REACTOR COOLANT SYSTEM

STEAM GENERATORS

LIMITING CONDITION FOR OPERATION

3.4.5 Each steam generator shall be OPERABLE with a maximum water level as specified on Figure 3.4-5 and a minimum water level of 18 inches.

APPLICABILITY: MODES 1, 2, 3 and 4.*

ACTION:

a. With one or more steam generators inoperable due to steam generator tube imperfections, restore the inoperable generator(s) to OPERABLE status prior to increasing T_{avg} above 200°F.

b. With one or more steam generators inoperable due to the water level being outside the limits, be in at least HOT STANDBY within 6 hours and in COLD SHUTDOWN within the next 30 hours.

SURVEILLANCE REQUIREMENTS

4.4.5.0 Each steam generator shall be demonstrated OPERABLE by performance of the following augmented inservice inspection program and the requirements of Specification 4.0.5.

4.4.5.1 Steam Generator Sample Selection and Inspection - Each steam generator shall be determined OPERABLE during shutdown by selecting and inspecting at least the minimum number of steam generators specified in Table 4.4-1.

4.4.5.2 Steam Generator Tube Sample Selection and Inspection - The steam generator tube minimum sample size, inspection result classification, and the corresponding action required shall be as specified in Table 4.4-2. The inservice inspection of steam generator tubes shall be performed at the frequencies specified in Specification 4.4.5.3 and the inspected tubes shall be verified acceptable per the acceptance criteria of Specification 4.4.5.4. The tubes selected for each inservice inspection shall include at least 3% of the total number of tubes in all steam generators; the tubes selected for these inspections shall be selected on a random basis except:

a. Where experience in similar plants with similar water chemistry indicates critical areas to be inspected, then at least 50% of the tubes inspected shall be from these critical areas.

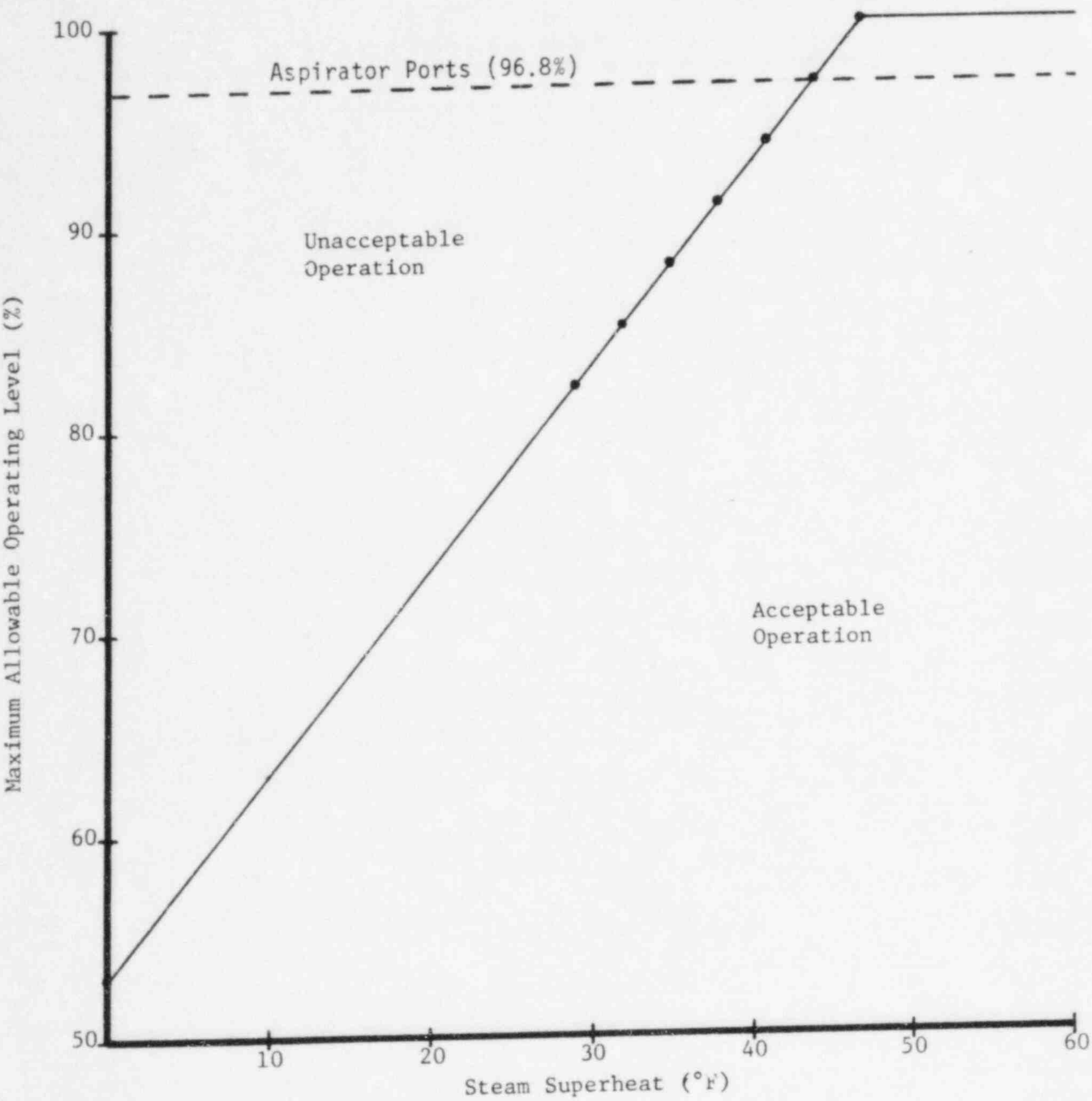
*As noted on Figure 3.4-5, maximum water level restrictions are not applicable in MODE 4.

Pages 3/4 4-7 through 3/4 4-10 contain Surveillance Requirements for the Steam Generators.

Pages 3/4 4-10a is a new page and marks the beginning of the Technical Specification pages that contain Tables concerning Specification 3.4.5.

FIGURE 3.4-5

MAXIMUM ALLOWABLE STEAM GENERATOR LEVEL*



*Not applicable to Mode 4 operation.

system and the secondary coolant system (primary-to-secondary leakage = 1 GPM). Cracks having a primary-to-secondary leakage less than this limit during operation will have an adequate margin of safety to withstand the loads imposed during normal operation and by postulated accidents. Operating plants have demonstrated that primary-to-secondary leakage of 1 GPM can be detected by monitoring the secondary coolant. Leakage in excess of this limit will require plant shutdown and an unscheduled inspection, during which the leaking tubes will be located and plugged.

Operational experience has shown that tube defects can be the result of unique operating conditions and/or physical arrangements in specific limited areas of the steam generators (for example, tubes adjacent to the open inspection lane or tubes whose 15th tube support plate hole is not broached but drilled). A full inspection of all of the tubes in such specific limited areas are detected. Because no credit is taken for these distinctive tubes in the constitution of the first sample or its results, the requirement is essentially equivalent to and meets the intent of the requirements set forth in Regulatory Guide 1.83, "Inservice Inspection of Pressurized Water Reactor Steam Generator Tubes", Rev. 1, July 1975, and does not reduce the margin of safety provided by those requirements.

Wastage-type defects are unlikely with proper chemistry treatment of the secondary coolant. However, even if a defect should develop in service, it will be found during scheduled inservice steam generator tube examinations. Plugging will be required for all tubes with imperfections exceeding the plugging limit of 40% of the tube nominal wall thickness. Steam generator tube inspections of operating plants have demonstrated the capability of reliably detect degradation that has penetrated 20% of the original tube wall thickness.

Whenever the results of any steam generator tubing inservice inspection fall into Category C-3, these results will be promptly reported to the Commission pursuant to Specification 6.9.1 prior to resumption of plant operation. Such cases will be considered by the Commission on a case-by-case basis and may result in a requirement for analysis, laboratory examinations, tests, additional eddy-current inspection, and revision of the Technical Specifications, if necessary.

The steam generator water level limits are consistent with the initial condition assumptions in the FSAR. The maximum steam generator level, as a function of steam superheat, is sufficient to assure a mass inventory of less than or equal to 62,600 lbm in the event of a main stream line rupture.

NO SIGNIFICANT HAZARDS CONSIDERATION DETERMINATION

Docket No: 50-302 **Facility:** Crystal River Unit 3

Licensee: DPR-72 **Date of Application:** January 30, 1984

Request For:

Revision to the Steam Generator maximum allowable operating level. This request for amendment revises the restriction on the Steam Generator operating level (360 inches) to a restriction based upon mass inventory (as a function of Steam Superheat and operating level).

Significant Hazards Consideration Determination:

(x) Amendment involves no significant hazards considerations.

( ) Amendment involves significant hazards considerations.

Basis for Determination:

This amendment is considered not likely to involve a significant hazard consideration because it is within applicable acceptance criteria.

The basis for imposing a maximum waterlevel on the Steam Generator is to assure that during a main steam line break accident, the mass inventory of water when converted to steam does not exceed design limits placed upon the Reactor Building, cause excessive overcooling or exceed environmental doses. The proposed change will continue to limit the available mass inventory within the Steam Generator below the mass inventory assumed in the initial Safety Analysis, therefore, this change does not involve a significant reduction in the margin of safety.

Requested Implementation Date:

Due to the probability of reduction in POWER OPERATION at and near the current imposed level limit and the apparent increasing operating level, Florida Power Corporation request implementation of this specification by March 1, 1984.

CALCULATION DATA/TRANSMITTAL SHEET

DOCUMENT IDENTIFIER CALC. 32 - ______ - ______ C.C. ______

TRANS. 86 - 1146234 - 02 REF. PG(s) ______

TYPE: ___RESEARCH & DEVELOPMENT ___SAFETY ANALYSIS REPORT ___DOC. SERV. INPUT ___DESIGN RQMT. ___DESIGN VERIF. ___OTHER

TITLE CR-3, Maximum Steam Generator Level (Tech Spec Limit 3.4.5)

PREPARED BY J. S. MURANSKY REVIEWED BY Robert Winks

TITLE ENGINEER DATE 9/15/83 TITLE Advisory Engineer DATE 9/15/83

PURPOSE

To summarize the results of the calculation file B&W 32-1143963-00.

This calculation file provides a detailed analytical background for the results summarized below.

SUMMARY OF RESULTS (INCLUDE DOC. ID'S OF PREVIOUS TRANSMITTALS & SOURCE CALCULATIONAL PACKAGES FOR THIS TRANSMITTAL)

1. The increase in SG level readings at CR-3 as intimated from these analytical results is believed to have been caused by fouling of the tube support plate flow areas. No evidence, from an analytical approach, for a fouling of the tube heat transfer area was found (see also Table 1, Page 8, Notes 3 and 4). 02

2. Steam generator inventory is a function of the steam superheat and the operate level. This relationship is shown in Figure 1 (Page 9). The startup and the full range levels should not be used as indicators of the mass inventory in the OTSG at high power. 01

3. The current (3/1/83) SG inventory at CR-3 is approximately 50,000 lbm per SG. This is well below the limits shown in Figure 1. Even with an operate level reading as high as 100%, the SG mass inventory would still remain within the limits, providing the steam superheat remains unchanged. In this case, the SG inventory would be approximately 55,000 lbm. An additional increase in the inventory is only possible if a simultaneous degradation of the steam superheat would be experienced.

4. It is recommended to define the new technical specification 3.4.5, i.e., the maximum SG level as the operate level vs. steam superheat (see Page 6).

DISTRIBUTION

1. Introduction

The Crystal River-3 Technical Specification No. 3.4.5 defines the maximum allowable steam generator level as 360". It is possible that if the SG level readings at CR-3 will continue to increase as in the past this limit could be violated.

The objective of this analysis was to show the following:

a. Does the SG mass inventory read the value of 52,000[1] lbm (which was assumed as the initial value for the steam line break accident in the CR-3 FSAR) when the SG level is 360"?

b. If not, could a new Technical Specification #3.4.5 be defined which would be less restricting?

2. Results

In order to calculate the steam generator inventory, the B&W digital code VAGEN was used. This code has been shown in the past to match data from operating plants (ANO-1, Oconee, CR-3, and other plants) as well as experimental data from the Alliance Research Center.

The VAGEN code calculates the steam superheat, the startup and full range levels and the mass inventory in the tube region. The downcomer inventory must be calculated by hand based on the operate level obtained by plant data.

The first step in the analysis was to show the cause for the increase of the SG level readings at CR-3 and to calculate how this increase impacted the SG inventory.

For this purpose VAGEN was run to simulate plant data obtained from Florida Power Co. on July 7, 1983 (Reference 1). The data set was for OTSG-B operating on 3/1/83 at 2475 MWth with the plant developing 879 MWe.

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[1] This inventory includes the downcomer, the secondary tube region, and the steam annulus. See Crystal River-3, FSAR, Volume 6, Chapter 14 (6/15/72), Rev. 00.

The first run was made with a clean heat transfer surface and clean tube support plate flow areas (see Table 1). It was shown that VAGEN under predicts the plant superheat by about 5°F which verifies the absence of fouling of the heat transfer area. This result was expected since CR-3 did not experience a degradation of the steam superheat. The startup and full range levels calculated by VAGEN were for the "benchmark" run somewhat 02
below the plant data. The total OTSG inventory for this case was calculated as 43,194 lbm. This approximately corresponds to the SG inventory during the startup in 1977 (provided other conditions were the same as T_{ave}, primary flow and steam generator outlet pressure).

For the next case, VAGEN code run (VAGENLN), the tube support plate fouling was simulated by increasing a fouling factor until both the startup and the full range levels matched the plant data. The significance of this run is in the fact that neither the calculated steam superheat nor the inventory 02
in the tube region changed considerably. Only the mass inventory in the donwcomer increased due to an increase in the operate level. This run represents the current status of the OTSG-B at Crystal River. The total SG inventory is 40,117 lbm which is an increase of about 7,000 lbm over the inventory at startup in 1977. Practically all of this mass increase was in the downcomer.

The next four runs were made to demonstrate how the inventory, the steam superheat, and the SG levels would change if the heat transfer area of the tubes fouled (which is not considered to be the case at CR-3). The 02
fouling of the tube support plates was held constant.

The results show a decline of superheat and an increase of the mass inventory in the tube region as expected. The significant finding is that both the startup and full range levels have dropped despite the increase of inventory in the SG. This single fact demonstrates that both levels are not suitable as indicators of the SG inventory. A situation exists with a significant increase in the inventory, but the startup and full range levels remained unchanged or reduced.

The explanation of this effect is relatively straightforward. The startup and full range level transmitters measure a differential pressure between the level taps. The differential pressure consists of the elevation, shock, friction, and momentum pressure drops of which the elevation and shock (or form loss at the tube support plates) are most significant. The shock ΔP is a function of the square of mass flow in the tube region and of the fouling at the tube support plates. This pressure drop is related to the secondary fluid density. Thus, the pressure drop across the last tube support plate with superheated steam is, at full power, approximately ten times larger than the pressure drop across the first tube support plate where the fluid density is relatively high.

When the mass inventory in the tube region increases as a result of the heat transfer area fouling, more tube support plates will be exposed to a two-phase mixture with a higher density resulting in a reduced shock pressure drop.

From the results in Table 1, we concluded that the inventory in the tube region is only a function of the fouling of the heat transfer area (steam superheat), and the inventory in the downcomer is only a function of the fouling of the tube support plate flow areas (operate level). For this reason, we conclude that the startup and the full range levels have no clear relation to the SG inventory at high power. 01

3. Summary of Results

A. Figure 1 on page 9 depicts a relationship between the total SG inventory for CR-3 and the steam superheat with the operate level as a parameter. These curves were calculated for the power level of 2544 MWth and are bounding for all other power levels.

The FSAR limit for maximum SG inventory, 62,600 lbm is also plotted in Figure 1. It is recommended to reduce this limit by a safety margin of 10% to account for uncertainties in the inventory prediction by VAGEN and for the uncertainty of the operating conditions at CR-3. (Note that slight deviations in T_{ave}, steam outlet pressure, FW temperature and other variables have an impact on the SG inventory.)

B. The increase of the startup level, the full range, and the operate level at CR-3 is most probably caused by fouling of the tube support plates. There is no evidence of any significant fouling of the heat transfer area on the tubes, based on the results of these analyses. 02

As a result of the fouling in the tube support plates, the OTSG inventory increased by approximately 7,000 lbm per steam generator since the startup in 1977. Practically all of the inventory increase was in the downcomer.

More specifically, the SG inventory has been calculated to increase from approximately 43,000 lbm in 1977 to a current value of about 50,000 lbm (per steam generator). If the rise in the operate level will continue up to the full scale reading of 100%, an additional mass of approximately 5,000 lbm will be added to each steam generator downcomer, increasing the total SG inventory to approximately 55,000 lbm which is still below the limits. This is the maximum inventory each steam generator can have provided the steam superheat remains reasonably constant (greater than 50°F). Crystal River-3 can thus operate with an operate level as high as 100% without violating the inventory limit (provided an operation at that level is possible). 02

Should the plant experience a degradation of the steam superheat, the SG inventory can go above 55,000 lbm; and it may be necessary to limit the operate level (by reducing power) to the values described below.

4.0 Recommendations

It is B&W's recommendation that FPC redefine the maximum allowable SG level for the Technical Specification 3.4.5 as a function of the steam superheat.

Max. Allowable[1] Operate Level (%)	Steam Superheat (°F)[2]
100	47
97	44
94	41
91	38
88	35
85	32
82	29

Applicability: Mode 1 (Modes 2, 3, and 4 are bounded by Mode 1). 01

(1) These limits were calculated based on the maximum allowable SG inventory only. Other effects, especially flooding of the aspirator, can be more limiting but were not considered here.

(2) These values were taken from Figure 1 assuming maximum allowable inventory at 56,340 lbm.

References

1. Letter: Florida Power Co. (G. T. Cowles/E. M. Howard) to B&W/J. F. Pearson, dated June 27, 1983. Title: "Task 564, Rev. 1, Modification of OTSG Secondary Side Level Tech. Spec." (A copy of this letter is included in Appendix B of Reference 2.)

2. B&W Calculation File 32-1143963-00, "CR-3 Maximum SG Operating Level (Tech. Spec. Limit), J. S. Muransky, 7/11/83.

TABLE 1. VAGEN PREDICTION VERSUS PLANT DATA FOR CLEAN AND FOULED CONDITIONS

VAGEN RUN IDENT.	VAGENSO	VAGENLN(3)	VAGENNH	VAGENNN	VAGENN4	VAGENOH	PLANT DATA
			→	INCREASING FOULING →			
HEAT TRANSFER SURFACE AREA (TUBES)	CLEAN	CLEAN	FOULED	FOULED	FOULED	FOULED	3/1/83
		→		CONSTANT FOULING →			2475 MWth
TUBE SUPPORT PLATE FLOW AREA	CLEAN	FOULED	FOULED (CLEAN)(4)	FOULED	FOULED	FOULED	879 MWth OTSG-B
STEAM SUPERHEAT, ^oF	50.8	50.5	(43.2) 43.2	38.5	33.	0.	56
STARTUP LEVEL, INCHES	150.	209	(146) 203(1)	203(1)	200(1)	200(1)	210
FULL RANGE LEVEL, INCHES	247.	309.	(241) 301(1)	298(1)	295(1)	285(1)	300
OPERATE LEVEL, %	53.(2)	80.3	(52) 80.3	80.3	80.3	80.3	80.3
INVENTORY, TUBE REGION, LBM	18,301	18,333	20,372 (20,372)	21,200	22,650	26,650	---
INVENTORY, DOWNCOMER, LBM	23,893	30,784	30,784 (23,641)	30,784	30,784 (30,784)	30,784	---
INVENTORY, STEAM ANNULUS, LBM	1,000	1,000	1,000 (1,000)	1,000	1,000 (1,000)	1,000	---
TOTAL SG INVENTORY, LBM	43,194	50,117	52,156 (45,013)	52,984	54,434	58,434	---

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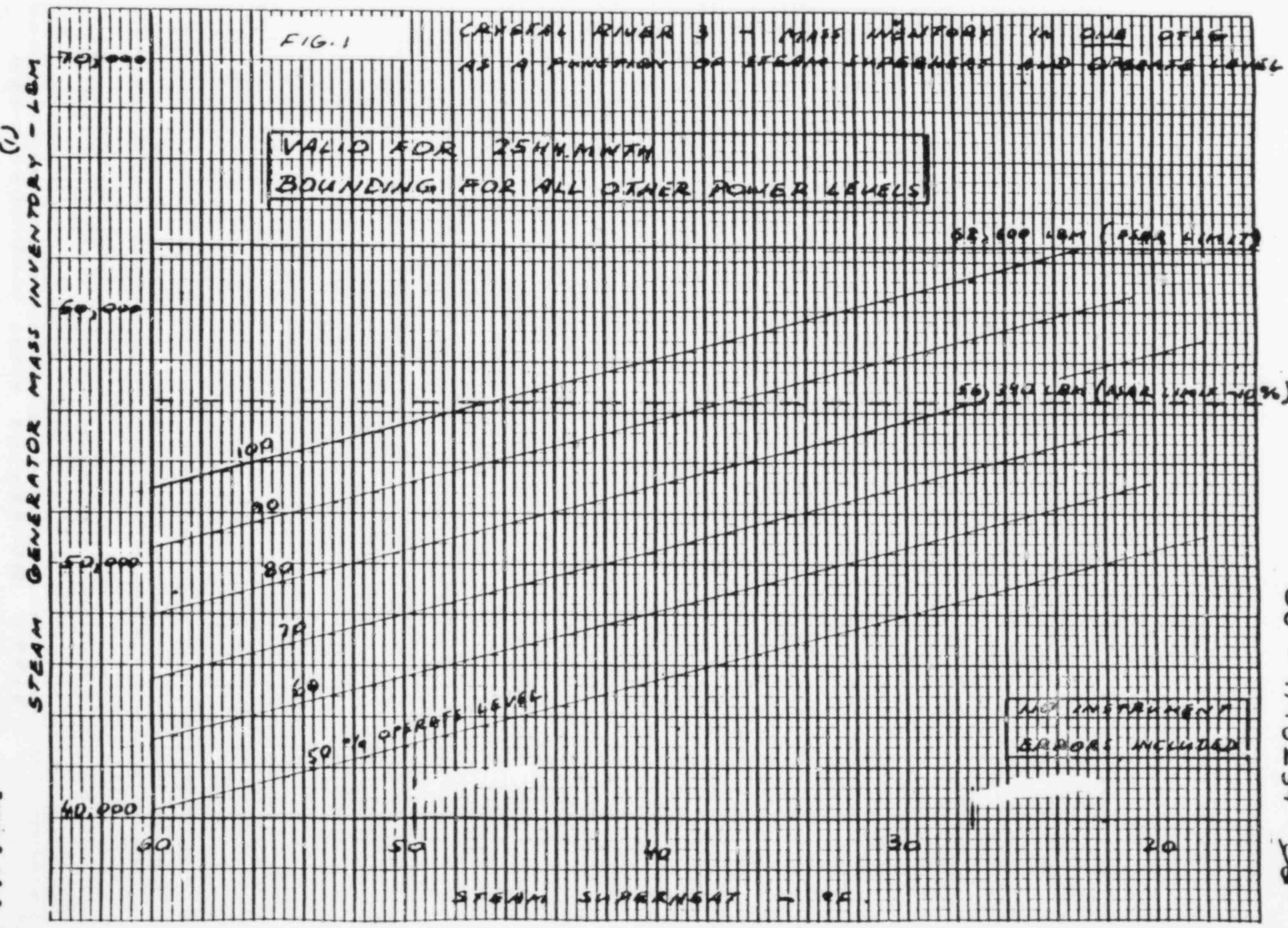
(1) FULL RANGE AND STARTUP LEVELS WERE PROJECTED FOR THESE RUNS.

(2) THE VAGEN CODE DOES NOT CALCULATE THE OPERATE LEVEL. 53% WAS THE READING ON OTSG-B DURING THE STARTUP TESTING IN APRIL, 1977.

(3) VAGENLN IS AN OUTPUT OF A CASE WITH PURELY FOULING OF TUBE SUPPORT PLATES. THIS RUN MOST CLOSELY SIMULATES THE ACTUAL PLANT DATA.

(4) VAGENNH (CLEAN) REPRESENTS PURELY FOULING OF TUBES.



(1) INCLUDES ALL WATER AND STEAM IN THE OTSG, BUT NO PIPING

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