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FLORIDA POWER CORPORATION

"Main Steam and Feedwater - Steam Hammer Observations and Instrumentation"

MAY 31, 1977

MAIN STEAM ANALYSES

II - 21

FLORIDA POWER CORPORATION

"Main Steam and Feedwater - Steam Hammer Observations and Instrumentation"

MAY 31, 1977

MAIN STEAM HANGERS

Gilbert/Commonwealth engineers and consultants

GILBERT ASSOCIATES, INC., P. O. Box 1498, Reading, PA 19603/Tel. 215 775-2600/Cable Gilasoc/Telex 836-431

June 7, 1977

FPC NO. 14415

Mr. R. S. Burns, H-8
CR-3 Engineering Manager
Florida Power Corporation
P. O. Box 14042
St. Petersburg, Florida 33733

Re: Crystal River Unit No. 3
Main Steam and Feedwater
Steam Hammer Observations
and Instrumentation

Dear Mr. Burns:

Attached please find two (2) copies of a report entitled "Main Steam and Feedwater - Steam Hammer Observations and Instrumentation". This document presents a fairly detailed history on the subject.

Should there be any questions, please contact me.

Very truly yours,

Santo Ferrarello

Santo Ferrarello
Piping Engineer

SF:lap
Attachment

cc: R. S. Burns, w/attachment (2)
A. L. Gomez
R. C. Bonner
G. P. Beatty, Jr.
E. Morea w/attachment
E. R. Hottenstein, 2L
F. J. Tomazic, w/attachment
M. Z. Lee, w/attachment
J. B. Muldoon, w/attachment
A. P. Rochino, w/attachment
Dept. 0430 File, w/attachment

FLORIDA POWER CORPORATION

CRYSTAL RIVER NUCLEAR POWER PLANT

UNIT NO. 3

MAIN STEAM AND FEEDWATER - STEAM HAMMER OBSERVATIONS AND INSTRUMENTATION

MAY 31, 1977

S. F. FERRARELLO

PIPING ENGINEERING DEPARTMENT

GILBERT ASSOCIATES, INC.

TABLE OF CONTENTS

1.0 INTRODUCTION

The final phase of design for a piping support system is observation during functional testing and during Initial Operation. For the main steam and feedwater systems one of the most severe loadings occurs immediately after the closure of the valves on the main steam turbine chest. These particular valves are designed to close in a very short time in order to terminate the flow of steam into the Turbine as quickly as possible. The abrupt termination of steam flow results in the creation of a pressure wave which travels from the Turbine steam chest, through the four main steam lines, back towards the Steam Generator. This wave is generated and dissipated before the main steam bypass valves to the condenser or the safety valves to the atmosphere can open. The unbalanced force, normally referred to as a steam hammer, created by the pressure wave traveling through the pipe tends to accelerate the piping. Large restraints, primarily hydraulic snubbers, were designed to arrest this unbalanced force.

In addition to visual observation by qualified GAI personnel, the main steam lines were instrumented to detect, and record, the pressure transient created. The recorded wave was then compared with the assumed curve used in the original steam hammer analysis.

The feedwater system might experience some water hammer as a result of the Turbine Trips. Thus this piping was observed along with the main steam lines during the 40%, 75% and 100% Turbine Trips.

2.0 STEAM HAMMER PIPING OBSERVATIONS

Section 5.4.4 of the CR3 FSAR (Pg. 5-64a and Pg. 5-64b) expresses a commitment to ANSI B31.7, Paragraph 1-701.5.4, "Piping shall be arranged and supported so that vibration will be minimized. The designer shall be responsible by design and by observation under start-up and initial operating conditions to assure that vibration of piping systems is within acceptable levels".

Determining whether any given vibration is within "acceptable levels" was made the responsibility of qualified personnel from GAI. Some written guidelines and specific piping areas to be observed were included in a report, issued on 9/2/75, entitled, "General Acceptance Criteria for Dynamic Movement, Vibration and Thermal Expansion of Piping for Crystal River Unit No. 3 Nuclear Plant". Test Procedures TP-600-14 and TP-800-25, in addition to providing checks on pipe supports and rupture restraints, also include specific details necessary to translate the FSAR commitments into the realities.

For the piping systems in general, the FSAR commitment was fulfilled by observations during Hot Functional Testing (July, 1976) and Power Escalation (March & April, 1977) by GAI Piping Engineer(s).

The observations of the dynamic movement of the main steam and feedwater lines, due to steam hammer, originally were planned only for the 24" Ø main steam piping during the previously scheduled Turbine Trips at the 15%, 40%, and 100% Power Levels. Later a Turbine Trip at the 75% Power Level was suggested by GAI (see Attachment 1).

In addition, one recommendation of the water hammer investigation of the feedwater system (Reference 7) was to include this piping in the observation program during the intentional Turbine Trips.

During the early stage of the Power Escalation Program, FPC decided not to do the 15% intentional Turbine Trip. GAI did not agree with this course of action (see Attachment 2). The first observation made for this steam hammer loading was at the 40% Power Level Reactor-Turbine Trip. Prior to that test the GAI Engineer investigated a cut sleeve reported by the operations personnel. This sleeve surrounds the discharge stack for safety valve, MSV33F, as it passes through the roof and is intended to anchor the stack to the roof of the intermediate building. The cut was a 360° circumferential, found approximately three feet above the rooftop elevation. It was not the result of previous safety valve discharges. It appeared to be made intentionally some time ago as evidenced by the overlap of paint, used on the exposed sleeve area, into the cut area. No reason for the cut was ever determined. The cut sleeve was welded together immediately upon GAI's recommendation.

On 3/9/77 at 1510 hours, personnel stationed in the Turbine and Intermediate Building observed the Turbine Trip at the 40% Power Level. GAI's report on this trip is included in this report as Attachment 3.

The 75% trip was performed on 3/30/77 at 0830. GAI's report on this observation is included as Attachment 4. The grout used for steam hammer restraints MSH-227, 232, 236, and 240 was found to be deteriorating. GAI requested that the grout be removed (see Attachment 4). Upon further investigation it was GAI's opinion that two of the concrete pedestals (MSH-227 and 232) required revisions. New baseplates were designed (see Reference

13). Twelve holes were core-drilled into the Intermediate Building floor (el. 119'0"). Bolts were placed in the holes and an epoxy grout was used to bond the bolts to the floors (4/11/77). The snubbers were shifted from the pedestals to the new plates and welded on Saturday, 4/16/77 from 0100 to 0300 hours. The 100% trip occurred on 4/18/77 at 1055. The Dynamic Movement, due to the travel of the pressure wave of the main steam lines (especially the two lines on the "B" loop) were significant but within values expected, and thus acceptable. The feedwater piping showed no appreciable movements.

The plant experienced an unintentional, and thus unobserved, trip at 100% Power late on 4/18/77. MSH 227 and 232, as well as the other steam hammer restraints, were checked, as they had been after the intentional trip, and were found to be free of any sign of damage or overloading.

3.0 STEAM HAMMER INSTRUMENTATION

The steam hammer restraints were designed based on the best available pressure wave data at that time (1973). The Main Steam; Steam Hammer Report for Crystal River Unit No. 3 (Reference 6) generated by M. Z. Lee (of GAI) on 11/2/73 contains the assumed curve as well as the calculations for the loadings on each steam hammer restraint. References "9a" to "9d" provides the history of the correspondence between FPC and GAI on this subject.

Figure 1 is a schematic diagram of the instrumentation and its connection, through tubing, to the 24 inch diameter main steam lines. Obtaining this data was included within Test Procedure TP-7-1-800-0, "Power Escalation". The applicable sections are:

Section	6.5	Page 8
	6.6	8
	9.3.4	43, 43a, 43b
Enclosure 16		
	Part A	85
	Part B	86
	Part C	87

The data was recorded during the 40%, 75%, and 100% Power Level Turbine Trips (see Figures 2, 3, and 4). Please note that the pressure scale is different for the 40% test than that shown for the 75% and 100% tests.

SCHEMATIC SET-UP OF EQUIPMENT FOR STEAM HAMMER MEASUREMENTS

T - TRANSDUCER (e.g. TELEDYNE/TABER 206)
A - SIGNAL CONDITIONER (e.g. ALLEGANY)

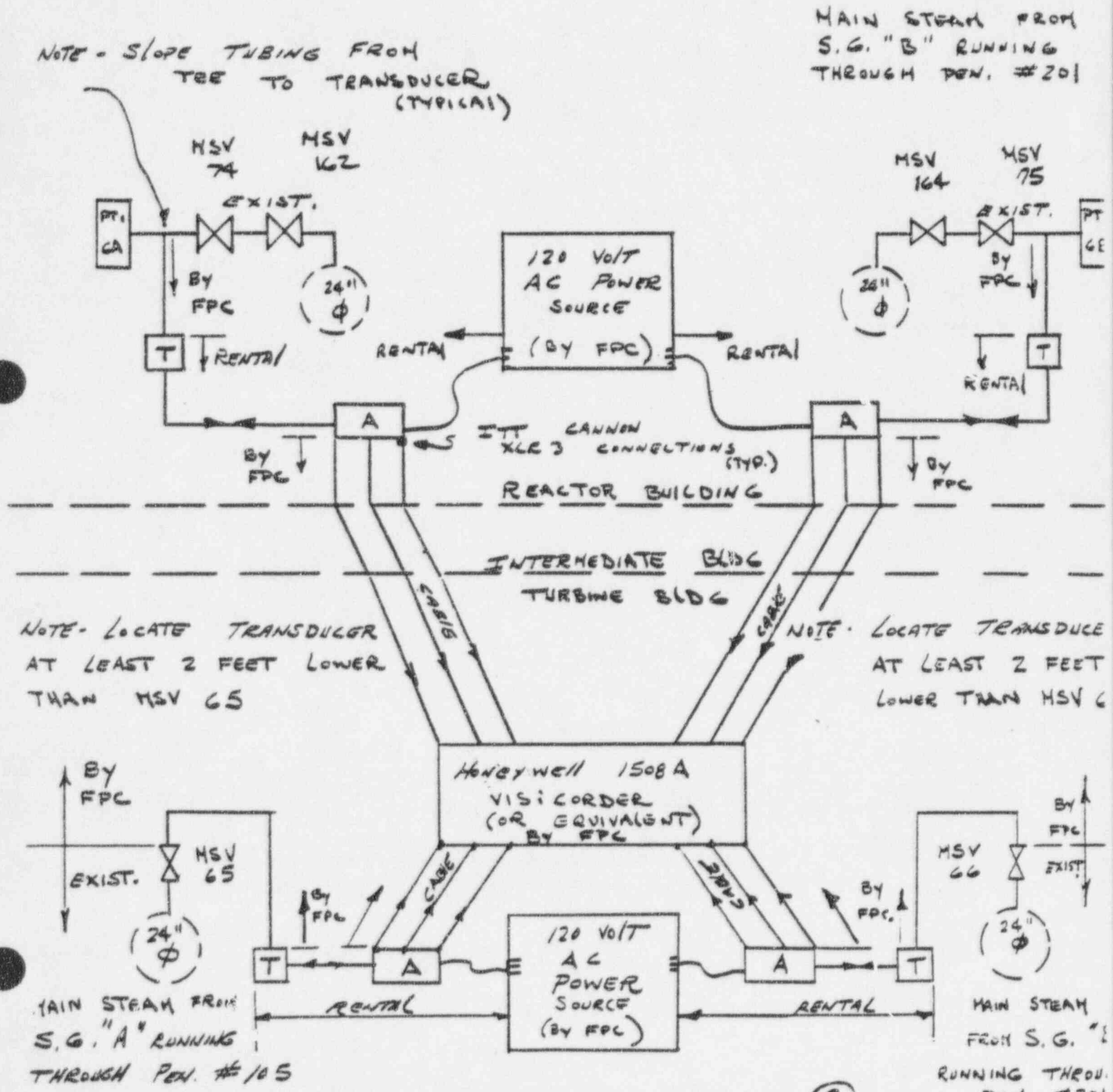
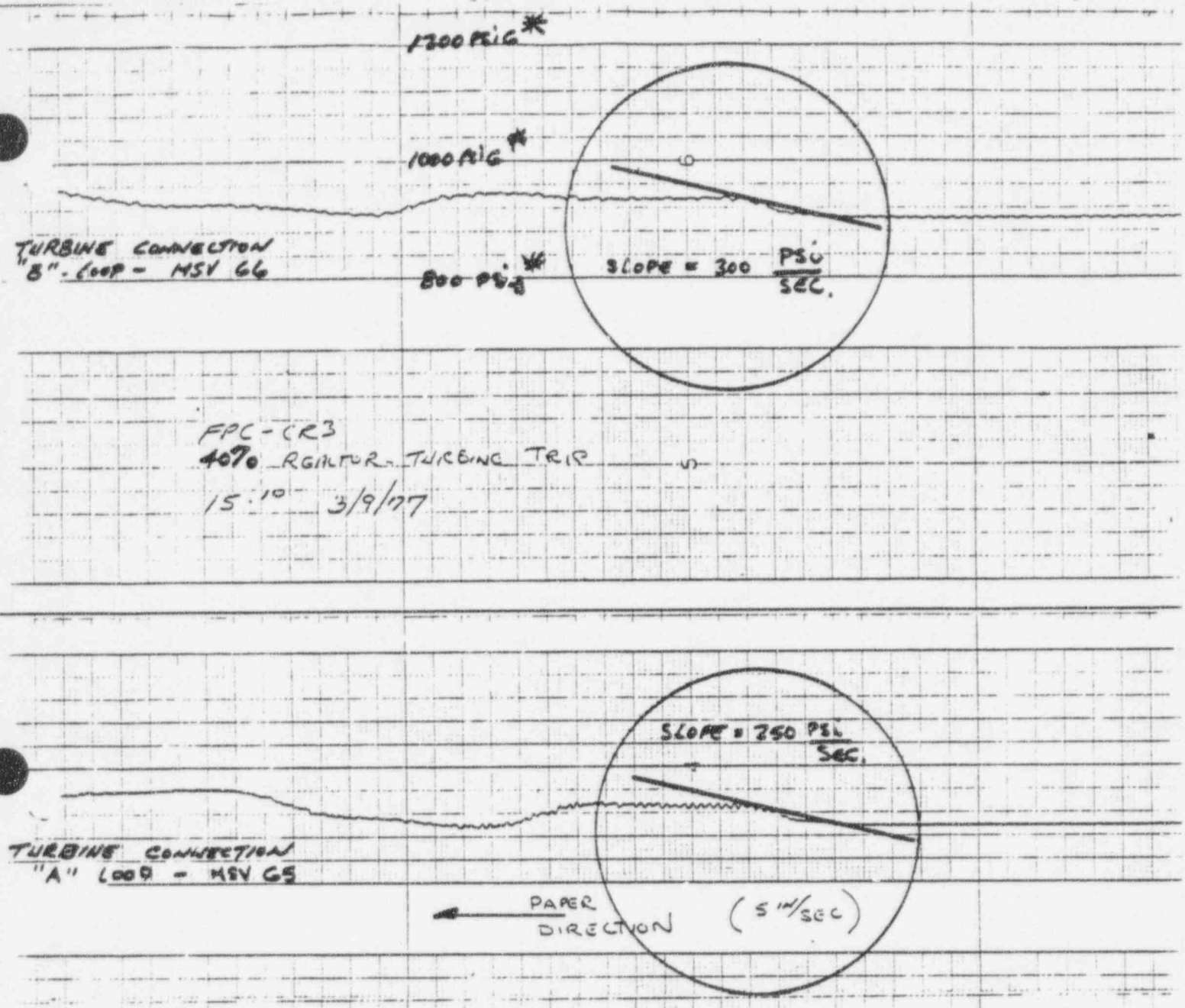


FIGURE 1

The primary areas of interest have been circled on figures 2, 3 and 4. The maximum slope of each curve has been determined and recorded. The slope used in the original design is 1280 psi/sec. It is this slope, along with the net pressure increase, and the speed of the propagation of the pressure wave that determines the unbalanced loading within the piping and imparted on the steam hammer restraints. Table 1 presents these parameters and determines this unbalanced force. In addition, it provides a comparison with the numbers used in the initial design.



* PRESSURE SCALE DIFFERS FROM 75% ↓ 100% OUTPUT

FIG. 2

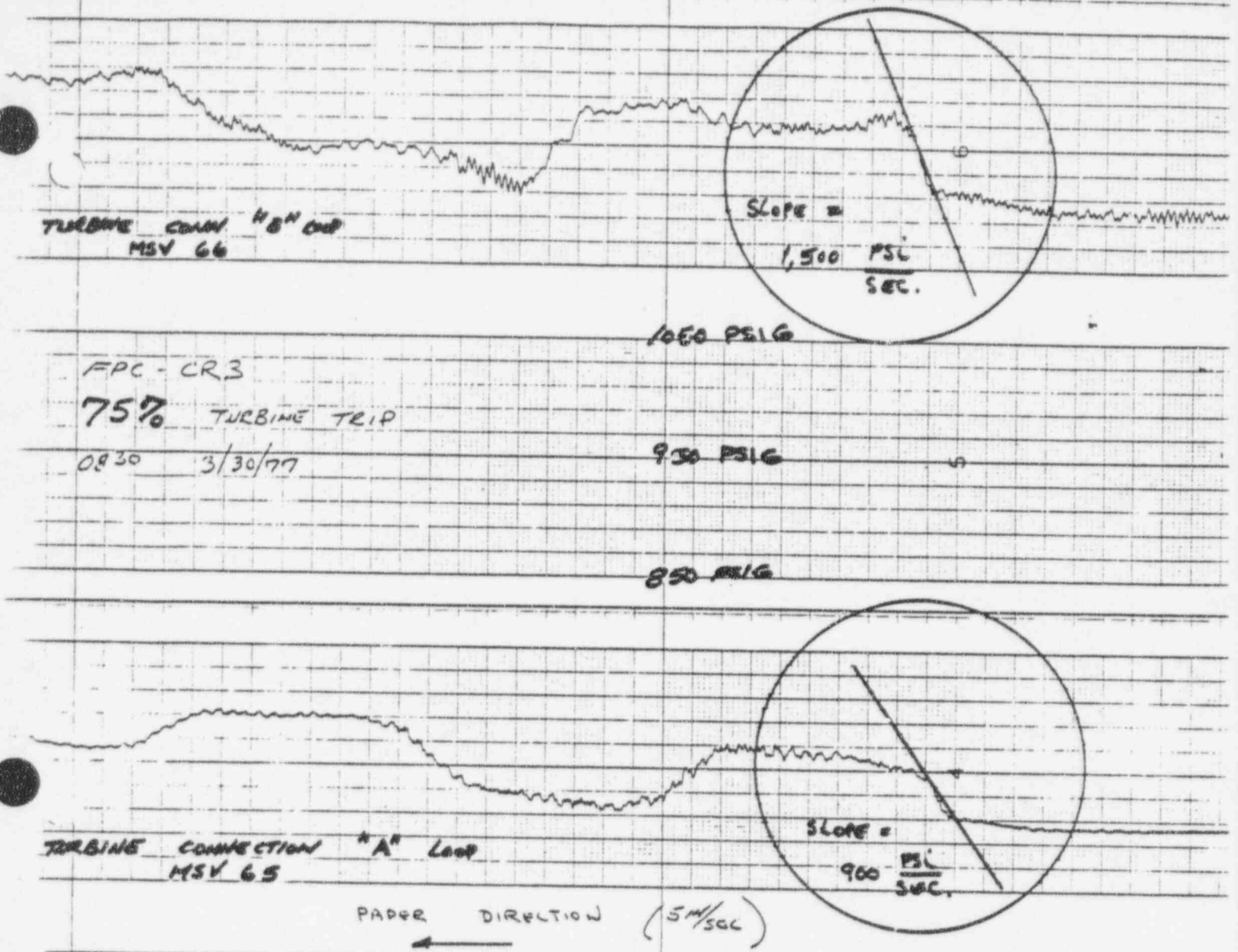

TURBINE CONN "B" OUT
MSV 66
SLOPE =
1,500 PSI/SEC.
1060 PSIG
FPC - CR3
75% TURBINE TRIP
0930 3/30/77
930 PSIG
850 PSIG
TURBINE CONNECTION "A" LOOP
MSV 65
SLOPE =
900 PSI/SEC.
PAPER DIRECTION (5 IN/SEC)
S.G. "B" LOOP
ONE SECOND
TIME REFERENCE CHANNEL
S.G. "A" LOOP

FIG. 3

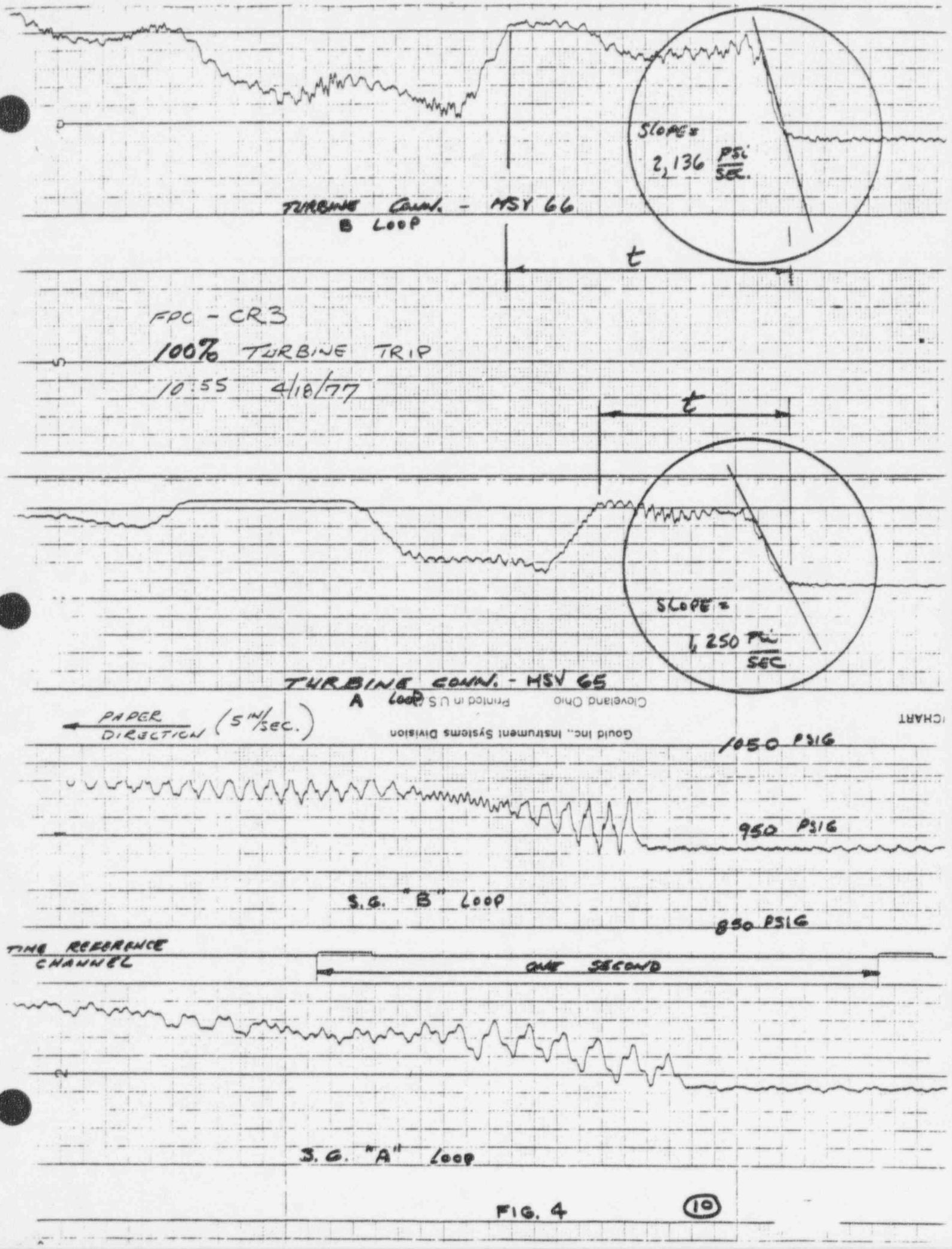

SLOPE =
2,136 PSI/SEC.
TURBINE COMM. - MSV 66
B LOOP
t
FPC - CR3
100% TURBINE TRIP
10:55 4/18/77
t
SLOPE =
1,250 PSI/SEC
TURBINE COMM. - MSV 65
A LOOP
PAPER DIRECTION (5 IN/SEC.)
1050 PSIG
950 PSIG
S.G. "B" LOOP
850 PSIG
TIME REFERENCE CHANNEL
ONE SECOND
S.G. "A" LOOP

FIG. 4

TABLE 1

	(1) LINE	(2) STEAM HAMMER RESTRAINT	(3) WAVE SPEED USED (ft/sec)	(4) PIPE SEGMENT LENGTH (ft)	(5) WAVE TRAVEL TIME (milli-sec.) Col.(4)/ Col.(3)	(6) MAXIMUM PRESSURE RISE (psi)	(7) PIPE FLOW AREA (in^2)	(8) NET UNBALANCED FORCE (F_u) Col.(6) x Col.(7)	(9) ACTUAL LOADING (kips) Col.(8) x D.L.F.	(10) ORIGINAL DESIGN LOAD (kips)	(11) RESTRAINT CAPACITY (kips)
I	East Line from S.G. "A"	MSH 238	1623	67.25	41.4	52	382	19.9 kip	22.9	28.8	49.5
II	West Line from S.G. "A"	MSH 234	1623	85.25	52.5	96	382	36.7 kip	42.2	36.6	49.5
III	East Line from S.G. "B"	MSH 232	1623	81.06	49.9	96	382	36.7 kip	42.2	34.5	49.5
IV	West Line from S.G. "B"	MSH 227	1710	98.6	57.7	96	382	36.7 kip	42.2	42.3	49.5

The wave speed (column 3) calculation appears in Attachment 5. Lines II and III are assumed to have the same wave velocity as Line I (conservative).

The pipe segment length (column 4) is that straight portion of piping which is restrained by the steam hammer restraint listed in column "2".

The maximum pressure rise (column 6) is that maximum pressure increase that can be experienced within the wave travel time (column "5") anywhere on Figure 4.

The Dynamic Load Factor (DLF) used in column 9 is 1.15. Attachment 6 presents the calculations which arrived at that number. The original Design Load (column 10) includes a DLF of 1.5.

The net result is that the steam hammer restraint system as originally designed is sufficient to perform its intended function without any modifications.

4.0 CONCLUSIONS

4.1 Item 3 of Attachment 1 (page 2) states that the snubber failures found during .ot Functional Testing, all on Line III, was due to a water slug. Section 3.0 demonstrates the fact that the piping is sufficiently restrained for a 100% steam hammer force. Therefore, an increased credence must be placed on the water slug theory for the failures.

4.2 Observation of Feedwater System indicates that steam hammer in main steam lines does not create water hammer conditions within feedwater piping.

4.3 Steam hammer instrumentation has served as a very valuable tool in determining the adequacy of the design and the actual margin of conservatism.

5.0 RECOMMENDATIONS

5.1 No steam hammer restraints be removed while plant is operating at a Power Level greater than 15%, without substituting a temporary restraint equal in capability to the original restraint.

5.2 Steam hammer restraints be observed on a periodic basis and immediately after each Turbine Trip from 75% load or greater for several more times to insure that no evidence of damage or unusual wear occurs undected.

6.0 REFERENCES

1) USAS B31.7-1969 Code for Nuclear Power Piping

2) Crystal River Unit No. 3, "Final Safety Analysis Report", Section 5.4.4 Pages 5-64a and 5-64b.

3) Test Procedure TP-7-1-800-0 "Power Escalation"

4) Test Procedure TP-7-1-600-14 - "Supports & Rupture Restraint Checks during Hot Functional Testing"

5) Test Procedure TP-7-2-800-25 - "Supports & Rupture Restraint Checks during Power Escalation and at 100% Power"

6) Main Steam; Steam Hammer Report for Crystal River Unit No. 3 by M. Z. Lee, 11/2/73.

7) Feedwater Water Hammer Investigation for CR3 - by G. A. Delp 10/11/76.

8) General Acceptance Criteria for Dynamic Movement, Vibration and Thermal Expansion for Crystal River Unit No. 3 Nuclear Power Plant, by S. Ferrarello, 9/2/75.

9) GAI - FPC Correspondence - Steam Hammer Measurements

   a) 8/26/74 GAI to FPC, FPC No. 11321

   b) 9/27/74 GAI to FPC, FPC No. 11549

   c) 7/10/75 FPC to GAI

   d) 8/26/76 GAI to FPC, FPC No. 11321

10) Memo from S. Ferrarello to F. J. Tomazic - 75% Trip Report, 4/7/77

11) Memo from S. Ferrarello to F. J. Tomazic - 40% Trip Report, 3/16/77

12) Memo from S. Ferrarello to R. S. Burns/J. C. Hobbs - Skipping 15% Trip 2/1/77

13) Modification Approval Record #77-4-6A (70A) dated 4/7/77

7.0 ATTACHMENTS

ATTACHMENT 1

File -

~~J. Tomazic~~
Jim JJP 12-23-76

Florida Power
CORPORATION

December 20, 1976

RECEIVED
DEC 23 1976
DEPT. 0430

Mr. F.J. Tomazic
Gilbert Associates, Inc.
P.O. Box 1498
Reading, PA 19603

Subject: Crystal River #3
Observations of MS & FW Piping
File: Main Steam Piping

Dear Mr. Tomazic:

We have reviewed Mr. Ferrarello's memo of December 2, 1976 on the above subject (sent to us December 15) and have discussed this with Mr. J.D. Robison and Mr. S.F. Ferrarello.

We concurr with GAI recommendations for piping observations during the turbine trips, however, the steam hammer observations and measurements are R&D type work. Therefore, we authorize Mr. Robison and Mr. Ferrarello as the qualified observers during the turbine trips. We would have no objections if GAI wishes to have other personnel present during these tests at Crystal River #3.

R.S. Burns

R.S. Burns

cc: J. Alberdi
G.P. Beatty
J.C. Hobbs
A.L. Gomes/J.E. Colby

RSB/hw 1/12

JM
SF
JR

A-1

(2)

memorandum Gilbert/Commonwealth

December 2, 1976

to: F. J. TOMAZIC

from: S. F. Ferrarello

subject: CRYSTAL RIVER UNIT NO. 3 - OBSERVATION OF DYNAMIC RESPONSE OF MAIN STEAM AND FEEDWATER SYSTEMS DURING TURBINE TRIPS

Test Procedure TP-800-0 calls for steam hammer measurements to be taken during Turbine Trips performed in the course of Power Escalation. The main steam and feedwater systems must be observed carefully, at that time, in order to determine satisfactorily the response of the piping and support systems to dynamic conditions which result from turbine trips at substantial power levels. This observation procedure has been employed, successfully, in the past by GAI to discover potential dynamic problems in piping systems that have a tendency to resonate with forcing functions generated by turbine trips. Discovery of these potential problems, at this stage, will enhance the reliability characteristic of the piping system during plant commerical operation.

The proposed plan for the Piping Engineering Department to accomplish the above, is the following:

I) Prior to Power Escalation

a) One person-visit to site to ensure that instrumentation is installed properly. — 40 Manhours

II) During Power Escalation

a) One person-visit to site at 15% power level to assist in taking steam hammer measurements. — 40 Manhours

b) Three person-visit to site at 40% power level to observe piping and supports. — 120 Manhours

*c)	Same as "b" except at 70% Power	120 Manhours
d)	Same as "b" except at 100% Power	120 Manhours

*Presently, FPC procedures do not call for a Turbine Trip between that scheduled at the 40% and the 100% power level. In discussions, it was felt that GAI should recommend strongly, to FPC, the addition of a Turbine Trip at some intermediate power level. The jump from the 40% to 100% power level was considered too large since the dynamic force generated by a Turbine Trip varies with the square of the steam velocity and linearly with the pressure. Test Procedure TP-800-0 already has provisions for stopping at the 70% power level to perform certain tests. A Turbine Trip could be added conveniently at this power level.

The four visits described in "a" to "d" perhaps could be reduced to three if either no Turbine Trip is performed at the 70% power level or if more than one Turbine Trip can be covered in one visit. An estimate of the total man-hours required are:

$$11 \text{ person-visits} \times 40 \frac{\text{man-hours}}{\text{person-visit}} = 440 \text{ man-hours}$$

The considerations which resulted in the plan proposed above are:

(1) Since GAI, as the designer, has the major responsibility for the proper performance of the main steam piping and supports, we should have our people on-site to evaluate their performance during the Turbine Trips.

(2) Although GAI strongly believes that a water slug was the cause of the snubber failures on the one (of four) main steam lines during HFT II, any uncertainty which still may exist can be further reduced by thorough observation of these lines (9/9/76 letter to FPC No. 14021).

(3) Since delays during Power Escalation can be especially costly due to delay of "Commercial Operation", people who can resolve quickly any problems discovered should be on-site during this period.

(4) Feedwater Water Hammer Investigation Report (10/11/76) recommended observation of the Feedwater System simultaneous with the main steam system during Turbine Trips.

If you have any questions or comments on the above, please call me.

Santo Ferrarello

SANTO FERRARELLO

SF:lap

cc: E. R. Hottenstein
J. B. Muldoon
M. Z. Lee
A. P. Rochino
J. D. Robison
Dept. 0430 File

ATTACHMENT 2

S. Ferrareilo

memorandum Gilbert/Commonwealth 2-2-77

February 1, 1977

to: R. S. Burns/J. C. Hobbs, Jr.

from: S. F. Ferrareilo

subject: Observations of Piping during Power Escalation Turbine Trips

In conversations with various testing personnel (1/30 and 1/31/77), it has come to my attention that Florida Power Corporation may adopt the following course of action:

1. Bypassing the 15% power testing including the intentional turbine trip.

2. Proceeding to 40% power testing.

3. Subsequent reduction in power; performance of loss of off-site power test (unintentional turbine trip may result).

I have discussed this matter with individuals in the Piping Engineering Department and the Project office. We disagree strongly, with this new course of action for the following reasons:

a. Observations of main steam and feedwater lines can only be performed effectively with an "intentional" turbine trip.

b. Proceeding to the 40% power level directly will almost certainly result in inadvertent trips. These will not have been observed and thus potential problem areas will not be identified.

c. The main steam turbine bypass valves are designed to accept a 15% power load rejection. The safety valves on the main steam should not lift during a 15% power turbine trip. Observations of the safety valves during such a trip will serve as a check on the load rejection system. The discharge piping from the dump valves require observations for excessive dynamic movements.

d. Steam hammer measurements can only be taken during intentional turbine trips. The unfamiliarity of this test will result in missed data. The recording of this data at the 15% trip would provide experience on the part of the FPC technicians in obtaining this data.

2-1-77

JL
SF

GAI 38 12/75

We, at GAI, share FPC's desire to bring CR-3 to the "Commercial Operation" date as soon as possible. However, accelerations of the Power Escalation Testing, as presently adopted, may result in the opposite effect. GAI recognizes its responsibility for the design of the piping systems. However, proper escalation of power and observations of the piping are prerequisites for the assumption of that responsibility. GAI cannot accept responsibility for the response of the piping systems which have not been tested and observed in accordance with established procedures.

S. F. Ferrarello

SFF:ejv

S. F. Ferrarelio

cc: E. R. Hottenstein (2)
F. J. Tomazic
B. F. Taylor

ATTACHMENT 3

memorandum Gilbert/Commonwealth

March 16, 1977

to: F. J. TOMAZIC

from: S. F. Ferrarello

subject: REPORT OF VISIT TO CR3 SITE BY J. ROBISON AND S. FERRARELLO FROM MARCH 7, 1977 TO MARCH 11, 1977

On Monday, March 7, 1977 it was learned that FPC (Operations-Testing) had advanced the scheduled [redacted] Power, Reactor-Turbine Trip from March 11, 1977 to March 8, 1977. J. Robison and S. Ferrarello departed that afternoon to fulfill GAI's responsibility of observing the piping and supports as authorized by R. S. Burns' letter of December 20, 1976. FPC Operations - Testing personnel reported, on Tuesday, March 8, that this 40% trip might be cancelled. J. Robison and S. Ferrarello briefly visited G. P. Beatty (FPC - Operations) to request that the test be performed as scheduled and to report GAI's position in this matter.

FPC argued that the two unintentioned trips experienced at the 40% power level was sufficient proof to the integrity of the piping and support systems. GAI stated that a fully observed 40% trip was a necessary intermediate step in a proper and safe escalation sequence especially since the 15% test was eliminated. The arrest of the tremendous energy generated during a trip by large snubbers supports and uncertaintities that cannot be factored into a design (e.g. installation) require that the last step in the design be the observation of the piping and supports at increasing energy levels from 0% to 100% power.

To FPC's credit, they did decide not to eliminate the 40% trip. GAI did emphasize that a full Reactor-Turbine Trip was not required for our purposes and that a Turbine Trip would suffice. However, FPC had decided to re-instate the original Reactor-Turbine Trip as previously scheduled.

The reaction of the main steam and feedwater system was considered satisfactory. The main steam lines evidenced the tremendous internal unbalanced forces, but the steam hammer restraints kept the movement to within acceptable limits.

The instrumentation installed to record the steam hammer pulse worked well, the data has been recorded and is in GAI's possession for evaluation.

At this writing, the 75% Turbine Trip is scheduled for March 18, 1977. J. Robison and S. Ferrarello are planning to visit the site to observe this test. Undoubtedly, FPC will be contemplating the elimination of the 75% Trip. This is certainly their prerogative but they should realize that we object strongly for the reasons mentioned earlier.

A brief report on GAI's piping and support observations as well as a summary of the steam hammer data collected will be submitted to FPC after the 100% Tests are complete.

FPC requested that S. Ferrarello stay one extra day to meet with FPC personnel working with the "2 inch and under seismic support criteria". On Friday (March 11, 1977), I met with:

J. Colby
D. Hodgson
E. Morea
M. Tampa

Various questions were raised, discussed and answered.

Santo Ferrarello

SANTO FERRARELLO

SF:lap

cc: E. R. Hottenstein
J. B. Muldoon
J. D. Robison
Dept. 0430 File

ATTACHMENT 4

memorandum Gilbert/Commonwealth

April 7, 1977

to: F. J. TOMAZIC

from: S. F. Ferrarello

subject: REPORT OF VISIT TO CR3 SITE BY J. ROBISON AND S. FERRARELLO FROM 3/20/77 TO 3/31/77 TO OBSERVE 75% POWER TURBINE TRIP

On Sunday (3/20) it was discovered that the [redacted] trip originally scheduled for Tuesday (3/22) had been postponed to Friday, (3/25). However, it had been decided that S. Ferrarello would depart as scheduled (3/20) and that J. Robison would follow at a date closer to the scheduled date for the 75% trip.

While on-site awaiting the trip, S. Ferrarello performed the following tasks:

(1) Checked out steam hammer supports on periodic basis (especially after two inadvertant turbine trips).
(2) Added restraints to reduce observed excessive vibration (HDH-374 as well as two restraints for 1" diameter EX piping).
(3) Drew up As-Builts of "FS" piping discovered as a result of resolving "hanger" vs. "piping" discrepancies.
(4) Assumed piping review duties for B. Seaholts for Test Procedure 800-25.

Further delays resulted in scheduling the trip for 8:00 a.m. on Wednesday (3/30). Jim Robison was present for the trip which was executed at 8:30 a.m. The piping reacted well to the steam hammer loading. However, the grout, for two of the steam hammer supports, which had been observed to be cracked prior to the test had deteriorated even more. Upon review it was determined that, left as is, the grout would fail completely and thus overload the bolts. FPC was requested to correct this situation (see attached memo).

The safety valve vent stack anchor found cut and corrected prior to the 40% turbine trip was observed to be holding up well.

The steam hammer pulse data was obtained and is in GAI's possession for review.

Only the 100% power level trip remains to be observed.

Santo Ferrarello

SANTO FERRARELLO

SF:lap

cc: E. R. Hottenstein
J. B. Muldoon
J. D. Robison
Dept. 0430 File

memorandum Gilbert/Commonwealth

March 30, 1977

to: J. Colby

from: S. Ferrarello

subject: Steam Hammer Restraints MSH 227, 232, 236 and 240

The reaction of the piping and supports to the Turbine Trip performed this morning (75% Power Level) was quite satisfactory. However the grout used for the subject steam hammer supports has been deteriorating steadily this past week. Further disintegration of this grouting was anticipated with a result of the failure of these supports to perform their intended function. Therefore I recommended to Mr. G. P. Beatty, Jr. that:

1. Grout be eliminated; steel plate would rest on concrete pedestal.

2. Work be performed immediately.

3. Power level be reduced to approximately 15% until modifications were completed (6 hours estimated).

Recommendation "3" was made since it was felt that the piping system might not withstand a trip at a higher power level if these supports are not active.

As of this writing, 2:30 p.m., FPC Operations has responded quickly and is in the process of making these fixes.

Santo Ferrarello

Santo Ferrarello
GAI Piping Engineer

SF:mak

xc: F. J. Tomazic
J. B. Muldoon
J. D. Robison
G. P. Beatty, Jr.

ATTACHMENT 5

GILBERT ASSOCIATES, INC. ENGINEERS AND CONSULTANTS READING, PA.	CLIENT FLORIDA POWER CORP.	FILING CODE
	PROJECT CRYSTAL RIVER UNIT NO. 3	W.O. 4203 PAGE 1 OF 1
SYSTEM 24" ϕ MAIN STEAM		ORIGINATOR S FERRARELLO DATE 5/6/77
CALCULATION FOR PRESSURE WAVE PROPAGATION SPEED (2)		REVIEWER DATE

RESULTS

REFERENCE

1) 100% TURBINE TRIP STEAM HAMMER DATA (4/18/77 - 10:55)

2) P-304-011 , P-304-012

THE TOTAL LENGTH OF PIPING FROM INSTRUMENT CONN. POINT TO S.G. IS

LINE I : $x = 279.2$ feet

" II - $x = 424.1$ feet

THE MEASURED TIME FOR THE WAVE TO TRAVEL THIS DISTANCE AND RETURN IS:

Line I - $t = 0.344$ sec

II - $t = 0.496$ sec

THEREFORE THE WAVE SPEED IS (2)

LINE I - $a = \frac{x}{t} = \frac{279.2'}{.344} = 1623 \frac{ft}{sec}$

LINE II - $a = \frac{x}{t} = \frac{424.1'}{.496} = 1710 \frac{ft}{sec}$

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FILING

ATTACHMENT 6

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT: FLORIDA POWER CORP.
PROJECT: CRYSTAL RIVER UNIT NO. 3
FILING CODE:
W.O. 4203 | PAGE 1 of 2

SYSTEM: 24" ϕ MAIN STEAM
ORIGINATOR: S. FERRARELLO
DATE: 5/6/77
REVIEWER:
DATE:

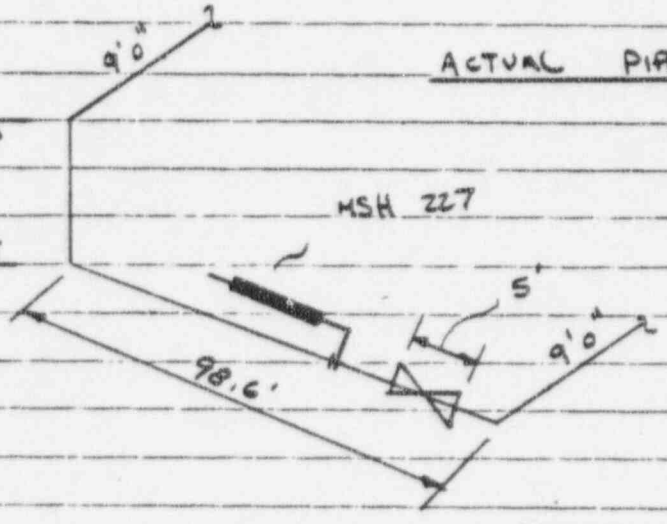
CALCULATION FOR: DYNAMIC LOAD FACTOR FOR STEAM HAMMER LOADING

RESULTS

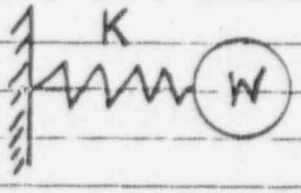
REFERENCES -

1) BIGGS, INTRODUCTION TO STRUCTURAL DYNAMICS pg 48

ONE DYNAMIC LOAD FACTOR WILL BE USED FOR ALL FOUR MAIN STEAM LINES. THE WEST LINE FROM STM. GEN. "B" WILL HAVE THE LARGEST D.L.F.



MODELLED AS



WHERE

W = W_T (120' PIPING) + W_T (VALVE)

K = SPRING CONSTANT FOR 5" BORE x 5" STROKE SNUBBER

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FILING CODE

GAI 350 REV. 10-72

GILBERT ASSOCIATES, INC.
ENGINEERS AND CONSULTANTS
READING, PA.

CLIENT: FPC
PROJECT: CR3
FILING CODE:
W.O. 4203 | PAGE 2 of 2

SYSTEM: HS
ORIGINATOR: S. FERRARELLO
DATE: 5/6/77

CALCULATION FOR: D.L.F. FOR STEAM HAMMER
REVIEWER:
DATE:

POWER PIPING STATES THAT THE SPRING CONSTANT FOR A 4" BORE x 5" STROKE IS { 900,000 #/in / 1,000,000 #/in } BUT HAS NO VALUE FOR A 5" BORE x 5" STROKE

REVIEWING OTHER HANG. A CONSERVATIVE VALUE TO BE USED IS $K = 500{,}000$ #/in

RESULTS: TENSION / COMPRESSION

$$W = 276 \frac{\#}{ft}(120') + 17{,}000\# \cong 50{,}000\#$$

THE NATURAL FREQ. OF THE MODELLED SYSTEM (f_n)

$$f_n = \sqrt{\frac{Kg}{W}} = \sqrt{\frac{500{,}000 \frac{\#}{in} \times 386.4 \frac{in}{sec^2}}{50{,}000\#}} = 62.16 \text{ cps}$$

$$T = \frac{1}{f} = 0.0161 \frac{1}{sec}$$

THE RISE TIME (t_r) = 0.0414 sec (line I)

$$\therefore \frac{t_r}{T} = \frac{.0414}{.0161} = 2.57$$

USING FIG. 2.9a (Pg 48) OF THE REF. A

D.L.F. = 1.15 IS DETERMINED

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