U.S. NUCLEAR REGULATORY COMMISSION
INDIAN POINT 2 NUCLEAR POWER PLANT
RESIDENT INSPECTOR'S OFFICE

FACSIMILE TO: Brian Holian

IN THE OFFICE OF:

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SUBJECT: Con Ed Calculation

This is part of the information that Con Ed owed from the regulatory conference. More to come.

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C/34

CON EDISON CALCULATION / ANALYSIS COVER SHEET

3/16/00

Calculation Number: PGI-00443-00 **Type:** CA34
Entry Date: 03/09/2000 PIPE FLOW

Project Number: NONE **Modification:** NONE
Document Page : 20 **Scanned:** N
Old_Calculation: **Revision:** NO

Title ESTIMATED PRIMARY TO SECONDARY LEAKAGE DURING TUBE RUPTURE EVENT

Tag Number
24SG

Component Type	Component Description
PIPE	PIPE

Component Style	Style Description
TUBE	TUBE OR TUBING

System	Description
RCS	REACTOR COOLANT SYSTEM

Structure	Description
VC	VAPOR CONTAINMENT BUILDING VCI

Preparer: R. WATERS **Update Date** 03/16/2000 **Reviewer:** D. C. INGRAM
Signature: **Signature/Date:** 3/16/00

Approval/Date 3/16/00 **Confirm. Required?**

Concurrence (If Required)

CON EDISON CALCULATION/ANALYSIS
Description of Change Sheet

Calculation No: PGI-00443-00

Revision No.	Description of Change	Reason for Change
0	Initial Release	

CON EDISON
CALCULATION/ANALYSIS
SUMMARY SHEET

	CALCULATION NO. PGT-00442-00 / REVISION 0	PAGE 3 OF 20
PREPARER/DATE Roger M. Waters Charles Hayes 3/16/00	REVIEWER/DATE D.C. Ingram 3/16/00	CLASS NONE
SUBJECT/TITLE Estimated Primary to Secondary Leakage Rate During Tube Rupture Event 2/15/00.		PROJECT NO. NONE
		MOD NO. NONE / REV.

OBJECT OF CALCULATION:

The intent of this calculation is to provide estimates for primary to secondary leakage rates at various time periods throughout the tube rupture event. These estimates will aid in the SL1 team in understanding of the event dynamics.

The total volume of water transferred from the primary side to the secondary side was also estimated.

CALCULATION METHOD/ASSUMPTIONS:

The development of the estimated leakage into 24 Steam Generator (SG) used, where possible, measured plant parameters. The key input parameters were the charging flowrate, letdown flowrate, pressurizer level and the water level in SG 24. The particular parameters used at a given time during the event were those that were determined to be less influenced by the plant transient. These parameters were not adjusted for measurement uncertainties or uncertainties introduced by the transient. As such the tube rupture flowrates determined must be regarded as nominal values.

DESIGN BASIS AND REFERENCES:

1. SAS or Proteus data via the Plant Information interface.
2. Properties of Saturated and Superheated Steam, Combustion Engineering
3. Westinghouse Pressurizer Vendor Manual #1890.
4. Graph SP-19, IP2 Steam Generator Volume versus Level.

CONCLUSIONS:

The flowrate through the ruptured tube varied throughout the event. The highest flowrate was encountered prior to the reactor trip and was estimated to be 109 gpm. After the reactor trip and prior to the manual SI the primary to secondary side pressure drop decreased and the flowrate decreased to an estimated 91 gpm. After the manual SI the primary to secondary side pressure drop decreased rapidly and consequently so did the flowrate. At times between the SI and Cold Shutdown this pressure drop was positive, zero or negative, When the pressure drop was negative there was back flow between SG 24 and the RCS. Between SI and Cold Shutdown the estimated flowrate varied between 70 gpm and 0 gpm.

The volume of water transferred from the primary side to the secondary side were estimated as follows:

Tube Rupture to Reactor Trip	1313 gallons
Reactor Trip to Manual SI	8685 gallons
Manual SI to Cold Shutdown	9199 gallons

The total volume of primary side water transferred to the secondary side is therefore estimated at 19200 gallons.

Summary

Event Period	Time	Average Primary to Secondary Leakage (gpm)*	Volume (gallons)**
Tube Rupture to Reactor Trip	19:17 to 19:29	109	1313
Reactor Trip to Manual SI	19:29 to 21:04	91	8685
Post SI	21:04 to 21:30	70	1824
Post SI	21:30 to 22:00	37	1120
Post SI	22:00 to 22:30	7	200
Post SI	22:30 to 23:00	3	80
Post SI	23:00 to 23:30	4	120
Post SI	23:30 to 06:00	0	0
Post SI	06:00 to 07:00	11	655
Post SI	07:00 to 12:30	11	3600
Post SI	12:30 to 14:00	18	1600
Post SI	14:00 to Cold Shutdown	0	0

The total volume of primary to secondary leakage = 19197 gallons**

*The leak rates calculated are in given in gpm of "cold" water (100 F and atmospheric pressure).
**The water volumes calculated are given in gallons of "cold" water (100 F and atmospheric pressure).

Introduction

The primary to secondary leakage rates during the tube rupture event are calculated. Inputs to the calculation are from measured plant parameters. The origin of each calculation input is identified in the body of the calculation. Figures 1 through 7 show some of the measured plant parameters that are used or refered to in this calculation. These Figures originate from SAS or Proteus (Ref. 1).

The tube rupture flowrate was estimated for four periods:

1. Just Prior to Tube Rupture
2. From Tube Rupture to Reactor Trip
3. From Reactor Trip to Manual SI
4. From Manual SI to Cold Shutdown

The calculations for each of these time periods are now presented.

Time Period **Just Prior to Tube Rupture**

One Charging Pump Operating
Pressurizer Level Steady
Charging Flow 59 gpm (From computer point F0128 - see Figure 2)
Letdown Flow 87 gpm (From computer point F0134 - see Figure 2)
During steady state at power operation the total inflow to the RCS is matched by the total outflow.

The total inflow is given by the charging flow as measured on F0128 plus the seal injection flow returned to the RCS via the pump shaft. The seal injection flow returned to the RCS is given by the difference between the as measured charging and letdown flowrates.

Therefore, seal injection returned to RCS = 28 gpm

Time Period **From Tube Rupture to Reactor Trip (19:17 to 19:29)**

Determine average charging flow (19:17 to 19:29)

Charging Flow from SAS computer point F0128 (See Figure 2).

Charging flow increased abruptly when the second charging pump was started.

19:17 to 19:19	61 gpm for	2 minutes
19:19 to 19:20	80 gpm for	1 minutes
19:19 to 19:21	118 gpm for	1 minutes
19:21 to 19:25	101 gpm for	4 minutes
19:25 to 19:29	119 gpm for	4 minutes

Therefore, average charging flow = 100 gpm for 12 minutes

Determine average seal injection flow returned to RCS (19:17 to 19:29)

The seal injection flow returned to the RCS increases (scales) as the charging flow increases

Therefore the seal inj. returned flow scaling factor is 100 divided by 60 = 1.67

Therefore the seal inj. return flow during this period is 28 times 1.67 = 47 gpm

Determination of total inflow to RCS from charging system (19:17 to 19:29)

The total inflow is the sum of the charging flow and the seal inj. returned flow

Therefore, total inflow = 100 plus 47 = 147 gpm

Letdown Flow (19:17 to 19:29)

Letdown Flow from SAS computer point F0134 (See Figure 2).

Letdown Flow remained constant during this period = 87 gpm

Pressurizer Level (19:17 to 19:29)

Pressurizer Level from SAS computer point L0480 (See Figure 3).

The pressurizer level decreased significantly during the period.

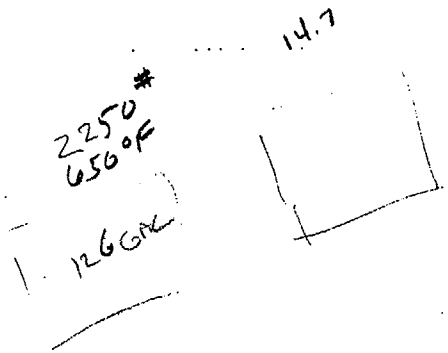
19:17 to 19:29 Level decreased from 43.4 % to 35.5 %

Assuming that 1% level is equivalent to 126 gallons of "hot" water (650 F and 2235 psig).
[Based on distance between taps and inside diameter from Ref. 3.]

Then, equivalent volume of "cold" water is 75.6 gallons (Conversion "hot" to "cold" from Ref. 2).

Then this level reduction is equivalent to an inventory change of -597 gallons of "cold" water

At an average rate of -50 gpm for 12 minutes



Estimation of primary to secondary flow rate during this period (19:17 to 19:29)

Total Inflow to RCS = Letdown Flow + Tube Rupture Flow + Pressurizer Inventory Change

Therefore, Tube Rupture Flow = Total Inflow to RCS - Letdown Flow - Pressurizer Inventory Change

Tube Rupture Flow =	147	minus	87	minus	-50	= 109 gpm
Total primary to secondary leakage volume during this period						= 1313 gallons

Time Period **From Reactor Trip to Manual SI (19:29 to 21:04)**

Determine average charging flow (19:29 to 21:04)

Charging Flow from SAS computer point F0128 (See Figure 2).

Charging flow varies between 120 gpm and 75 gpm.

19:29 to 19:38	119 gpm for	9 minutes
19:38 to 19:52	94 gpm for	14 minutes
19:52 to 20:08	82 gpm for	16 minutes
20:08 to 20:31	104 gpm for	23 minutes
20:31 to 21:00	85 gpm for	29 minutes
21:00 to 21:04	115 gpm for	4 minutes

Therefore, average charging flow = 95 gpm for 95 minutes

Determine average seal injection flow returned to RCS (19:29 to 21:04)

The seal injection flow returned to the RCS increases (scales) as the charging flow increases

Therefore the seal inj. returned flow scaling factor is 95 divided by 60 = 1.58

Therefore the seal inj. return flow during this period is 28 times 1.58 = 44 gpm

Determination of total inflow to RCS from charging system (19:29 to 21:04)

The total inflow is the sum of the charging flow and the seal inj. returned flow

Therefore, total inflow = 95 plus 44 = 139 gpm

Letdown Flow (19:29 to 21:04)

Letdown Flow from SAS computer point F0134 (See Figure 2).

Letdown flow dropped to zero and reestablished at 41 gpm.

19:29 to 19:32	34 gpm for	3 minutes
19:32 to 19:41	14 gpm for	9 minutes
19:41 to 21:04	41 gpm for	83 minutes

Therefore, average letdown flow = 38 gpm for 95 minutes

Pressurizer Level (19:29 to 21:04)

Pressurizer Level from SAS computer point L0480 (See Figure 3).

After the trip the pressurizer level recovered from 14 % to 35% and then decreased to 26% at SI

19:29 to 21:04 Level increased from 14 % to 26 %

Assuming that 1% level is equivalent to 126 gallons of "hot" water [see above.]

Then, equivalent volume of "cold" water is 75.6 gallons

Then this level increase is equivalent to an inventory change of 907 gallons of "cold" water

At an average rate of 10 gpm for 95 minutes

Estimation of primary to secondary flow rate during this period (19:29 to 21:04)

Total Inflow to RCS = Letdown Flow + Tube Rupture Flow + Pressurizer Inventory Change

Therefore, Tube Rupture Flow = Total Inflow to RCS - Letdown Flow - Pressurizer Inventory Change

Tube Rupture Flow =	139 minus	38	minus	10	=	91 gpm
Total primary to secondary leakage volume during this period					=	8685 gallons

The above methodology is appropriate for time periods prior to SI. For times after SI it is concluded that the pressurizer level measurements are inaccurate due to the emptying of the pressurizer and possible steam intrusion into the instrument's reference leg. Consequently, a secondary side balance is used to determine leak rate for the periods after SI. This gives more accurate result as the steam generator was isolated by closing the MSIV and the steam generator blowdown prior to this time period.

If the steam generator is isolated then the level increase in the generator can be attributed to primary to secondary side leakage and the leakage rate can be determined from the SG 24 level increase. (SP-19 (Ref. 4) gives the relationship between SG WR level and gallons).

Time Period **Post Manual SI (21:04 to 21:30)**

Steam Generator 24 Level from SAS computer point L0463 (See Figure 6).

21:04 to 21:30	Steam generator level increased from approximately	62.5 to	68.2 %	
	Assuming 1% wide range level is equivalent to 320 gallons then the volume increase over [Based on Graph SP-19].			
	this	26 minute period	was	1824 gallons
			or	70 gpm

Time Period **Post Manual SI (21:30 to 22:00)**

Steam Generator 24 Level from SAS computer point L0463 (See Figure 6).

21:30 to 22:00 Steam generator level increased from approximately 68.2 to 71.0 %

Assuming 1% wide range level is equivalent to 400 gallons then the volume increase over [Based on Graph SP-19].

this	30 minute	period	was	1120 gallons
			or	37 gpm

Time Period **Post Manual SI (22:00 to 22:30)**

Steam Generator 24 Level from SAS computer point L0463 (See Figure 6).

21:30 to 22:00 Steam generator level increased from approximately 71.0 to 71.5 %

Assuming 1% wide range level is equivalent to 400 gallons then the volume increase over [Based on Graph SP-19].

this	30 minute	period	was	200 gallons
			or	7 gpm

Time Period **Post Manual SI (22:30 to 23:00)**

Steam Generator 24 Level from SAS computer point L0463 (See Figure 6).

22:30 to 23:00 Steam generator level increased from approximately 71.5 to 71.7 %

Assuming 1% wide range level is equivalent to 400 gallons then the volume increase over [Based on Graph SP-19].

this	30 minute	period	was	80 gallons
			or	3 gpm

Time Period **Post Manual SI (23:00 to 23:30)**

Steam Generator 24 Level from SAS computer point L0463 (See Figure 6).

23:00 to 23:30 Steam generator level increased from approximately 71.7 to 72.0 %

Assuming 1% wide range level is equivalent to 400 gallons then the volume increase over [Based on Graph SP-19].

this 30 minute period was 120 gallons
or 4 gpm

Time Period **Post Manual SI (23:30 to 06:00)**

23:30 to 06:00 Steam generator and RCS pressure were approximately equal throughout this time period. Steam generator level changes are therefore not due to leakage and cannot be used. RCS backfill from SG 24 and addition of auxiliary feedwater contribute to the level changes. (See Figures 1 and 7).

For this time period of 390 minutes there was 0 gallons transferred.
or 0 gpm.

Time Period **Post Manual SI (06:00 to 07:00)**

06:00 to 07:00 Steam generator level is increasing due to the addition of auxiliary feedwater and the primary to secondary leakage. Assume leak rate equal to that between 07:00 and 12:30. (See Figure 1).

For this time period of 60 minutes there was 655 gallons transferred.
or 11 gpm.

Time Period **Post Manual SI (07:00 to 12:30)**

Steam Generator 24 Level from SAS computer point L0463 (See Figure 1).

07:00 to 12:30 Steam generator level increased from approximately 81.0 to 90.0 %

Assuming 1% wide range level is equivalent to 400 gallons then the volume increase over [Based on Graph SP-19].

this	330 minute	period	was	3600 gallons
			or	11 gpm

Time Period **Post Manual SI (12:30 to 14:00)**

Steam Generator 24 Level from SAS computer point L0463 (See Figure 1).

During this period the indicated SG 24 water level held constant at approx. 90%. However, there was also a substantial primary to secondary side pressure drop which would suggested continued leakage. It is conservative to assume that leakage continued at the same rate as in the previous time period. An "artificial" level is therefore used in this calculation.

12:30 to 14:00 Steam generator level increased from approximately 90.0 to 94.0 %

Assuming 1% wide range level is equivalent to 400 gallons then the volume increase over

this	90 minute	period	was	1600 gallons
			or	18 gpm

Time Period **Post Manual SI (14:00 to Cold Shutdown)**

14:00 to Shutdown Steam generator and RCS pressure were approximately equal throughout this time period. Therefore, there was no primary to secondary leakage during this period. (See Figure 1).

For this time period there were		0 gallons transferred.
	or	0 gpm.

Figures

FIGURE 1

CALCULATION PGI-001443-00

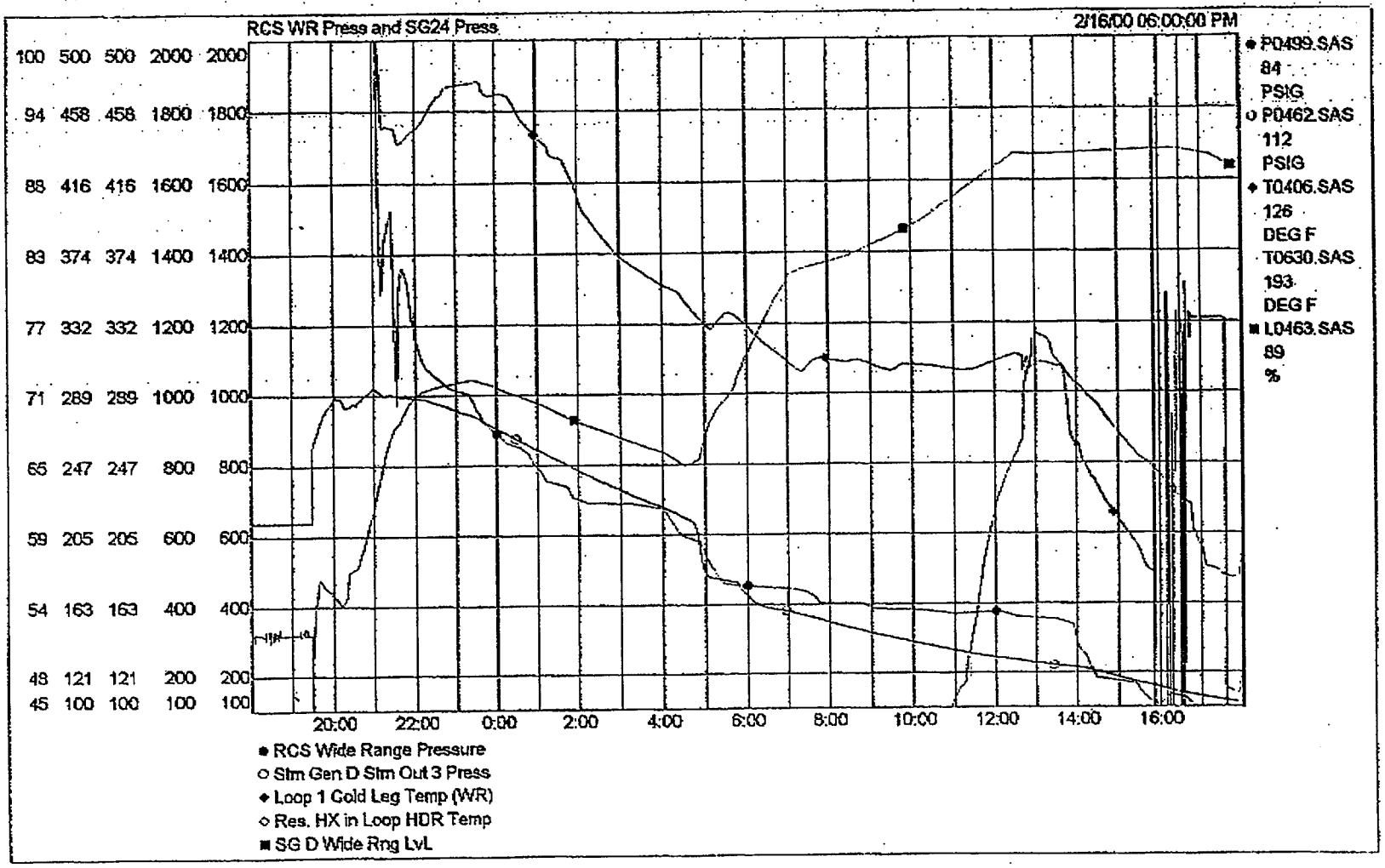


FIGURE 2

CALCULATION PGI-00443-00

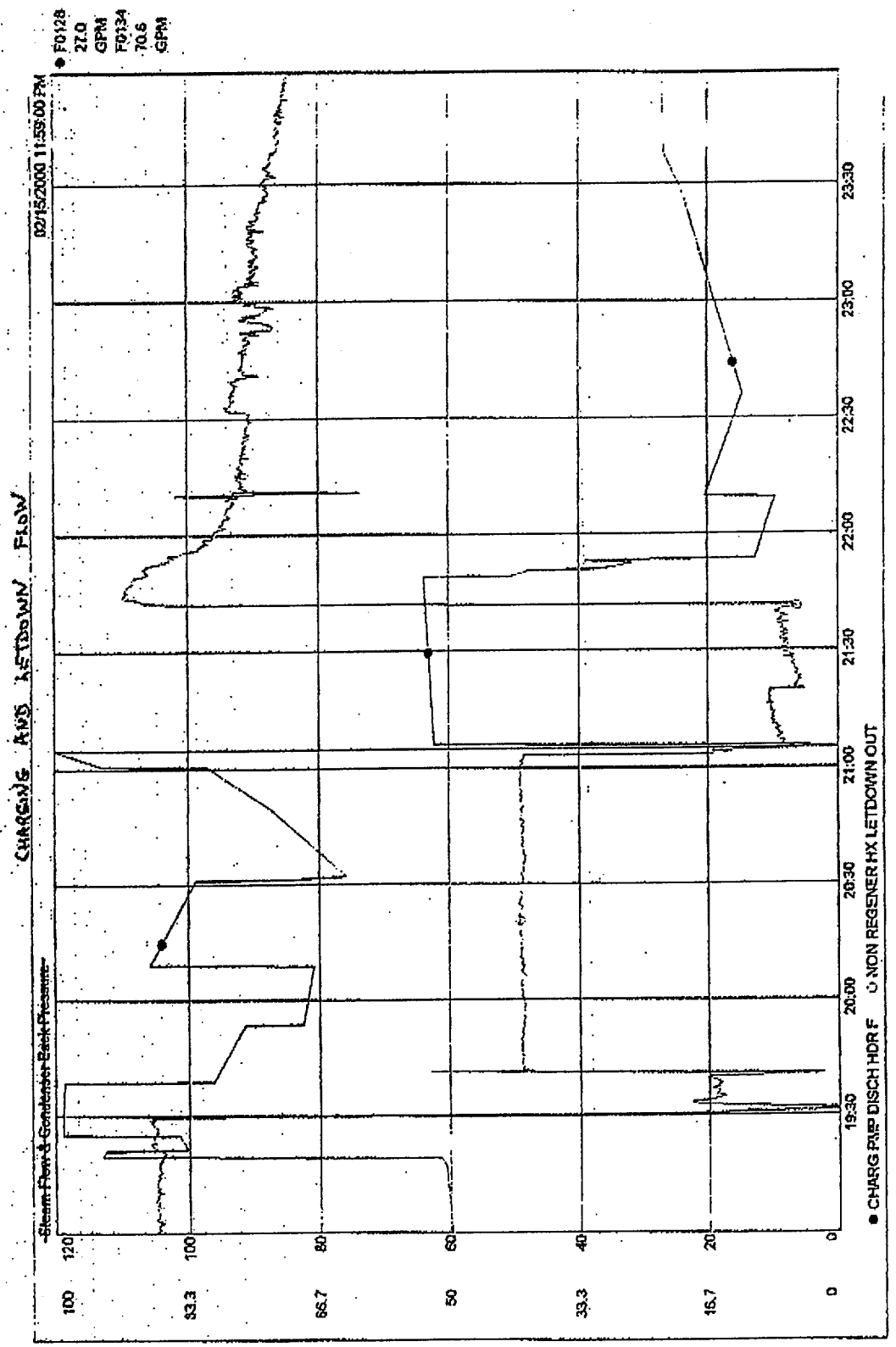


FIGURE 3

CALCULATION PGI-00443-00

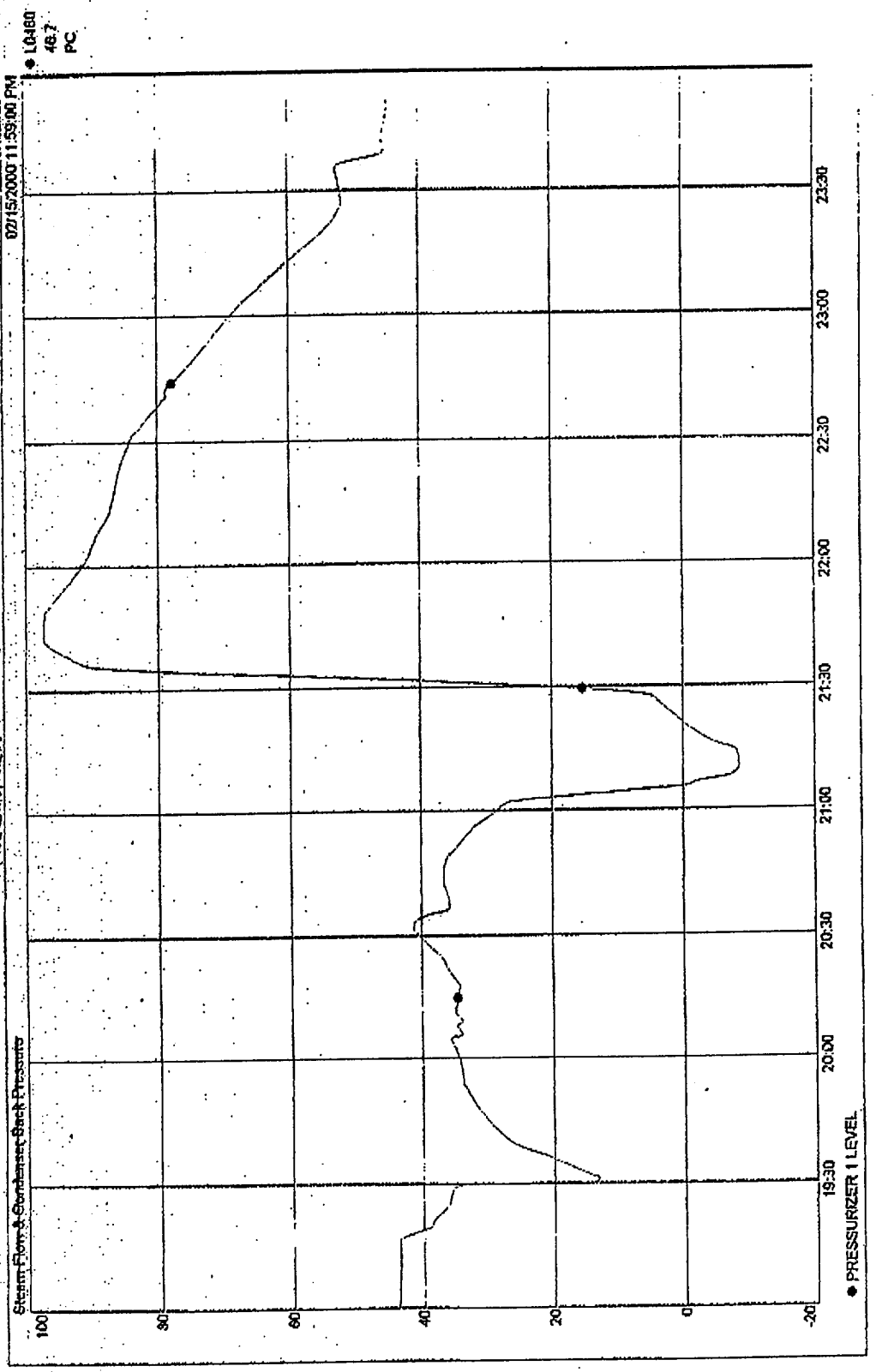


FIGURE 4

CALCULATION PGI-00443-00

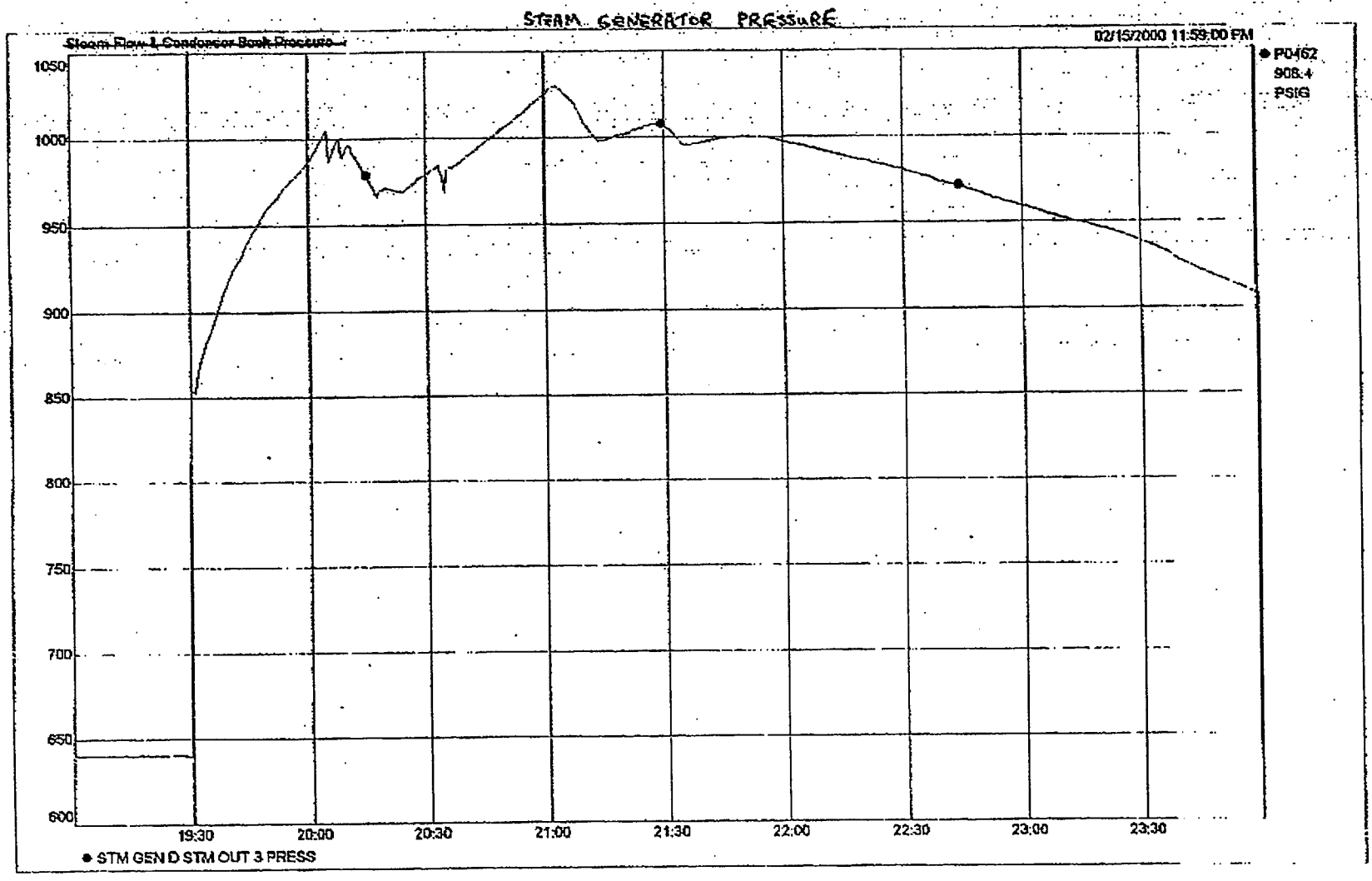


FIGURE 5

CALCULATION PGI-00443-00

RCS PRESSURE

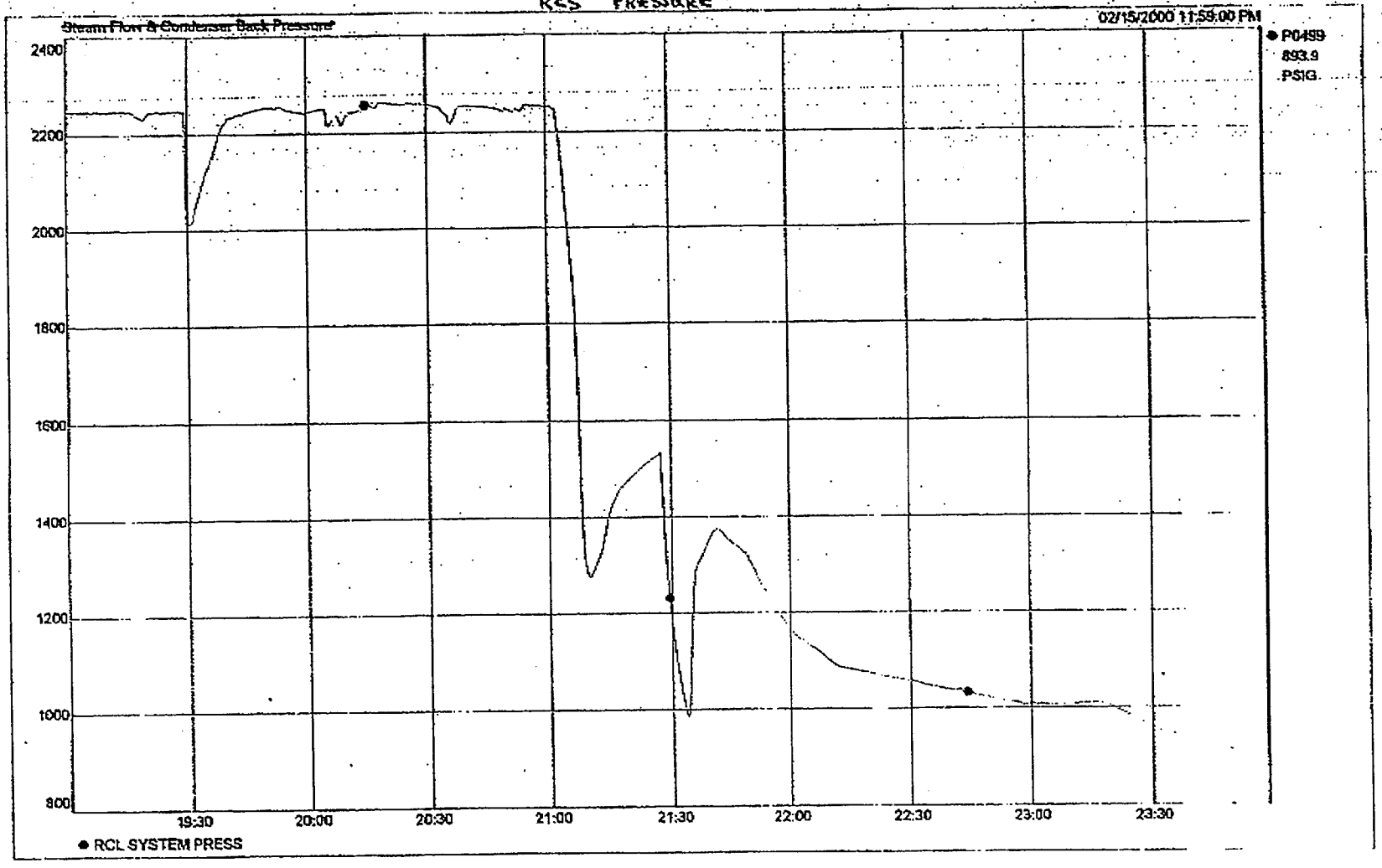


FIGURE 6

CALCULATION PGI-00443-00

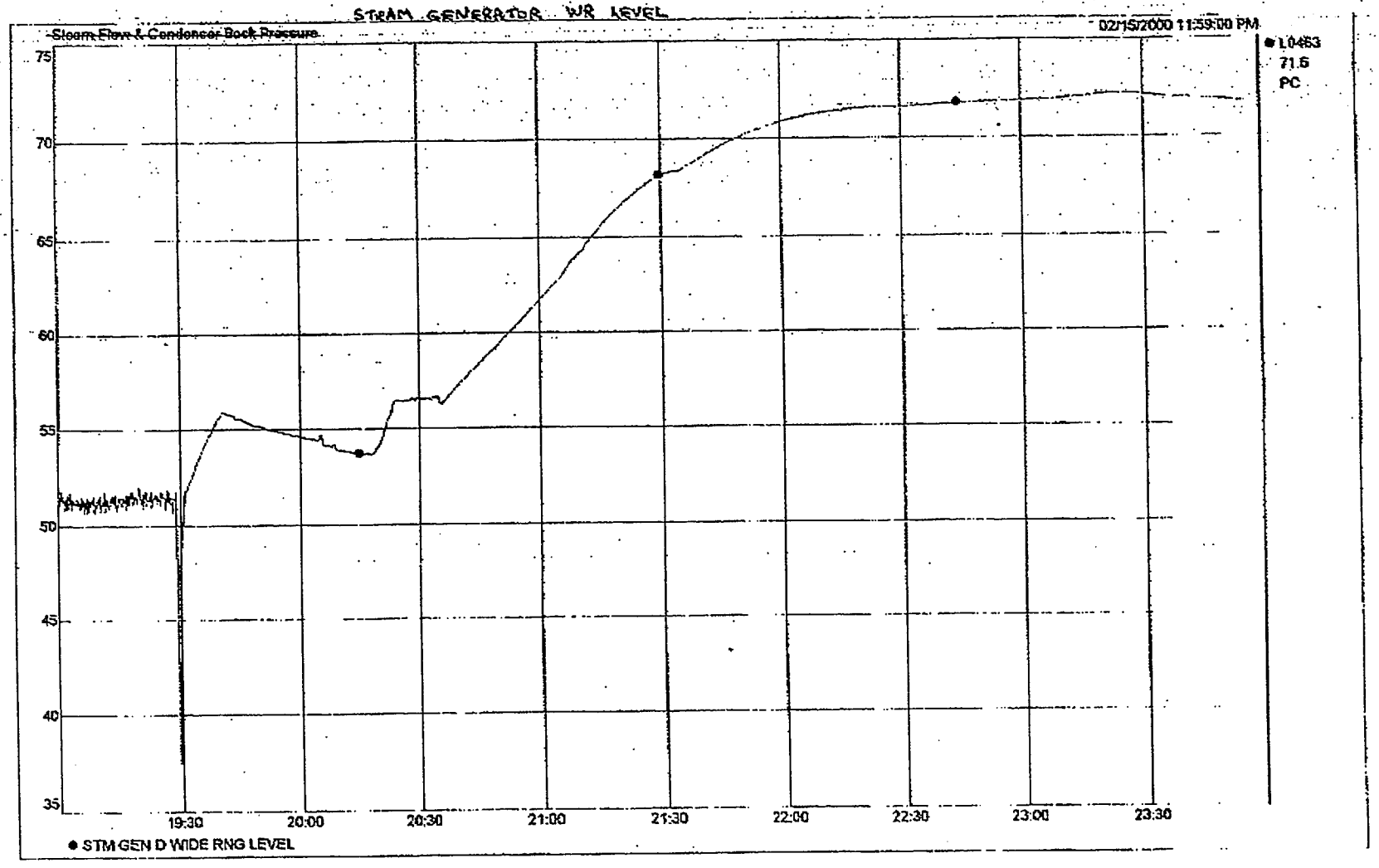


FIGURE 7

CALCULATION PGI-00443-00