Template NRR-105

March 16, 2000

MEMORANDUM TO: Thomas L. King, Director
Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research

FROM: Mark Cunningham, Chief
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SUBJECT: TRIP REPORT FOR SITE VISIT TO WOLF CREEK NUCLEAR OPERATING CORPORATION

On July 27, 1999, Sandia and Brookhaven National Laboratories' staff visited the Wolf Creek Generating Station. The purpose of the visit was to collect information on methods and tools employed by the licensee to evaluate and manage low power and shutdown (LPSD) risk.

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Trip Report for Site Visit to Wolf Creek Generating Station

On July 27, 1999, NRC, Sandia National Laboratories (SNL) and Brookhaven National Laboratory (BLN) staff met with Wolf Creek Nuclear Operating Corporation personnel. The purpose of the visit was to collect information on methods and tools employed by the licensee to evaluate and manage low power and shutdown (LPSD) risk. The meeting took place at the Wolf Creek Generating Station. Attendees included:

- Doug Holderbaum, Wolf Creek
- Richard Flannigan, Wolf Creek
- John Stamn, Wolf Creek
- Vernon Luckert, Wolf Creek
- Bill Ketchum, Wolf Creek
- David Claridge, Wolf Creek
- David Alford, Wolf Creek
- John Stamn, Wolf Creek
- Jeff Julius, Scietech
- Ronald Fraas, Kansas Department of Health and Safety
- Erasmia Lois, Nuclear Regulatory Commission (NRC)
- Tsong-Lun Chu (Brookhaven National Laboratory [BNL]), and
- Donnie Whitehead (Sandia National Laboratories [SNL])

The meeting opened with introductions and a brief discussion of the purpose of the meeting. Wolf Creek personnel then discussed how LPSD risk is managed and controlled at Wolf Creek. As part of the discussion, NRC, SNL, and BNL staff asked questions to help clarify and/or confirm the information presented. This information is summarized in Attachment 1 (Completed LPSD Questionnaire from Site Visit: Wolf Creek). Also attached are the Agenda of the meeting (Attachment 2), and a presentation related to outage management that had been prepared by Wolf Creek personnel for a different occasion and which was also distributed during this meeting (Attachment 3).

The meeting was adjourned on July 27, at approximately 5:00 pm

ATTACHMENT 1

Completed LPSD Questionnaire from Site Visit: Wolf Creek

1. **How is LPSD risk controlled or managed at your facility?**

   Risk is managed by a combination of qualitative (defense-in-depth) and quantitative (Safety Monitor) tools. An outage schedule is developed, an independent assessment is preformed to identify SSCs for backup to key safety functions, to optimize safety system availability in the schedule, and to develop contingency plans to ensure desired defense-in-depth is maintained. Quantitative tools are then used to examine the schedule, and changes are made if necessary. Both quantitative and qualitative tools are used during the outage to track and monitor the plant's current state (i.e., risk) and to deal with emergent work if it becomes necessary. A post-outage assessment is performed to identify lessons learned from the outage. This information can then be used during the next outage schedule development process.

2. **What resources are allocated to controlling LPSD risk?**

   Controlling risk during an outage is an integral part of doing business at Wolf Creek involving a significant level of effort. Individuals from operations, scheduling, and the PRA group are all involved with the development and execution of the outage schedule.

Scope and Level of Detail Questions

1. **What is the scope of your LPSD analyses (e.g., transients, loss of coolant, fire, flood, seismic, planned outages, unplanned outages, plant operating state transitions, others)?**

   The Safety Monitor software is used to perform the quantitative analyses. Currently, loss of heat removal, loss of offsite power, and loss of inventory events are modeled for planned outages. The same initiating events are also modeled for the spent fuel pool. Fire, flood, and seismic events are not modeled, as well as unplanned outages. Safety Monitor does include transitions from power operation to shutdown states–a total of 14 POSs.

2. **What are the bases for your current decisions to include or exclude:**
   - **initiating events (e.g., loss of decay heat removal, loss of support system, fire, and flood),**

     Currently, there is no efficient method for focusing analyses that are spatially dependent (i.e., fire, flood, and seismic); thus these events are not analyzed. Reactivity insertion events (e.g., the French scenario) have been screened; however, additional research in this area could identify the need to include this type of event.

   - **operational states,**

     A spectrum of POS from power to refueling are modeled–14 POSs.

- **outage types (i.e., planned, unplanned, forced, unforced, etc.)**

  Planned outages are examined. Other outages are examined on an as-needed basis.

- **fuel pool cooling, fuel handling, and/or fuel misloading, and**

  Fuel pool cooling is examined. Fuel handling and fuel misloading are not examined. Fuel handling accidents would not be expected to exceed licensing limits. Fuel misloading could result in localized fuel damage, but would not lead to significant damage to the core; thus, it should not pose undue risk to the public.

- **transitions between operational states.**

  Transitions are included in the Safety Monitor model.

3. **Are there any scope issues that you believe should be included that are not now included in your analyses?**

   Not at this time.

4. **What additional research or guidance (if any) would be required before these issues could be efficiently addressed?**

   For fire, initiating event frequencies specific to shutdown conditions are needed, along with an approach to account for detection/suppression of fires during shutdown conditions (i.e., a significantly larger number of people on site during all hours of the day).

5. **What is the level of detail used in your analyses? Is it the same as or different from the level of detail used in your full power analyses?**

   Component level–the same as full power.

6. **How did (or how do) you decide what level of detail is appropriate?**

   Maintains the same level of detail as used in the full power analysis; thus, results can be compared more readily, and the models are easier to update since changes would be made only once (i.e., two model changes would not be required for any one change/update).

7. **Are there any instances where you think the level of detail currently used might prove inadequate? If so, where?**

   No. However, portions of systems not currently modeled may be added to make the analysis more realistic; thus, less conservative. Examples include: electrical configurations and cross-tie of AFW pumps. The models could also be expanded to capture additional system configurations. Again, with the goal of reducing conservatism.

8. **What guidance, if any, should be provided on the appropriate level of detail for an analysis?**

It will depend on the application (i.e., it is application specific). However, if the same level of detail is used for all applications, this would tend to reduce any modeling differences among applications; thus, putting all applications on a more level basis.

9. **How does your LPSD risk assessment scope meet the guidelines of NUMARC 91-06?**

The qualitative method follows 91-06 guidelines.

Methods and Assumptions Questions

1. **What are the basic methods and approaches (e.g., ORAM, EOOS, Safety Monitor, defense-in-depth, or probabilistic risk assessment) that are used to manage LPSD risk at you facility?**

The quantitative tool used is Safety Monitor. Worksheets are used to check for defense-in-depth.

2. **How or why do you choose methods and approaches for use in a particular analysis?**

Safety Monitor – Speed and flexibility of its computational capabilities.

3. **What are the strengths and weaknesses (if any) of the methods and approaches that you use?**

Qualitative: **Strengths**

Simple process
A lot of personnel know how to use it
Yields conservative results

Weaknesses

Conservative results
Restricts flexibility because of conservative process

Quantitative: **Strengths**

Level of detail comparable to full power
Full model can be quantification in a short time
Simpler to maintain one model

Weaknesses

Models rather complex–must know what each change affects to update
Lack of guidance on what is an acceptable update frequency
Unknown cost-benefit ratio for model update

4. **If there are any weaknesses, can these weaknesses be minimized by additional research? If so, what additional research would you suggest?**

No for both qualitative and quantitative approaches.

5. **What are the major assumptions (e.g., development of success criteria, human performance, and appropriate data sources) used in your analyses?**

   See next question.

6. **What are the bases for these assumptions?**

   Data: Uses NUREG/CR-6144 for initiating event frequency, NSAC 161 and IPE for other data.

   Human Performance: Uses THERP, EPRI's CBDTM (cognitive) and HCR/ORE (time dependent) for various human actions.

   Success Criteria: Uses WCAP report on steam cooling (reflux cooling) and the EOPs (differences in elevation) for gravity feed.

7. **What method(s) do you use to identify and quantify potential human errors?**

   Identification: Look at procedures. For Type A (per-initiator) ruled them out. For Type B (causing initiating event) added contribution to LOCA, loss of RHR, and loss of offsite power using plant-specific and generic data.

   Quantification: Used methods described in response to above question.

8. **Do theses methods have any limitations that you would like to see corrected? If so, what are they?**

   Yes. Identification and analysis of errors of commission. HEP estimates for actions where the operators have a long time frame in which the action can be performed. In addition, need new data for repair and/or replacement of components for the longer time frames.

9. **For the data included in your analyses (e.g., initiating events, equipment failure rates, and maintenance unavailabilities) what are your sources and how do you analyze the information?**

   Generic data comes from NUREG/CR-6144. Other data is plant-specific. Maintenance unavailabilities are either zero or one (TRUE) per the outage schedule.

   A qualitative decision is made as to whether the data is applicable to the plant and plant state.

10. **As a result of your data analysis, are there any specific data needs that you have identified? If so, what are they?**

    Yes.

    Better, more up-to-date information on the probability of repair and/or recovery of failed equipment versus time is needed. Better (or approved) methods for estimating HEPs for long time frames.

Need update for initiating event frequencies involving RHR (i.e., shutdown cooling).

Does use of generic initiating event frequencies mask risk for a specific plant, and if so, what, if anything, can be done about it?

11. **Based on your current LPSD analyses, are there any areas that require additional research (e.g., boron dilution, maintenance or testing induced drain-down events, nuclear grade crane failures, impact of the definition of "Success Terms" on the selection of computational tools, fire and flood initiators, cold overpressurization, and impact of plant procedures (both emergency and administrative) on LPSD modeling assumptions)?**

No. For example, procedures should be valid and plant personnel are trained on their use and crane failures are outage specific with no assurance that any research work would be cost beneficial.

LPSD Risk Analysis Results Questions

1. **What are the results from your LPSD analyses?**

Pre-outage CDF estimate was 2.16E-5 per year. Actual cumulative CDF was 2.28E-5 per year.

2. **What core damage frequency and release metrics do you use?**

CDF: cumulative and instantaneous
Boiling: risk and time to
Release: no quantitative measure used; however, did use a qualitative measure (containment status)

3. **Why do you think these are the appropriate metrics to use?**

CDF is the logical measure since it can be compared with the full power measure.

Boiling is or can be a precursor to CDF.

It is more appropriate to track containment status because you can close it before boiling, core damage, etc.

4. **If you do not currently use a release metric (e.g., large early release frequency), what is your bases for not doing so?**

No recognized metric exist. Additional research would be needed to understand the source term from accidents occurring during shutdown conditions. Furthermore, LERF does not have the same meaning as in full power. The response time to put a plan in place is greater for most shutdown accidents than it is for full power accidents. There are many more resources available at the plant to respond to an event due to the nature of the outage work.

5. **What characteristics should a release metric possess to be useful in LPSD analyses?**

Time to closure of the containment versus time to boil or time to uncovery of the fuel.

6. **Are there other metrics that should be considered for LPSD analyses? If so, what are they?**

   No.

Structure and Format of LPSD Standard Questions

1. **Is a LPSD Standard needed? Please explain your answer.**

   Unsure whether a standard is needed. The answer depend on one or more of the following:
   - Not sure that any benefit has been achieved with the current (full power) process.
   - Need to wait until full power standard is developed.
   - If no standard is developed, then at least a product describing what are the minimal accepted requirements.
   - If no standard developed, then a defacto standard will ensue from previous submittals.
   - It would depend on the application and should consider the different tools and methodologies currently used in industry.

2. **If a LPSD Standard is needed:**
   - **what should be its scope and structure,**

     No response. See answer to previous question.

   - **what are the appropriate risk metrics, and**

     No response.

   - **should it endorse any specific methods or techniques for analyzing LPSD risk?**

     No response.

ATTACHMENT 2

Low Power and Shutdown Risk

Meeting with NRC and National Laboratories

Wolf Creek
Nuclear Operating Corporation
July 27, 1999

Agenda

- **Welcome and Opening Remarks**
- **Introduction of Attendees**
- **PSA History and Tool Development**
- **Outage Risk Presentation**
  - Overall Outage Risk Management Program
  - Pre-outage Results
  - Actual Results
  - Comparison of Qualitative and Quantitative Methods
  - Shutdown Safety Monitor Details
- **Open Discussion**

ATTACHMENT 3

Outage Risk Assessment

Wolf Creek
Nuclear Operating Corporation
May 11, 1999

Station Risk Overview

- **AP 22C-003 Operational Risk Assessment Program**

- **AP 22B-001 Outage Risk Management**

  Risk Condition 1 -- Normal

  Primary and back-up means available

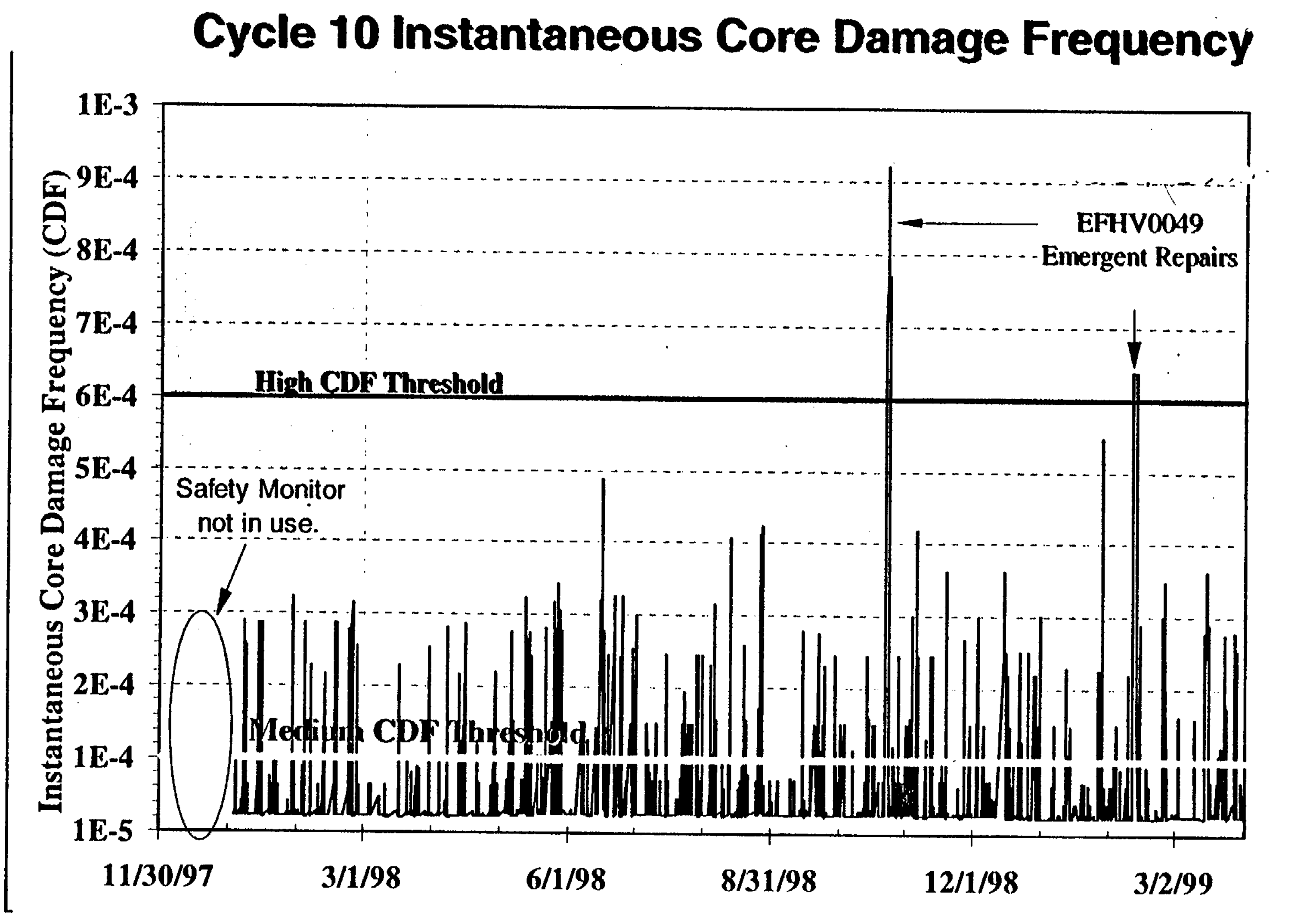
  Risk Condition 2 -- Moderate

  Reduction in equipment for safety function

  Risk Condition 3 -- High

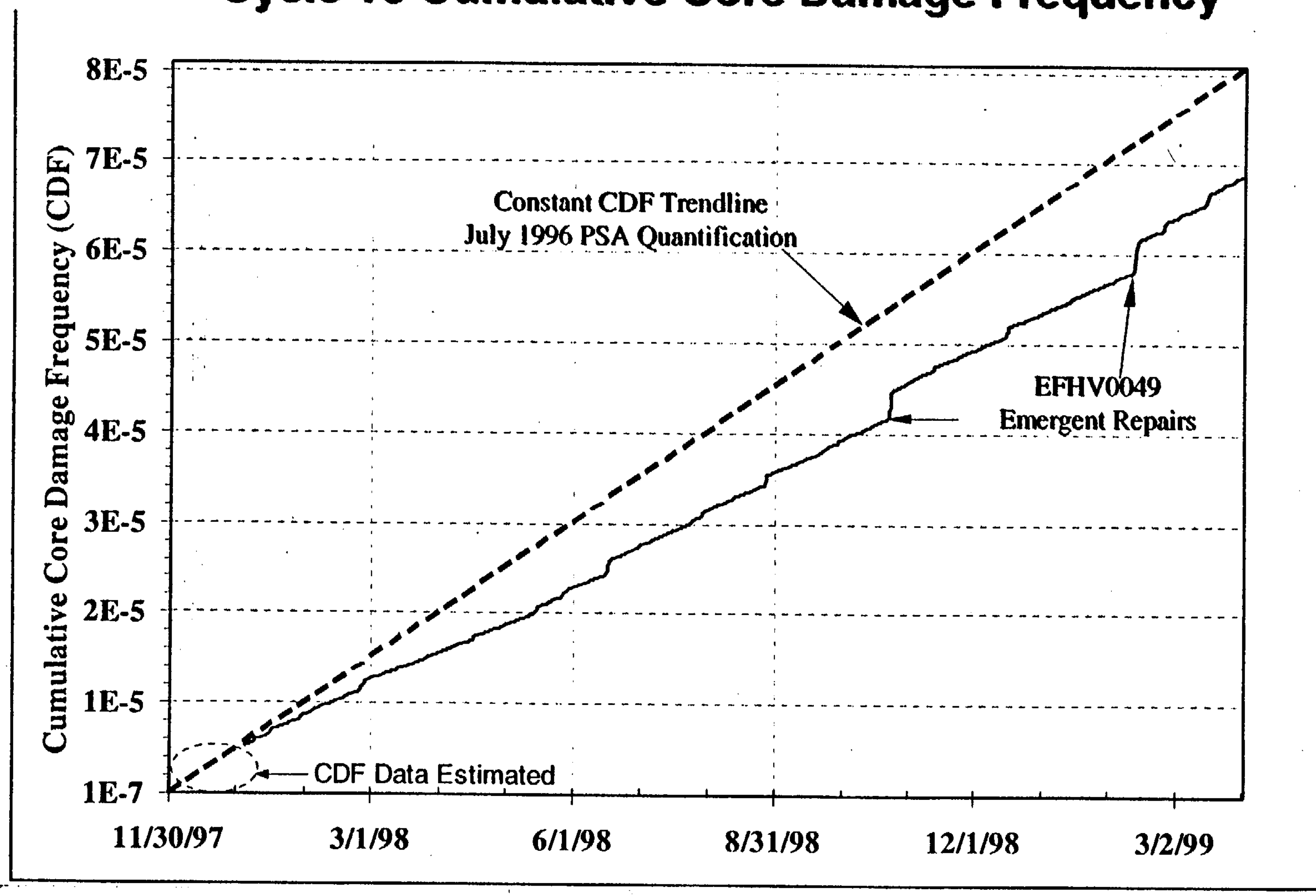
  Only primary **<u>or</u>** back-up available for safety function

Safety Monitor Risk Profile



Safety Monitor Risk Profile

Cycle 10 Cumulative Core Damage Frequency



Outage Risk Management

"All outage activities shall be conducted in a manner to ensure that the safety of the nuclear fuel is not compromised."

Higher Risk Evolutions

- **Reflects outage activities, plant configurations or conditions where the margin of safety is significantly reduced for a shutdown safety function.**

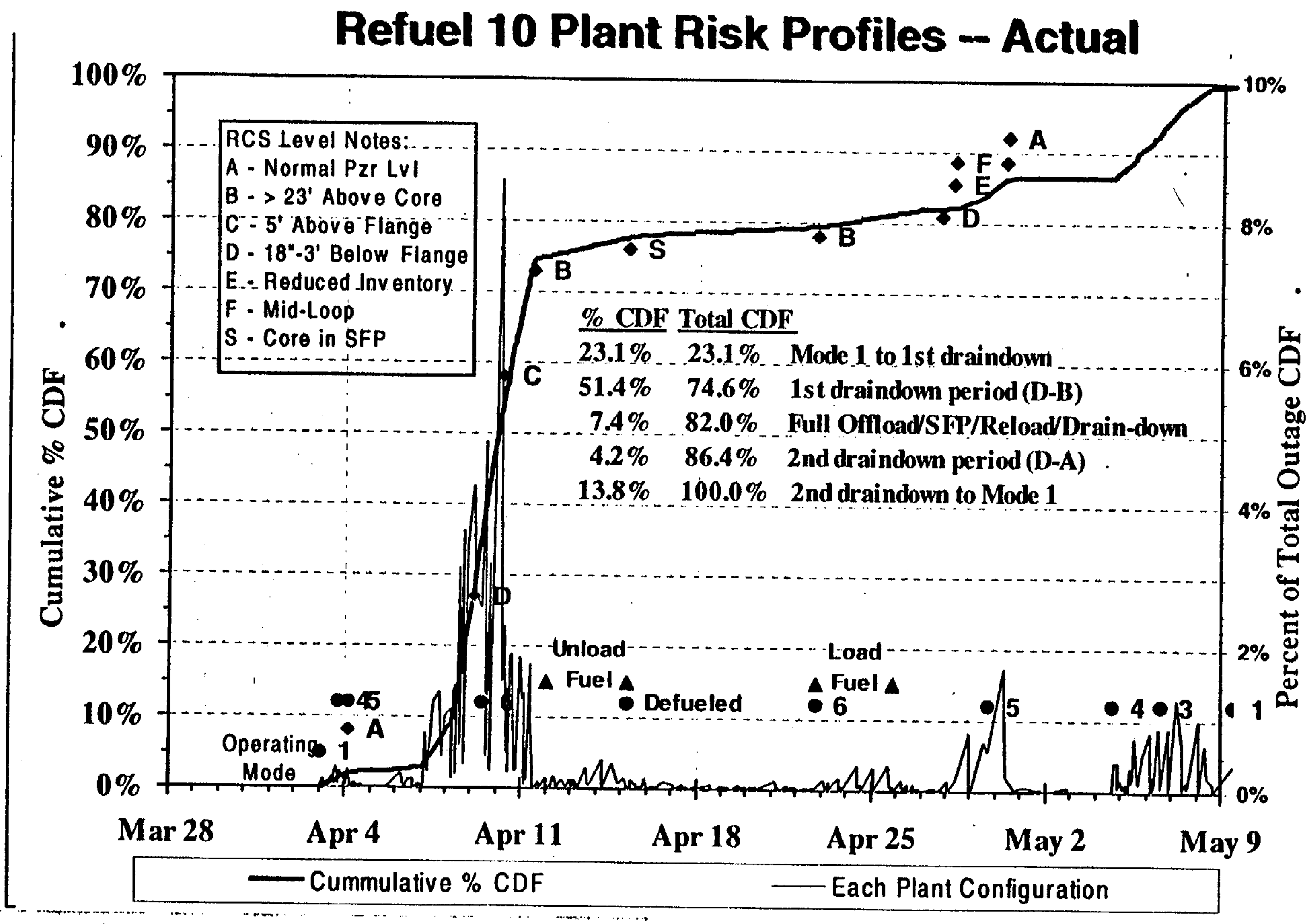
Focus on Defense-in-Depth

Independent Assessment

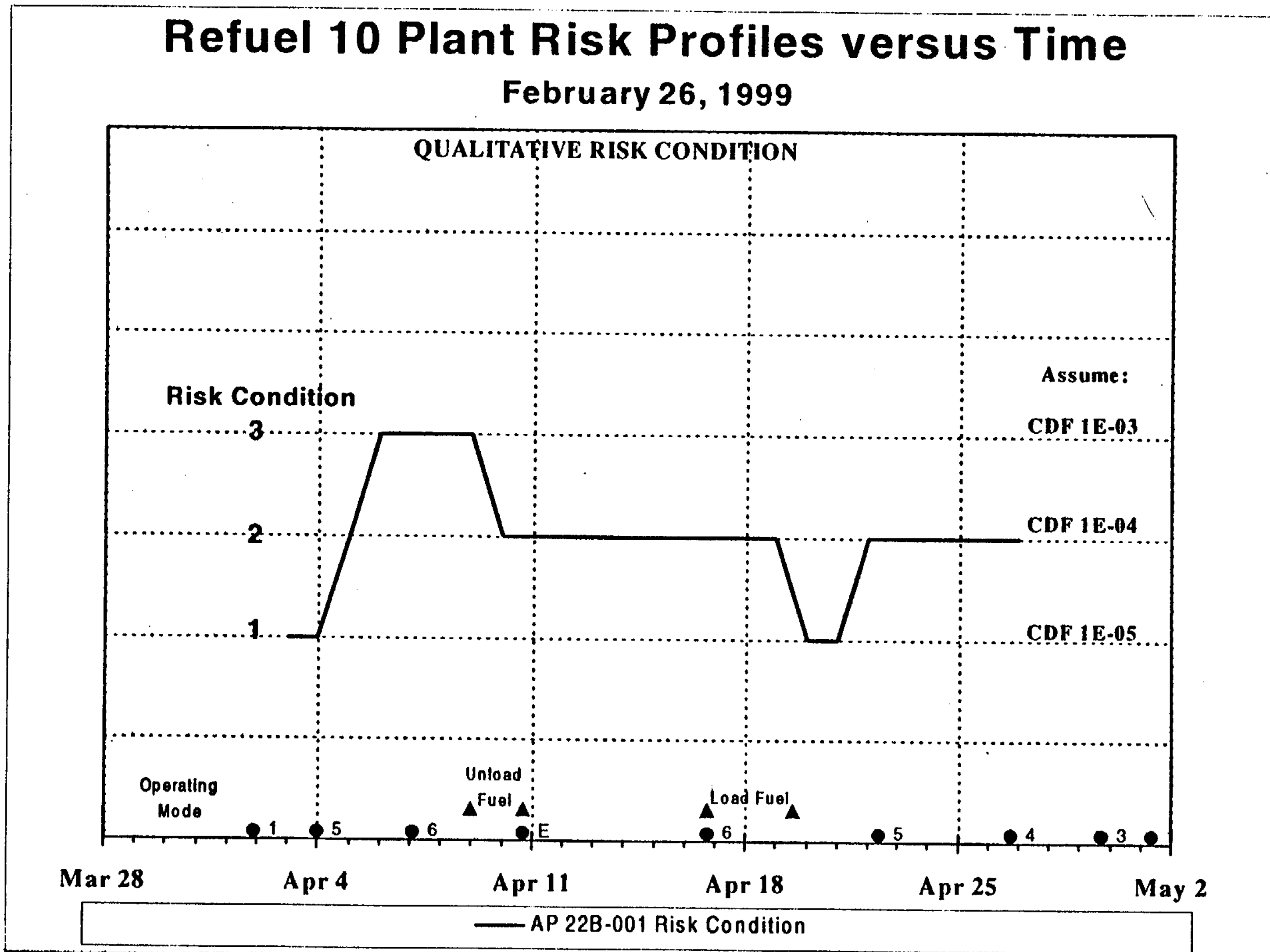
Risk Assessment Team Review Guidelines

- SSCs for Back-up to key safety functions
- Back-up Safety Functions by redundant, alternate or diverse SSCs
- Schedule to optimize safety system availability
- Contingency plans for desired defense-in-depth level

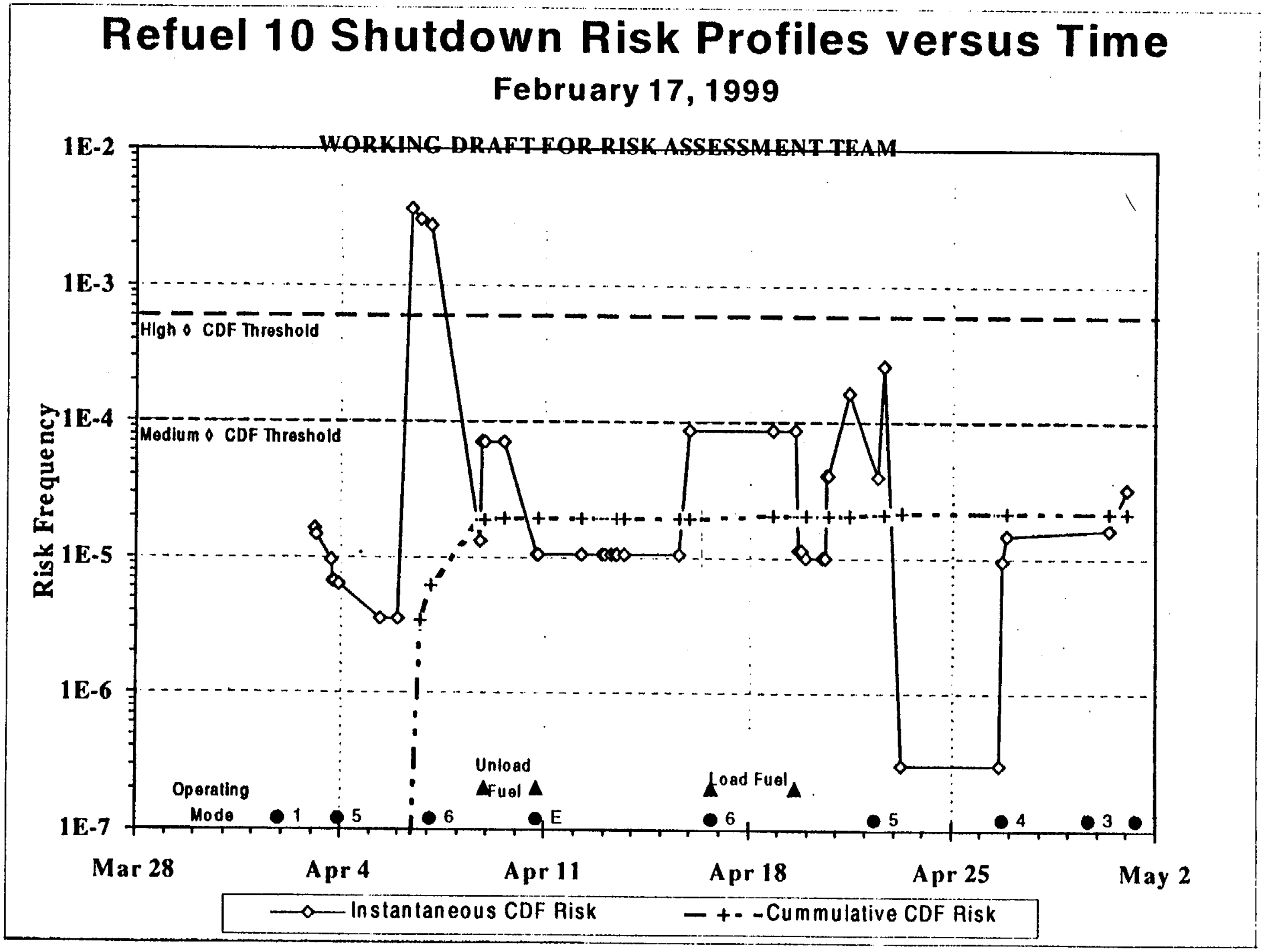
Outage CDF in Percentages



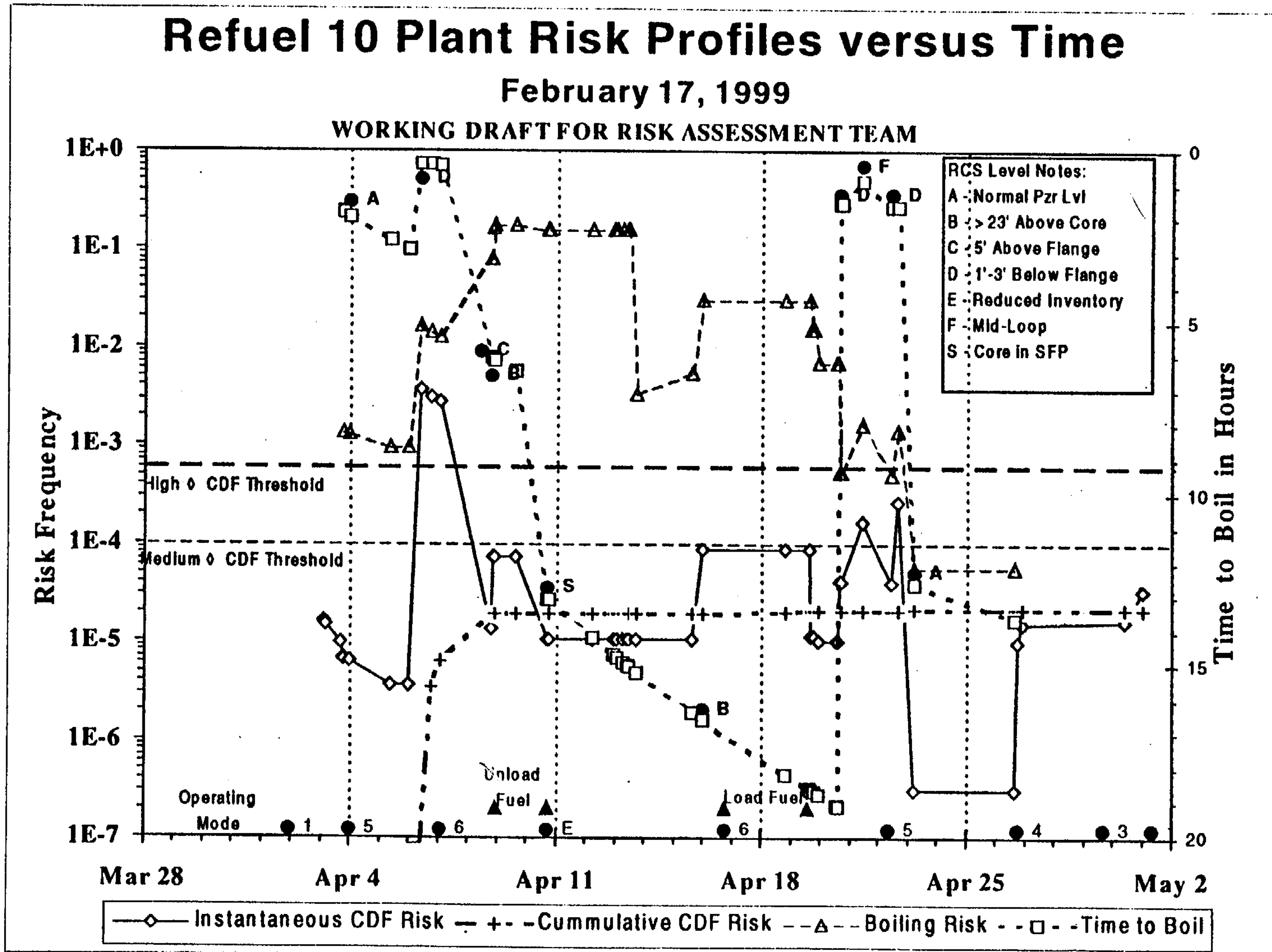
Qualitative Risk Condition



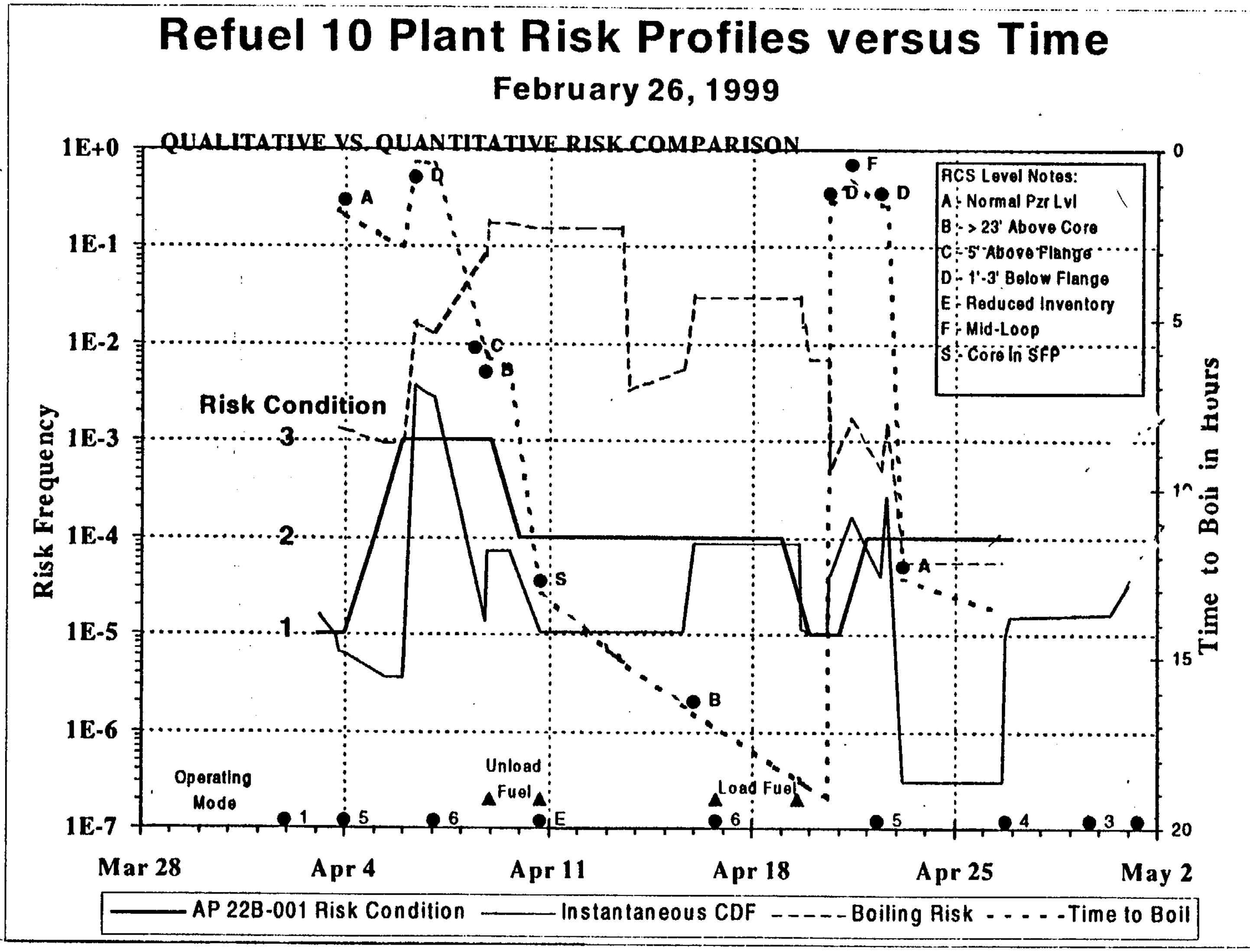
Shutdown Core Damage Risk



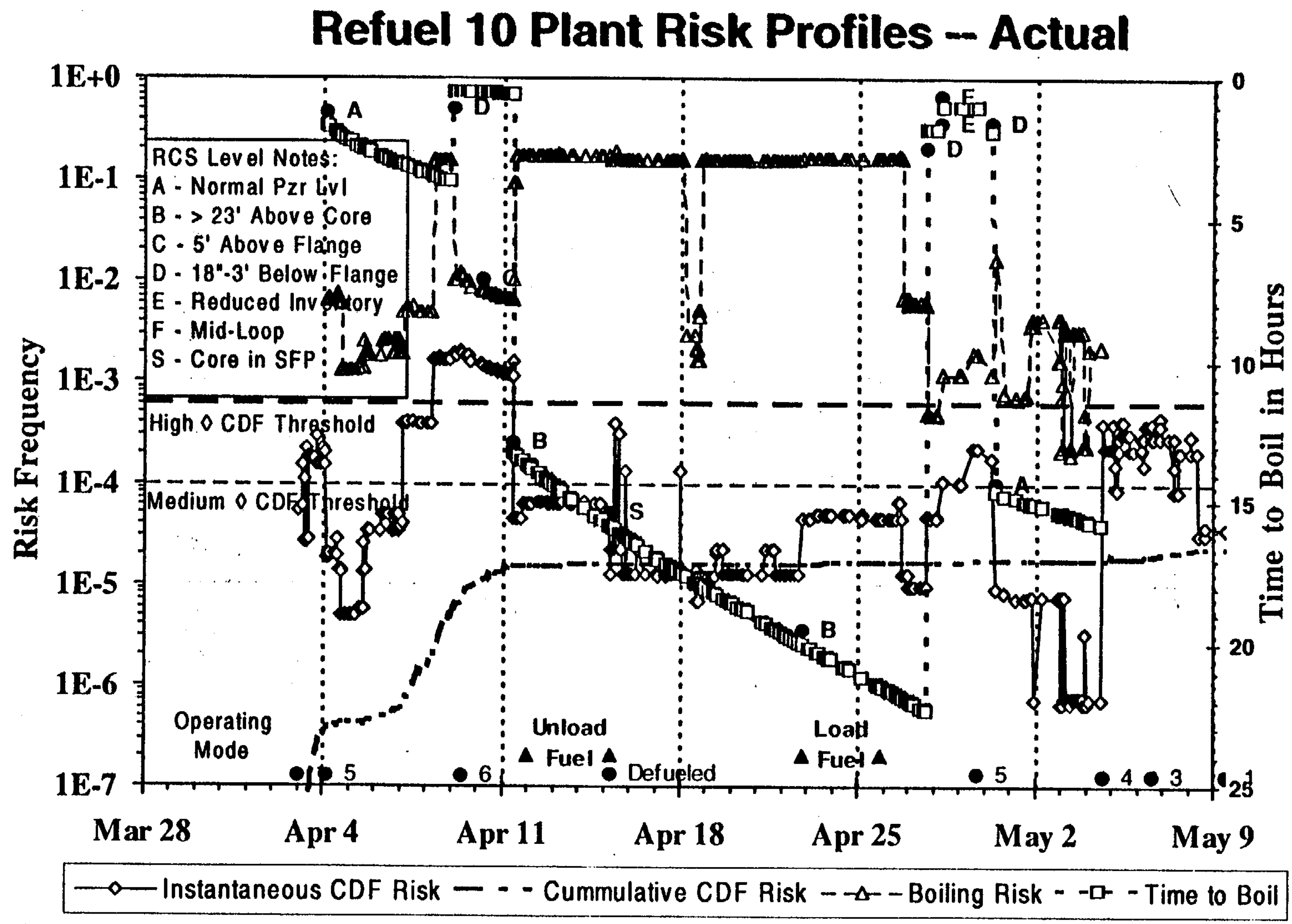
CDF and Boiling Risk Measures



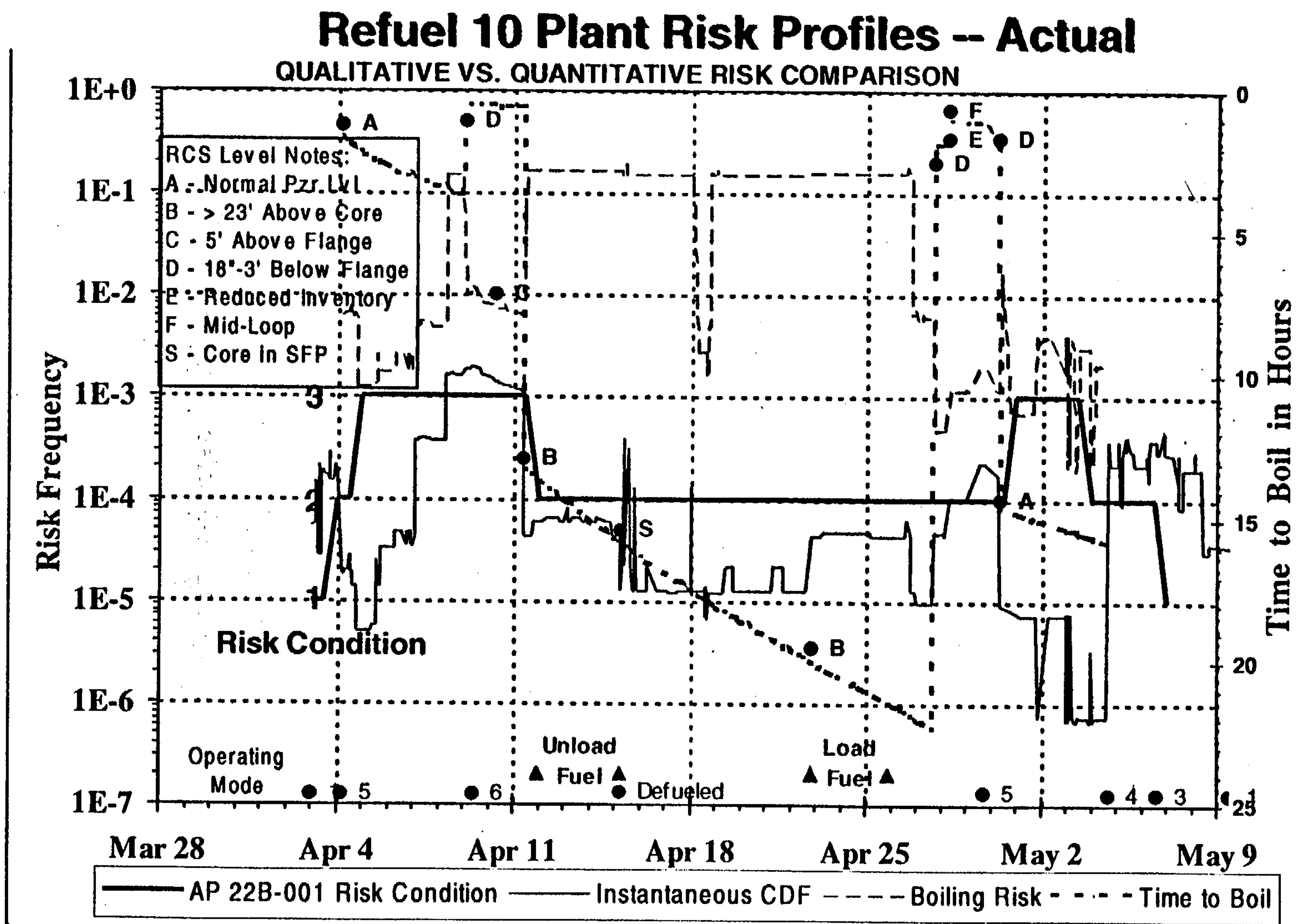
Risk Assessment Check



CDF and Boiling Risk Measures



Risk Method Comparison



Summary

- Shutdown risk assessed by two methods
  - Provide similar end results
  - Methods are complimentary
- Qualitative risk assessment by procedure is generally more conservative
- Outage risk is being effectively managed
- With experience, quantitative risk reductions may be proposed for entire operating cycle

Safety Monitor

- Total Plant Operation divided into 14 separate Plant Operating States (POS)

- Plant Operating States are defined by:
  - Plant Operating Mode
  - RCS Level
  - Presence of an RCS vent

Plant Operating States (POS)

Operating Mode	# of POSs
1 - Power	1
2 - Startup	1
3 - Hot Shutdown	1
4 - Hot Standby	1
5 - Cold Shutdown	6
6 - Refuel	4

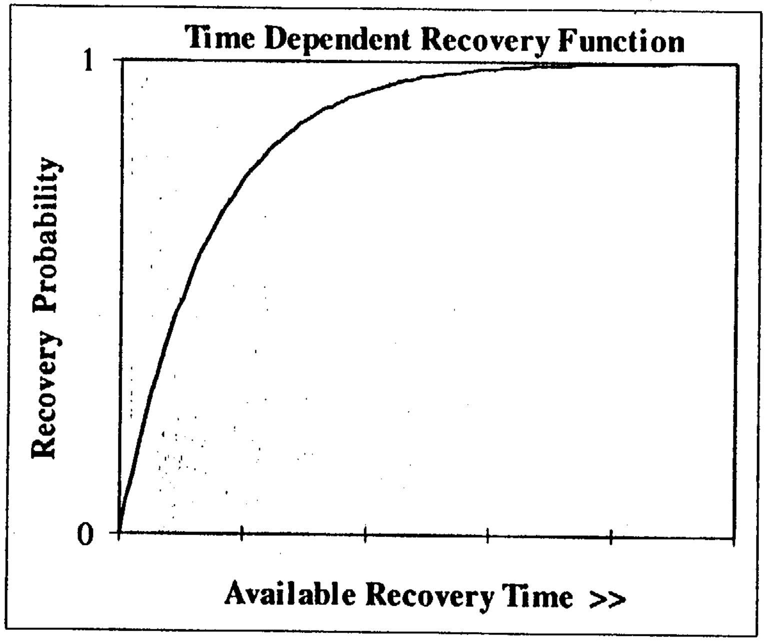
Mode 5 POSs

ID	RCS Water Level	RCS
5CSP	Normal Pressurizer Water Level	---
5CSS	Pressurizer Solid	---
5FLN	One (1) Foot Below Vessel Flange	Not Vented
5FLV	One (1) Foot Below Vessel Flange	Vented
5MIN	Mid-Loop Level	Not Vented
5MIV	Mid-Loop Level	Vented

Mode 6 POSs

ID	RCS Level & Core Location	RCS Vented?
6 FLV	One (1) Foot Below Vessel Flange	Vented or Vessel Head Off
6MIV	Mid-Loop Level	Vented or Vessel Head Off
6BAS	Refueling Basin Full; Core in Containment <u>or</u> Spent Fuel Pool	Vented or Vessel Head Off
6FPE	Core is Off-Loaded to the Spent Fuel Pool	NA

Time-Based Recovery Factors



- **Probability of Restoring a Failed System or Function Increases with Available Recovery Time**

- **Available Recovery Time =**
  Time to Boiling <u>OR</u> Time to Core Uncovery
- **Calculation based on RCS Inventory and Decay Heat Level**

Shutdown PSA Model Changes

Mode 5/6 POSs - Added Initiating Events

- Loss of Operating RHR Train
- Loss of Both RHR Trains

- Loss of Operating SFP Cooling Train
- Loss of Both SFP Cooling Trains

Shutdown PSA Model Changes

Configuration Options Included:

- Disable SI Signal - Modes 3-6
- Racking out Breakers on SI Pumps and CCPs
- Isolate ESW to suction side of AFW Pumps
- RHR System to be in ***Injection*** or ***Shutdown Cooling*** alignment
- Various Electrical Power lineups
- Spent Fuel Pool cooling system ***Normal*** and ***Refueling Pool*** cleanup alignment

Shutdown PSA Model Changes

Functions Added:

- RHR Suction alignment for Shutdown Cooling function
- Spent Fuel Pool Fault Tree
  - Cooling function
  - Makeup function
- RWST Gravity Drain function

Independent Assessment

Defense-in-Depth Objectives

- Technical Specification compliance
- Primary/back-up capabilities of safety function
- Maximize systems availability
- Unacceptable reductions due to single failures
- Recommendations to preserve or improve shutdown safety functions

Recommendations

Letter OM 99-0011

- **Power Supplies**
  - NB01, PA, Station batteries, Switchyard work
- **Containment Ventilation and Closure**
  - To support open hatch and steam generator work
- **Surveillances**
  - Align w/ system availability
- **Verify boric Acid flow-path**