

October 28, 1996

MEMORANDUM TO: Edward L. Jordan, Director
Office for Analysis and Evaluation
of Operational Data

FROM: Charles E. Rossi, Director
Safety Programs Division
Office for Analysis and Evaluation
of Operational Data

SUBJECT: PRESENTATION TO B&W OWNERS GROUP STEERING COMMITTEE

The purpose of this memorandum is to summarize my participation in the B&W Owners Group Steering Committee meeting on October 17, 1996. I attended this meeting to discuss recently completed and currently ongoing studies in the Safety Programs Division. I have attached a copy of the handout used as the basis for my discussion which lasted about 1.5 hours.

Attachment:
As stated

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OFFICE FOR ANALYSIS AND EVALUATION
OF OPERATIONAL DATA

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AEOD

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INDEPENDENT REVIEW

- **ALL LICENSEE EVENT REPORTS ARE REVIEWED IN A SYSTEMATIZED WAY BY AEOD REVIEWERS TO CLASSIFY FOR SIGNIFICANCE**
- **THE DATA IS ENCODED IN THE SEQUENCE CODING AND SEARCH SYSTEM TO ASSIST IN IDENTIFYING RELATED EVENTS — CAUSAL AND TIME ASPECTS OF OCCURRENCES WITHIN THE EVENT SEQUENCE**
- **AEOD ALSO REVIEWS FOREIGN EVENT DATA, IRS AND BILATERAL, TO ADD TO THE DOMESTIC EXPERIENCE**

INDEPENDENT LONG TERM STUDIES AND ANALYSES

- **OPERATIONAL DATA SYSTEMS AND RELIABILITY DATA COLLECTION**
- **BROAD SCOPE SYSTEMATIC REVIEW OF OPERATING EXPERIENCE**
- **IDENTIFICATION OF SAFETY ISSUES**
- **INDEPTH COMPONENT, SYSTEMS, HUMAN PERFORMANCE STUDIES**
- **PERFORMANCE INDICATOR PROGRAM**
- **ACCIDENT SEQUENCE PRECURSOR PROGRAM**
- **SYSTEM RELIABILITY STUDIES**

RAB REPORTS ISSUED IN 1994

SPECIAL STUDY REPORTS

DATE	TITLE	NO.	AUTHOR
02/94	OPERATING EXPERIENCE FEEDBACK REPORT— RELIABILITY OF SAFETY-RELATED STEAM TURBINE-DRIVEN STANDBY PUMPS	S94-01	J. BOARDMAN
09/94	TURBINE-GENERATOR OVERSPEED PROTECTION SYSTEMS AT U.S. LIGHT-WATER REACTORS	S94-02	H. ORNSTEIN

TECHNICAL REVIEW REPORTS

DATE	TITLE	NO.	AUTHOR
03/94	THE ELECTRICAL TRANSIENT WHICH FOLLOWED THE LOS ANGELES EARTHQUAKE—JANUARY 17, 1994	T94-01	M. WEGNER
05/94	REVIEW OF MISPOSITIONED EQUIPMENT EVENTS	T94-02	S. ISRAEL
07/94	COMPUTER-BASED DIGITAL SYSTEM FAILURES	T94-03	E. LEE
12/94	POTENTIAL FOR BOILING WATER REACTOR EMERGENCY CORE COOLING SYSTEM STRAINER BLOCKAGE DUE TO LOSS-OF-COOLANT ACCIDENT-GENERATED DEBRIS	T94-04	J. BOARDMAN

RAB REPORTS ISSUED IN 1995

SPECIAL STUDY REPORTS

DATE	TITLE	NO.	AUTHOR
03/95	REACTOR COOLANT SYSTEM BLOWDOWN AT WOLF CREEK ON SEPTEMBER 17, 1994	S95-01	J. KAUFFMAN S. ISRAEL

ENGINEERING EVALUATIONS

DATE	TITLE	NO.	AUTHOR
07/95	OPERATING EVENTS WITH INAPPROPRIATE BYPASS OR DEFEAT OF ENGINEERED SAFETY FEATURES	E95-01	J. KAUFFMAN

TECHNICAL REVIEW REPORTS

DATE	TITLE	NO.	AUTHOR
03/95	MAJOR DISTURBANCES ON THE WESTERN GRID AND RELATED EVENTS	T95-01	M. WEGNER
10/95	POTENTIAL DAMAGE TO LOW-PRESSURE INJECTION VALVES DURING SURVEILLANCE TESTING	T95-02	E. BROWN

RAB REPORTS ISSUED IN 1996

SPECIAL STUDY REPORTS

DATE	TITLE	NO.	AUTHOR
04/96	STEAM GENERATOR TUBE FAILURES	NUREG/CR-6365	INEL
06/96	OCONEE ELECTRICAL SYSTEM DESIGN AND OPERATION	—	G. LANIK
09/96	ASSESSMENT OF SPENT FUEL COOLING	—	J. IBARRA

ENGINEERING EVALUATIONS

DATE	TITLE	NO.	AUTHOR
03/96	MOTOR-OPERATED VALVE KEY FAILURES	E96-01	C. HSU
04/96	ANALYSIS OF ALLEGATION DATA	E96-02	S. ISRAEL
09/96	INSIGHTS FROM UNDETECTED FAILURES OF SAFETY SYSTEMS	E96-XX	S. PULLANI

TECHNICAL REVIEW REPORTS

DATE	TITLE	NO.	AUTHOR
03/96	AEOD TECHNICAL REPORTS BY CATEGORY REVISION 1	T96-01	S. ISRAEL
04/96	TARGET ROCK TWO-STAGE SRV PERFORMANCE UPDATE	T96-02	M. WEGNER
09/96	RESPONSE OF B&W PLANTS ON LOSS OF NONEMERGENCY AC POWER	T96-03	W. RAUGHLEY

STEAM GENERATOR TUBE FAILURE STUDY

NUREG/CR-6365

- **PEER REVIEWED BY NRR**
- **INCLUDES BOTH A HISTORICAL REVIEW AND AN OVERVIEW OF EVENTS AND ACTIONS WORLDWIDE RELATED TO STEAM GENERATOR TUBE FAILURES, INCLUDING NRC GENERIC LETTER 95-05**
- **COVERS THE FOLLOWING:**

STEAM GENERATOR DESIGN

STEAM GENERATOR DEGRADATION MECHANISMS, SITES, AND FAILURE MODES

STEAM GENERATOR TUBE RUPTURES

THERMAL-HYDRAULIC RESPONSE OF A TYPICAL PWR PLANT WITH A DEFECTIVE STEAM GENERATOR

STEAM GENERATOR TUBE FAILURE STUDY NUREG/CR-6365 (CONT.)

- **COVERS THE FOLLOWING (CONT.):**

TRANSIENT STEAM GENERATOR ACCIDENT RESPONSE

**RISK SIGNIFICANCE OF STEAM GENERATOR TUBE RUPTURE
ACCIDENTS**

**WORLDWIDE REGULATORY PRACTICES AND FITNESS-FOR-
SERVICE GUIDELINES**

STEAM GENERATOR TUBE DEFECT DETECTION AND SIZING

MOTOR-OPERATED VALVE KEY FAILURES

- **STUDY INITIATED BY EVENT AT PALO VERDE ON APRIL 18, 1995**
- **A TOTAL OF 73 REPORTS WERE IDENTIFIED FROM 46 OPERATING PLANTS IN THE PERIOD FROM 1990 TO SEPTEMBER 1995**
 - **ANTI-ROTATION KEY FAILURES — 11 REPORTS**
 - **VALVE OPERATOR-TO-VALVE STEM KEY FAILURES — 22 REPORTS**
 - **MOTOR PINION KEY FAILURES — 40 REPORTS**
- **SAFETY SIGNIFICANCE**
 - **MANY KEY FAILURES WERE NOT DETECTED DURING SURVEILLANCE AND HAD EXISTED FOR SOME TIME BEFORE DISCOVERY**
 - **POTENTIAL COMMON-MODE FAILURE COULD RENDER CERTAIN SAFETY-RELATED SYSTEMS INOPERABLE**

MOTOR-OPERATED VALVE KEY FAILURES (CONT.)

- **ANTI-ROTATION KEY FAILURE**
 - 11 EVENTS FROM 11 PLANTS
 - TWO CAUSES: INSTALLATION AND DESIGN DEFICIENCIES

- **VALVE OPERATOR-TO-VALVE STEM KEYS**
 - 22 EVENTS FROM 19 PLANTS. AMONG THESE 16 KEY FAILURES ON DEMAND OR DETECTED DURING SYSTEM OPERATIONS, THE OTHERS FAILED DURING TESTING
 - DOMINANT CAUSE: LOOSE OR SLIPPING OUT (ASSOCIATED WITH SETSCREW LOOSENING OR IMPROPER STAKING)

- **LIMITORQUE MOTOR PINION GEAR KEYS**
 - 40 EVENTS FROM 27 PLANTS
 - THREE MAIN CAUSES: HIGH IMPACT LOAD (15 EVENTS), IMPROPER MATERIAL (8 EVENTS), AND IMPROPER INSTALLATION — SLIPPING OUT OR MISSING KEYS (13 EVENTS)

CATEGORIZATION OF AEOD TECHNICAL REPORTS

OVER 500 REPORTS ISSUED SINCE 1980

CROSS-REFERENCED IN FOUR TABLES

- PWR SYSTEMS**
- BWR SYSTEMS**
- ACTIVITY/DEFICIENCY**
- TOPIC**

COMPILED IN AEOD/T96-01

**RESOURCE FOR CHECKING OPERATING EXPERIENCE RELATED
TO EMERGING TECHNICAL ISSUES**

**CATEGORIZATION TABLES AND REPORT SUMMARIES WILL BE
PUT ON INTERNET**

HUMAN PERFORMANCE

HUMAN PERFORMANCE EVENT DATABASE (HPED)

- **A SYSTEM FOR STORING, MANIPULATING, AND RETRIEVING DATA ON HUMAN PERFORMANCE DURING OPERATING EVENTS**
- **CONTAINS RECORDS FROM AITs (40) AND HUMAN PERFORMANCE STUDIES (20)**
- **RECORDS WILL BE ADDED FOR OTHER AITs, EVENT-DRIVEN SPECIAL INSPECTIONS, AND SELECTED LICENSEE EVENT REPORTS**
- **WILL PROVIDE DATA FOR STUDIES OF HUMAN PERFORMANCE AND RELIABILITY AND WILL BE USED TO EVALUATE REQUIREMENTS FOR HUMAN PERFORMANCE DATA**

HUMAN PERFORMANCE PROGRAM PLAN (HPPP)

- **A SYSTEM FOR DESCRIBING AND MONITORING THE STATUS OF ALL AGENCY PROGRAMS RELATED TO HUMAN PERFORMANCE**
- **INTENDED TO PROMOTE INTEROFFICE COOPERATION AND COORDINATION AND AVOID DUPLICATION**
- **ESTABLISHED AND MAINTAINED BY THE HUMAN FACTORS COORDINATION COMMITTEE (WITH REPRESENTATIVES FROM AEOD, NRR, RES, AND NMSS)**
- **TO BE REVISED AND PUBLISHED SEMIANNUALLY**

REVIEW OF OCONEE EMERGENCY ELECTRICAL SYSTEM

- **AEOD TASK**
 - **PROVIDE AN INDEPENDENT EVALUATION OF SYSTEM DESIGN AND OPERATION**
 - **REVIEW SAFETY CONCERNS AND POTENTIAL RISKS**

- **METHODOLOGY**
 - **REVIEW OF THE FOLLOWING:**
 - **OPERATIONAL EVENTS**
 - **VULNERABILITIES**
 - **TESTING**
 - **HUMAN PERFORMANCE**
 - **MANAGEMENT ISSUES**
 - **KEOWEE RELIABILITY ASSESSMENT**
 - **OTHER AVAILABLE PROBABILISTIC RISK ASSESSMENTS**
 - **SITE VISITS**

REVIEW OF OCONEE EMERGENCY ELECTRICAL SYSTEM (CONTINUED)

CONCLUSION: A LEVEL OF SAFETY COMPARABLE TO THAT OF A PLANT WITH DIESEL GENERATORS MAY BE ACHIEVED ASSUMING

- INSTALLATION AND TESTING OF DESIGN CHANGES PROPOSED BY OCONEE OR IDENTIFIED BY NRC — EXAMPLES ARE CHANGES TO ENSURE ADEQUATE VOLTAGE AND FREQUENCY DURING LOADING OF EMERGENCY POWER SOURCES**
- TESTING TO DEMONSTRATE CAPABILITY OF SYSTEMS TO PROGRESS THROUGH A START AND LOAD CYCLE OF EMERGENCY EQUIPMENT**
- PERIODIC TESTING OF EMERGENCY ELECTRICAL SYSTEM**
- UPGRADE AND TEST OPERATOR PROCEDURES AND TRAINING FOR EMERGENCY POWER SYSTEM**
- TESTING OF THE SAFE SHUTDOWN FACILITY TO VERIFY DESIGN AND PERIODIC TESTING TO MAINTAIN SYSTEM RELIABILITY**

TECHNICAL REVIEW REPORT, "RESPONSE OF B&W PLANTS FOLLOWING A LOSS OF NONEMERGENCY AC POWER"

FOLLOWUP TO OCONEE EMERGENCY POWER STUDY

CONCERN:

COMPLETE LOSS OF AC AT OCONEE COULD LEAD TO:

- TRIPS OF ALL 3 REACTORS**
- POTENTIAL OVERCOOLING TRANSIENTS**
- MULTIPLE UNIT EMERGENCY CORE COOLING SYSTEM ACTUATIONS**
- EMERGENCY AC SYSTEM LOADS BEYOND THOSE CONSIDERED**
- VOLTAGE AND FREQUENCY REDUCTIONS BEYOND THOSE CONSIDERED**

REVIEWED:

B&W PLANT OPERATING EXPERIENCE (1987 TO 1996)

- 18 COMPLETE OR PARTIAL LOSSES OF NONEMERGENCY AC POWER EVENTS**
- 13 WHILE PLANTS SHUTDOWN**
- 5 DURING POWER OPERATION**

FINDINGS:

- NO OVERCOOLING TRANSIENTS OCCURRED**
- NO FULL ECCS ACTUATIONS OCCURRED**
- 4 OF THE 5 EVENTS AT POWER HAD AUTO INITIATION OF MOTOR DRIVEN EMERGENCY FEEDWATER PUMPS FROM EMERGENCY POWER**

INDEPENDENT SPENT FUEL POOL STUDY

- **STUDY REQUESTED BY EXECUTIVE DIRECTOR FOR OPERATIONS**
- **DEVELOPED GENERIC CONFIGURATIONS TO ASSESS LOSS OF SPENT FUEL POOL COOLING AND INVENTORY**
- **ASSESSED 12 YEARS OF OPERATIONAL EXPERIENCE**
- **PERFORMED SITE VISITS TO GATHER INFORMATION ON PHYSICAL CONFIGURATION, PRACTICES, AND PROCEDURES**
- **REVIEWED REGULATIONS, STANDARD REVIEW PLAN AND REGULATORY GUIDES**
- **PERFORMED ASSESSMENTS OF ELECTRICAL SYSTEMS, INSTRUMENTATION, HEAT LOADS, AND RADIATION**
- **CONTRACTOR EVALUATED RISK OF LOSING SPENT FUEL COOLING**

SFP STUDY FINDINGS AND CONCLUSIONS

LIKELIHOOD AND CONSEQUENCES

- **CONSEQUENCES OF ACTUAL EVENTS HAVE NOT BEEN SEVERE**
- **PRIMARY CAUSE OF EVENTS HAS BEEN HUMAN ERROR**
- **RELATIVE RISK IS LOW COMPARED WITH OTHER REACTOR RISKS**
- **HIGHLY DEPENDENT ON HUMAN PERFORMANCE AND PLANT DESIGN**

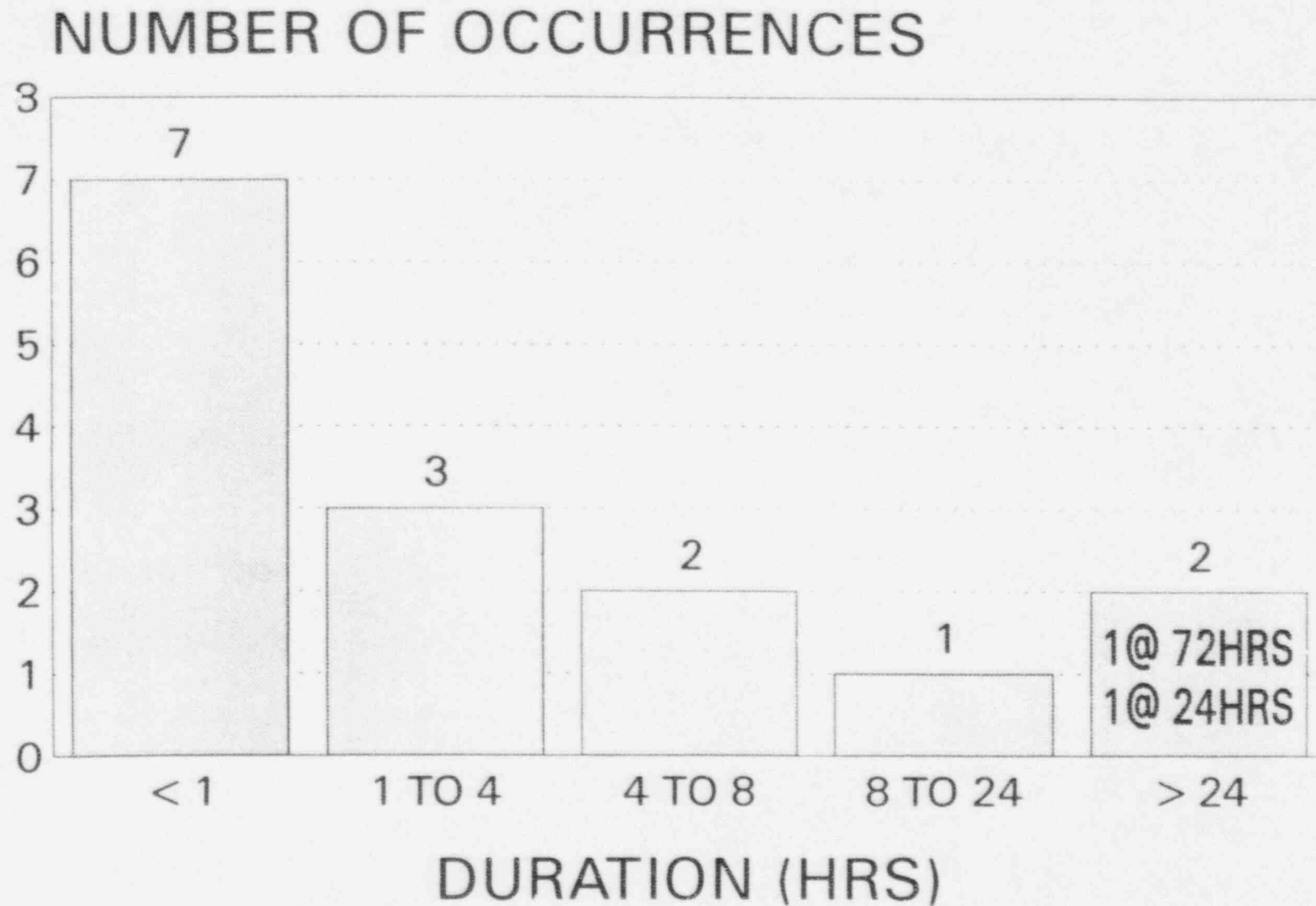
PREVENTION

- **CONFIGURATION CONTROL IMPROVEMENTS CAN PREVENT AND/OR MITIGATE SFP EVENTS**
- **EVALUATIONS MAY BE NEEDED AT SOME MULTI-UNIT SITES FOR POTENTIAL SFP BOILING EFFECTS ON SAFE SHUTDOWN**

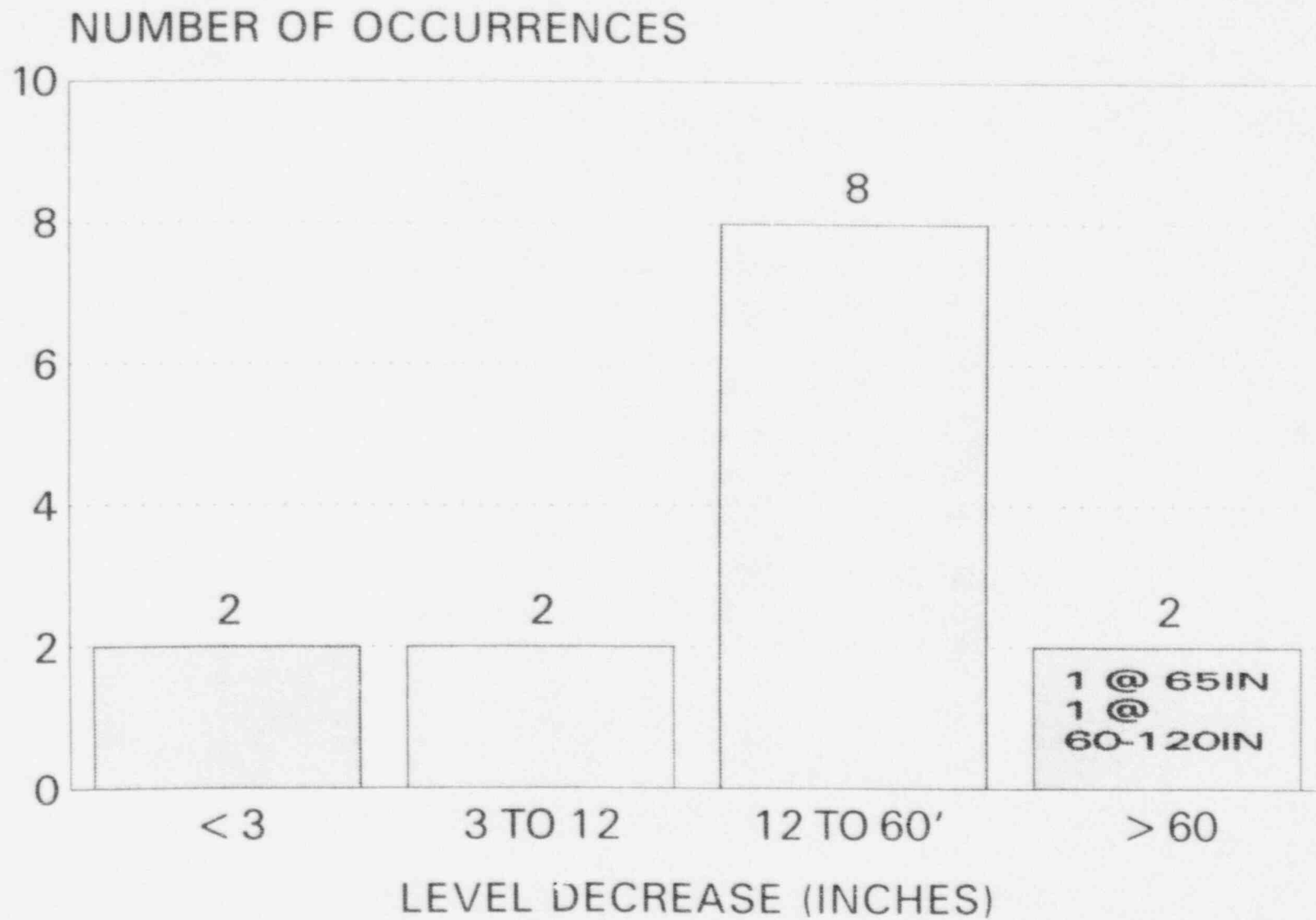
RESPONSE

- **IMPROVED PROCEDURES & TRAINING MAY BE NEEDED**
- **IMPROVEMENTS TO INSTRUMENTATION AND POWER SUPPLIES MAY BE NEEDED**

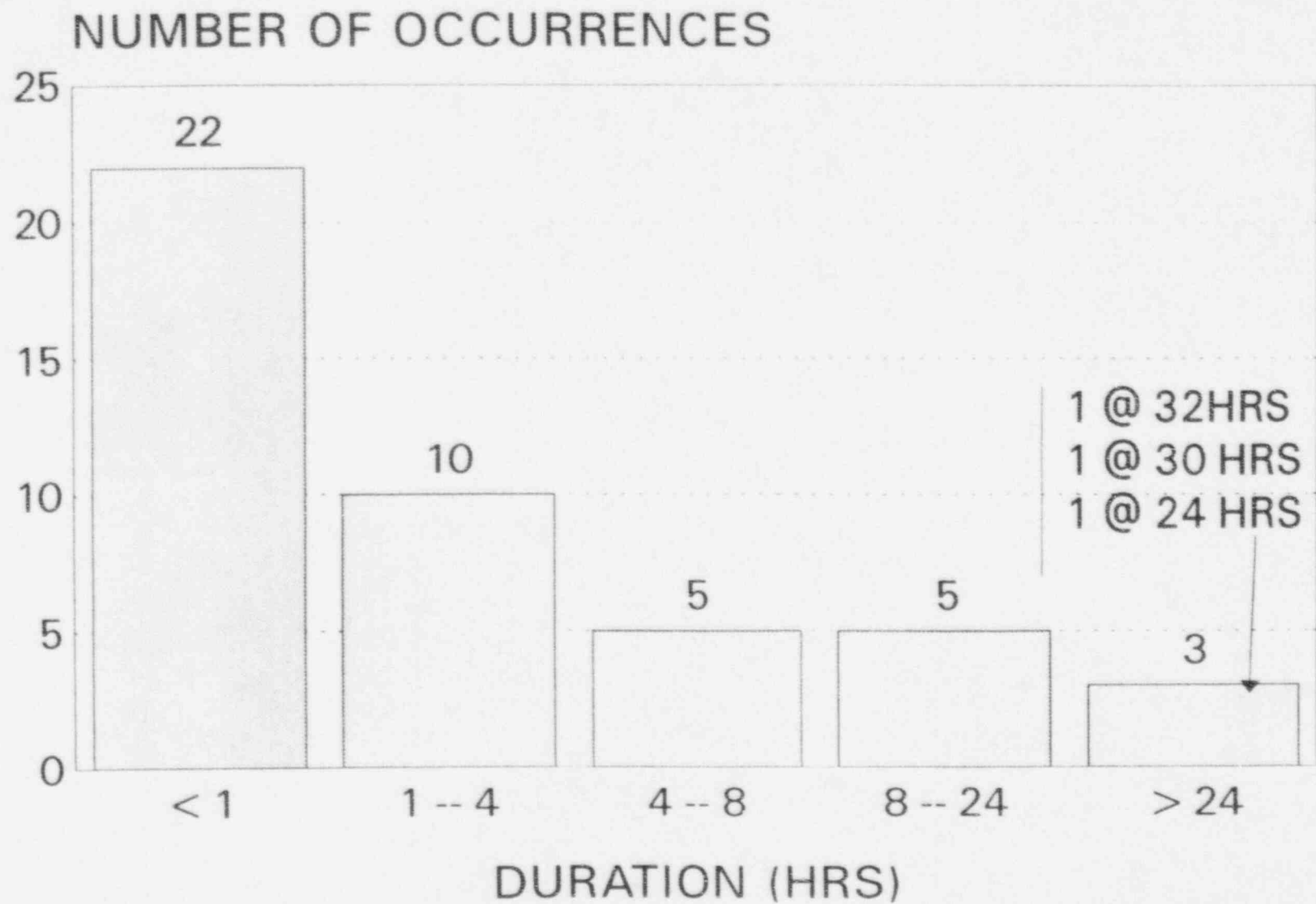
LOSS OF INVENTORY DURATION



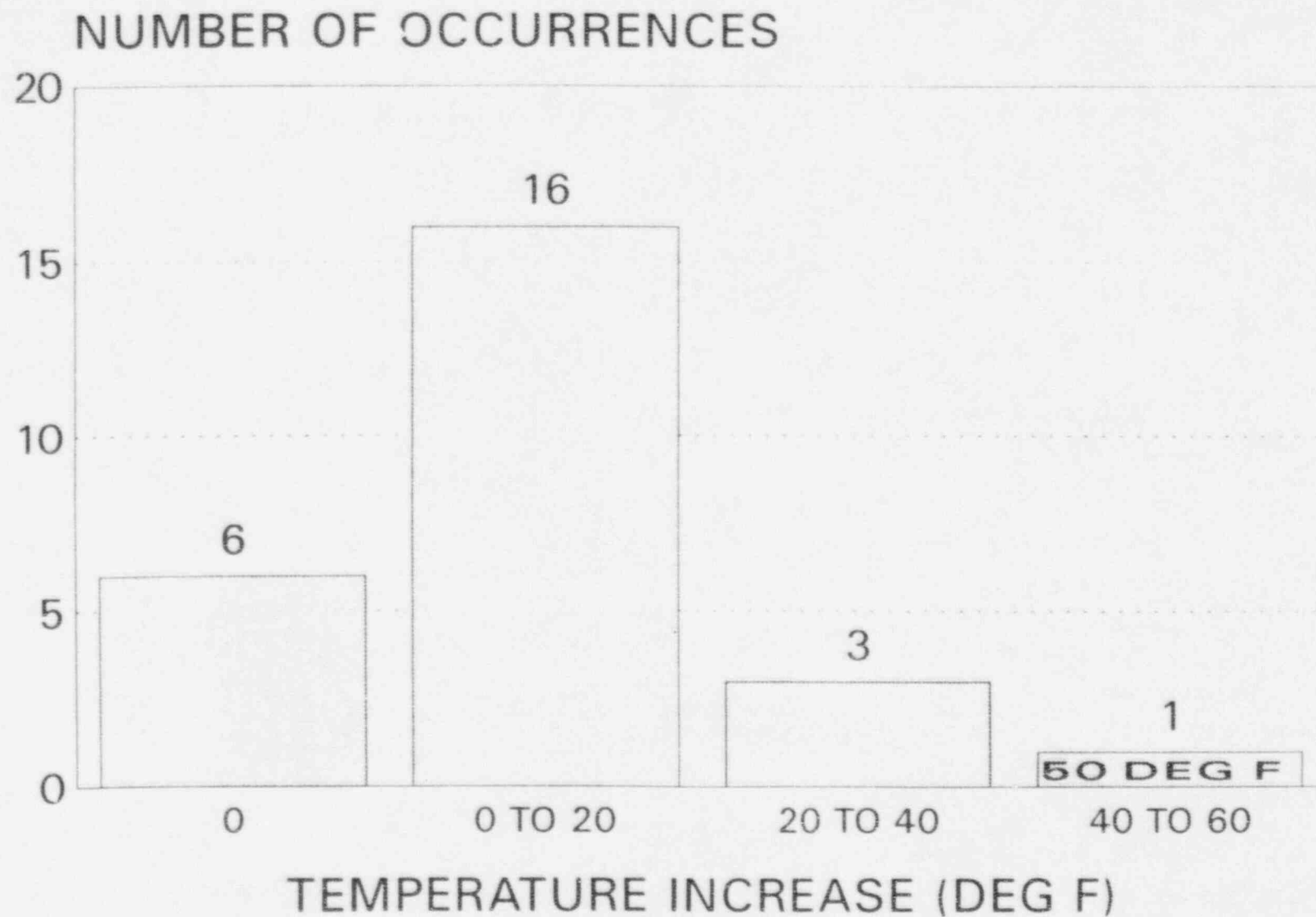
LEVEL DECREASE DUE TO LOSS OF INVENTORY



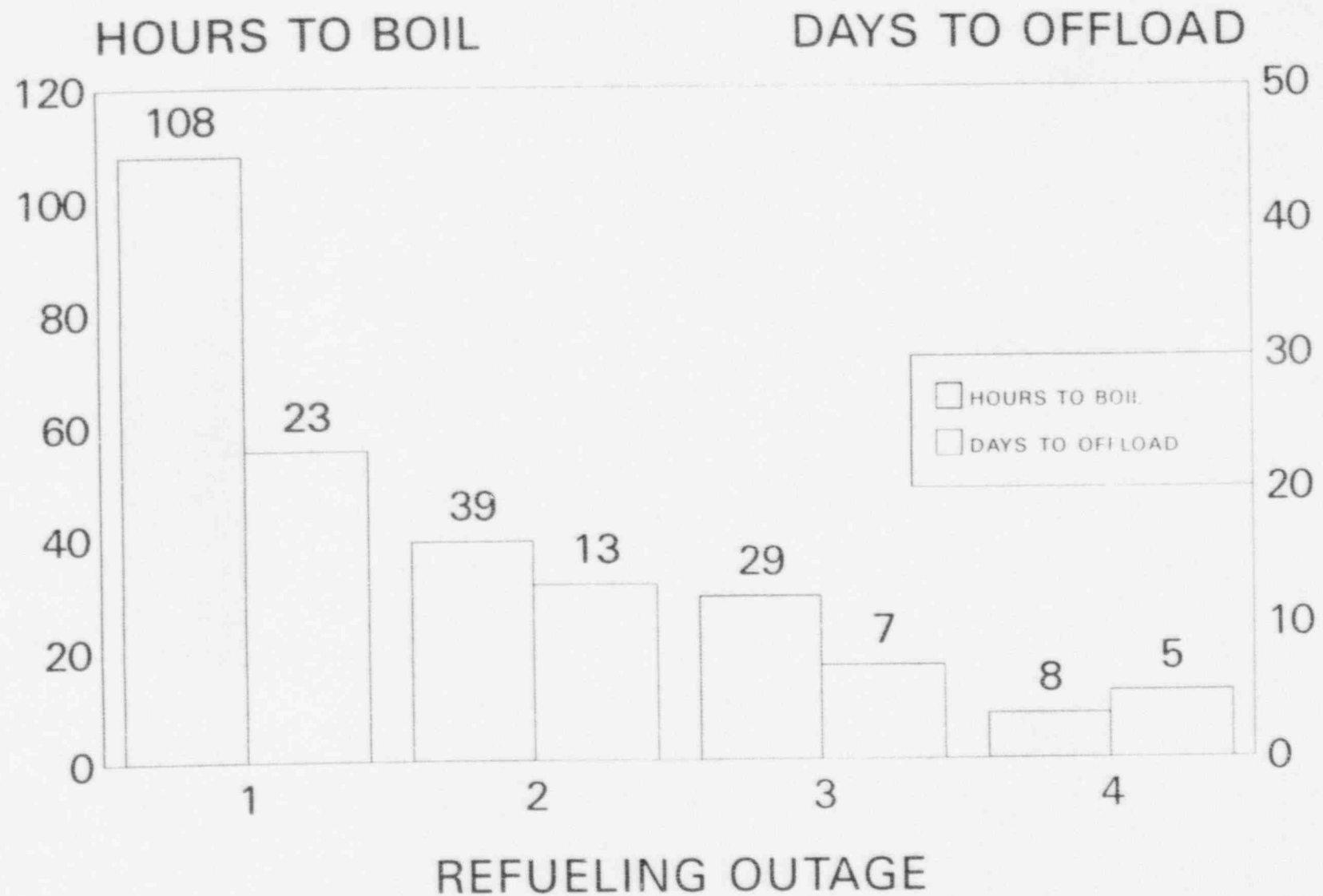
DURATION OF LOSS OF COOLING EVENTS



TEMPERATURE INCREASE DUE TO LOSS OF COOLING EVENTS



REDUCED TIME TO BOIL AT NINE MILE UNIT 2



INSIGHT FROM UNDETECTED FAILURES OF SAFETY SYSTEMS

BACKGROUND

- **33 EVENTS HAVING CONDITIONAL CORE DAMAGE PROBABILITY ABOVE 10^{-6} OCCURRED DURING 1991-93**
- **THE EVENTS IDENTIFIED FROM ACCIDENT SEQUENCE PRECURSOR DATA BASE**
- **THE STUDY IS AN EVALUATION OF US EVENTS, THE INPUT ORIGINALLY GIVEN TO NUCLEAR ENERGY AGENCY'S WORLD-WIDE STUDY**

OBJECTIVE

- **TO GAIN INSIGHTS USEFUL IN PREVENTION OR REDUCTION OF LIKELIHOOD OF SUCH FAILURES**

METHODOLOGY

- **THE FAILURES WERE ANALYZED WITH RESPECT TO:**
 - **DISCOVERY METHOD**
 - **TIME TO DISCOVER**
 - **FAILURE CAUSES**
 - **CORRECTIVE/PREVENTIVE ACTIONS BY LICENSEES**
 - **REGULATORY ACTIONS TAKEN**

INSIGHT FROM UNDETECTED FAILURES OF SAFETY SYSTEMS (CONTINUED)

FINDINGS AND CONCLUSIONS

- **FAILURES REMAINED UNDISCOVERED FOR A LONG TIME: 4 (1-10 YRS), 4 (10-18 YRS), 4 POSSIBLY SINCE PLANT STARTUP**
- **11 EVENTS/YR OR .1 PER REACTOR YEAR**
- **29 AT PWRs AND 4 AT BWRs (NO RATIONALE FOR THE SKEW)**
- **> 75% DISCOVERED BY TESTING OR ANALYSIS OF OPERATIONAL PROBLEMS**
- **~ 70% CAUSED BY COMPONENT FAILURE, DESIGN DEFICIENCY, OR INADEQUATE TESTING/MAINTENANCE PROCEDURE**
- **MOST FREQUENT LICENSEE ACTIONS: PLANT MODIFICATION, ADDITIONAL TRAINING, MODIFIED OPERATING/MAINTENANCE PROCEDURE**
- **7 EVENTS WERE THE SUBJECT OF NRC GENERIC COMMUNICATIONS**
- **4 OF THE ABOVE 7 WERE THE SUBJECT OF AUGMENTED INSPECTION TEAMS (AIT)**
- **OUT OF 12 RELATIVELY MORE SIGNIFICANT EVENTS, 1 WAS THE SUBJECT OF NRC GENERIC COMMUNICATION AND NONE WAS THE SUBJECT OF AN AIT**

NRC ALLEGATION DATA

- **COMMISSION DIRECTED TREND ANALYSIS TO ALERT AGENCY TO CHANGES**
- **ALLEGATION DATA INCLUDES:**
 - **TECHNICAL CONCERNS**
 - **HARASSMENT AND INTIMIDATION (H & I)**
 - **SOME WITH BOTH**
- **GROUPINGS:**
 - **MULTIPLE-UNIT SITES**
 - **SINGLE-UNIT SITES**
 - **VENDORS**

NRC ALLEGATION DATA (CONTINUED)

- **INEL PERFORMED ANALYSIS TO IDENTIFY OUTLIERS**
 - **1994 COUNT**
 - **CHANGE FROM 1993 TO 1994**
 - **TREND OF COUNT (SLOPE OVER 5 YEARS)**
- **RESULTS OBTAINED FOR EACH MEASURE FOR BOTH TOTAL ALLEGATIONS AND H & I ALLEGATIONS**
- **WATTS BAR, MILLSTONE, BURNS SECURITY HAVE A DISPROPORTIONATE NUMBER OF ALLEGATIONS**

PERFORMANCE INDICATORS

- **AUTOMATIC SCRAMS WHILE CRITICAL**
- **SAFETY SYSTEM ACTUATIONS**
- **SIGNIFICANT EVENTS**
- **SAFETY SYSTEM FAILURES**
- **FORCED OUTAGE RATE**
- **EQUIPMENT FORCED OUTAGES PER 1000 CRITICAL HOURS**
- **COLLECTIVE RADIATION EXPOSURE**
- **CAUSE CODES**

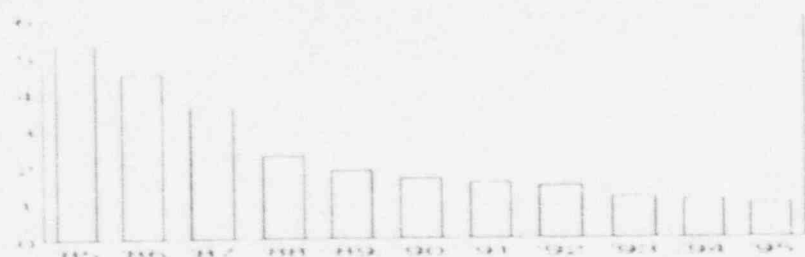
CAUSE CODES

- **ADMINISTRATIVE CONTROL PROBLEMS**
- **LICENSED OPERATOR ERRORS**
- **OTHER PERSONNEL ERRORS**
- **MAINTENANCE PROBLEMS**
- **DESIGN, CONSTRUCTION, INSTALLATION OR FABRICATION PROBLEMS**
- **MISCELLANEOUS FAILURES**

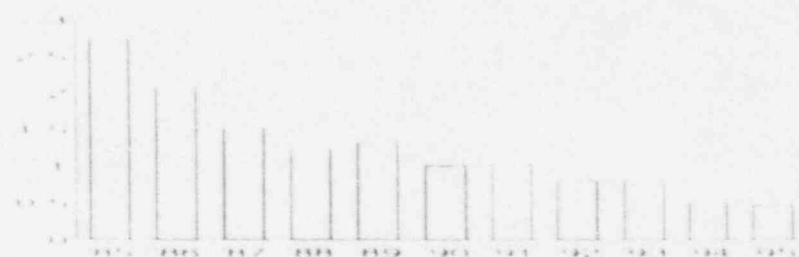
PERFORMANCE INDICATORS

ANNUAL INDUSTRY AVERAGES

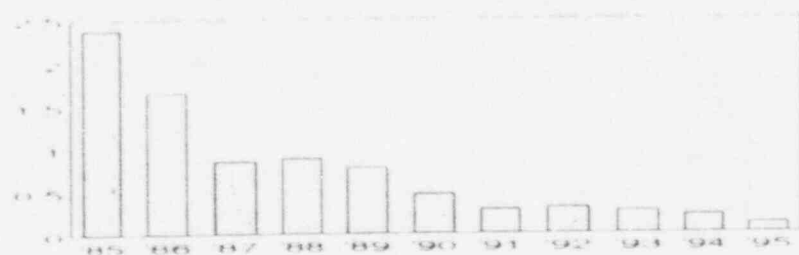
AUTOMATIC SCRAMS



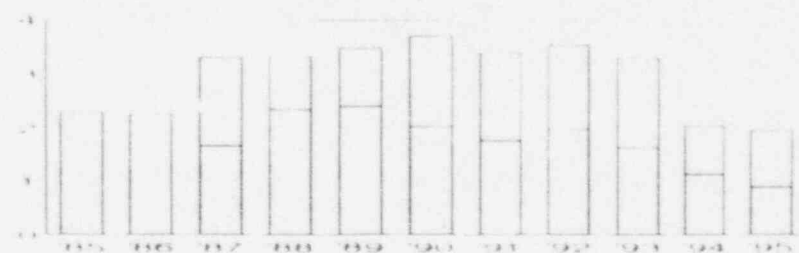
SAFETY SYSTEM ACTUATIONS



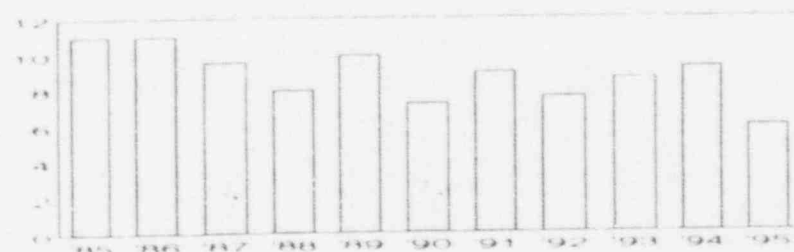
SIGNIFICANT EVENTS



SAFETY SYSTEM FAILURES



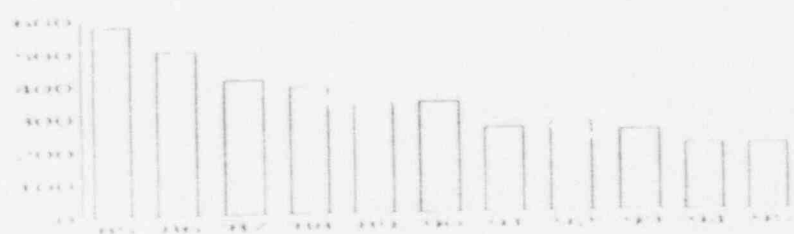
FORCED OUTAGE RATE (%)



EQUIPMENT FORCED OUTAGES PER 1000 CRITICAL HOURS



COLLECTIVE RADIATION EXPOSURE
(person rem)



Notes:

Collective Radiation Exposure projected from nine months of data.

Safety System Failure counts changed in 1987 due to improved classification methods.

RISK—BASED ANALYSIS OF REACTOR OPERATING EXPERIENCE

USE REACTOR OPERATING EXPERIENCE TO:

- **ASSESS AND TREND RISK INDICATORS**
- **COMPARE WITH PROBABILISTIC RISK ASSESSMENTS (PRAs) AND INDIVIDUAL PLANT EXAMINATIONS (IPEs)**
- **IDENTIFY TECHNICAL INSIGHTS RELATING TO RISK CONTRIBUTORS**
- **PROVIDE INSIGHTS TO INDUSTRY AND REGULATORY ACTIVITIES RELATED TO RISK**

PROGRAM ELEMENTS

- **ACCIDENT SEQUENCE PRECURSOR (ASP) ANNUAL REPORT**
 - **ASP METHODS**
 - **ASP DATABASE**

- **INITIATING EVENTS PERIODIC REPORT**
 - **LOSS OF OFFSITE POWER (LOOP) DATABASE**
 - **SPECIAL INITIATORS (e.g., POWER-OPERATED RELIEF VALVES, STEAM GENERATOR TUBE RUPTURES, HUMAN ERRORS)**

- **SYSTEM RELIABILITY STUDIES**
 - **RELIABILITY INDICATORS**
 - **COMPONENT ANALYSES**

PROGRAM ELEMENTS (CONTINUED)

- **COMMON-CAUSE FAILURES (CCFs)**
 - **DATABASE AND ANALYSIS SOFTWARE**
 - **PERIODIC ANALYSIS**
 - **INTERNATIONAL COMMON-CAUSE DATA EXCHANGE EFFORT**

- **PERFORMANCE INDICATORS (RISK/RELIABILITY)**

- **DATA SYSTEMS**
 - **SEQUENCE CODING AND SEARCH SYSTEM (SCSS) AND NUCLEAR PLANT RELIABILITY DATA SYSTEM (NPRDS)**
 - **RELIABILITY DATA**

ACCIDENT SEQUENCE PRECURSOR PROGRAM

- **DETERMINE CONDITIONAL PROBABILITY OF SUBSEQUENT SEVERE CORE DAMAGE — CONDITIONAL CORE DAMAGE PROBABILITY (CCDP) — GIVEN THE FAILURES DURING AN OPERATIONAL EVENT**

OBJECTIVES OF THE ASP PROGRAM

- **IDENTIFY AND RANK RISK SIGNIFICANCE OF OPERATIONAL EVENTS**
- **DETERMINE GENERIC IMPLICATIONS OF AN OPERATIONAL EVENT/CHARACTERIZE RISK INSIGHTS**
- **PROVIDE SUPPLEMENTAL INFORMATION ON PLANT-SPECIFIC PERFORMANCE**
- **PROVIDE A CHECK WITH PRAS**
- **PROVIDE AN EMPIRICAL INDICATION OF INDUSTRY RISK AND ASSOCIATED TRENDS**

DEFINITIONS

- **ACCIDENT SEQUENCE PRECURSORS - EVENTS OR CONDITIONS THAT ARE IMPORTANT ELEMENTS IN THE SEVERE CORE DAMAGE SEQUENCES (e.g., AN UNUSUAL INITIATING EVENT OR FAILURES OF MULTIPLE COMPONENTS THAT, WHEN COUPLED WITH ONE OR MORE POSTULATED EVENTS, COULD RESULT IN A PLANT CONDITION LEADING TO SEVERE CORE DAMAGE)**
- **CONTAINMENT-RELATED EVENTS - FAILURES THAT COULD RESULT IN REDUCED CONTAINMENT PERFORMANCE (e.g., UNAVAILABILITY OF A CONTAINMENT FUNCTION SUCH AS CONTAINMENT ISOLATION, CONTAINMENT COOLING, CONTAINMENT SPRAY, OR POST-ACCIDENT HYDROGEN CONTROL).**

1994 AT-POWER PRECURSORS INVOLVING UNAVAILABILITIES

<u>PLANT</u>	<u>CCDP</u>	<u>DESCRIPTION</u>
HADDAM NECK	1.4×10^{-4}	POWER-OPERATED RELIEF VALVES AND VITAL 480-V AC BUS DEGRADED
ZION 2	2.3×10^{-5}	UNAVAILABILITY OF TURBINE-DRIVEN AUXILIARY FEEDWATER PUMP AND EMERGENCY DIESEL-GENERATOR
POINT BEACH 1 & 2	1.2×10^{-5}	BOTH DIESEL-GENERATORS UNAVAILABLE
DRESDEN 2	6.1×10^{-6}	MOTOR CONTROL CENTER TRIPS DUE TO IMPROPER BREAKER SETTINGS
DRESDEN 2	3.1×10^{-6}	LONG-TERM UNAVAILABILITY OF HIGH PRESSURE COOLANT INJECTION
TURKEY POINT 3 & 4	1.8×10^{-6}	LOAD SEQUENCERS PERIODICALLY UNAVAILABLE

1994 AT-POWER PRECURSORS INVOLVING AN INITIATOR

<u>PLANT</u>	<u>CCDP</u>	<u>DESCRIPTION</u>
RIVER BEND	1.8×10^{-5}	SCRAM, MAIN TURBINE-GENERATOR FAILS TO TRIP, REACTOR CORE ISOLATION COOLING AND CONTROL ROD DRIVE SYSTEMS UNAVAILABLE
CALVERT CLIFFS 2	1.3×10^{-5}	TRIP, LOSS OF 13.8 KV BUS, AND SHORT-TERM UNAVAILABILITY OF SALTWATER COOLING SYSTEM

1994 SHUTDOWN PRECURSORS INVOLVING AN INITIATOR

<u>PLANT</u>	<u>CCDP</u>	<u>DESCRIPTION</u>
WOLF CREEK	3.0×10^{-3}	REACTOR COOLANT SYSTEM BLOWS DOWN TO REFUELING WATER STORAGE TANK DURING HOT SHUTDOWN

COMMON-CAUSE FAILURE DATABASE INSIGHTS

- **ESTIMATED CCF PARAMETERS FOR OVER 40 COMBINATIONS OF RISK-IMPORTANT SYSTEMS AND COMPONENTS USING DATA FROM 1980 THROUGH 1993.**
- **BETA FACTORS DO NOT GENERALLY EQUAL 0.1.**
- **BETA FACTORS FOR SIMILAR COMPONENTS VARY AMONG SYSTEMS AND FAILURE MODES.**
- **CCF SUMMARY REPORTS CONTAINING CCF PARAMETER ESTIMATES FOR USE IN PRAS AND RISK STUDIES**
- **MAIN CAUSES OF FAILURE ARE INTERNAL TO THE COMPONENT (50%), DESIGN AND CONSTRUCTION (17%), AND HUMAN-RELATED (11%)**

BETA FACTORS FOR MOTOR-OPERATED VALVES

SYSTEM	FAIL TO OPEN	FAIL TO CLOSE
BWR ISOLATION CONDENSER	1.1E-3	1.3E-3
BWR RESIDUAL HEAT REMOVAL	1.9E-2	2.8E-2
PWR HIGH PRESSURE INJECTION	5.0E-2	1.4E-2
PWR LOW PRESSURE INJECTION	6.1E-3	2.3E-3
PWR AUXILIARY FEEDWATER	2.7E-2	9.1E-3

SYSTEM RELIABILITY STUDIES

PURPOSE:

**TO EVALUATE RELIABILITY AND PROVIDE INSIGHTS OF RISK
IMPORTANT SYSTEMS BASED ON OPERATING EXPERIENCE**

OBJECTIVE:

- **USE ACTUAL DEMANDS, FAILURES AND
UNAVAILABILITIES TO ESTIMATE RELIABILITY**
- **ANALYZE TRENDS IN RELIABILITY**
- **QUANTIFY UNCERTAINTIES**
- **COMPARE WITH PRA/IPE VALUES**
- **IDENTIFY PLANT SPECIFIC DIFFERENCES**
- **PROVIDE ENGINEERING INSIGHTS**

STUDIES BEING CONDUCTED

- **BOILING WATER REACTOR (BWR) SYSTEMS**
 - **HIGH PRESSURE COOLANT INJECTION (HPCI)**
 - **REACTOR CORE ISOLATION COOLING (RCIC)**
 - **HIGH PRESSURE CORE SPRAY (HPCS)**
 - **ISOLATION CONDENSER (IC)**

- **PRESSURIZED WATER REACTOR (PWR) SYSTEMS**
 - **AUXILIARY FEEDWATER (AFW)**
 - **HIGH PRESSURE SAFETY INJECTION (HPSI)**

- **BWR AND PWR LOW PRESSURE INJECTION SYSTEMS**

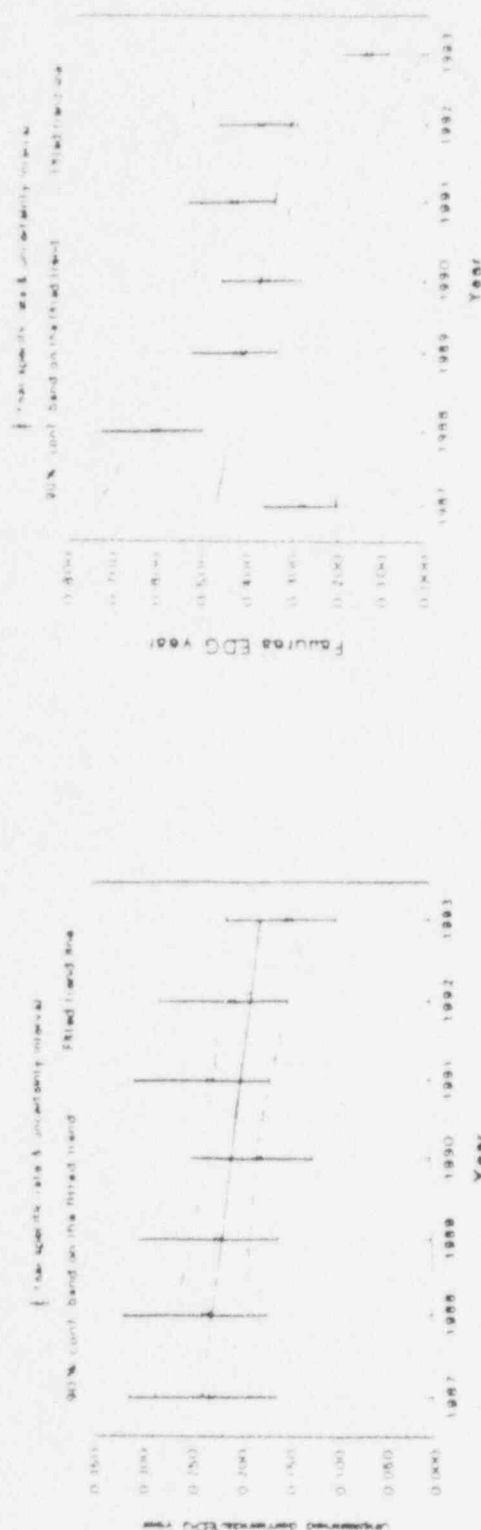
- **BWR AND PWR REACTOR TRIP SYSTEMS (RPS)**

- **EMERGENCY DIESEL GENERATORS (EDGs)**

METHODOLOGY OVERVIEW

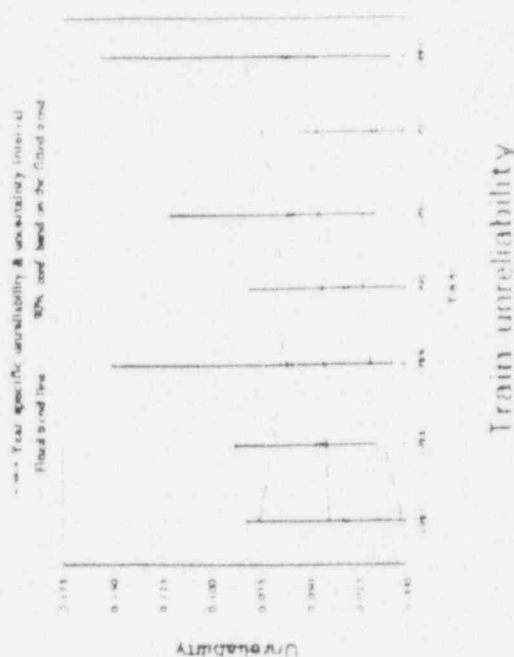
- **STANDARDIZED AND SYSTEMATIC STUDY PROCEDURE**
- **DETAILED EVALUATION OF EVENTS USING RISK ANALYSIS METHODS AND MODELS**
- **RIGOROUS MATHEMATICAL TREATMENT OF RELIABILITY AND AVAILABILITY DATA, INCLUDING UNCERTAINTIES**
- **DETAILED ANALYSIS OF RESULTS, INCLUDING INDEPENDENT PEER REVIEW**

EDG TRAIN TRENDS

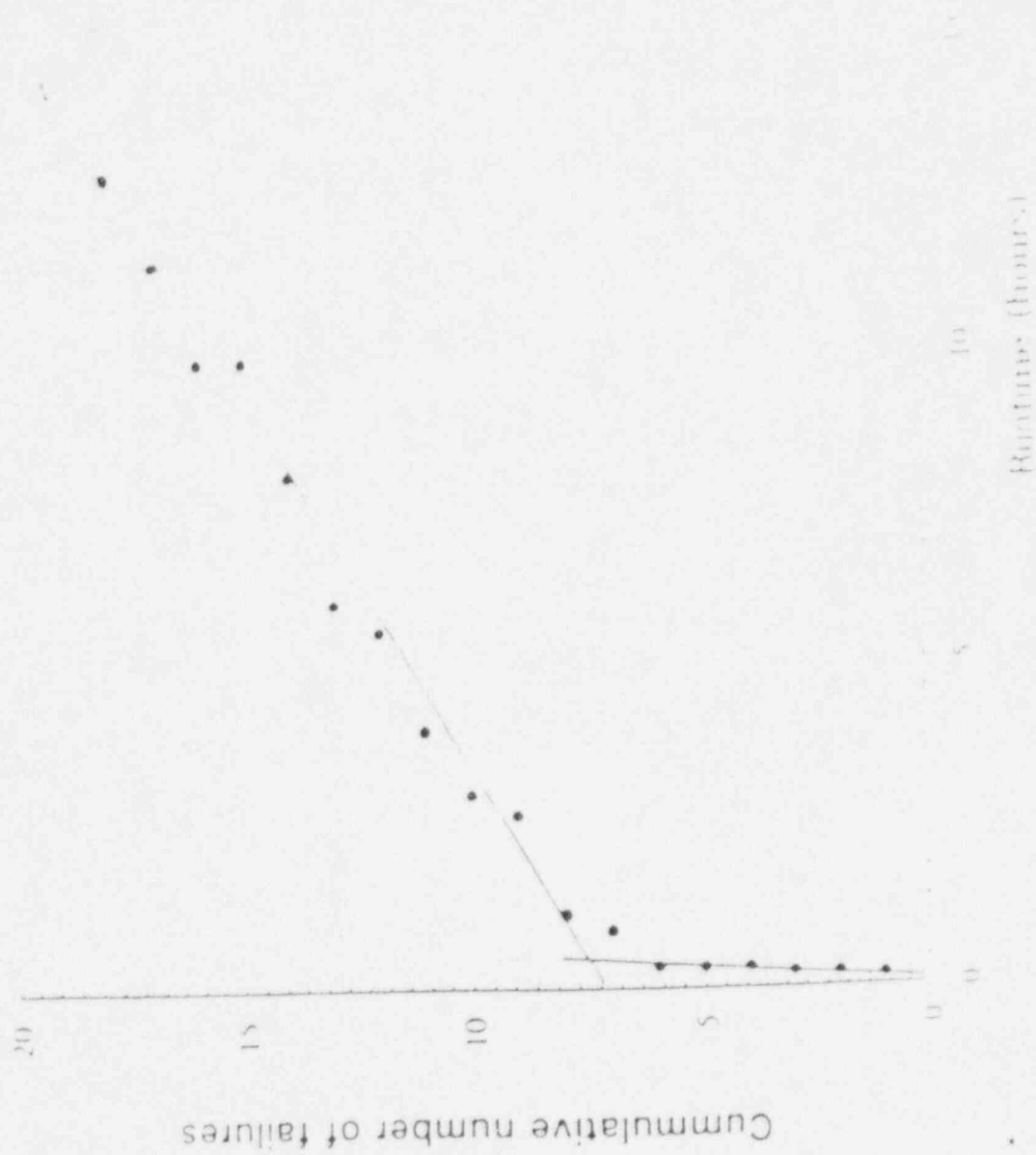


Train unplanned demand rate

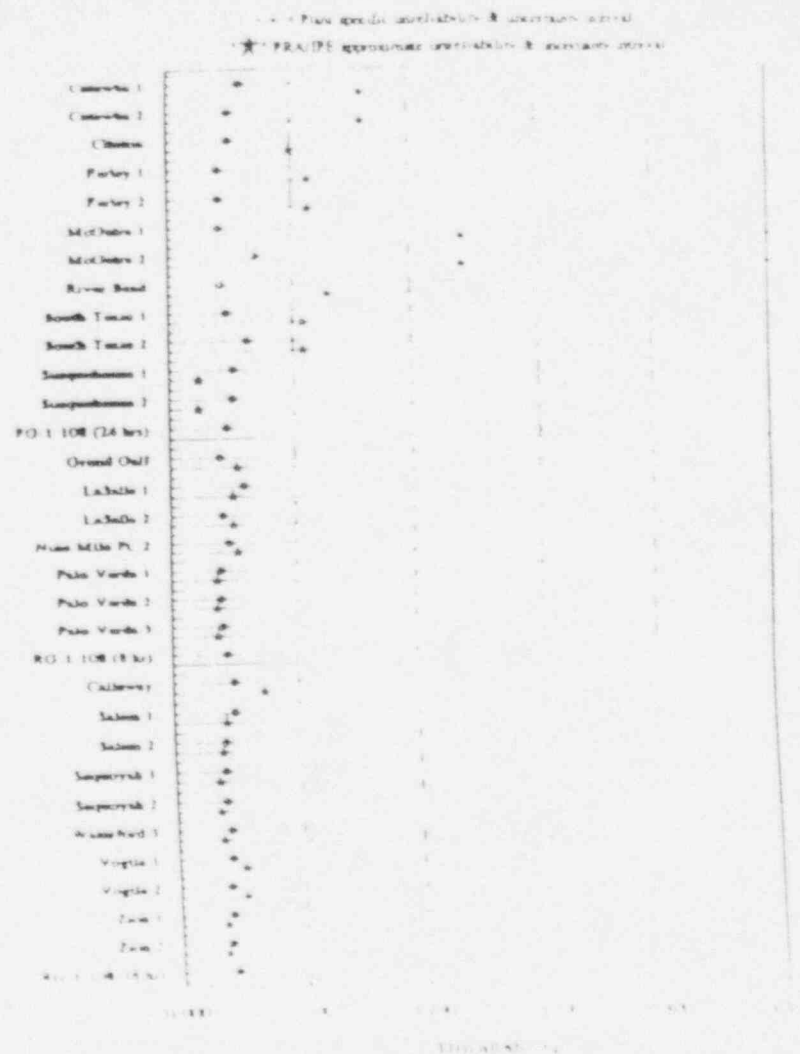
Train failure rate



EDG FAILURE-TO-RUN TREND



EDG UNRELIABILITY COMPARISONS ACTUAL EXPERIENCE VERSUS PRA/IPE VALUES



EDG INSIGHTS

- **NO DISCERNIBLE TREND IN RELIABILITY**
- **FAILURE RATE AND UNPLANNED DEMAND RATE BOTH DECREASING**
- **HIGHER FAILURE RATES FOR PLANTS LICENSED FROM 1980 TO 1990**
- **THREE DISTINCT FAILURE-TO-RUN RATES**
- **GENERAL AGREEMENT WITH PRAs AND IPEs**
- **FAILURE DIFFERENCES BETWEEN ACTUAL DEMANDS AND ROUTINE SURVEILLANCE OR INSPECTIONS**
- **ACTUAL DEMAND FAILURES-TO-START NOT EASILY RECOVERABLE**

EDG INSIGHTS (CONTINUED)

- **NO COMMON-CAUSE FAILURES OF MULTIPLE DIESELS OBSERVED DURING ACTUAL UNPLANNED DEMANDS**
- **DEMAND RELIABILITY CONSISTENT WITH STATION BLACKOUT RULE**
- **MAINTENANCE OUT OF SERVICE (MOOS) MUCH HIGHER THAN EARLIER DATA USED IN STATION BLACKOUT RULE**
- **MOOS SIGNIFICANTLY HIGHER DURING SHUTDOWN THAN DURING OPERATION**