# STEAM GENERATOR WATER HAMMER TECHNICAL EVALUATION TURKEY POINT UNIT NOS. 3 AND 4

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EG&G Idaho, Inc.

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### CONTENTS

Ι.	INTRODUCTION
п.	WATER HAMMER EXPERIENCE
III.	MEANS TO REDUCE THE POTENTIAL FOR WATER HAMMER
IV.	OPERATING EXPERIENCE AND WATER HAMMER SUSCEPTIBILITY 4
۷.	CONCLUSIONS AND RECOMMENDATIONS
VI.	REFERENCES

#### I. INTRODUCTION

An evaluation was performed for the Turkey Point Power Station (TPPS) Unit Nos. 3 and 4 feedwater system. The purpose of this evalution was to access the susceptibility of the feedwater system to water hammed during operating transients and situations that could result in conditions conducive to water hammer.

Steam-water slugging resulting in water hammer in the steam generator feedrings and adjacent feedwater piping was considered in this review. This type of water hammer is generally referred to as steam generator water hammer.

The information for this evaluation was obtained from: 1) discussions with the licensee, 2) licensee submittals to NRC of July 3, 1975<sup>1</sup>, and January 3, 1978<sup>2</sup>, 3) the "Turkley Point Unit Nos. 3 and 4 Final Safety Analysis Report<sup>3</sup>, 4) "An Evaluation of PWR Steam Generator Water Hammer", NUREG-0291<sup>4</sup>, and 5) "NRC requirements for Auxiliary Feedwater Systems at the Turkey Point Power Station<sup>5</sup>".

A review of steam generator water hammer events at TPPS is presented in Section II. The means to reduce the potential for water hammer at this facility are presented in Section III. Section IV presents descriptions of the feedwater system geometry and operation pertaining to the susceptibility of the system to steam generator water hammer. Conclusions and recommendations are presented in Section V concerning the susceptibility of the feedwater system at this facility to steam generator water hammer.

1

#### II. WATER HAMMER EXPERIENCE

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There are three known occurrences of water hammer prior to feedring piping modifications in 1974 in the feedwater piping at TPPS Unit Nos. 3 and 4.

The first occurrence was indicated by body-to-bonnet leakage and slight elongation of some body-to-bonnet bolts on the 3B feedwater check valve.

The second occurrence was indicated by the same kind of leakage and bolt elongation on the 48 feedwater check valve.

The third occurrence was indicated by the following deformations discovered inside containment during an outage of Unit No. 4. They occurred on the "A" steam generator feedwater piping.

- Some expansion bolts for two hydraulic pipe restraints had been pulled approximately one inch out of a concrete wall.
- 2. Two spring hanger mounting plates had been deformed.
- A 90<sup>o</sup> elbow located in the piping leading to the steam generator feedwater nozzle experienced plastic deformation.

Subsequent to the 1974 feedwater piping modifications, no steam generator water hammers have occurred.

#### III. MEANS TO REDUCE THE POTENTIAL FOR WATER HAMMER

In 1974 the effective horizontal length of main feedwater piping adjacent to any steam generator was modified not to exceed eight feet.

The corrective action was to minimize the length of feedwater piping which could drain into the steam generator through the feedring. This was done by shortening the horizontal length of pipe at the level of the feedring inlet nozzle. As a result of these modifications, the piping turns downward through a 90° elbow approximately five feet from the steam generator. These modifications were performed on the "A" and "B" steam generator feedwater piping for both units. The feedwater piping for the "C" steam generator was not modified because the eight foot horizontal length at the nozzle elevation was evaluated and found to be acceptable. There has been no evidence of water hammer occurrences in any steam generator feedwater piping since completion of the modifications.

Auxiliary feedwater flow is manually controlled to the minimum necessary to meet operating requirements. However, specific administrative means, or other positive means, such as top discharge feedrings or administrative auxiliary feedwater flow limitations, have not been incorporated into plant design or procedure.

Based on past experience, steam generator water hammer would be most likely during startup, shutdown, and low power situations when feedwater is under manual control and the flow rates are insufficient to maintain uncovered feedrings full of water. To avoid admission of steam and possible slugging during these operational conditions, the feedrings must remain covered with water.

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## IV. OPERATING EXPERIENCE AND WATER HAMMER SUSCEPTIBILITY

The conditions most conducive to steam generator water hammer occur when the steam generator feedrings are uncovered and steam enters the feedrings and attached horizontal feedwater piping. Steam-water slugging and subsequent water hammer may occur when incoming feedwater mixes with the steam in the piping and rapid condensation occurs. These conditions could conceivably occur during certain operating conditions for facilities with bottom discharge feedrings because of large drainage rates.

Since the piping modifications in 1974, TPPS Unit Nos. 3 and 4 have experienced numerous reactor trips. A reactor trip almost always results in feedring uncovery in all steam ger thrs. The drop or "shrinkage" in water level and subsequent feedring uncovery is the result of interrupted reactor power production causing the collapse of steam voids within the secondary side of the steam generators. A similar situation would be experienced during events such as loss of main feedwater, loss of offsite power, steam line break, or loss-of-coolant accident. Normal startups and shutdowns with feedwater under manual control could also result in a substantial number of feedring uncovery events even with the administrative steam generator water level controls.

Our review of the operating history shows that drainage of the feedrings and adjacent piping has been experienced at TPPS Unit Nos. 3 and 4. Although we would expect steam generator water hammer to occur under certain operating conditions, no steam generator water hammer has been experienced at the facility since 1974. This has demonstrated that subsequent to the feedwater piping modifications, the facility at the Turkey Point site has an apparently low susceptibility to steam generator water hammer under all conditions.

4

#### V. CONCLUSIONS AND RECOMMENDATIONS

We have reviewed the operating history of the TPPS Unit Nos. 3 & 4 pertinent to steam generator water hammer and the related operational and procedural characteristics of the feedwater system. The review has shown that conditions conducive to steam generator water hammer have occurred at the TPPS Unit Nos. 3 & 4 but no water hammer events have been observed subsequent to the 1974 steam generator feedwater piping modifications. The conditions have been encountered during normal operating transients and startup and shutdown operation. Such conditions would also be expected in the future during the normal and accident operating situations addressed in the review. Based on this review we have concluded that the potential for steam generator water hammer is sufficiently low to permit continued operation of this facility.

#### VI. REFERENCES

- Robert E. Uhrig (FPL), letter to George Lear, NRC, Subject -"Water Hammer in PWR Feedwater System", July 3, 1975.
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- Final Safety Analysis Report, Turkey Point Units 3 and 4, Florida Power and Light Company, NRC Docket Nos. 50-250 and 50-251.
- J. A. Block, et al, An Evaluation of PWR Steam Generator Water Hammer, Creare, Inc. NUREG-0291 (December 1976).
- D. G. Eisenhut letter to R. E. Uhrig, FPL, Subject "NRC Requirements for Auxiliary Feedwater Systems at Turkey Point Units 3 and 4", October 16, 1979.