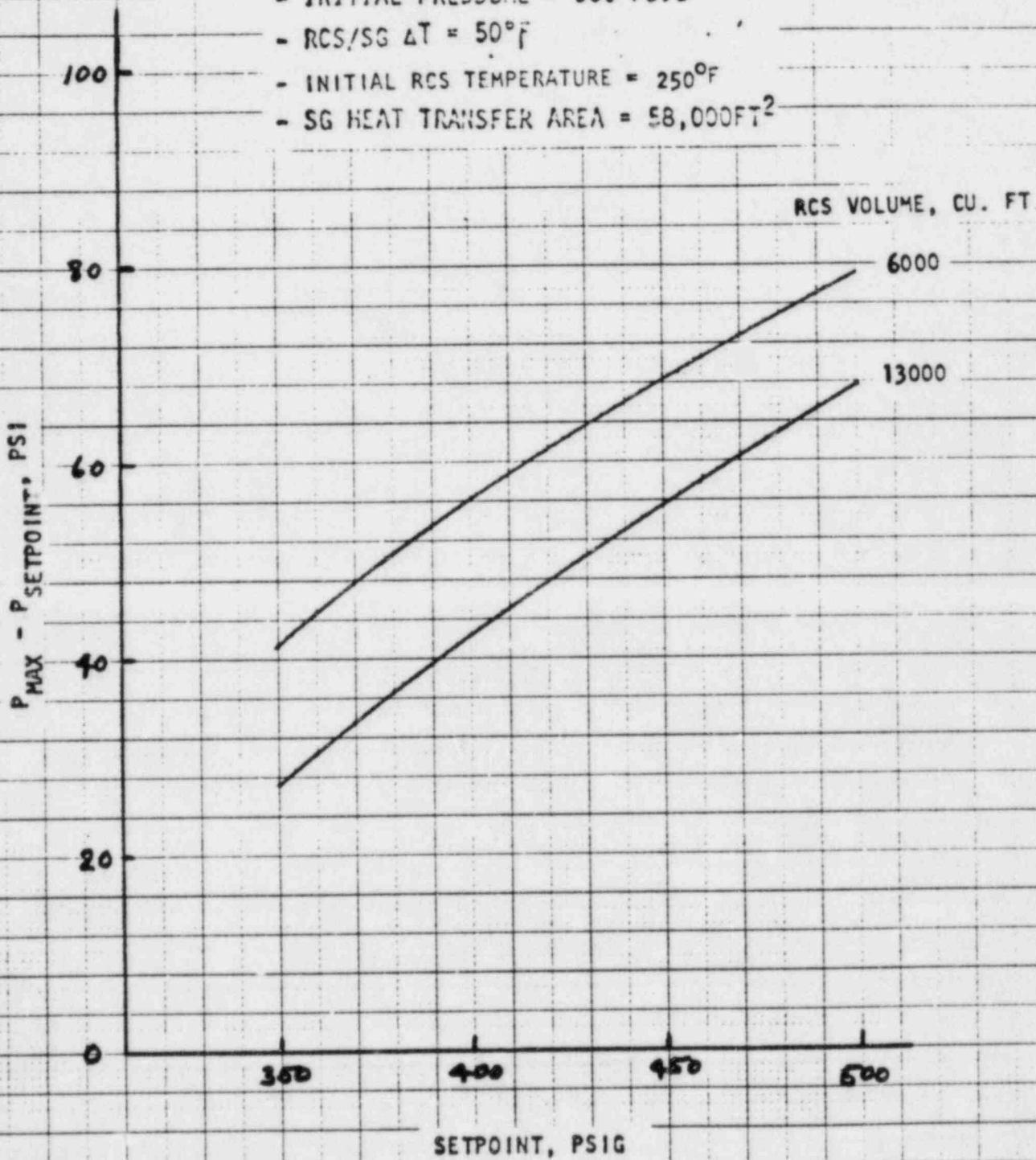
EFFECT OF RELIEF VALVE SETPOINT ON PRESSURE OVERSHOOT

- RCS PUMP STARTUP IN 1 LOOP
- 1.5 SEC. RELIEF VALVE OPENING
- INITIAL PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^{\circ}F$
- INITIAL RCS TEMPERATURE = $100^{\circ}F$
- SG HEAT TRANSFER AREA = 58,000FT²



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 $\Delta T = 50^{\circ}F$
- INITIAL RCS TEMPERATURE = $250^{\circ}F$
- SG HEAT TRANSFER AREA = 58,000FT²

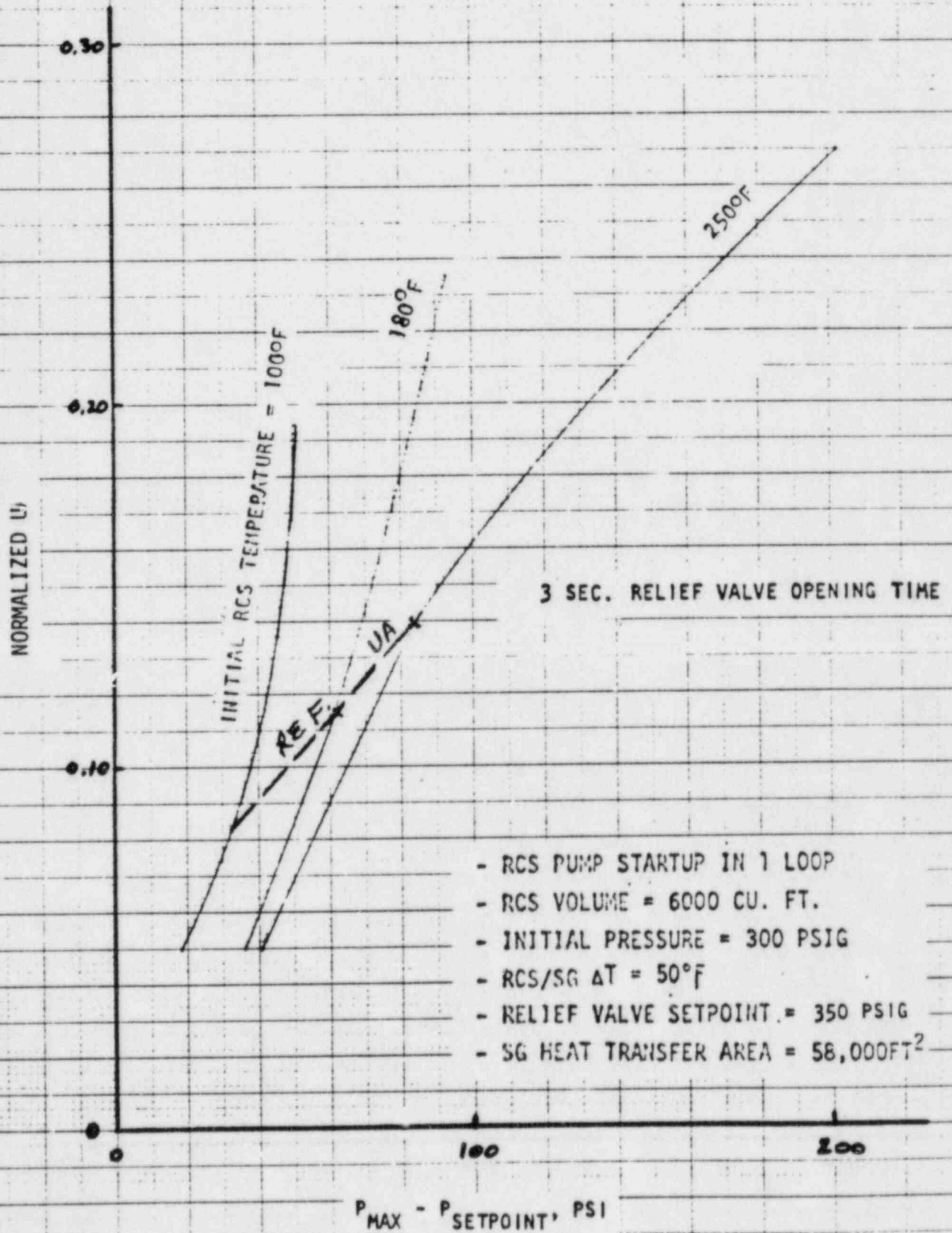


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K-E 10 X 10 TO 1/2 INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

C. SETPOINT OVERSHOOT VARIATION WITH
NORMALIZED STEAM GENERATOR UA

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT



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K-E 10 X 10 TO 1/2 INCH 7 X 10 INCHES
KROFFEL & ESSER CO. MADE IN U.S.A.

EFFECT OF STEAM GENERATOR UA ON
 PRESSURE OVERTHOOT

Figure 13

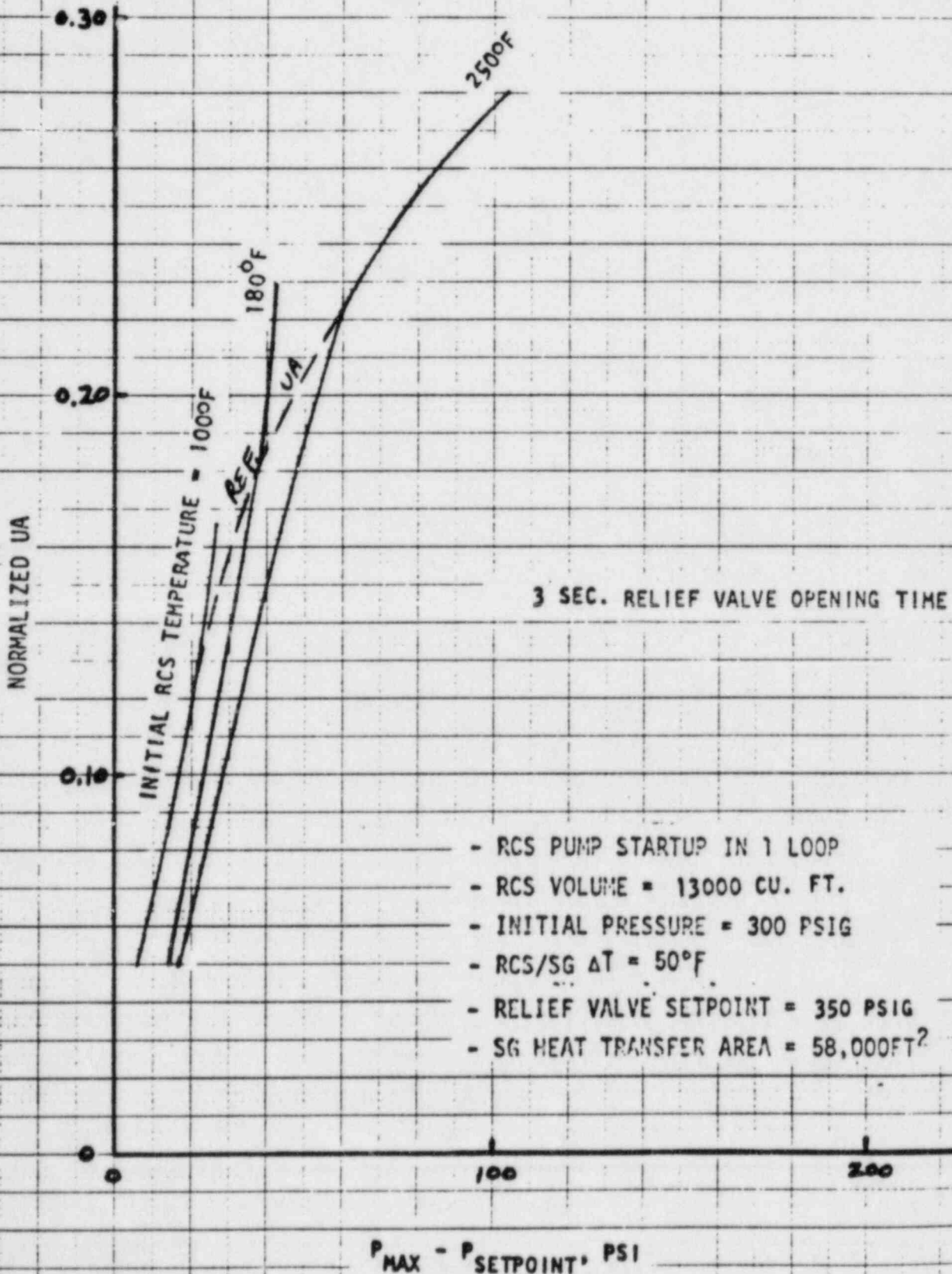
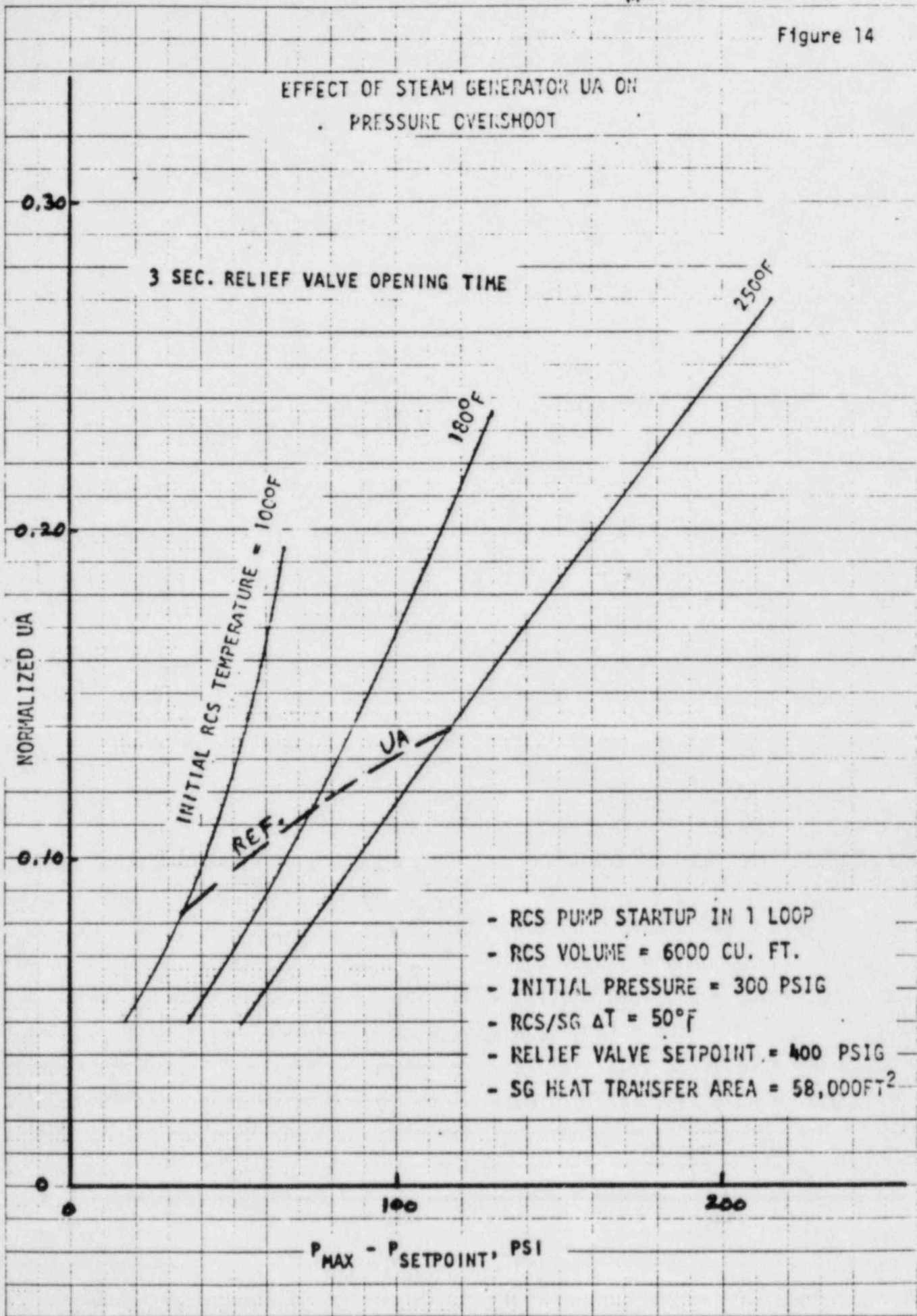


Figure 14

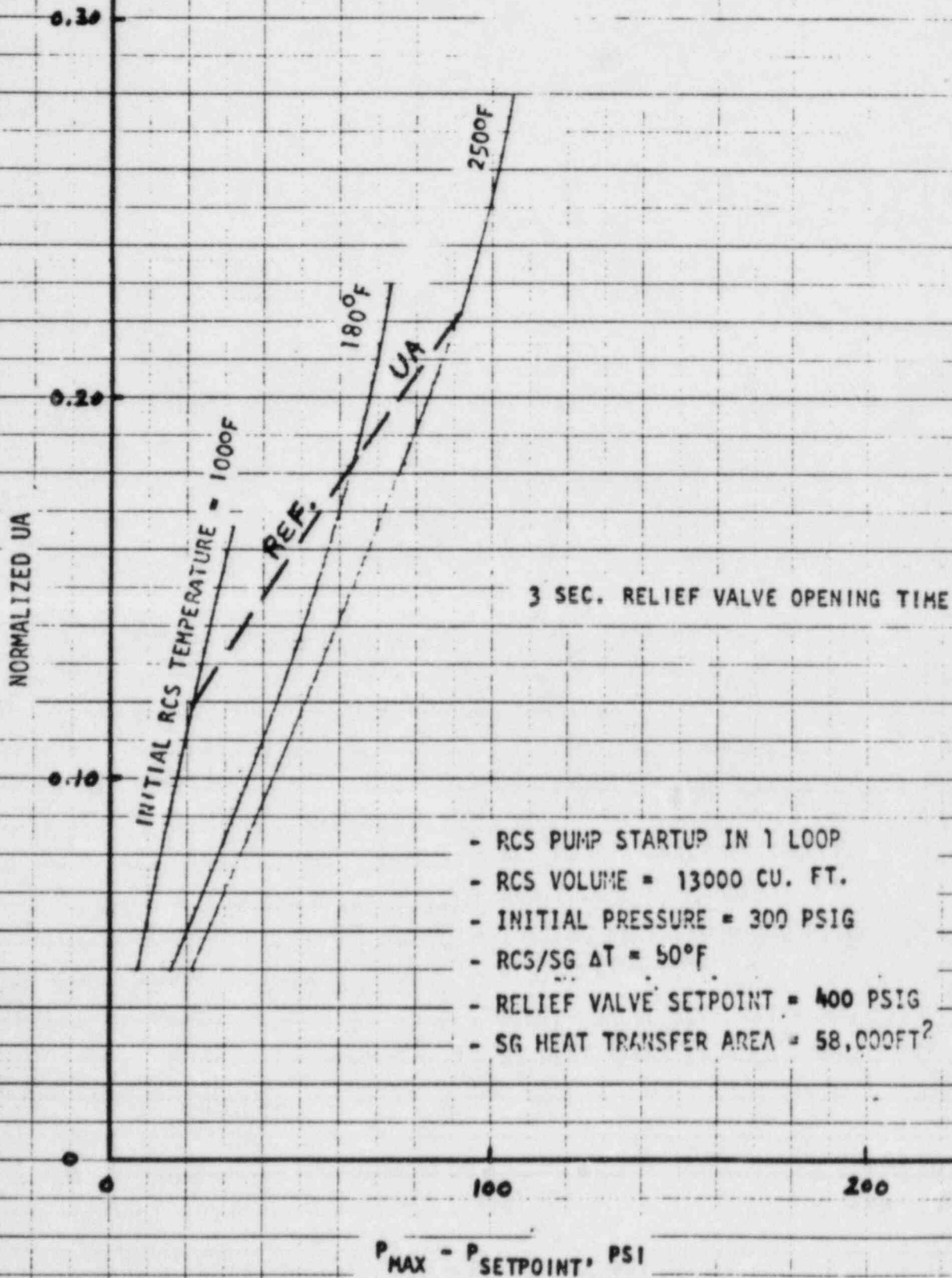


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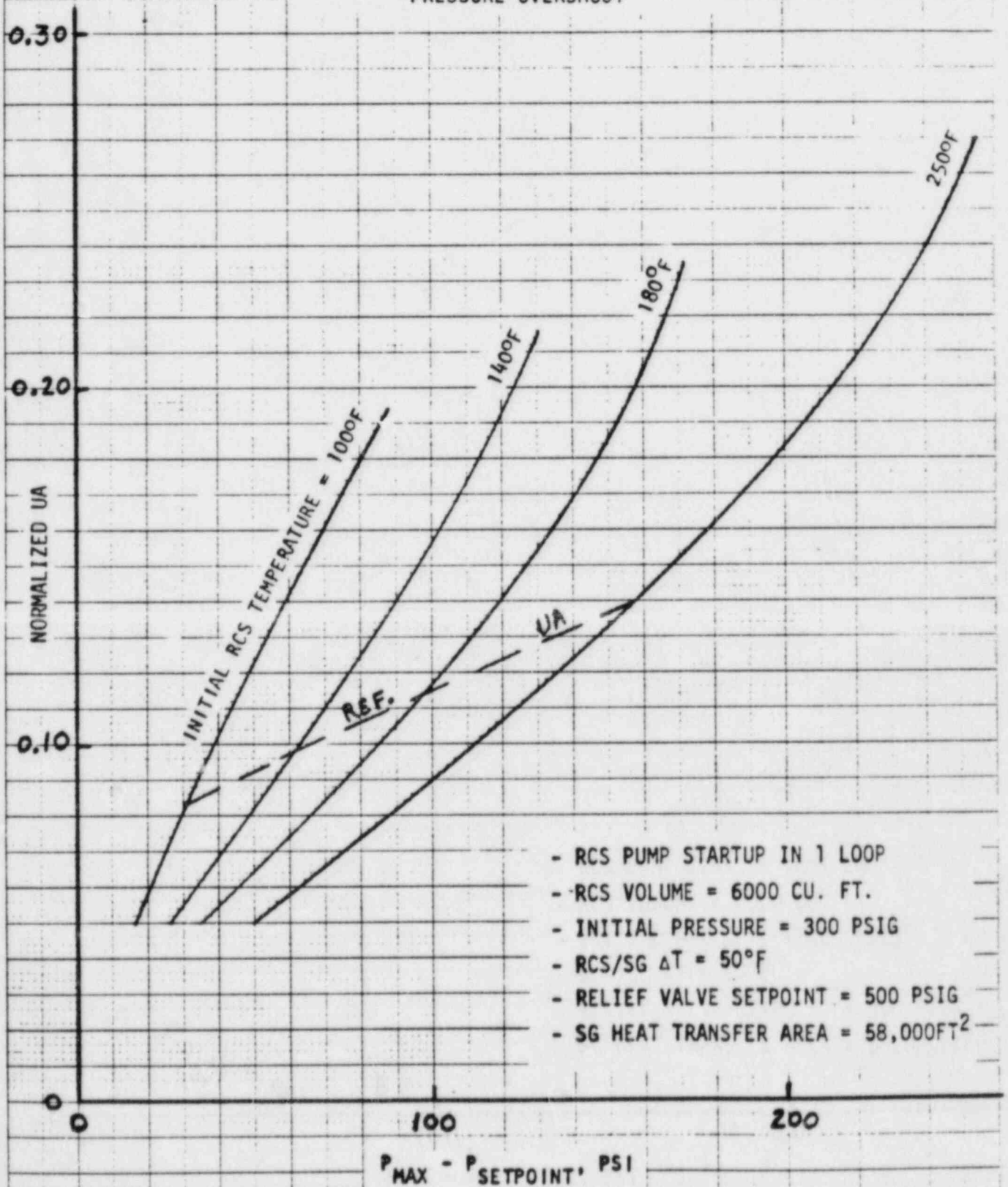
K&E 10 X 10 TO 1/2 INCH 7 X 10 INCHES
KODAK & ESSER CO. MADE IN U.S.A.

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERTHOOT

Figure 15



EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT



- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 6000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^\circ F$
- RELIEF VALVE SETPOINT = 500 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²

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K-E 10 X 10 TO 1/2 INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 17

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

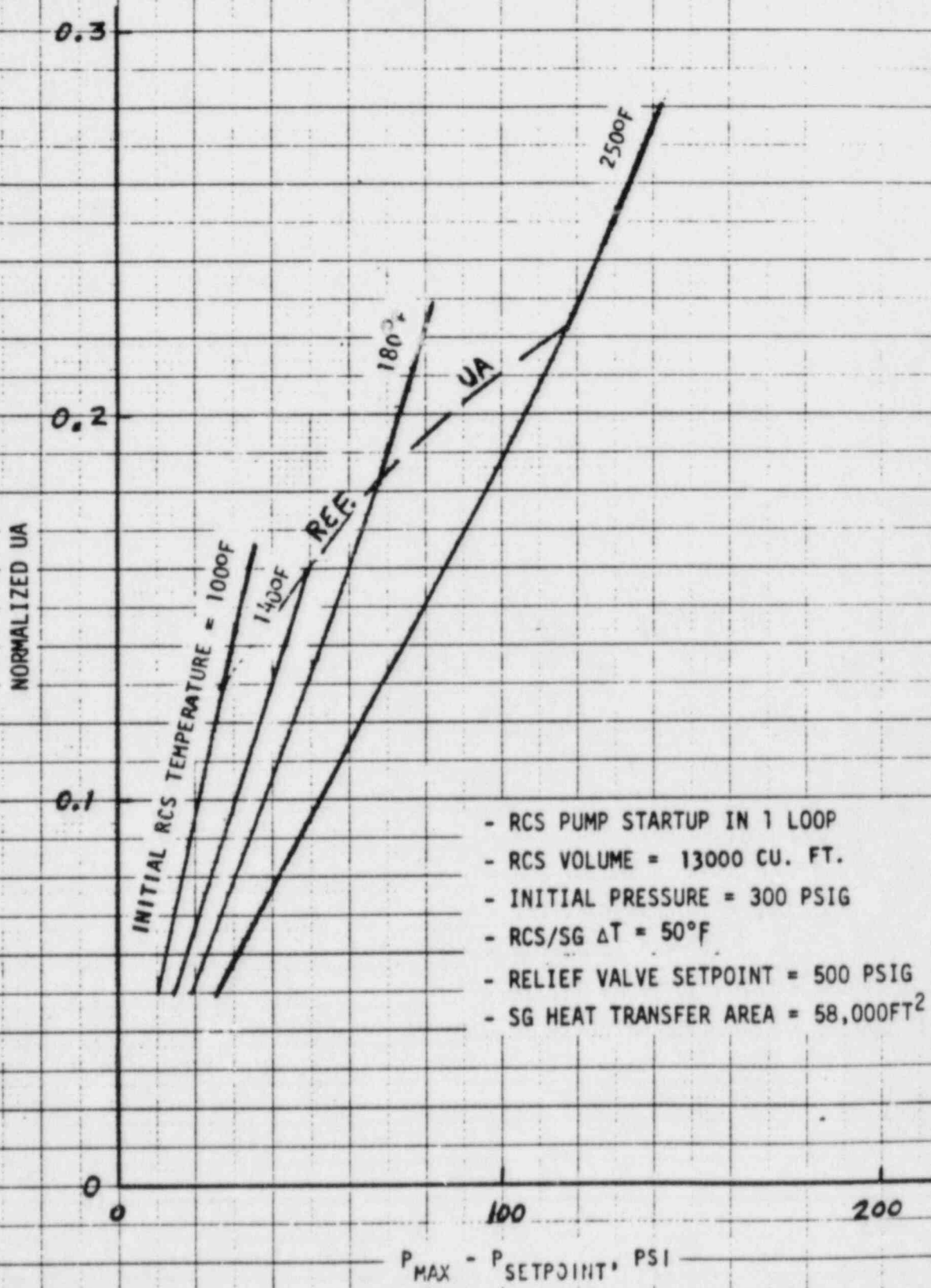
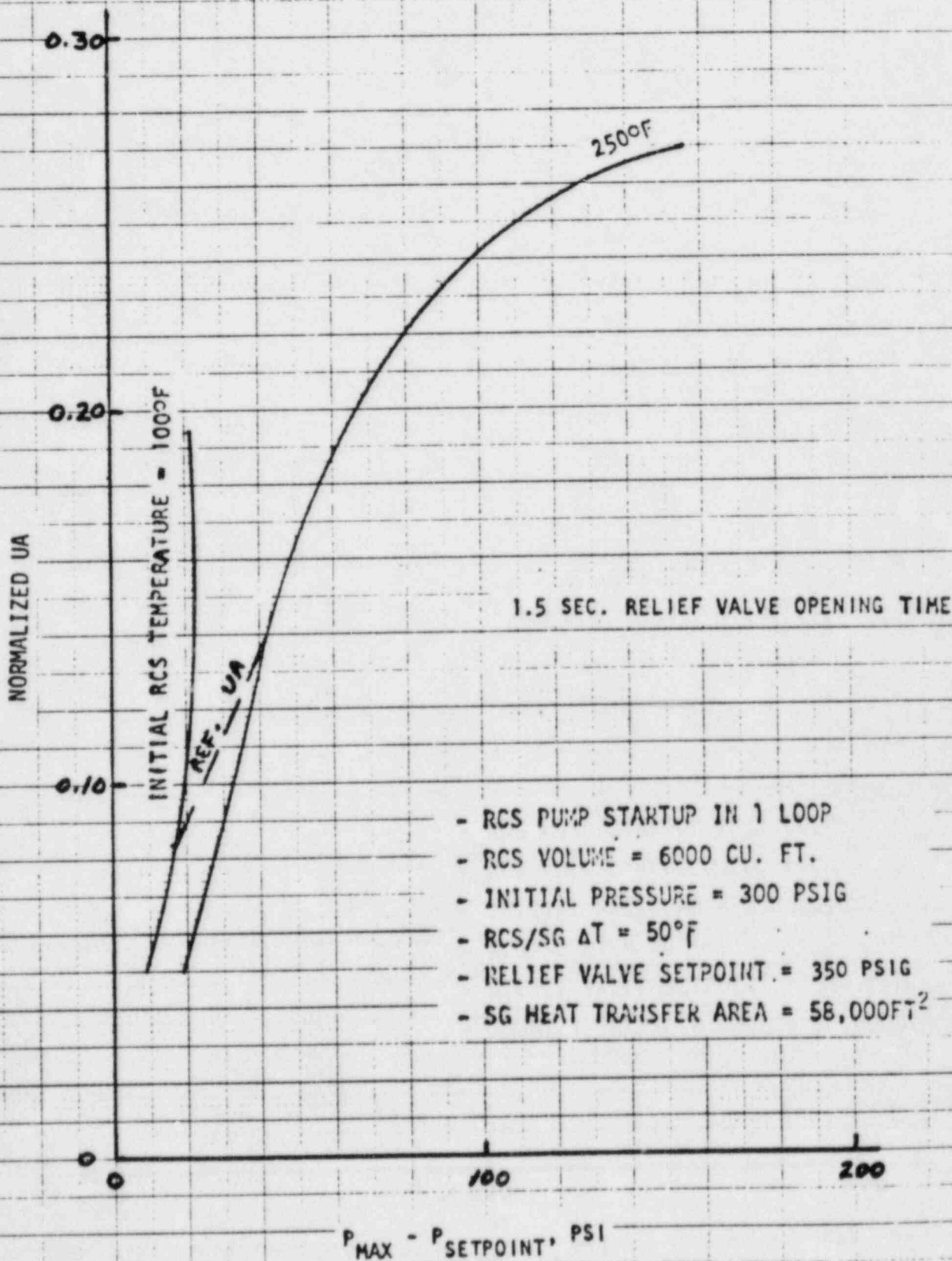


Figure 18

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERTHOOT



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K-E 10 X 10 TO 1/2 INCH 7 X 10 INCHES
KEUFEL & ESSER CO. MADE IN U.S.A.

Figure 19

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT

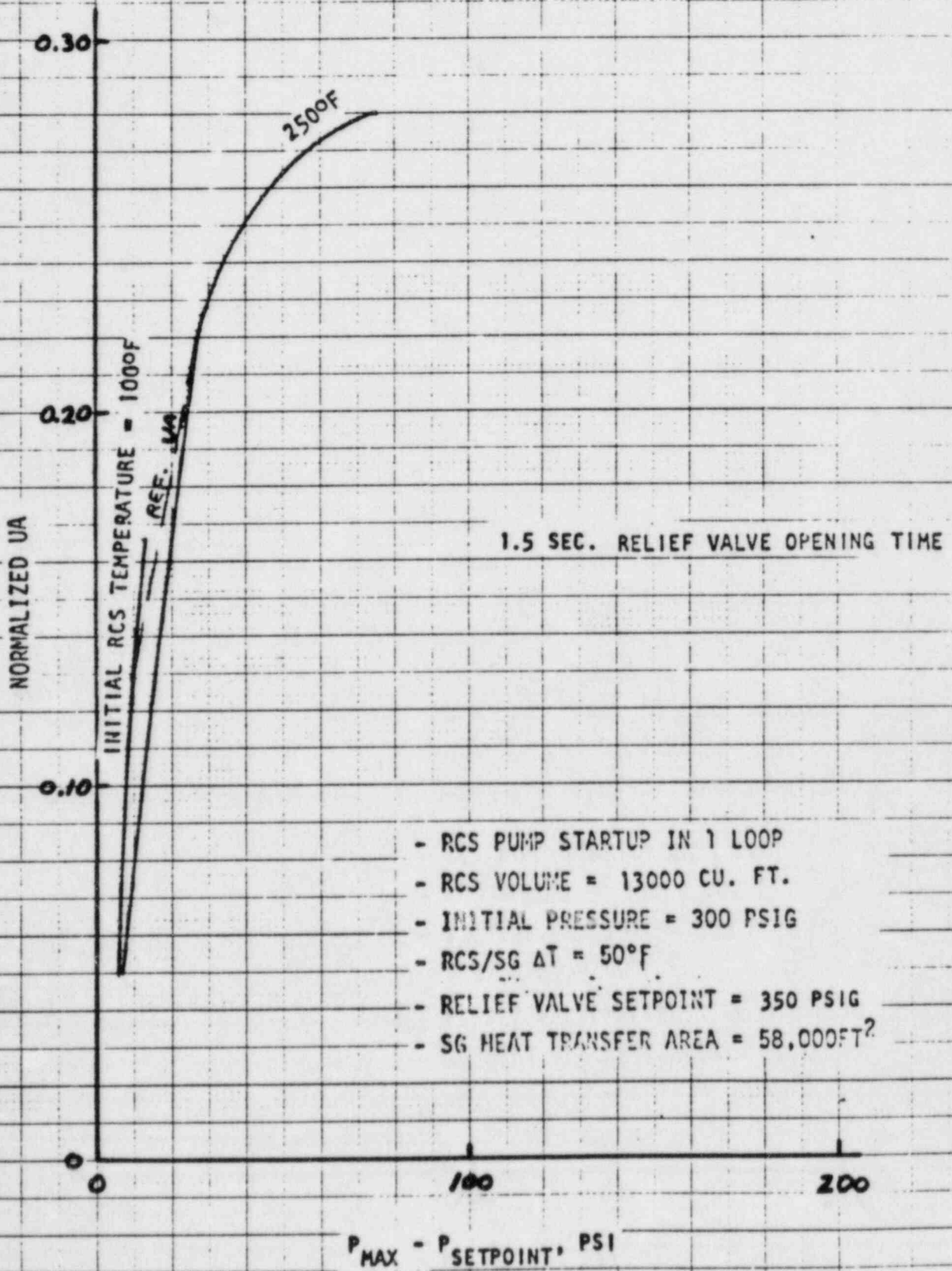
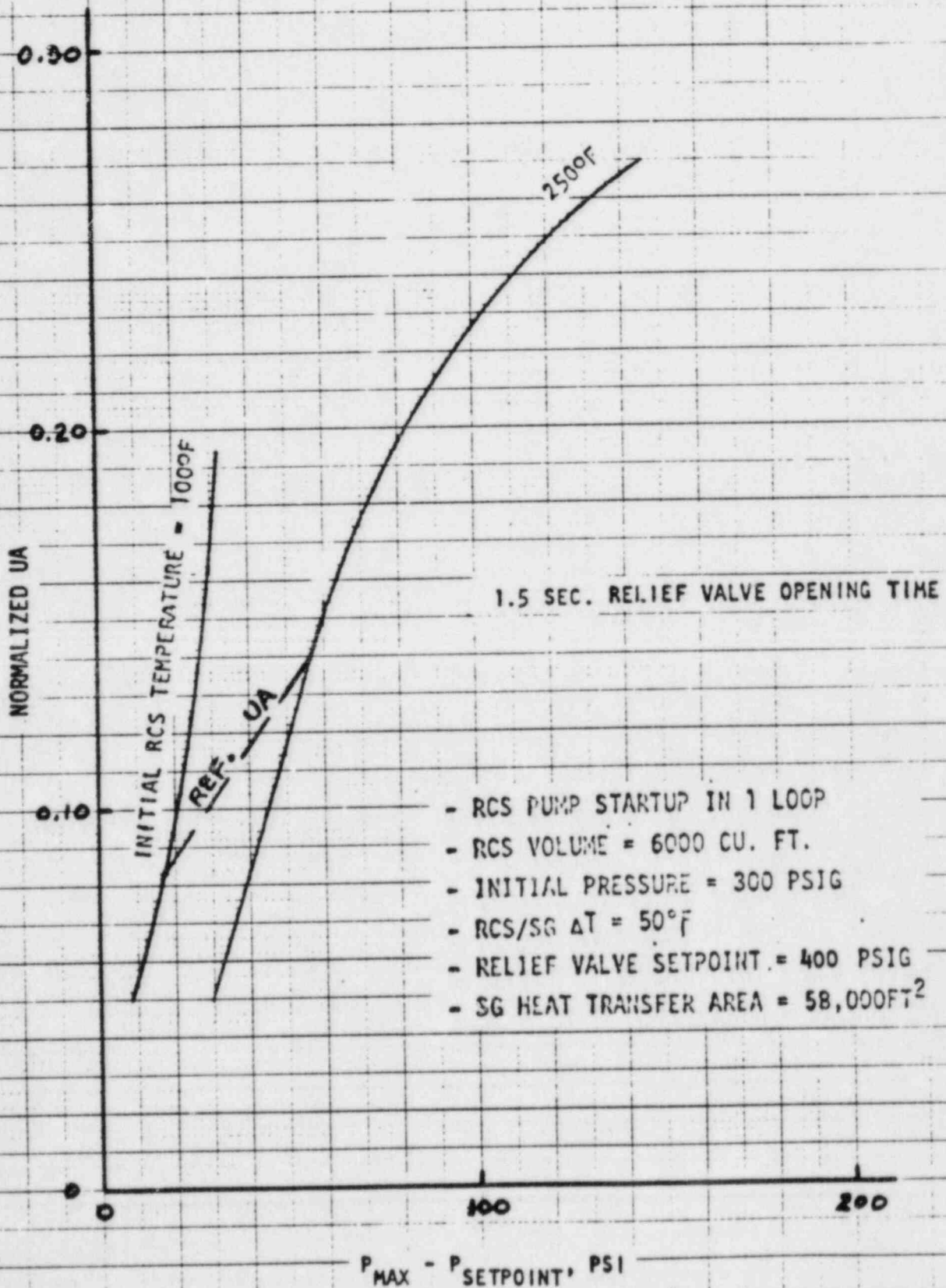


Figure 20

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT



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K•E 10 X 10 TO 1/2 INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 21

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

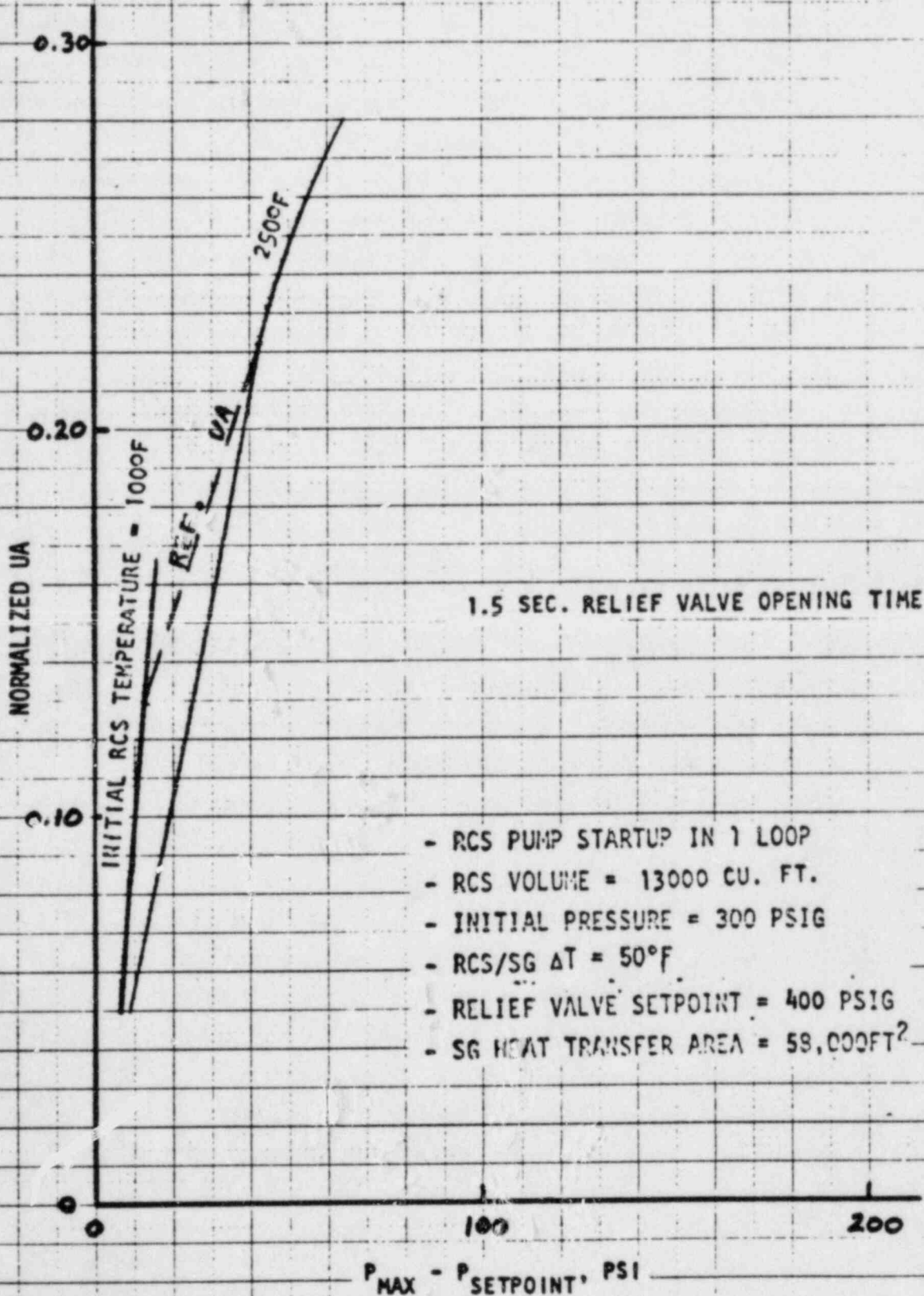
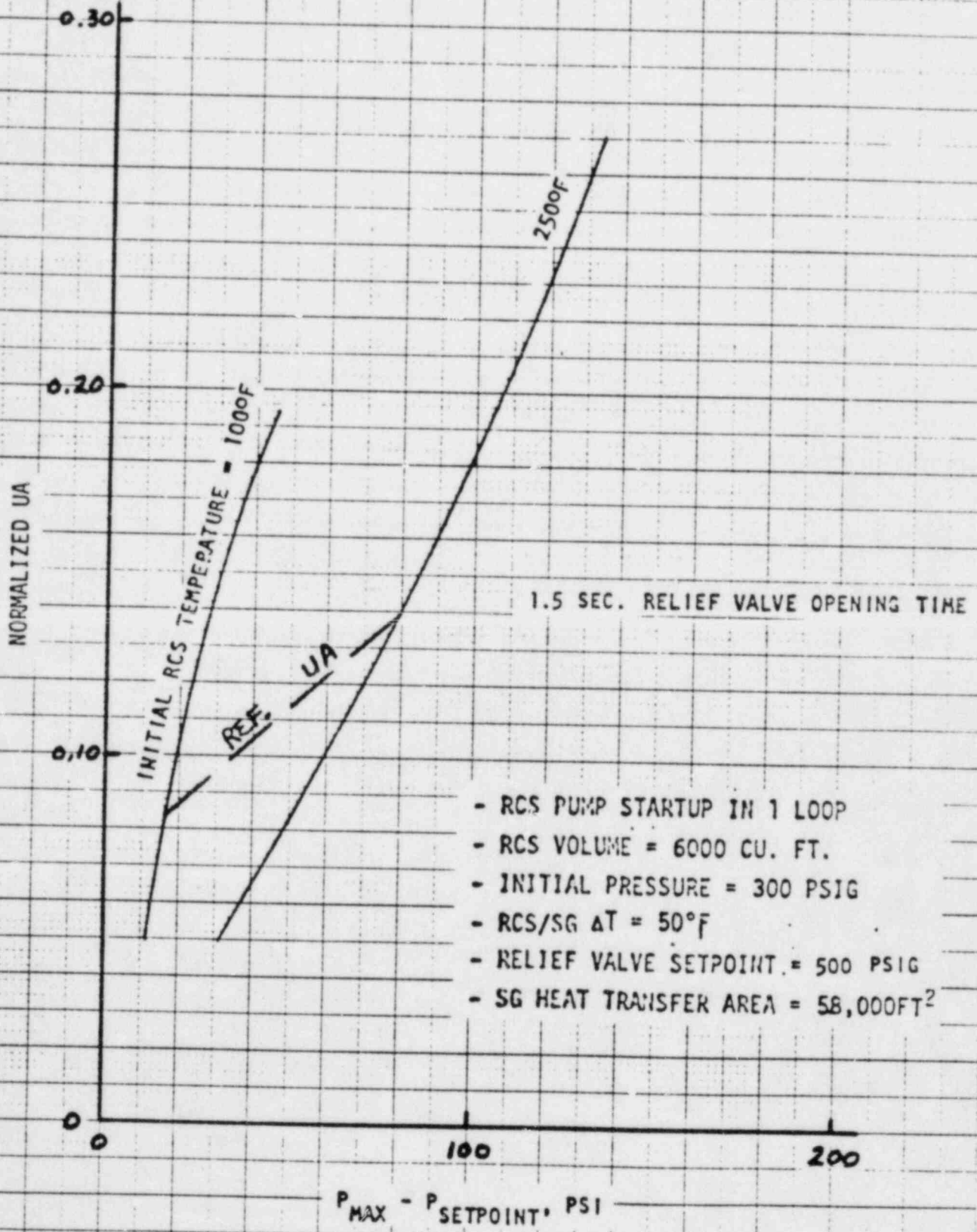


Figure 22

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT

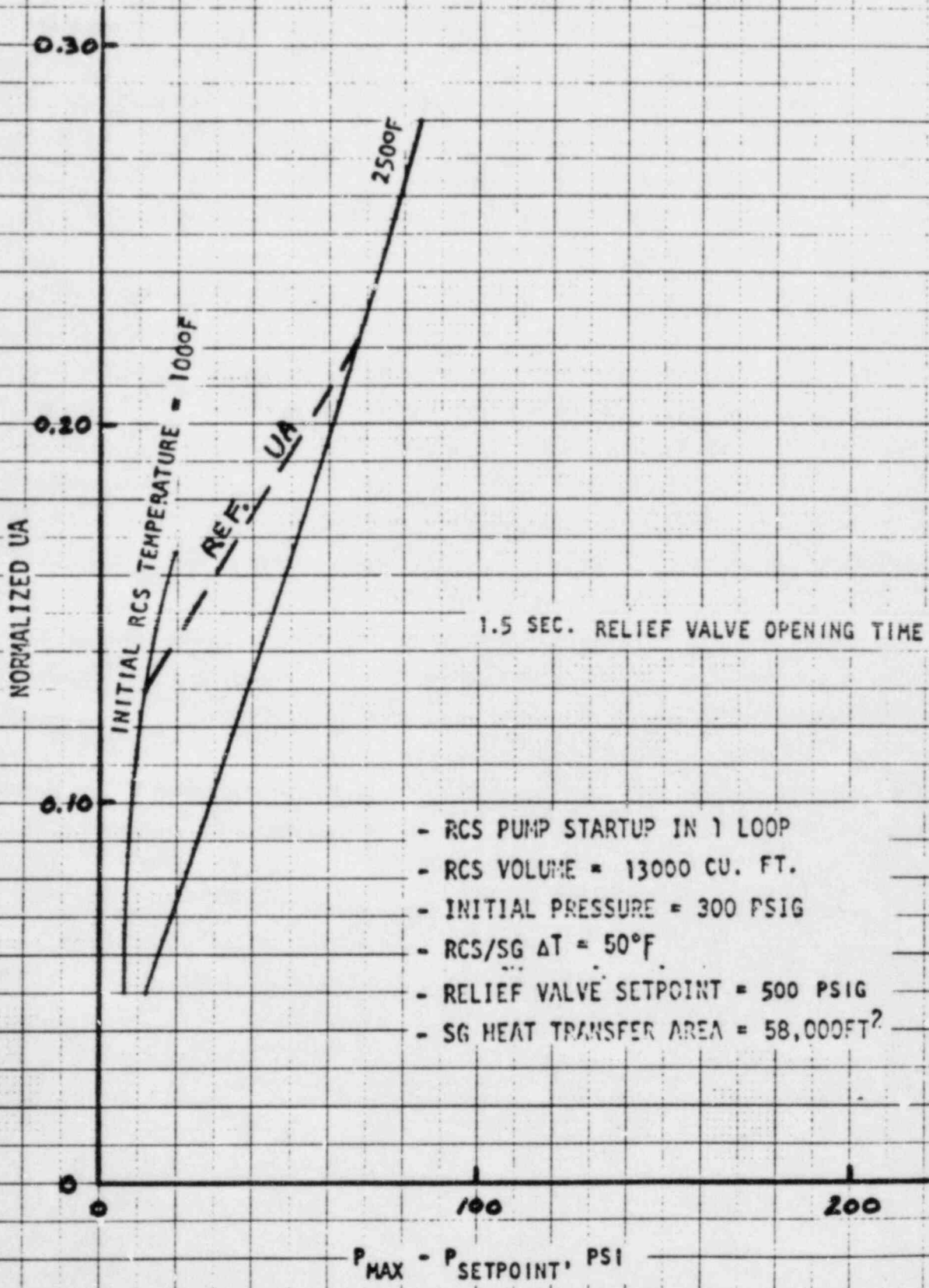


VITAL NOTES

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Figure 23

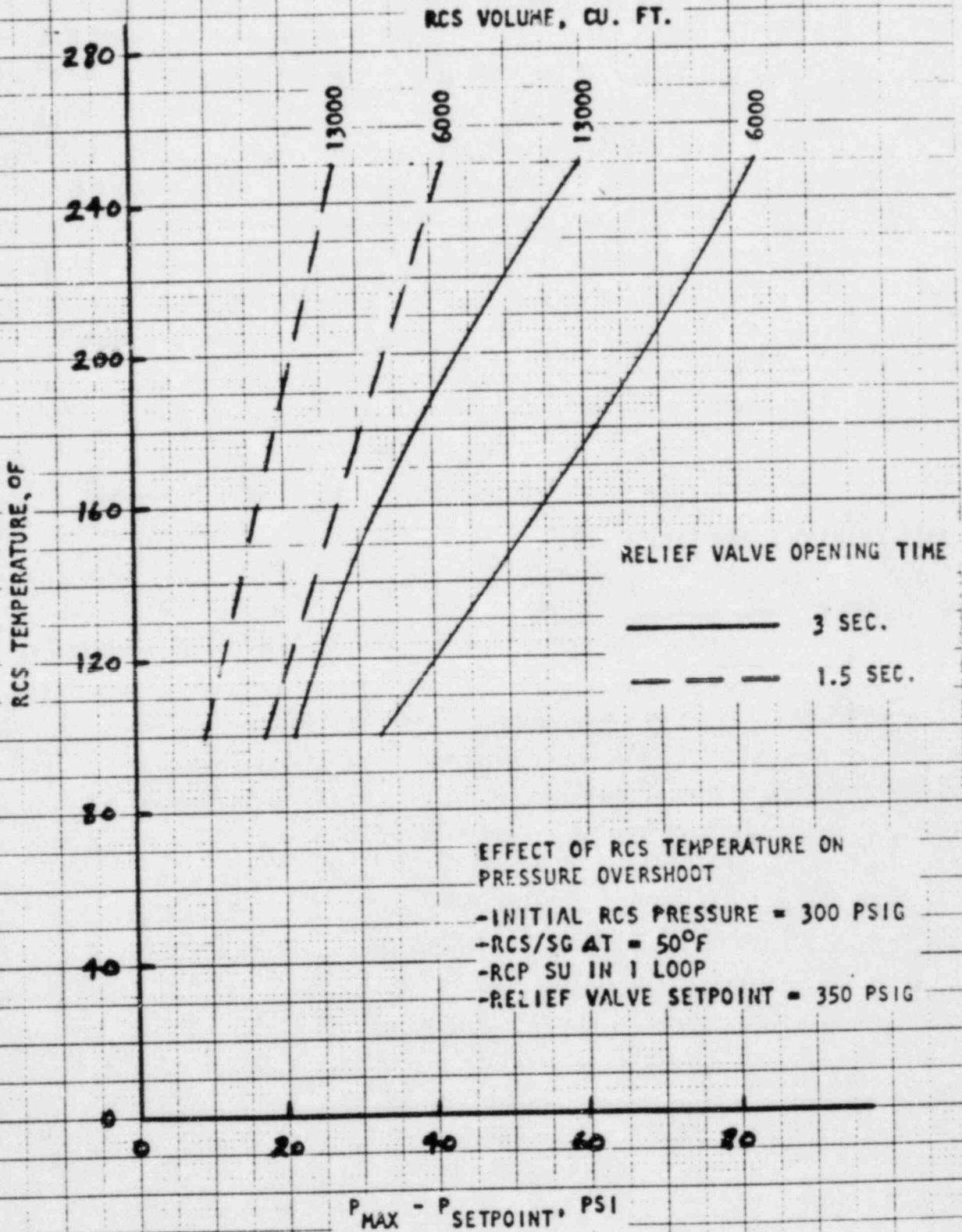
EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 13000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^{\circ}F$
- RELIEF VALVE SETPOINT = 500 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²

D. SETPOINT OVERSHOOT VARIATION WITH
REACTOR COOLANT SYSTEM TEMPERATURE

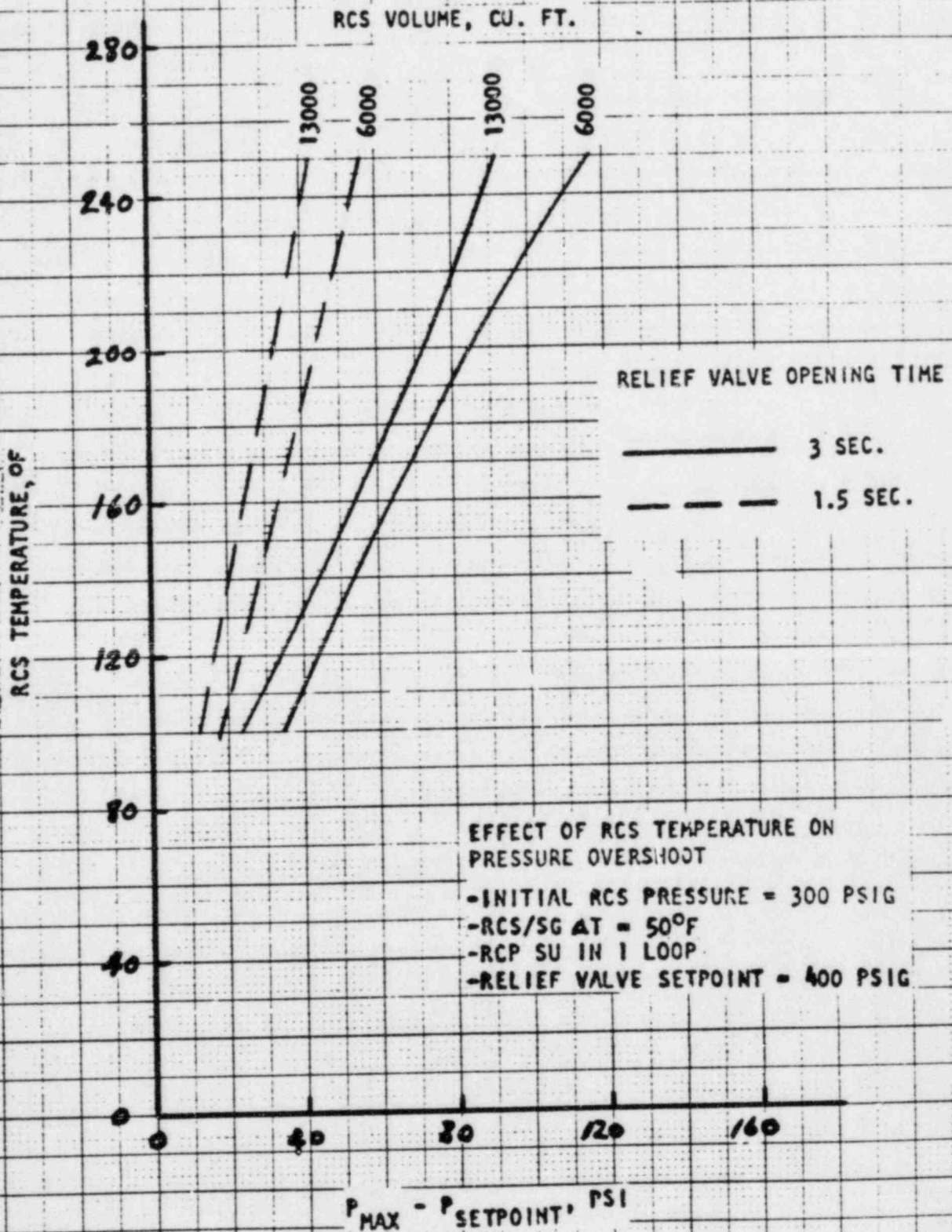
Figure 24

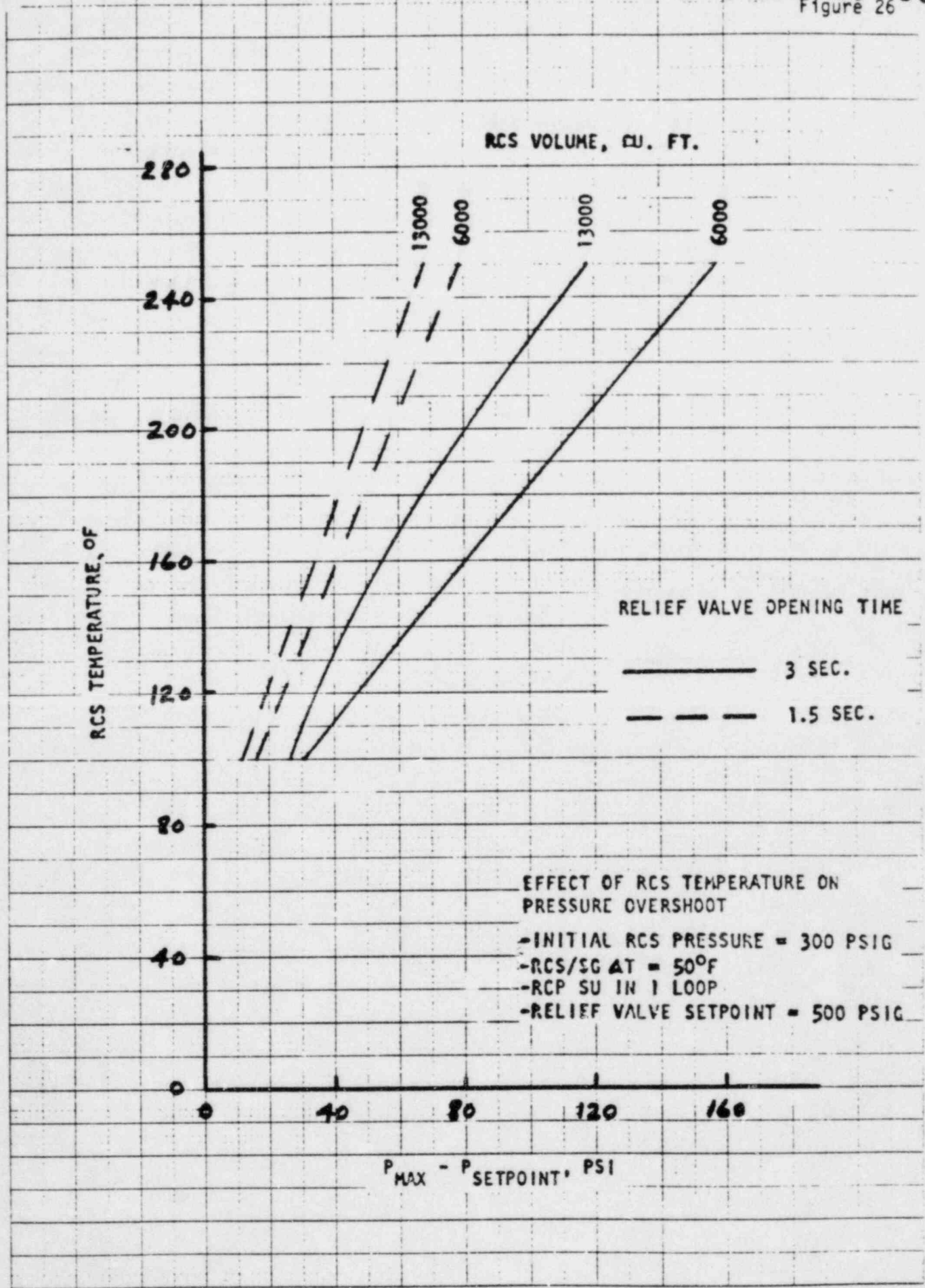


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K-E 10 X 10 TO 1 1/2 INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure 25





RELIEF VALVE OPENING TIME

————— 3 SEC.

- - - - - 1.5 SEC.

EFFECT OF RCS TEMPERATURE ON PRESSURE OVERTHOOT

- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^\circ F$
- RCP SU IN 1 LOOP
- RELIEF VALVE SETPOINT = 500 PSIG

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K-E 10 X 10 TO 1/2 INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

II. INSTRUCTIONAL GUIDE FOR OVERTHOOT 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.

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

*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

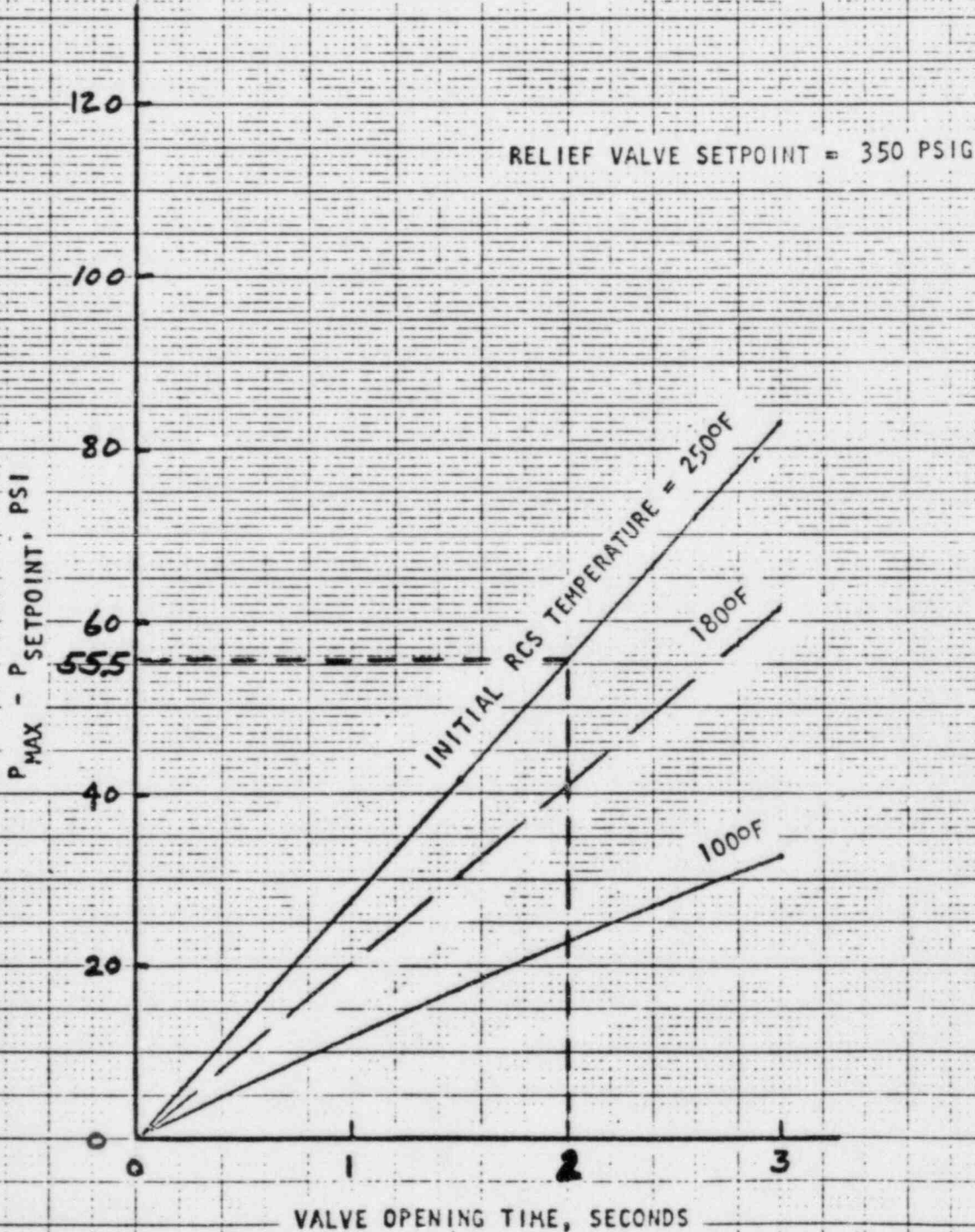
Initial RCS Pressure	300 psig
SG Heat Transfer Area	58,000 ft ²
RCS Volume, V _{RCS}	6,000 cu.ft.
Initial RCS Temperature, T _{RCS}	250°F
RCS/SG ΔT	50°F
Relief Valve Opening Time, Δt	<u>2 sec.</u>
Relief Valve Setpoint, S	<u>375 psig</u>

<u>Step</u>	<u>Procedure</u>	<u>Example Application</u>
1	Using Figures C1 and C2 (V _{RCS} = 6000 ft ³), 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 = <u>55.5 psi</u> (Figure C1) and ΔP ₄₀₀ = <u>75.5 psi</u> (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, $\Delta P = 55.5 + \frac{375-350}{50} (75.5 - 55.5)$ $= \underline{65.5 \text{ psi}}$

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 $\Delta T = 50^{\circ}F$
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 6,000 CU.FT.



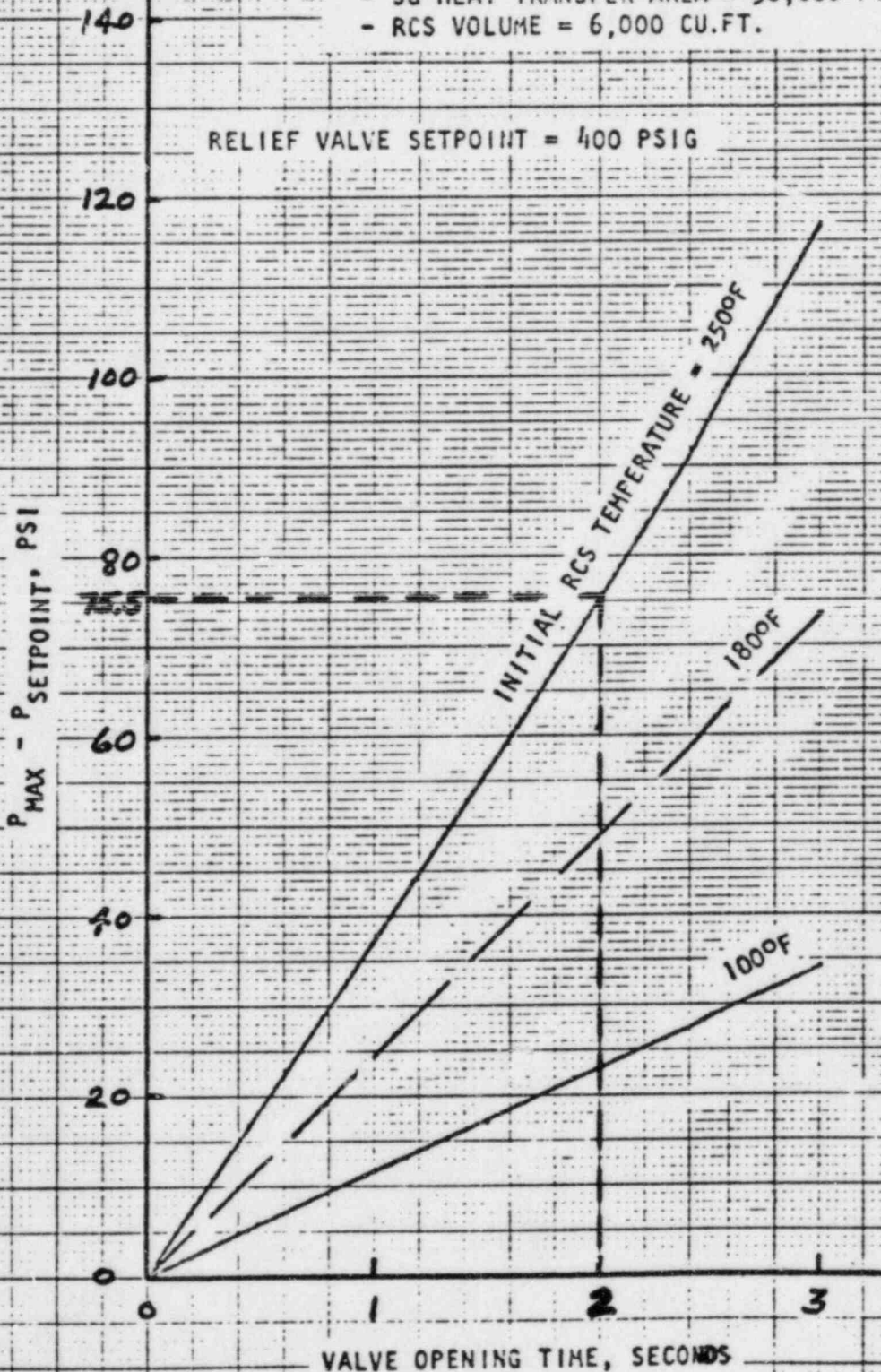
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K-E 10 X 10 TO 1/2 INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

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 $\Delta T = 50^{\circ}F$
- SG HEAT TRANSFER AREA = 58,000 FT^2
- RCS VOLUME = 6,000 CU.FT.



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 1.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}	<u>10,000 cu.ft.</u>
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG ΔT	50°F
Relief Valve Setpoint, S	400 psig
Relief Valve Opening Time, Δt	<u>2 sec.</u>

StepProcedureExample 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 $T_{RCS} = 250^{\circ}F$ 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:

For $V_{RCS} = 10,000$ cu.ft.
 (S = 400 psig),
 $T_{RCS} = 250^{\circ}F$ and $\Delta t = 2$ seconds,

$$\Delta P_{10K} = \Delta P_{6K}$$

$$\Delta P = 75.5$$

$$= \frac{V_{RCS} - 6000}{13,000 - 6,000} (\Delta P_{6K} - \Delta P_{13K})$$

$$= \frac{10,000 - 6000}{7000} (75.5 - 57.5)$$

$$= \underline{65.2 \text{ psi}}$$

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 $\Delta T = 50^{\circ}F$
- SG HEAT TRANSFER AREA = 58,000 FT²
- RCS VOLUME = 6,000 CU.FT.

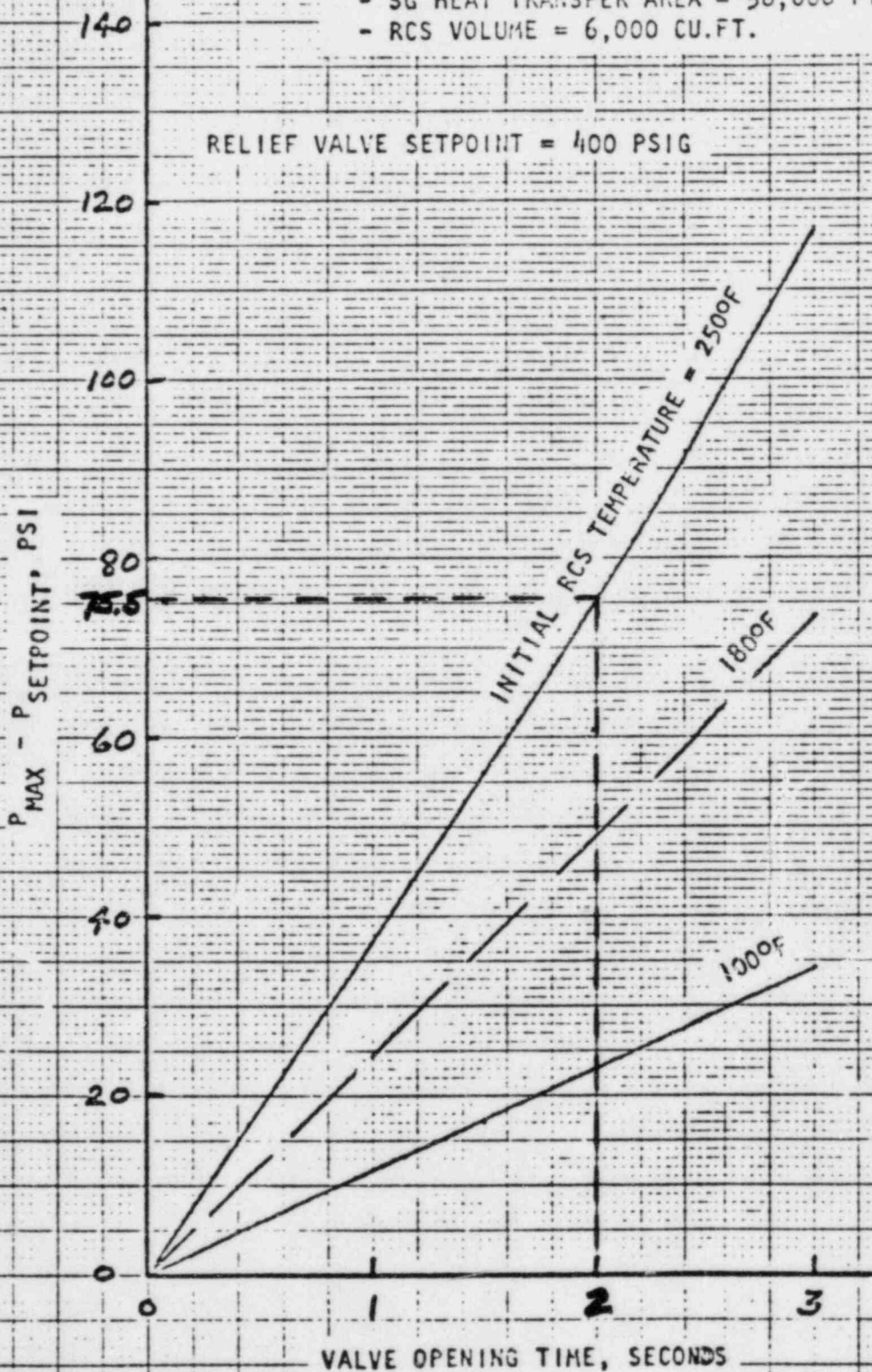
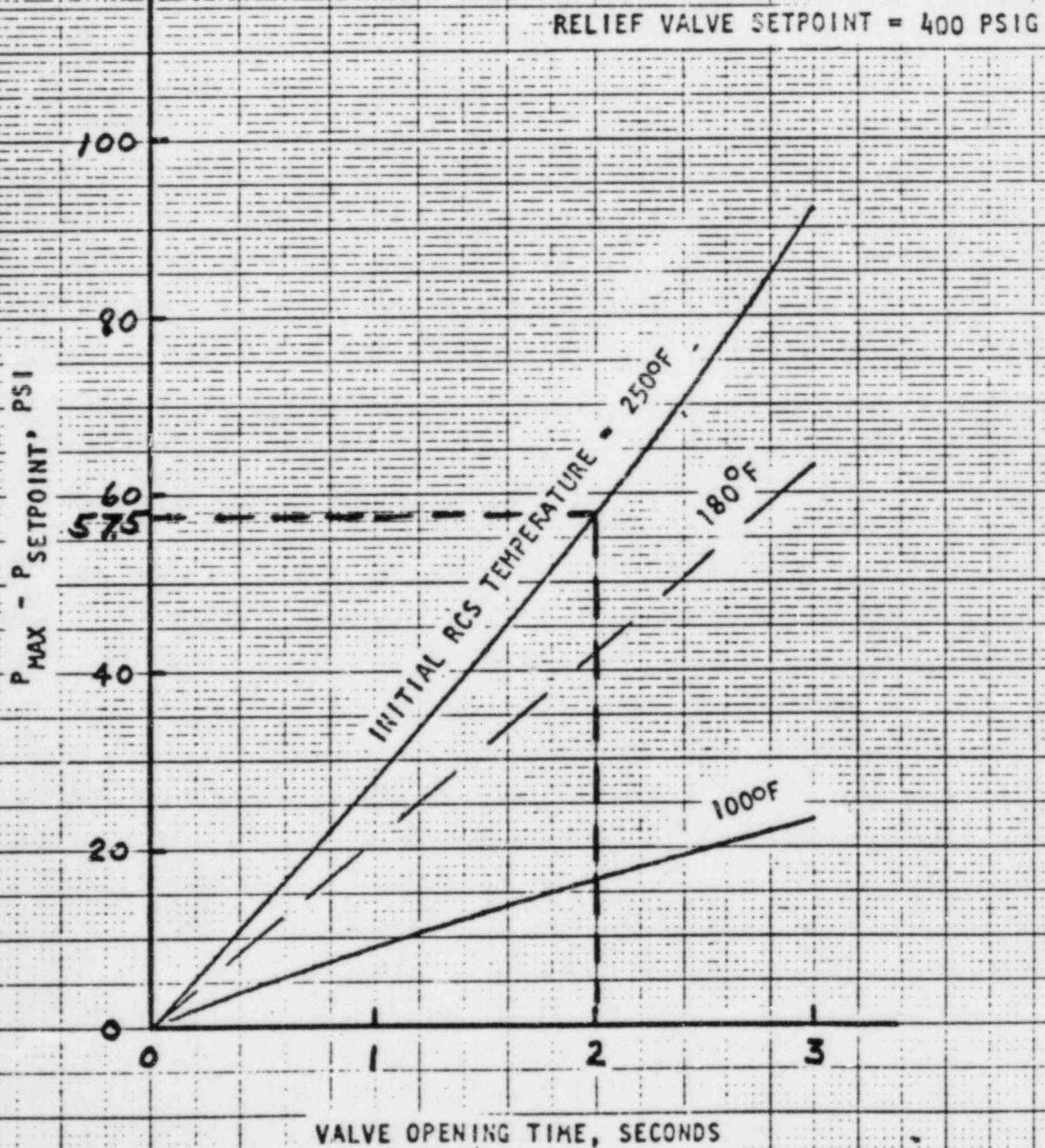


Figure C4

EFFECT OF RELIEF VALVE
OPENING TIME ON RCS
PRESSURE OVERTHOOT

- RCS PUMP STARTUP IN 1 LOOP
- LINEAR RELIEF VALVE
- VALVE DELAY = 20% OF OPENING TIME
- INITIAL RCS PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^{\circ}F$
- 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}	<u>10,000 cu.ft.</u>
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG ΔT	50°F
Relief Valve Setpoint, S	<u>375 psig</u>
Relief Valve Opening Time, Δt	3 sec.

Step

Procedure

Example Application

1 For relief valve setpoint(s) equal to 375 psig (t = 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.
 (t = 3 seconds), and
 T_{RCS} = 250°F,

$$P_{10K} = P_{6K}$$

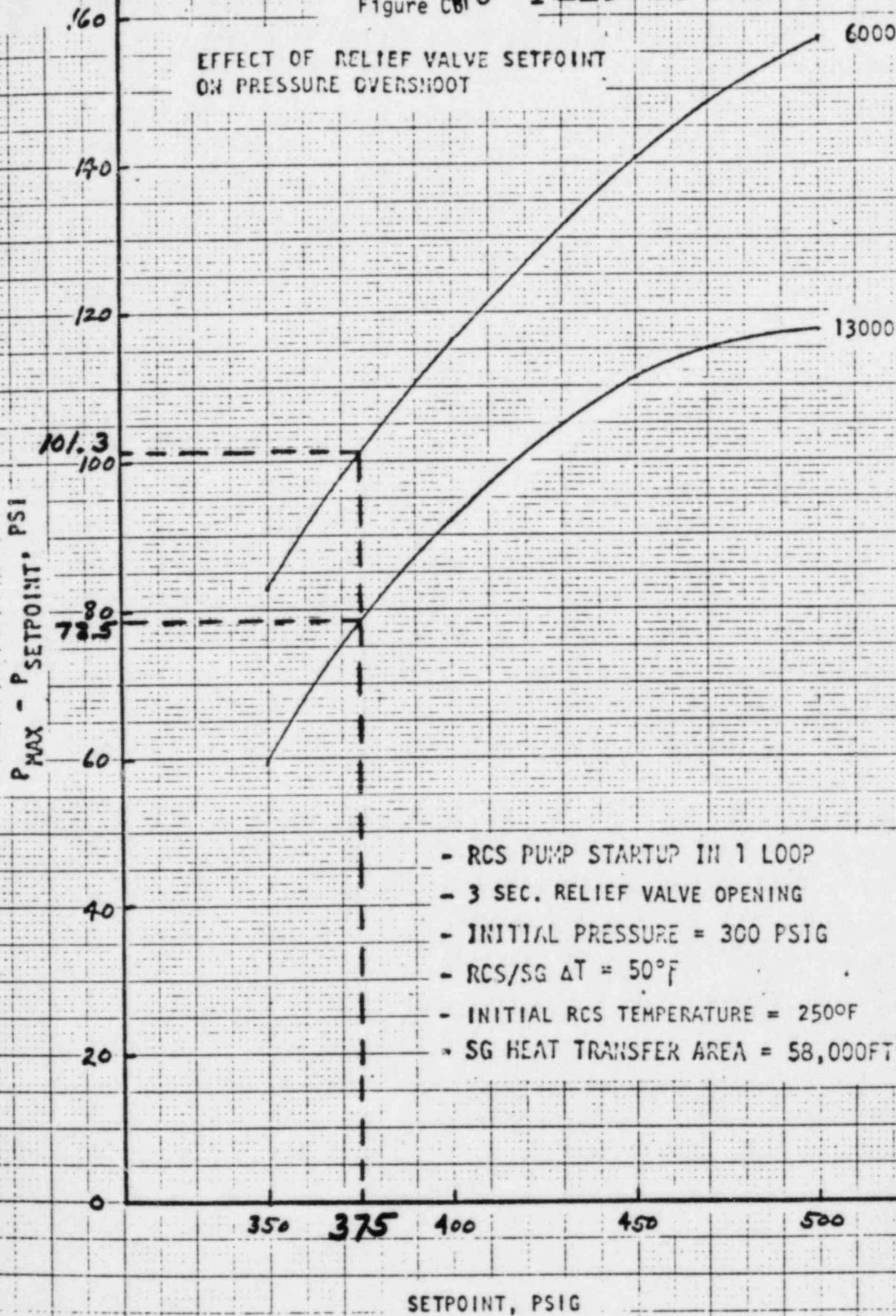
$$P = 101.3$$

$$- \frac{V_{RCS} - 6000}{13,000 - 6,000} (P_{6K} - P_{13K})$$

$$- \frac{10,000 - 6,000}{7000} (101.3 - 78.5)$$

$$= \underline{88.3 \text{ psi}}$$

EFFECT OF RELIEF VALVE SETPOINT ON PRESSURE OVERSHOOT



- 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 = 58,000FT²

SETPOINT, PSIG

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 ft², 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 (t); 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 t , 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 t , 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	<u>29,000 ft²</u>
RCS Volume, V_{RCS}	<u>10,000 cu.ft.</u>
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.

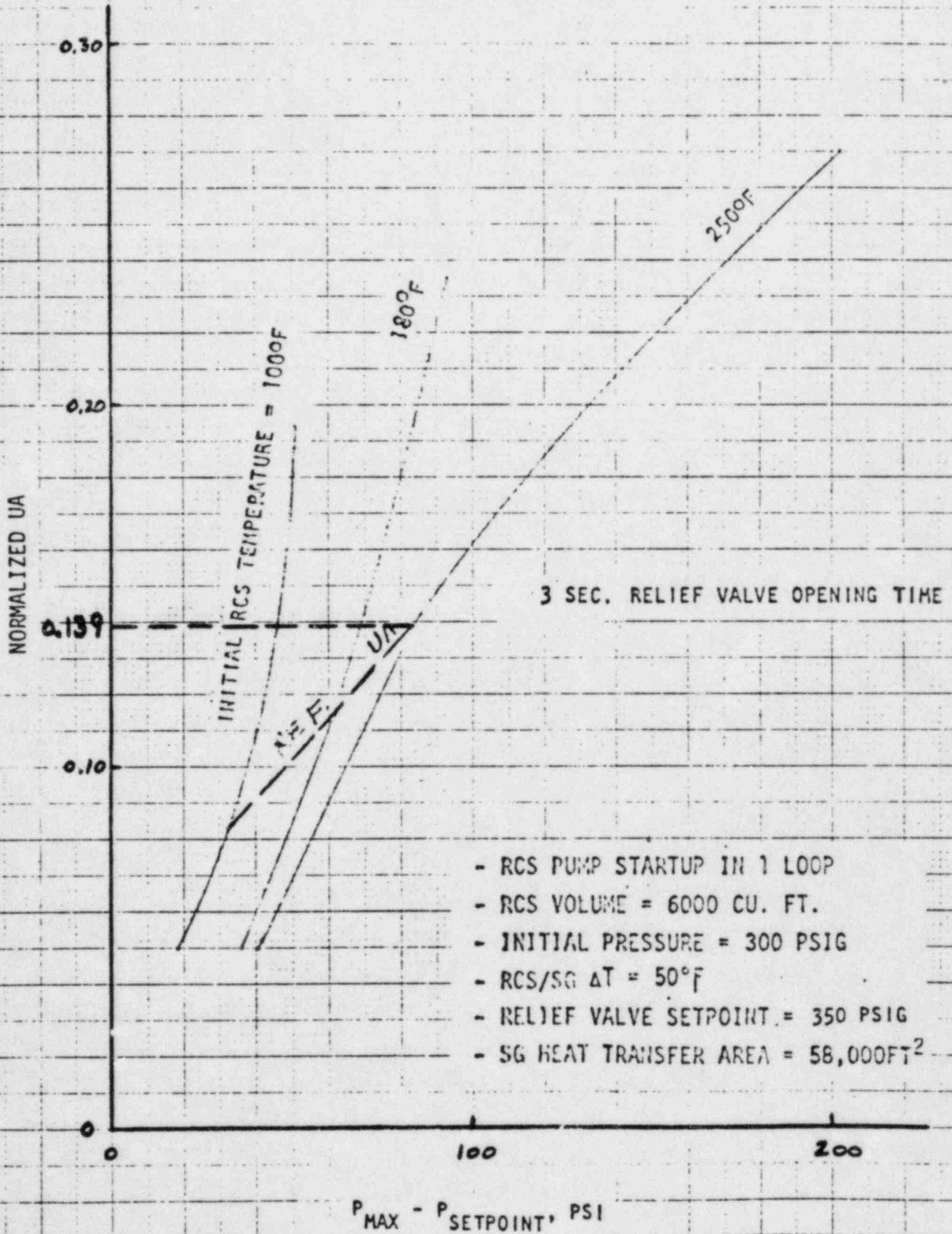
Applying the heat input procedure:

<u>Step</u>	<u>Procedure</u>	<u>Example Application</u>
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 $T_{RCS} = 250^{\circ}\text{F}$ and $S = 350$ psig, $UA_{6K} = \underline{0.139}$ (Figure C6) and $UA_{13K} = \underline{0.222}$ (Figure C7).
2	Determine what fraction, f, of 58,000 ft ² constitutes the actual steam generator heat transfer area.	$29,000 \text{ ft}^2 / 58,000 \text{ ft}^2 = \underline{0.5}$

Figure C6

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EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



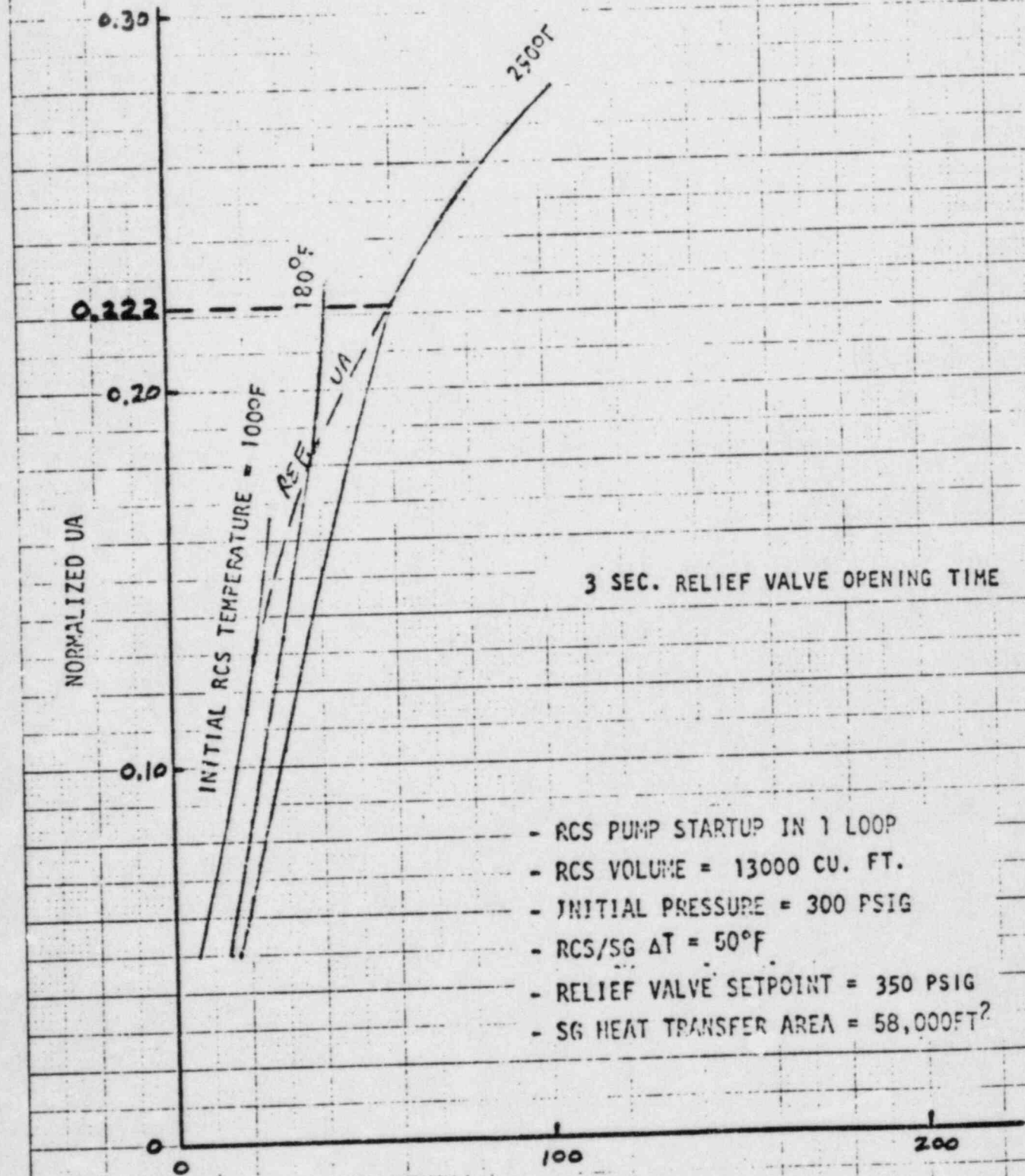
46 1320

K-E 10 X 10 TO 1 1/2 INCH KEUFFEL & ESSER CO MADE IN U.S.A.

$P_{MAX} - P_{SETPOINT}$, PSI

Figure C7

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT



- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 13000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^\circ F$
- RELIEF VALVE SETPOINT = 350 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²

$P_{MAX} - P_{SETPOINT}$, PSI

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.

$$UA'_{6K} = 0.139 * 0.5 = \underline{0.0695} \text{ and}$$

$$UA'_{13K} = 0.222 * 0.5 = \underline{0.111}$$

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 C9, for $T_{RCS} = 250^{\circ}F$, $S = 350$ psig and $UA'_{6K} = 0.0695$, $P'_{6K} = \underline{50}$ psi. From Figure C9 for $T_{RCS} = 250^{\circ}F$, $S = 350$ psig and $UA'_{13K} = 0.111$, $P'_{13K} = \underline{31}$ 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

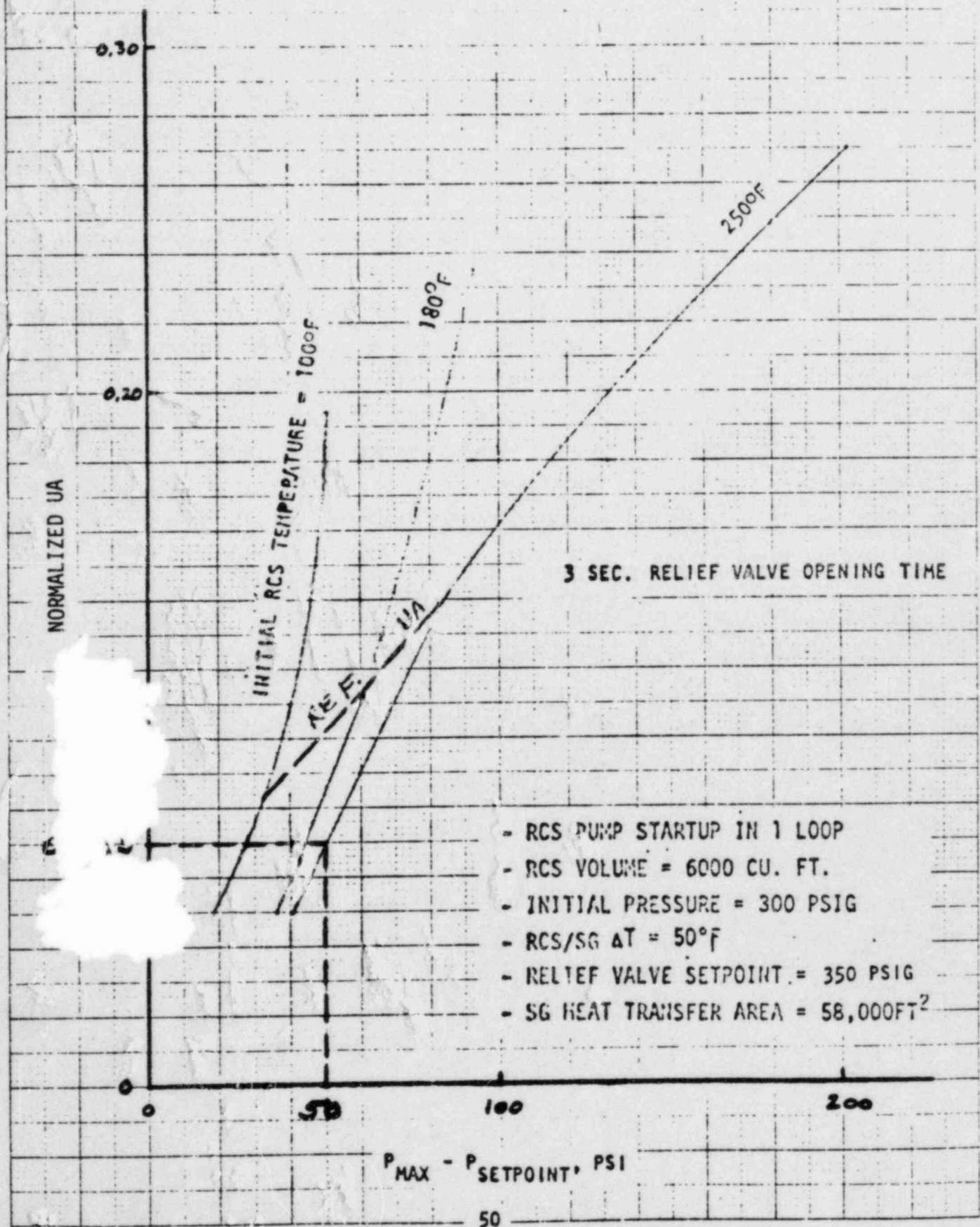
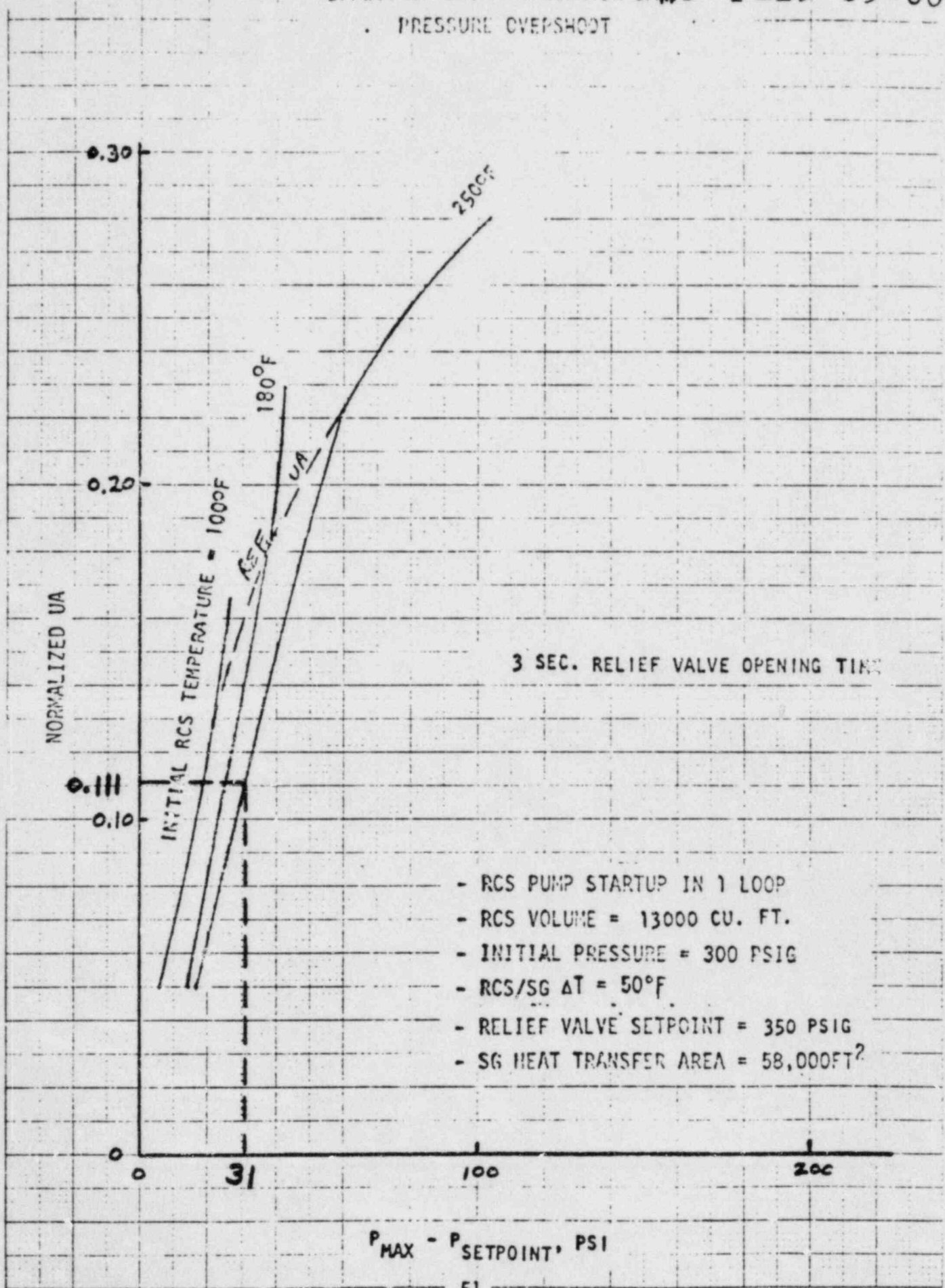


Figure C9

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT

1223-03-00

K-E 10 X 10 TO 1 1/2 INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 1320



- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 13000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^\circ\text{F}$
- RELIEF VALVE SETPOINT = 350 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²

5. ILLUSTRATIVE EXAMPLE 5: DETERMINATION OF SETPOINT
 OVERTHROOT 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	<u>29,000 ft²</u>
RCS Volume, V_{RCS}	6,000 cu.ft.
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG ΔT	50°F
Relief Valve Setpoint, S	350 psig
Relief Valve Opening Time, t	<u>2 sec.</u>

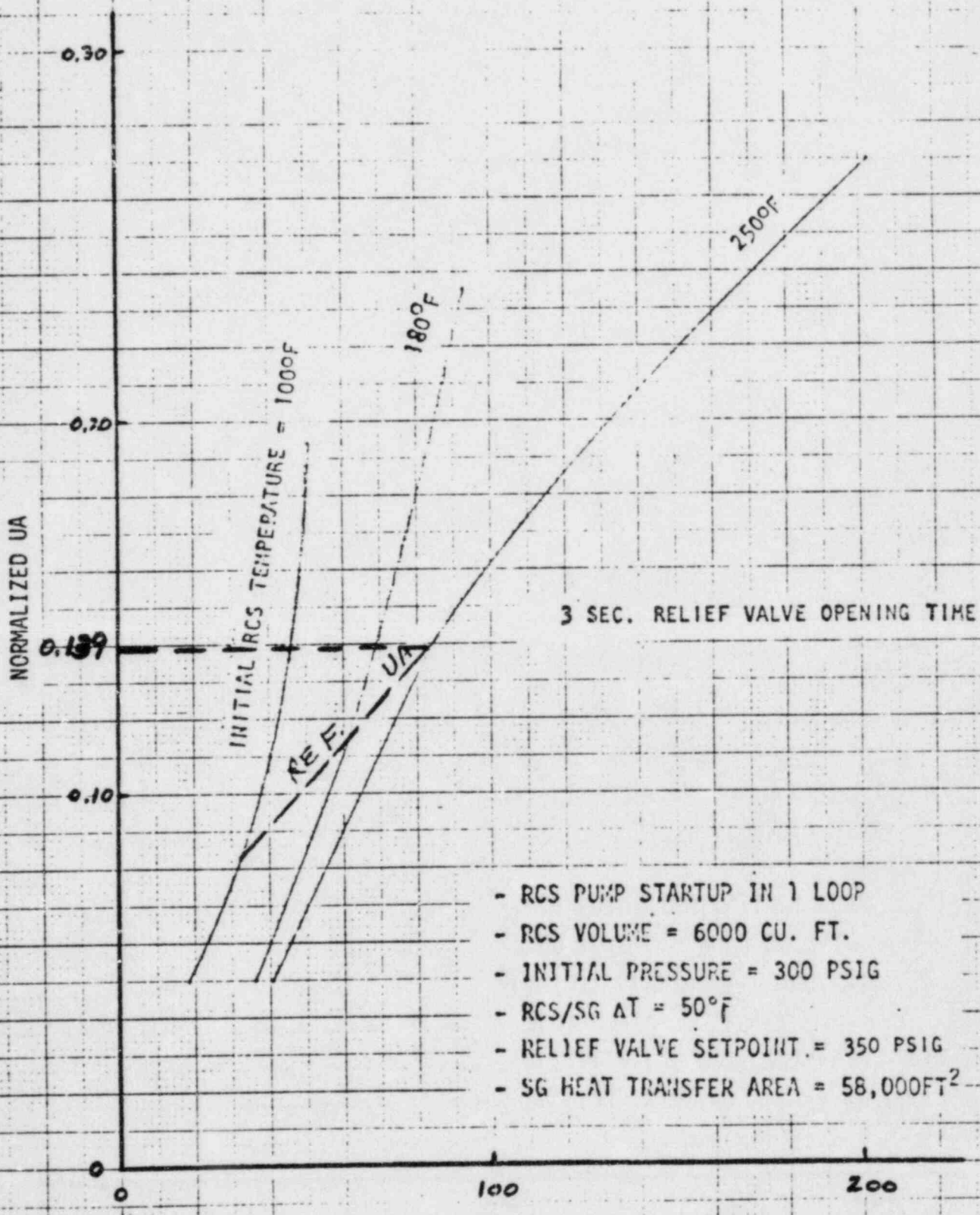
Applying the heat input procedure:

StepProcedureExample 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 $T_{RCS} = 250^{\circ}F$ 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 $58,000 \text{ ft}^2$ constitutes the actual steam generator heat transfer area. | $29,000 \text{ ft}^2 / 58,000 \text{ ft}^2 = \underline{0.5}$ |
| 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 $UA_{1.5}^1$ values. | $UA_3^1 = UA_{1.5}^1 = 0.139 \times 0.5$
$= \underline{0.0695}$ |

Figure C10

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



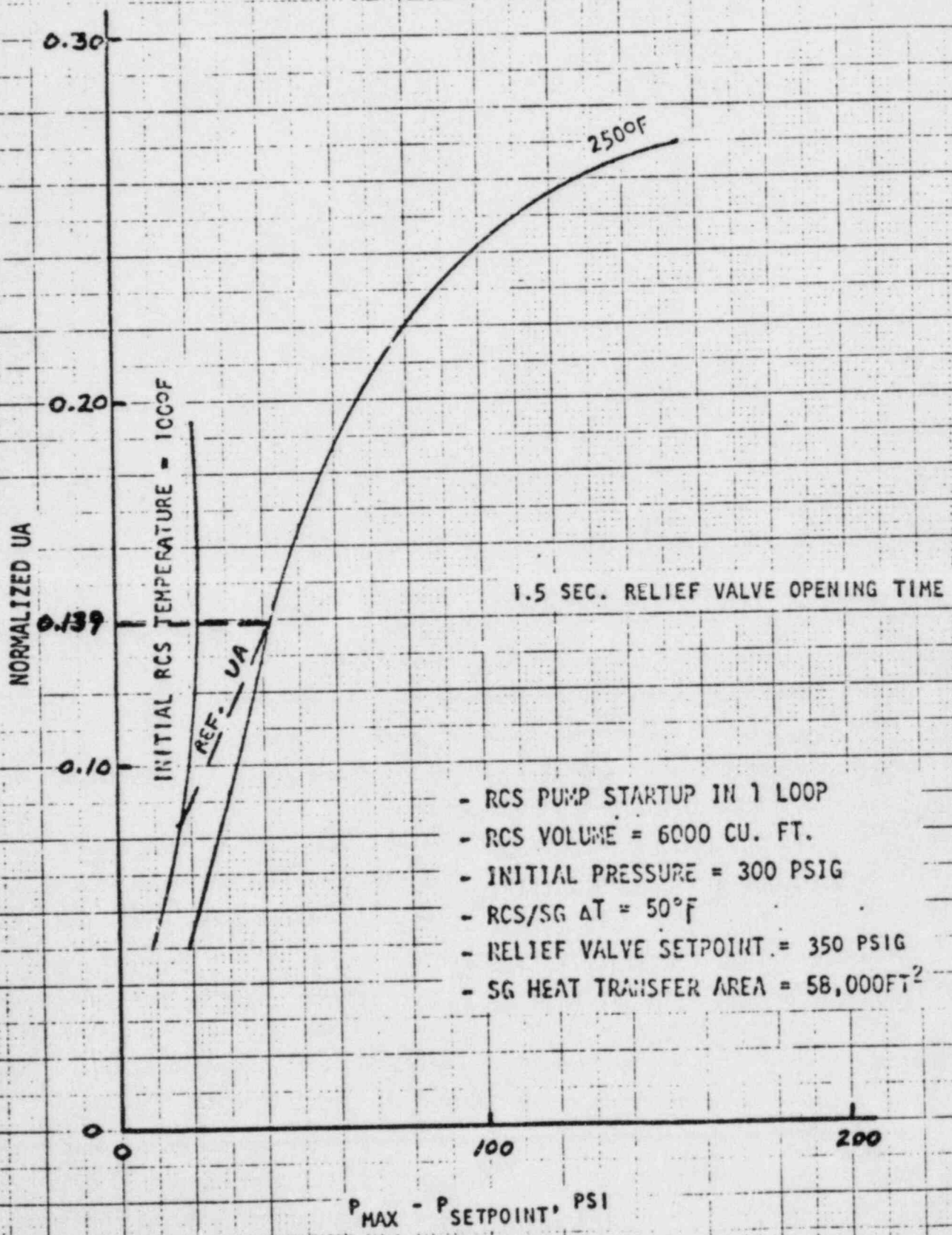
- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 6000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^\circ F$
- RELIEF VALVE SETPOINT = 350 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²

$P_{MAX} - P_{SETPOINT}$, PSI

46 1320

K-E 10 X 10 TO 1/2 INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

Figure C11
EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERTHOOT



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 $T_{RCS} = 250^\circ F$, $S = 350$ psig and $UA_3^1 = 0.0695$, $P_3^1 = \underline{50}$ psi. From Figure C13, for $T_{RCS} = 250^\circ F$, $S = 350$ psig and $UA_{1.5}^1 = 0.0695$, $P_{1.5}^1 = \underline{25}$ psi.

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:

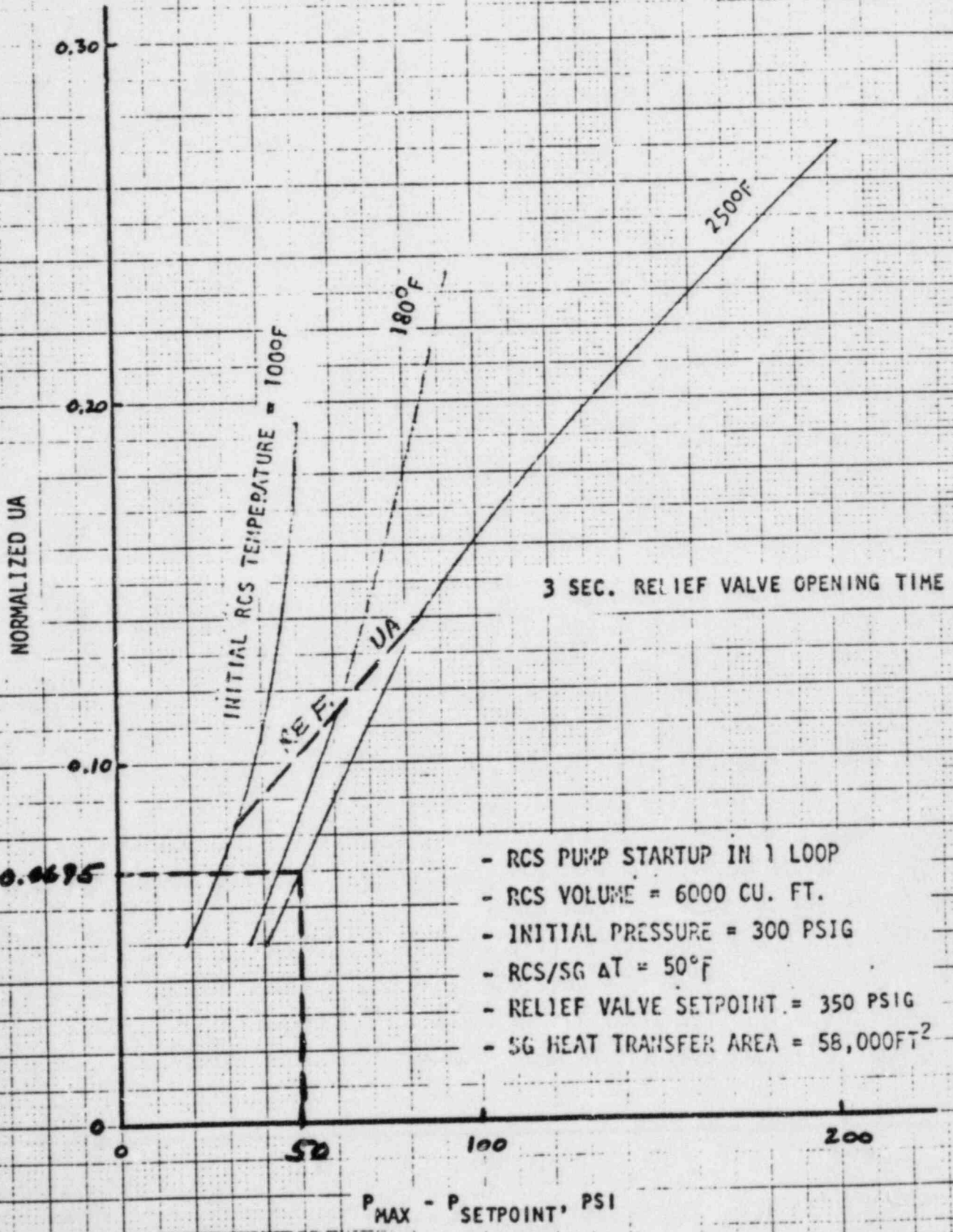
For $t = 2$ seconds,
 $P_3^1 = 50$ psi and
 $P_{1.5}^1 = 25$ psi,

$$P_{\Delta t}^1 = P_{1.5}^1 + \frac{t - 1.5}{3 - 1.5} (P_3^1 - P_{1.5}^1)$$

$$P_2^1 = 25 + \frac{2 - 1.5}{3 - 1.5} (50 - 25) = \underline{33.4} \text{ psi}$$

Figure C12

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERTHOOT



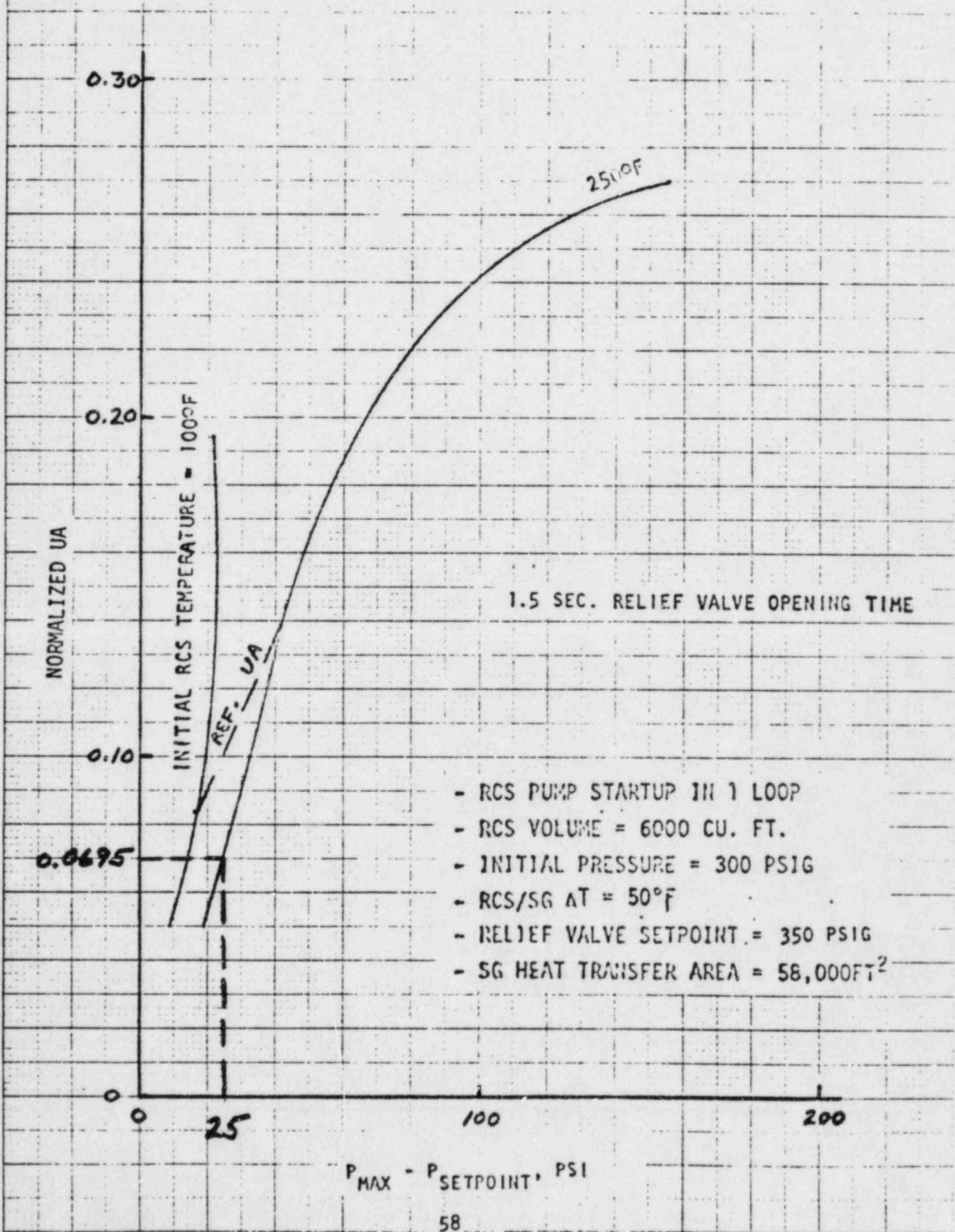
KUPFEL & ESSER CO. MADE IN U.S.A.

Figure C13

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERTHROTT

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K&E 10 X 10 TO 1/4 INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.



6. ILLUSTRATIVE EXAMPLE 6: DETERMINATION OF SETPOINT
 OVERTHOOT 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

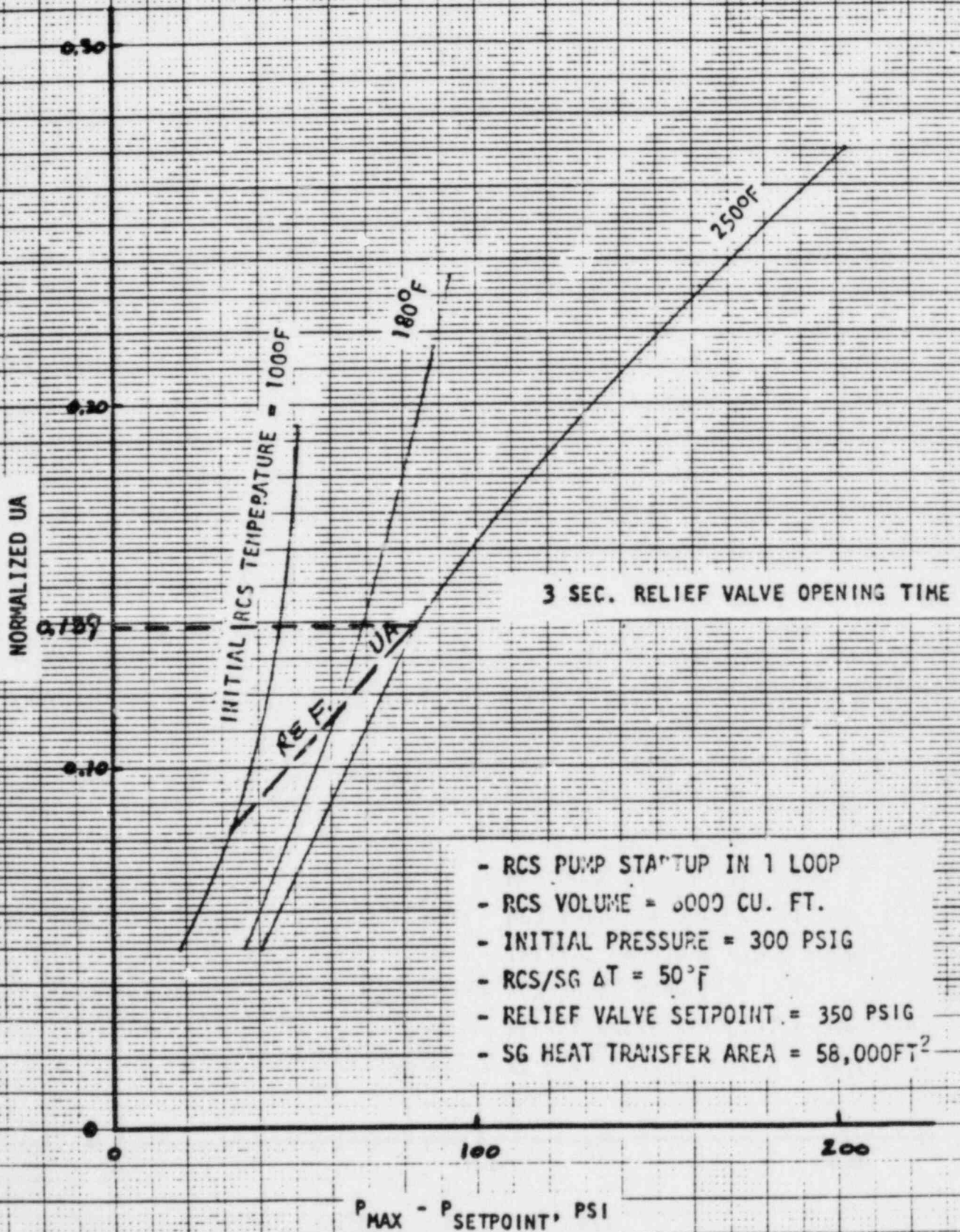
Initial RCS Pressure	300 psig
SG Heat Transfer Area	<u>29,000 ft²</u>
RCS Volume, V_{RCS}	6,000 cu.ft.
Initial RCS Temperature, T_{RCS}	250°F
RCS/SG ΔT	50°F
Relief Valve Setpoint, S	<u>375 psig</u>
Relief Valve Opening Time, t	3 sec.

Applying the heat input procedure:

<u>Step</u>	<u>Procedure</u>	<u>Example Application</u>
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 $T_{RCS} = 250^{\circ}\text{F}$ and $t = 3$ seconds, $UA_{350} = UA_{400} = \underline{0.139}$ from Figures C14 and C15. ($V_{RCS} = 6000$ cu.ft.)
2	Determine what fraction, f , of $58,000 \text{ ft}^2$ constitutes the actual steam generator heat transfer area.	$29,000 \text{ ft}^2 / 58,000 \text{ ft}^2 = \underline{0.5}$
3	Multiply both UA_{350} and UA_{400} (from Step 1) by f (from Step 2) to obtain new normalized UA_{350}^1 and UA_{400}^1 values.	$UA_{350}^1 = UA_{400}^1 = 0.139 * 0.5 = \underline{0.0695}$

Figure C14

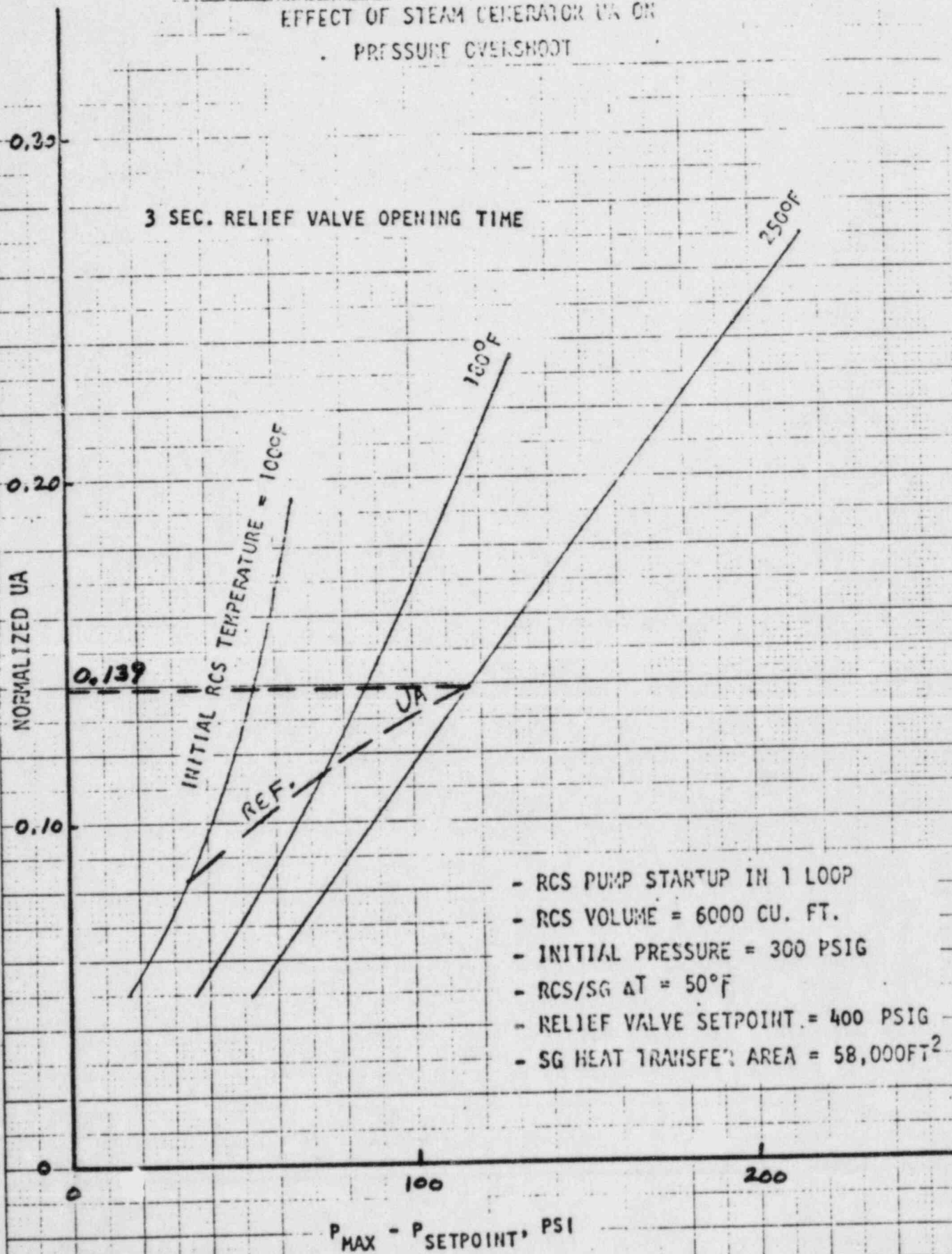
EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 6000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^\circ\text{F}$
- RELIEF VALVE SETPOINT = 350 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²

Figure C15

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERTHROTT



- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 6000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^\circ F$
- RELIEF VALVE SETPOINT = 400 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²

46 1320

K-E 10 X 10 TO 1/2 INCH 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

Step

Procedure

Example Application

4 For the same isotherm, T_{RCS} , and for UA_{350}^1 and UA_{400}^1 obtain new setpoint overshoots, P_{350}^1 and P_{400}^1 for the 350 psig and 400 psig relief valve setpoints, using Figures C16 and C17.

From Figure C16, for $T_{RCS} = 250^{\circ}F$, $t = 3$ seconds and $UA_{350}^1 = 0.0695$, $P_{350}^1 = 50$ psi. From Figure C17, for $T_{RCS} = 250^{\circ}F$, $t = 3$ seconds and $UA_{400}^1 = 0.0695$, $P_{400}^1 = 66$ psi.

5 For the actual relief valve setpoint, S , linearly interpolate the setpoint overshoot, P_S^1 , for the new steam generator UA from the relationship:

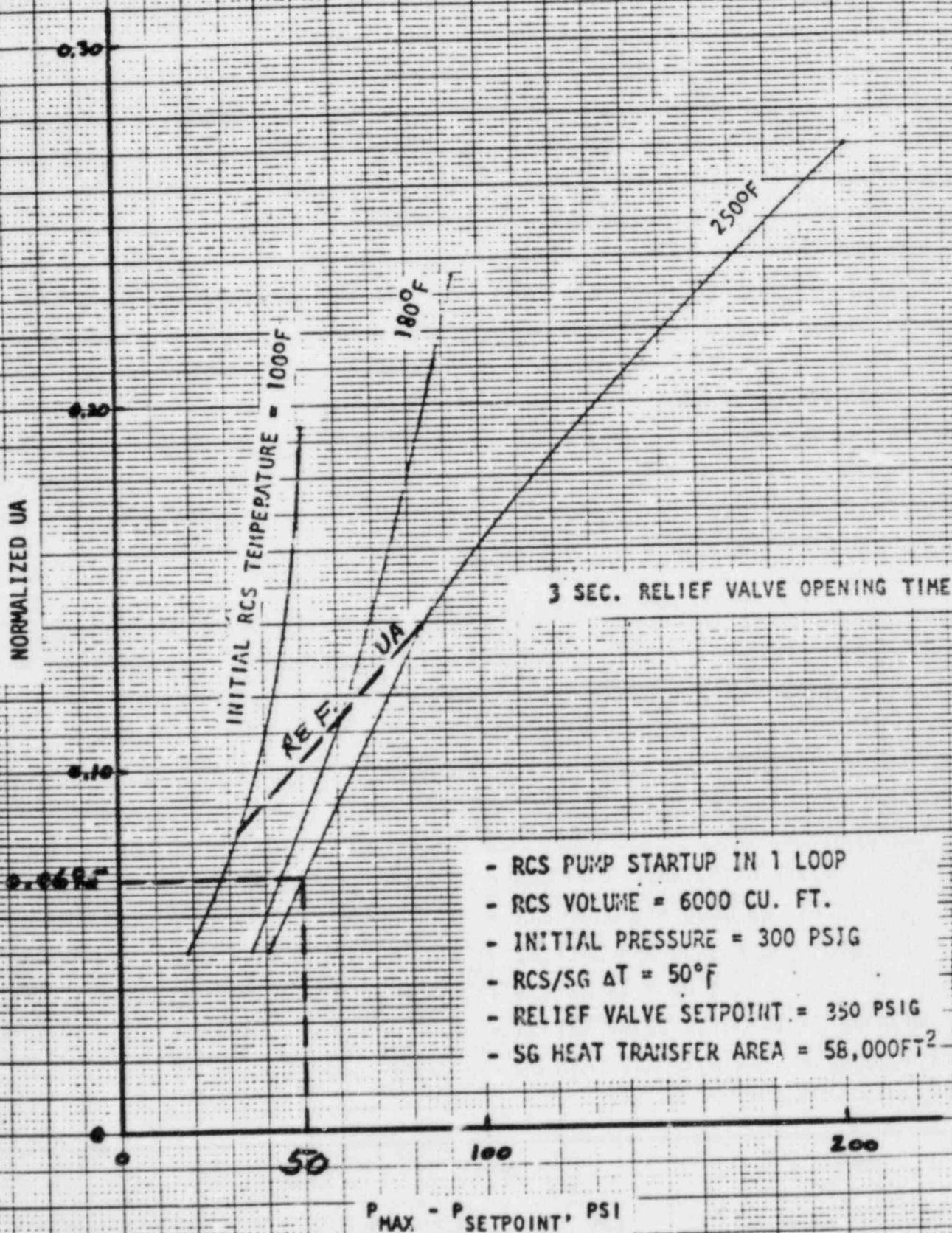
For $S = 375$ psig, $P_{350}^1 = 50$ psi and $P_{400}^1 = 66$ psi,

$$\Delta P_S^1 = P_{350}^1 + \frac{S - 350}{400 - 350} (P_{400}^1 - P_{350}^1)$$

$$\begin{aligned} \Delta P_{375}^1 &= 50 + \frac{375 - 350}{400 - 350} (66 - 50) \\ &= 58 \text{ psi} \end{aligned}$$

Figure C16

EFFECT OF STEAM GENERATOR UA ON PRESSURE OVERSHOOT



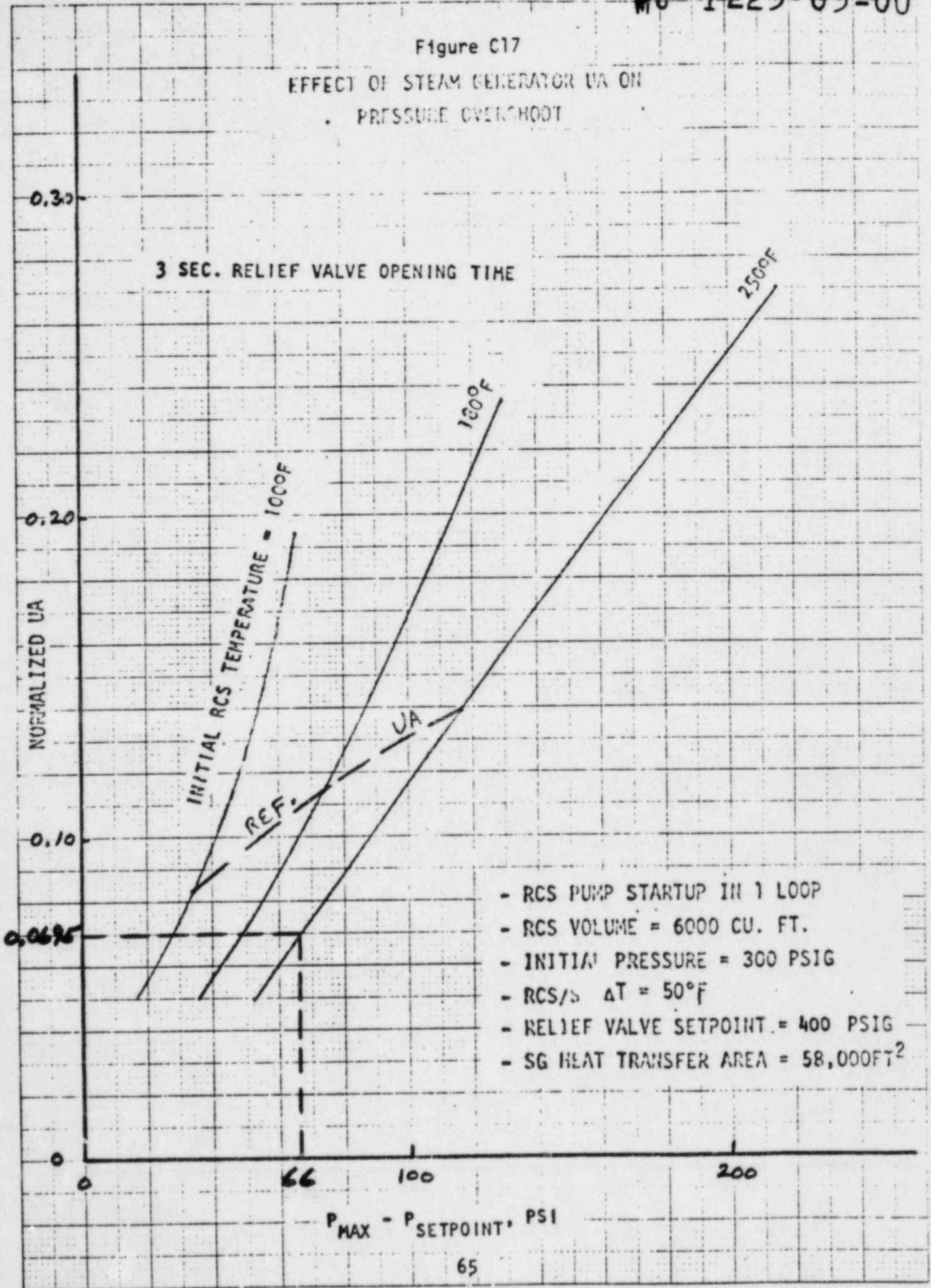
- RCS PUMP STARTUP IN 1 LOOP
- RCS VOLUME = 6000 CU. FT.
- INITIAL PRESSURE = 300 PSIG
- RCS/SG $\Delta T = 50^\circ\text{F}$
- RELIEF VALVE SETPOINT = 350 PSIG
- SG HEAT TRANSFER AREA = 58,000FT²

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

Figure C17

EFFECT OF STEAM GENERATOR UA ON
PRESSURE OVERSHOOT



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K&E 10 X 10 TO 1/2 INCH 7 X 10 INCHES
NEUFFEL & ESSER CO. MADE IN U.S.A.

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.)

DL CANUP
Design Engineering

December 6, 1977

(For copies in DE; please
pass on to RCDay if
he has copy)

TO: Utility Group Participants

REFERENCE: "Pressure Mitigating Systems Transient Analysis Results,"
July 1977. (Westinghouse Report on RCS Solid Water Over-
pressurization)

Emy

Utility Group on Reactor Coolant System Overpressurization

Attached are three revised figures which should be substituted for the corresponding figures to be found in Appendix B of Reference 1. The revisions accommodate modifications made to the letdown isolation transients represented in these figures to upgrade the analytical basis and account for an input data correction.

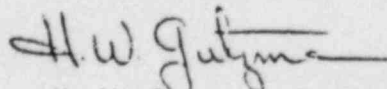
Setpoint pressure overshoot has not been altered in any of the transients plotted in these figures; however, setpoint pressure undershoot has been modified in several of the letdown isolation transients. In every case, the modification has resulted in an improvement in (i.e., smaller) setpoint pressure undershoot.

In both Figures M6 and M10, the common transient exhibiting RCS setpoint pressure undershoot response for two relief valve operation at a setpoint of 600 psig has been replotted to reflect valve closure at a reset pressure 20 psi below the setpoint. The original transient depicted in Figure M6 and Figure M10 of Reference 1 (Appendix B) represented valve closure at a reset pressure 120 psi below the 600 psig setpoint. As would be expected, the setpoint pressure under shoot has been significantly reduced to the extent that violation of the RCS pump seal pressure limit is no longer a consideration for this transient.

In Figure M7, the setpoint pressure undershoots for both the 500 psig and 600 psig relief valve setpoint transients have been adjusted to reflect a correction to the LOFTRAN input data. A reduction in setpoint pressure undershoot is evident in both transients.

Should you have any questions regarding the attachments, please contact the undersigned.

Very truly yours,



H. W. Gutzman, Project Engineer
Projects & Regional Support