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SUBJECT: Forwards response to 860530 request for addl info re NUREG-0737, Item II. E. 1. 1 re capability of emergency feedwater sys (EFW) to withstand totnado generated missiles. Results from two studies including PRA also encl.

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September 15, 1986

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. John F. Stolz, Project Director
PWR Project Directorate No. 6

RE: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287

Dear Sir:

By letter dated May 30, 1986 the NRC staff requested additional information to complete their review of the capability of the Oconee EFW system to withstand tornado generated missiles, item II.E.1.1 of NUREG-0737. In a letter dated June 25, 1986 the NRC was informed that Duke Power Company (Duke) anticipates to provide a response by September 15, 1986.

In response to your request for additional information, please find attached the results of Duke's analyses of Oconee Nuclear Station Emergency Feedwater (EFW) tornado protection.

Attachment 1 summarizes the results from two independent studies - the Oconee PRA and a tornado simulation utilizing the TORMIS computer code. In both studies, damaging-strike frequencies were combined in fault trees to produce overall mean probabilities for loss of the EFW System. The resulting probabilities are 3.35E-07 for the Oconee PRA and 9.53E-07 for the TORMIS study. Both values are within the 1.0E-06 mean probability specified by the NRC. Additionally, the close correspondence of the two studies enhances the confidence in the final results.

Attachment 2 provides the results of an analysis which indicate that the auxiliary service water (ASW) pump can provide adequate decay heat removal at the Oconee Nuclear Station, even in the unlikely event of a tornado which disables all normal plant cooling systems. In light of the PRA result that the likelihood of EFW system failure due to tornado is very small, significant reliance on the ASW pump should not be considered necessary.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

MAH/03/slb

Attachments

A046
1/1

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<u>Attachment 1</u>

Response to NRC Request for Additional Information
Dated May 30, 1986
EFW Tornado Protection
Oconee Nuclear Station Units 1, 2, and 3

Item 1

1.0 INTRODUCTION

The objective of this study is to determine the probability of significant damage to the Oconee Nuclear Station Emergency Feedwater (EFW) System due to missile strikes resulting from tornados and other high winds. This study is in response to a Nuclear Regulatory Commission (NRC) request for information (Ref. 1).

2.0 BACKGROUND

2.1 Review of Previous Correspondences

The NRC has previously requested information regarding methods of supplying steam generator cooling water. By letter dated April 8, 1982, the Oconee license was amended, with the Staff requesting information supporting the availability of steam generator cooling water and/or an evaluation demonstrating an acceptably low probability of tornado damage to both the EFW and SSF-ASW Systems. The Duke response, dated August 6, 1982, provided a conservative, bounding evaluation which indicated an annual frequency of tornado damage to both systems of no higher than approximately 7.5E-05. Upon this response, the NRC requested the details of the evaluation. Duke responded, citing conservatisms, historical data, and required assumptions, resulting in a mean probability of 8.1E-05 per reactor-year. The present request regards only the hazards of missiles generated by either tornados or high winds.

2.2 Description of EFW System

The EFW System is comprised of pumps, tanks, and piping designed to provide feedwater to the Once-Through Steam Generators (OTSG's) following a reactor trip. The pumps, two (AC) motor driven and one turbine driven, are located in the Turbine Building basement. Suction may be provided by either the Upper Surge Tanks (UST), located on the Turbine Building sixth floor platform, or the condenser Hotwell, which is located in the Turbine Building basement. Normally suction is aligned to the UST.

Two trains of piping from the discharge of the pumps run across the Turbine Building into the Auxiliary Building, where the two trains separate. "A" train goes to the East Penetration Room, entering the Reactor Building to supply flow to OTSG-A. "B" train goes to the West Penetration Room, where it enters the Reactor Building to supply flow to OTSG-B.

Normal (AC) electrical power is supplied to the motor-driven EFW pumps from Main Feeder Buses TD and TE, while emergency power is supplied by the Keowee Hydro Units via the underground feeder line to transformer CT-4. Control power

(DC) is provided by the control batteries, located in the Control Battery Room on the Auxiliary Building Fourth floor, and by the control battery chargers, located in the Cable Rooms of the Auxiliary Building. Steam for the turbine-driven pump turbine is supplied by either Main Steam or Auxiliary Steam.

2.3 Vulnerabilities of the EFW System

The EFW System is susceptible to missile strikes as follows:

1. Both the East and West Penetration Rooms. The East Penetration Room is one level of the Auxiliary Building, while the West Penetration Room, for this study, is a separate structure. Strikes to both would disable the supply lines of both trains, thus making flow to the OTSG's unlikely.
2. The Upper Surge Tanks. Failure of the Upper Surge Tanks by missile strikes would fail the normal suction source to the EFW system. Since the transfer valve for realigning from the Upper Surge Tanks to the Hotwell is loadshed on loss of off-site power, which is assumed to occur, suction would be lost to the EFW pumps unless either the transfer valve was reloaded on the power bus and then manipulated or an operator went to the valve and manually realigned suction. This analysis conservatively assumes no operator action.
3. The EFW pumps themselves.

3.0 METHODOLOGY

First, an independent probabilistic risk assessment based on the TORMIS (Tornado Missile Simulation) code, which uses actual plant lay-out, combined with ballistic studies and historical data, was performed to evaluate the potential for missile damage. Next, the Oconee Probabilistic Risk Assessment (OPRA) was reviewed as a second analysis to provide damaging-strike probabilities. Data from each study was then used in fault trees to determine the final damaging-strike probability for the EFW System.

3.1 TORMIS

The TORMIS study employs a computer simulation of tornados to determine the susceptibility of structures at the Oconee Nuclear Station to missile strikes. A plant survey was conducted to determine available missiles, plant lay-out, and principal areas of concern. Historical tornado data was obtained for comparison to the wind speed versus probability curve provided by the NRC in Ref. 1. The plant and surrounding areas were then modeled to provide lay-out and missile availability for use by the TORMIS code. Tornado frequencies were obtained from the NRC curve, with separate computer runs being made for each F-scale tornado.

The TORMIS code randomly selects a tornado and a path through the site. As the tornado tracks across the plant, each potential missile encountered is evaluated. If the tornado has sufficient strength to lift the missile, it is lifted and ejected in some random direction based on ballistical studies. The targets are structures, which, if struck by missiles, are evaluated in terms of penetration and/or scabbing. The results of all tornados modeled are compiled in a structure-by-structure summary, including 5% and 95% confidence bounds. A detailed description of the TORMIS code is available in Ref. 3.

A fault tree was developed for each F-scale tornado, with the results combined to produce the overall failure probability. The West Penetration Room walls were conservatively assumed to fail in the event of any missile strike. This failure was also assumed to disable the EFW piping in the West Penetration Room due to the small room size.

3.2 OPRA

The OPRA addresses the effect of tornado missiles on the EFW System in Appendix K. The hazard was estimated on the following basis:

1. Data on tornados that have occurred within 50 nautical miles of the plant.
2. A survey of available missiles within a mile of the site.
3. An extrapolation of the results of two other detailed simulation studies of tornado-missile hazards on the basis of comparative local tornado characteristics, missiles available at each plant, and specific plant designs.

4.0 RESULTS

4.1 TORMIS

The TORMIS study produced computer simulations for each F-scale tornado. A total of 300 tornados, evaluating 150,000 missiles, were simulated. Strike and penetration frequencies were produced for various structures on the site, including the Turbine Building, Auxiliary Building, and West Penetration Room. The Upper Surge Tanks were modeled, but received no strikes due to shielding afforded by the Reactor Building. However, for conservatism, a value 1/12 times the penetration frequency for the Turbine Building was used. This reduction factor is the ratio of the Upper Surge Tank surface area to the Turbine Building surface area.

The damaging-strike probabilities for the vulnerable areas are as follows:

Emergency Feedwater Pumps	7.33E-09
Upper Surge Tanks	4.63E-07
East Penetration Room	1.31E-05
West Penetration Room	7.78E-05

Therefore, based on the TORMIS study, the probability of significant damage to the EFW system due to missile strikes in a given year is

(7.33E-09) + (4.63E-07) + (1.31E-05)(7.78E-05) = 4.72E-07.

Since TORMIS can only evaluate tornado missiles, high winds generating missiles must be addressed separately. Above 150 mph, the probability of high winds without tornados becomes insignificant and only tornados need evaluation. For 90 mph winds, the frequency for high winds is 2 orders of magnitude greater than the corresponding tornado frequency. Therefore, the probability for tornado damage for 90 mph (an F-1 tornado) is increased by 2 orders of magnitude to account for missiles generated by high winds alone. Similarly, for the 113 mph winds, corresponding to an F-2 tornado, the high wind frequency is 1 order of magnitude greater than the tornado frequency. Therefore, the F-2 tornado damage probability is increased by 1 order of magnitude. This, combined with tornado values for wind speeds above 150 mph, gives a combined probability of 9.53E-07 per yer.

4.2 OPRA

The following parameters were used to determine the frequency of missile strikes to critical plant areas:

Exposed plant area (sq.ft.)	1.59E+05
Annual tornado frequency	2.99E-03
Probability per tornado of incurring missile strikes on plant	5.39E-02

The resulting annual frequency of tornado-missile strikes per unit area of exposed plant is 1.01E-09.

The area of each region identified in section 2.3, times the ratio of damaging strikes to total strikes for each region, times the annual frequency of tornado-missile strikes per unit area, equals the annual damaging-strike frequency for each region. These values, taken from table K-6 of the OPRA, are listed below.

Emergency Feedwater Pumps	5.5E-08
Upper Surge Tanks	2.8E-07
East Penetration Area	1.6E-07
West Penetration Area	2.0E-07

Therefore, based on the OPRA analysis, the probability that a missile strike does siginificant damage to the EFW System in a given year is

(5.5E-08) + (2.8E-07) + (1.6E-07)(2.0E-07) = 3.35E-07.

5.0 CONCLUSIONS

Based on the OPRA, the annual damage frequency to the EFW System due to tornado-generated missiles is 3.35E-07. From the TORMIS study, for high-wind missiles and tornado-generated missiles, the value is 9.53E-07. Both of these values are within the 1.0E-06 mean specified by the NRC.

Two independent studies with similar results provide confidence in the numbers generated. Furthermore, additional sources of water are available to the OTSG, these being the Standby Shutdown Facility's Auxiliary Service Water System and the Unit's Auxiliary Service Water System. Therefore, protection in the event of a tornado strike at the site is considered to be more than acceptable.

6.0 REFERENCES

1. Nuclear Regulatory Commission- Request for Additional Information, Dockets Nos. 50-269, 50-270, and 50-287, May 30, 1986.

2. Oconee PRA- Unit 3, EPRI NSAC-60, June 1984.

3. Tornado Missile Simulation and Design Methodology, EPRI NP-2005, August 1981.

<u>Attachment 2</u>

Response to NRC Request for Additional Information
Dated May 30, 1986
EFW Tornado Protection
Oconee Nucelar Station Units 1, 2, and 3

Item 2

A simulation is performed of the plant response to a catastrophic tornado which results in the loss of main and emergency feedwater, Standby Shutdown System auxiliary service water, high pressure injection (HPI), and all four reactor coolant pumps. No automatic protective system actions or operator action are assumed until forty minutes after reactor trip on loss of feedwater. At that time the manual atmospheric dump valves are opened on both steam lines and the auxiliary service water (ASW) pump is started. In addition, injection flow from one HPI pump, powered by the tornado-protected ASW switchgear, is initiated. This analysis is performed for a total of 47 minutes using the RETRAN-02 MOD003 computer code (Reference 1).

Following reactor trip from full power, the initial steam generator (SG) inventory is boiled off in 7 minutes. The Reactor Coolant System (RCS) heats up and pressurizes following the loss of steam generator heat transfer. Also at 7 minutes, the pressurizer safety valves begin to cycle to relieve pressure at their 2500 psig setpoint. By 16 minutes the pressurizer is water solid due to the heatup and expansion of the reactor coolant. Continued heat addition to the coolant leaks to void formation in the RCS beginning at 30 minutes. Opening the atmospheric dump valves on the steam lines at 40 minutes and initiating ASW flow reestablishes decay heat removal via the SGs. Primary inventory loss from the pressurizer safety valves ceases at that time, and HPI begins to make up for the previous RCS inventory loss. The core remains covered throughout the analysis, and the primary system is cooling and depressurizing when the simulation is terminated at 47 minutes. Plots of RCS pressure, RCS temperature, SG pressure, SG level, ASW flow rate, core normalized power, and integrated primary coolant loss through the safety valves are shown on Figures 1-7.

The effectiveness of water injection into the steam generator is illustrated by Figure 8. The total steam flow capacity of the atmospheric dump valves and the total injection capability of the ASW pump are plotted vs. SG pressure. The steam flow graph assumes flow from both SGs, and the ASW flow is the minimum of the total flow to Unit 1 (the limiting unit). The curves intersect at 46 psia and 119 lbm/sec, or 850 gpm ASW flow. This flowrate is adequate to remove decay heat within a minute following reactor trip from full power. At 40 minutes after trip only 33 lbm/sec is required to remove core decay heat. Thus the capacity of the ASW system will ensure adequate decay heat removal.

Accidental overpressurization of the ASW System piping is not a concern. The system design includes check valves which will prevent overpressurization due to high SG pressures.

Cold shocking the steam generator as a result of injecting cold water into a relatively dry SG is also not a concern. ASW water and emergency feedwater are approximately the same temperature, and they are injected into the same location in the SG. The SG is designed to have cold emergency feedwater injected into the portion of the tubes when the secondary inventory is low. Therefore the SG should be structurally capable of withstanding ASW injection.

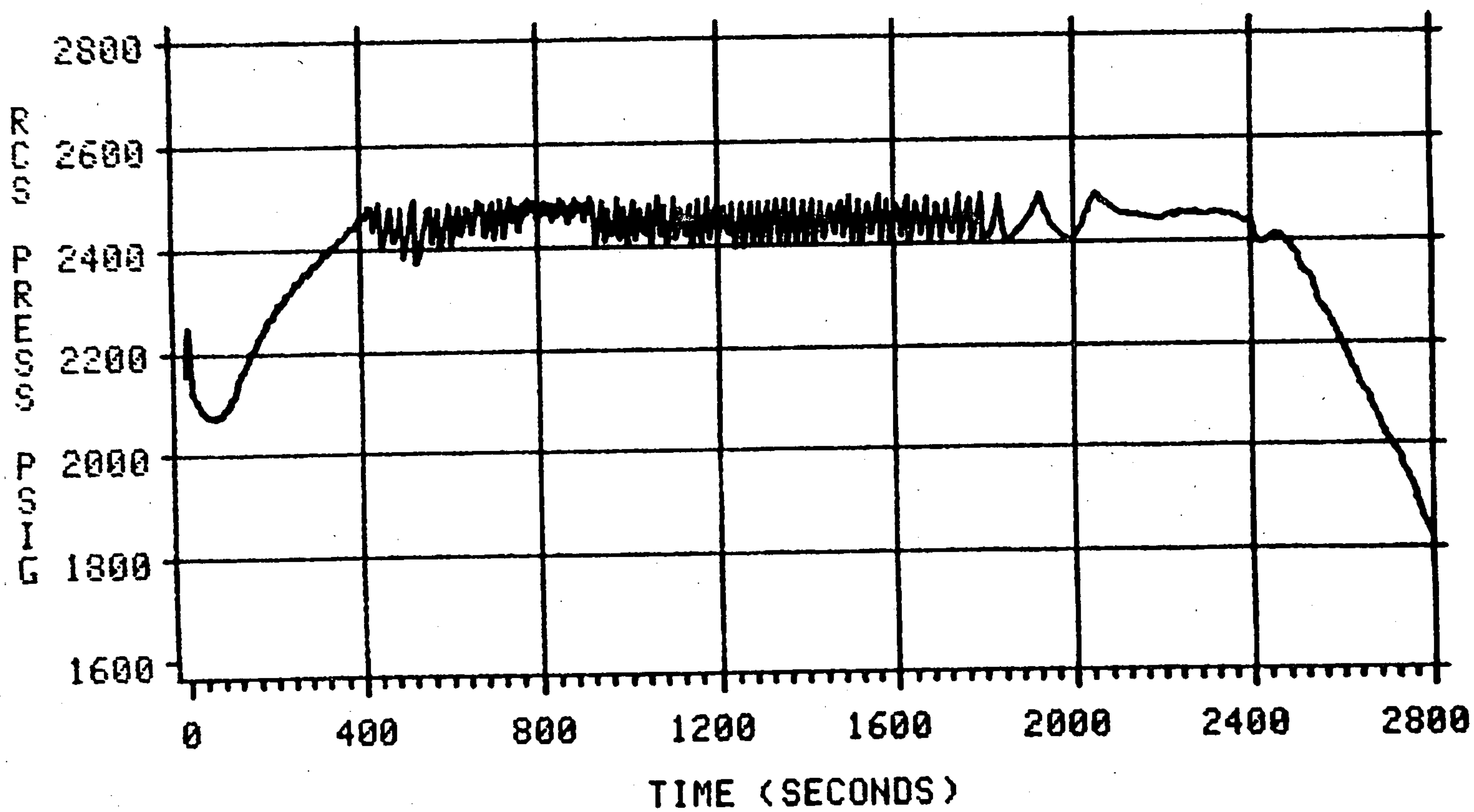
This analysis indicates that the ASW pump can provide adequate decay heat removal at the Oconee Nuclear Station, even in the unlikely event of a tornado which disables all normal plant cooling systems.

References:

1. Letter, Thomas, C. O. (NRC) to Schnatz, T. W (UGRA), Acceptance for Referencing of Licensing Topical Reports EPRI CCM-5, "RETRAN-A Program for One Dimensional Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems," and EPRI NP-1850-CCM, "RETRAN-02-A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems," 9/2/84.

TORNADO PROTECTION ANALYSIS

ASW COOLDOWN



SOURCE ——— RETRAN

Figure 1

TORNADO PROTECTION ANALYSIS

ASW COOLDOWN

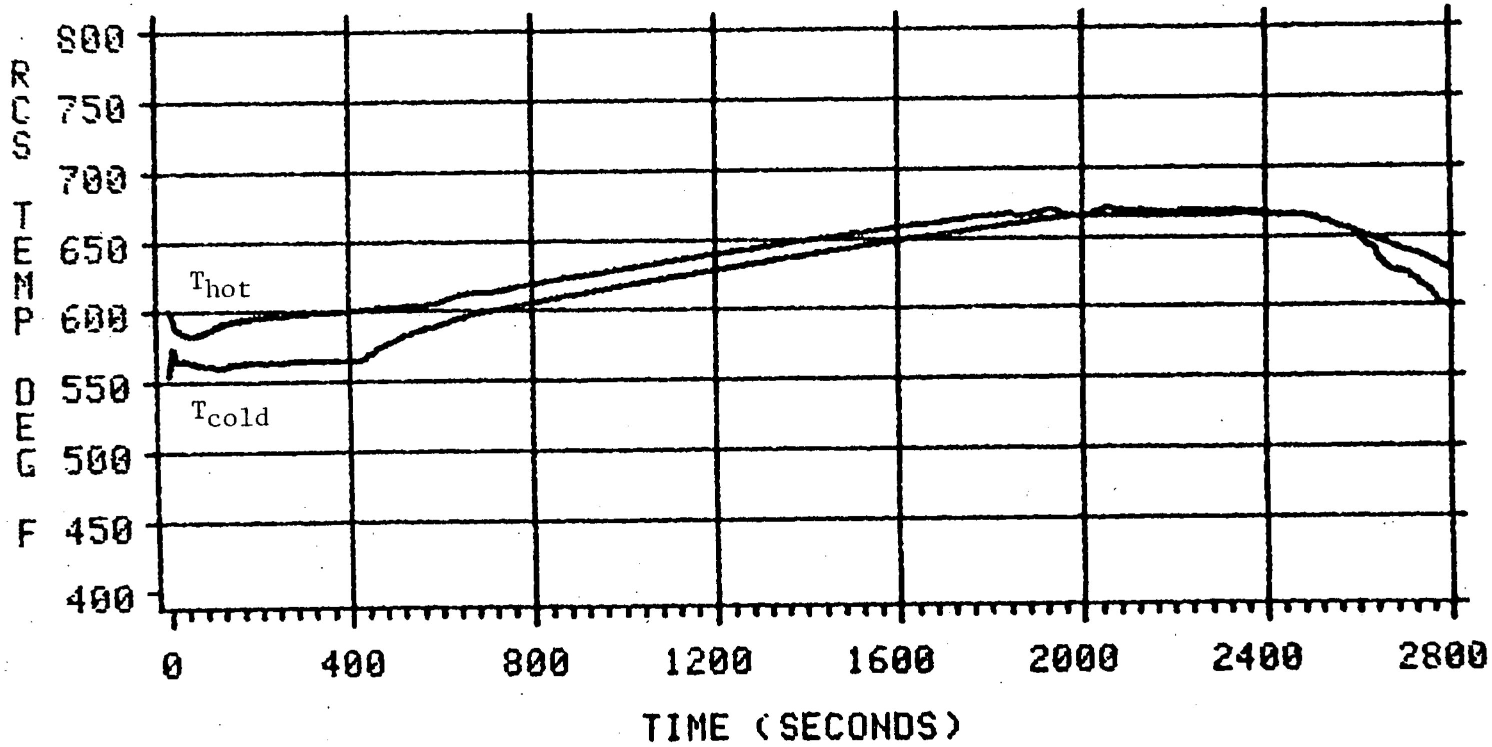


Figure 2

TORNADO PROTECTION ANALYSIS

ASW COOLDOWN

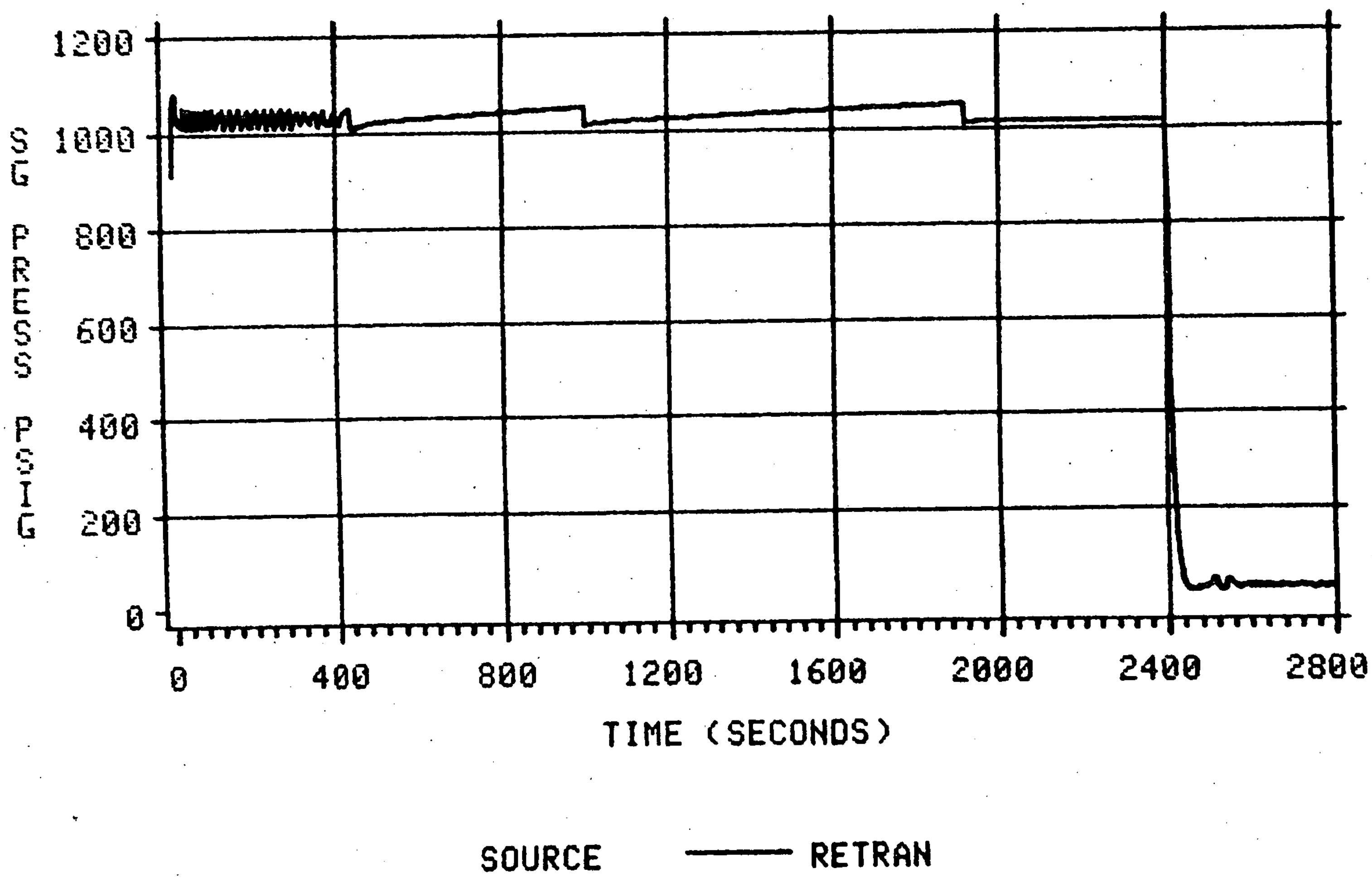


Figure 3

TORNADO PROTECTION ANALYSIS

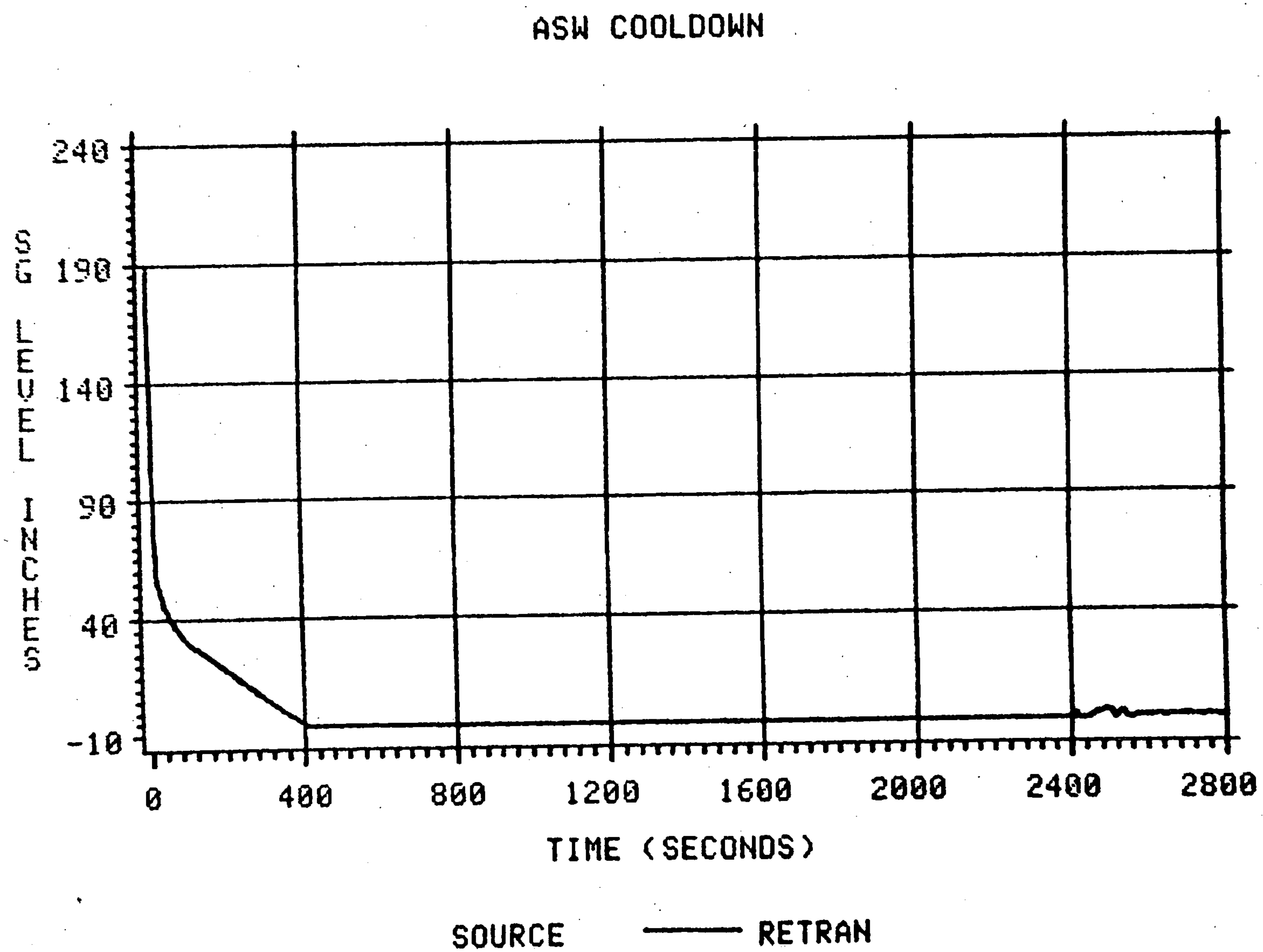


Figure 4

TORNADO PROTECTION ANALYSIS

ASW COOLDOWN

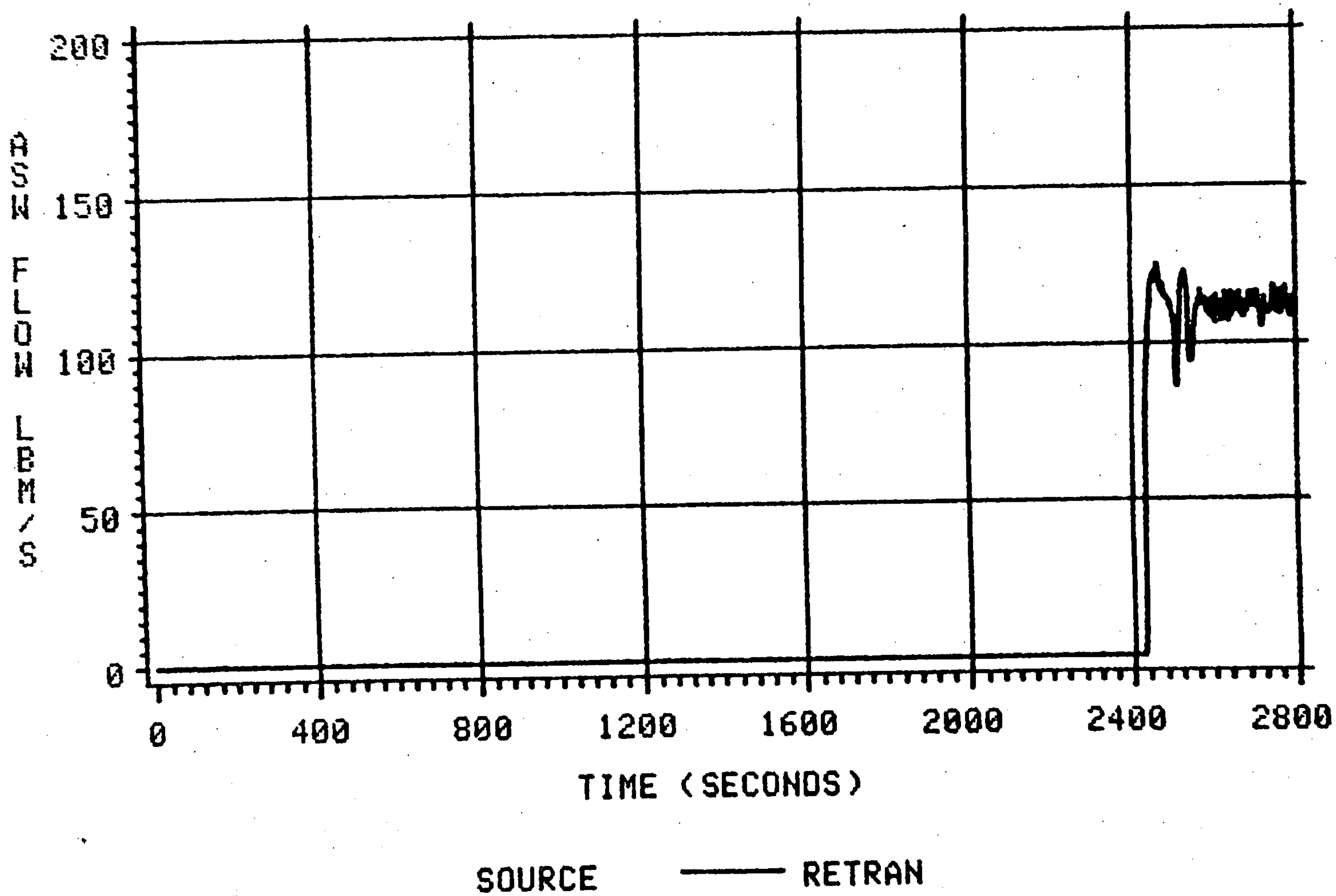


Figure 5

TORNADO PROTECTION ANALYSIS

ASW COOLDOWN

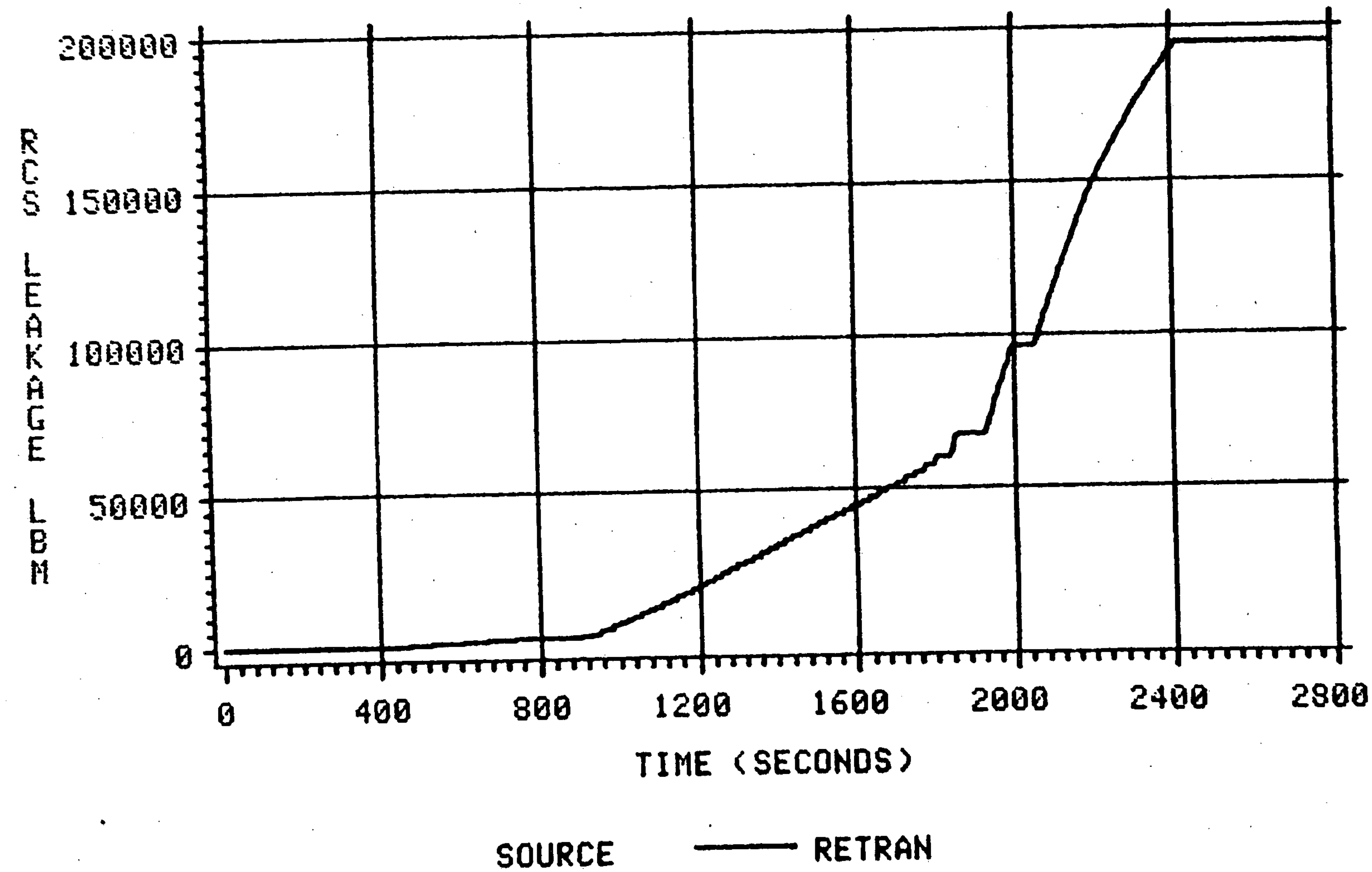
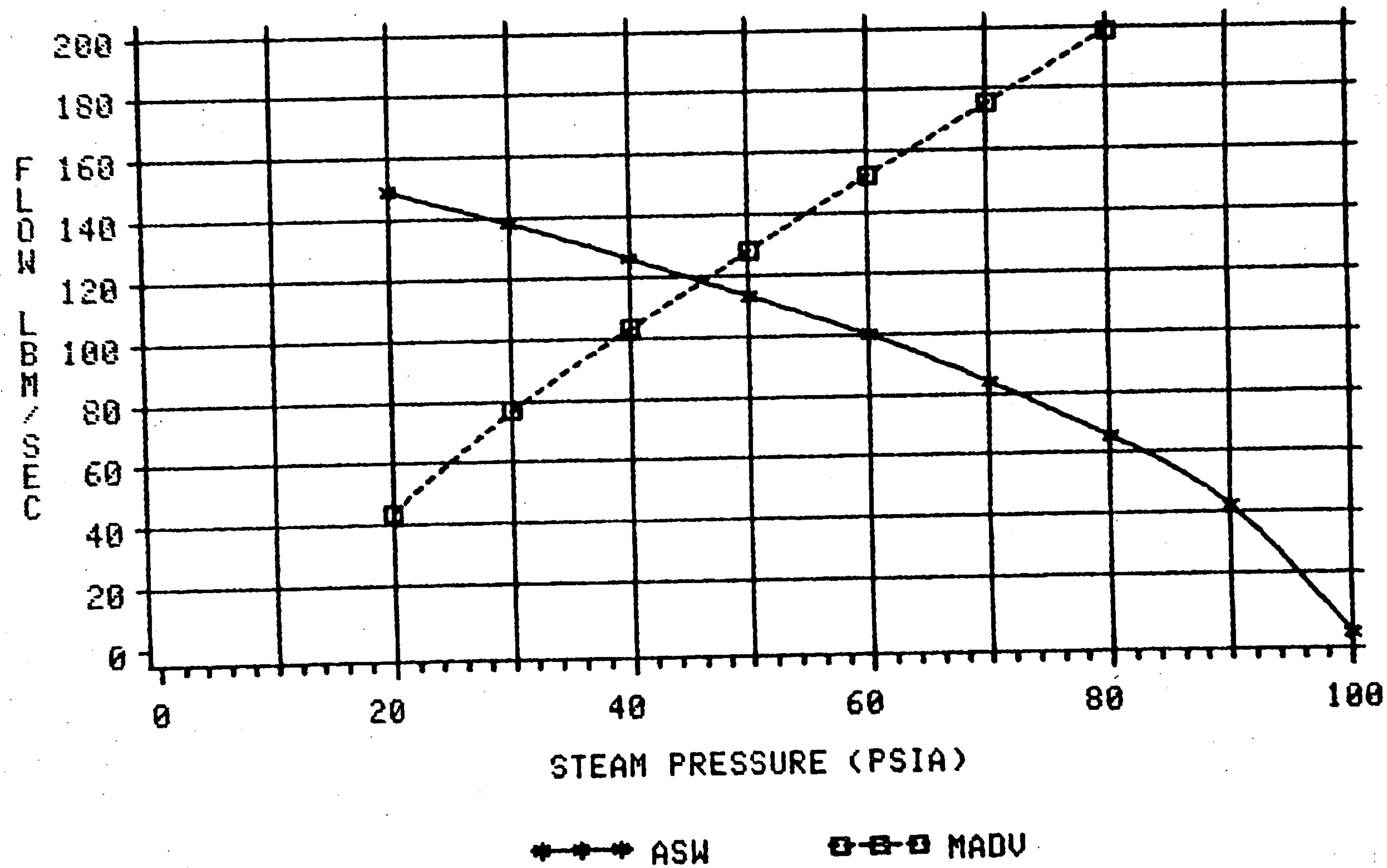


Figure 6

OCONEE MADV AND ASW FLOW



FLOWS ARE BASED ON BOTH STEAM GENERATORS

Figure 7

TORNADO PROTECTION ANALYSIS

ASW COOLDOWN

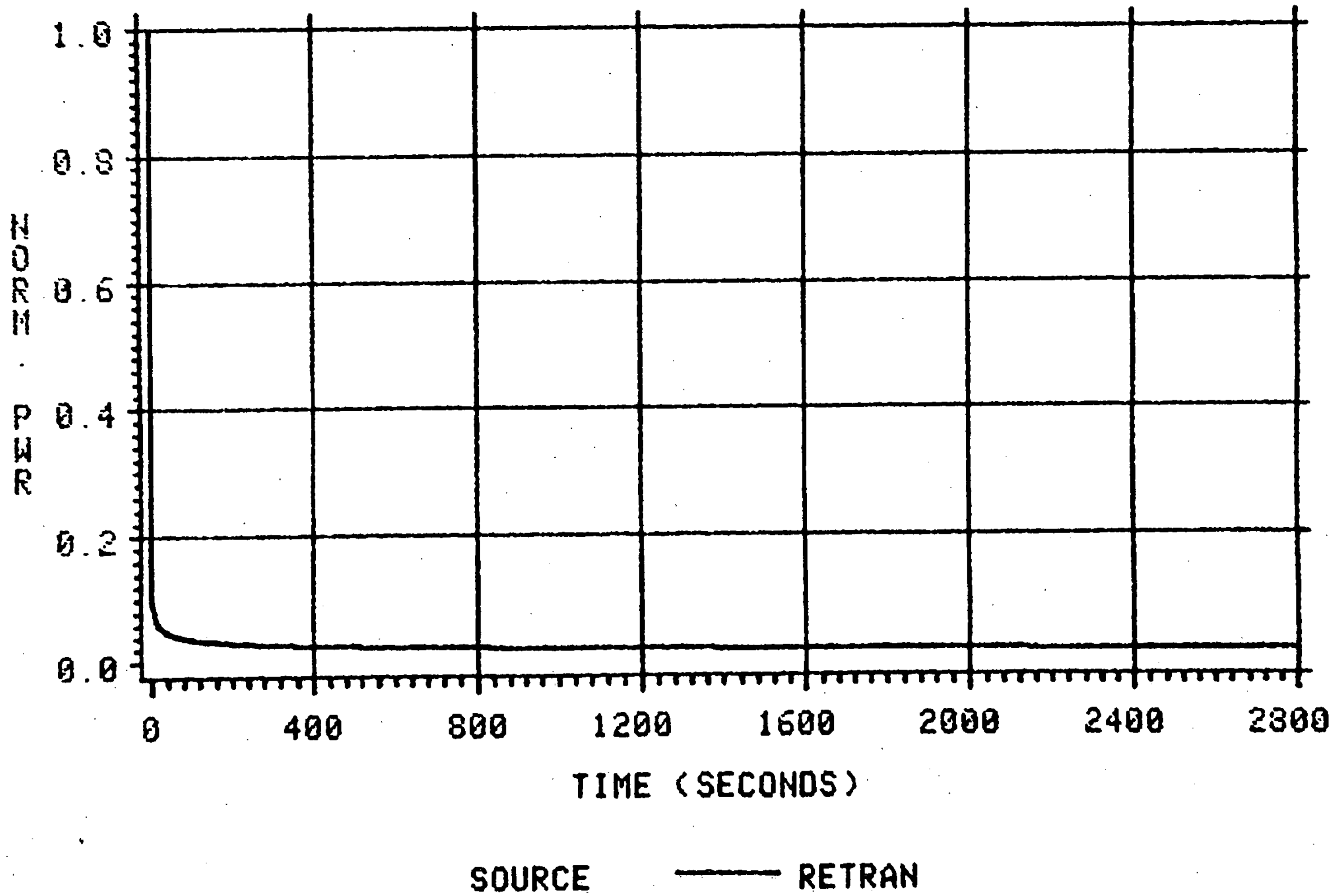


Figure 8