Operational Reactor Safety

22.091/22.903

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Integration of Safety Analysis into Operational Requirements

Lecture 13

How is Nuclear Plant Safety Managed?

- There is a close link between:
  - Core Design
  - Plant Design
  - Safety Analysis
  - NRC Requirements
  - Operating Requirements
  - Organizational Structure
  - Management
  - Safety Culture

Plant Design to Licensing to Operations

- Vendor proposes reactor plant design
- Vendor performs core and plant design analysis demonstrating power and safety
- Vendor summarizes all analyses in a Safety Analysis report which demonstrates compliance to NRC regulatory requirements – 10 CFR Part 50.
- Utility submits Safety Analysis and Environmental Report to NRC for review and acceptance.
- Possible adjudicatory licensing hearings before the Atomic Safety and Licensing Board

NRC Regulations - Examples

- 10 CFR Parts

http://www.nrc.gov/reading-rm/doc-collections/cfr/

- 10 CFR Part 50

http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/

Chapter 15 Accident Analyses

- Based on Requirements of 10CFR Part 50 and all appendices – Appendix K – LOCA
- Includes:
  - Normal Operation and Operational Transients
    - Loss of feedwater
  - Infrequent Faults
    - Small pipe breaks
  - Limiting Faults
    - Loss of Coolant Accidents

Contents of Safety Analysis Report

- General Description
- Site Characteristics
- Design Criteria SSC
- Reactor Design
- Reactor Coolant Sys.
- Engineered Safety Features.
- Instrumentation & Controls
- Electric Power
- Auxiliary Systems
- Steam & Power Conversion System
- Radioactive Waste Management
- Radiation Protection
- Conduct of Operations
- Initial Tests and Operations
- Accident Analyses
- Technical Specifications
- Quality Assurance

Roughly 15 - 3 inch thick Notebooks

Design Basis Accidents

- Overcooling – increase in secondary side heat removal – steam line break – Pressurized thermal shock
- Undercooling –decrease in above
- Overfilling – reactor water
- Loss of flow
- Loss of cooling – LOCA (large and small) STGR
- Reactivity – rod ejection, power anomalies
- Anticipated Transients Without Scram (ATWS)
- External events – tornadoes, earthquakes, floods, etc.

- Beyond Design Basis – Class 9 > leading to meltdown

NRC Requirements

- Deterministic and prescriptive as to how to analyze accidents and allowed assumptions.
- NRC reviews and licenses computer codes used in analysis.
- The results of the analyses identify operational limits, limiting conditions for operation, test and surveillance requirements - all of which are contained in the Technical Specifications

Key NRC Appendices to 10 CFR 50

- A – General Design Criteria
- B – Quality Assurance
- G – RV Fracture Toughness Requirements
- H – Reactor Vessel Surveillance Requiremts
- I – Allowed release limits from plant
- J – Containment leak rate testing
- K – ECCS rule
- R – Fire Protection

Other Requirements on Licenses

- Generic Letters
- Bulletins and Orders
- Information Notices
- Maintaining Plant Design Basis current
- Confirmatory Action Letters
- Commitments made in response to the above

Design Basis – Licensing Basis

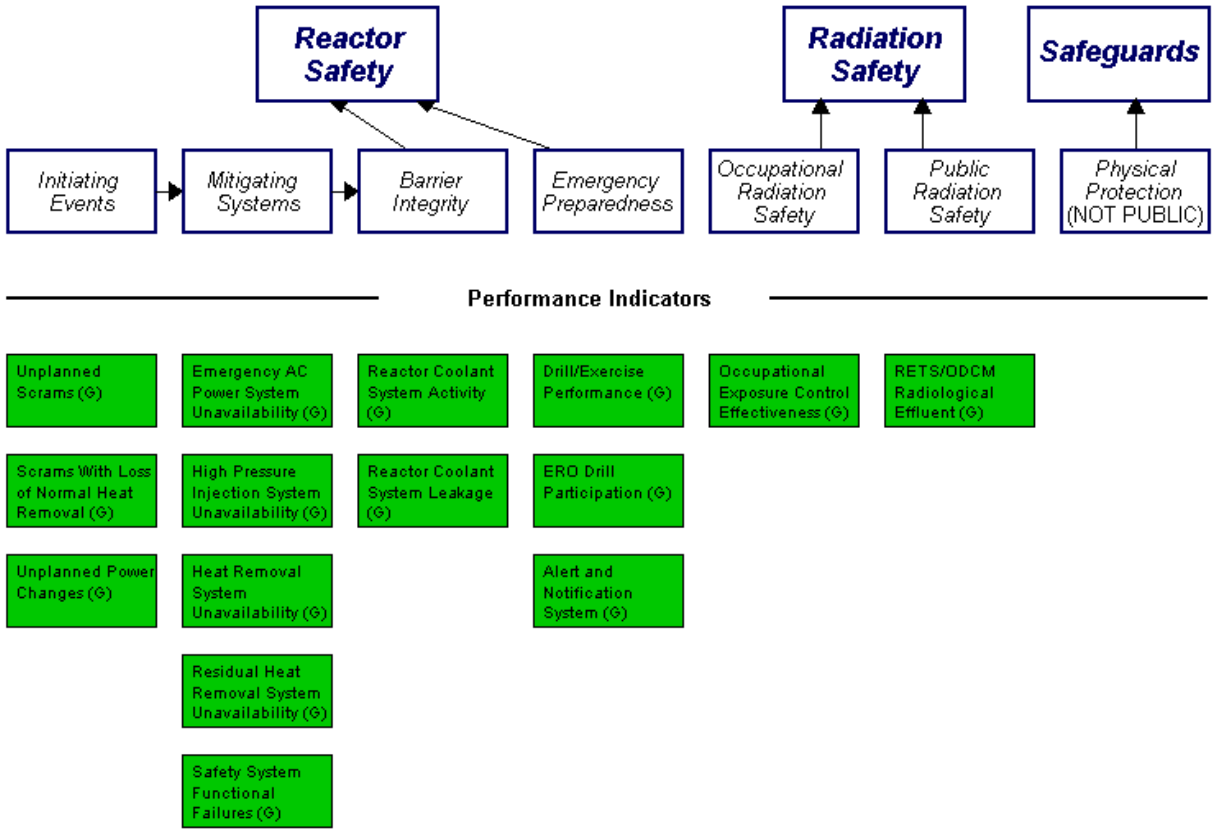
- Design Basis
  - How the plant is actually designed and works.

- Licensing Basis
  - All the collected commitments of the licensee to the NRC including the safety analysis reports, technical specifications, etc.

NRC Oversight

- NRC requires compliance to licensing basis:
  - Two resident inspectors per site (plant)
  - Special inspections on key regulatory issues
  - Licensee event reports (LERs)
  - Enforcement actions based on performance
  - Reactor Oversight Process – “risk informed – performance based”
  - Highly transparent – web based

Reactor Oversight Process



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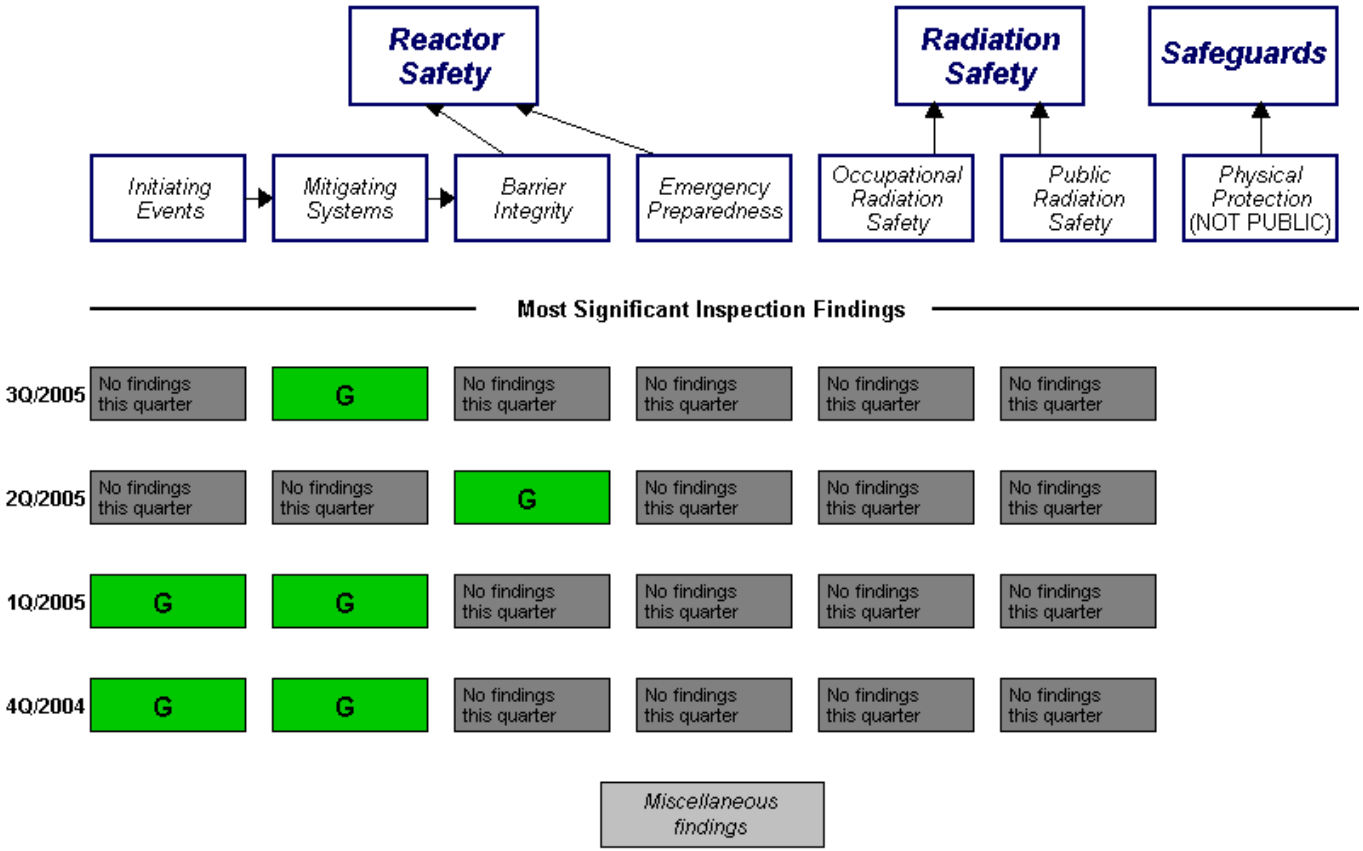

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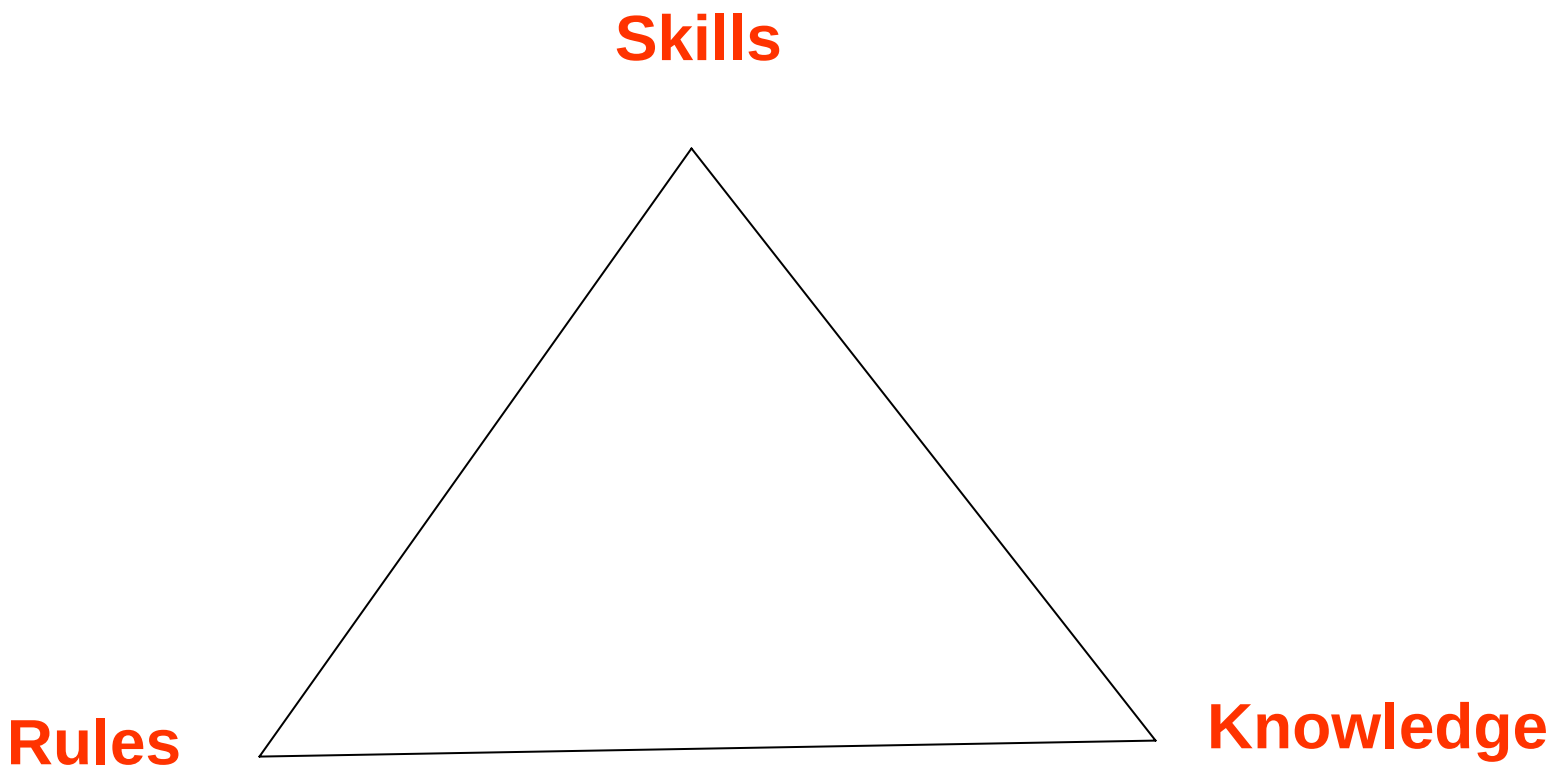
Reactor Oversight Process

- NRC's process to monitor reactor performance

http://www.nrc.gov/NRR/OVERSIGHT/ASSESS/index.html

Requires Balance



Objective

- Maintain Compliance to all NRC Regulations
- Operate within safety envelope
- Maintain Critical Safety Functions
  - Reactivity Control
  - Core Heat Removal
  - Secondary Heat Removal
  - Containment Integrity
- Make Electricity !

Managing Safety

- Technical Specifications are the key operational criteria
- Procedure Based
  - Operating
  - Abnormal Operating Procedures
  - Emergency Operating Procedures
  - Maintenance
  - Engineering
  - Security
  - Radiation Protection (As Low As Reasonably Achievable)

Safety Envelope

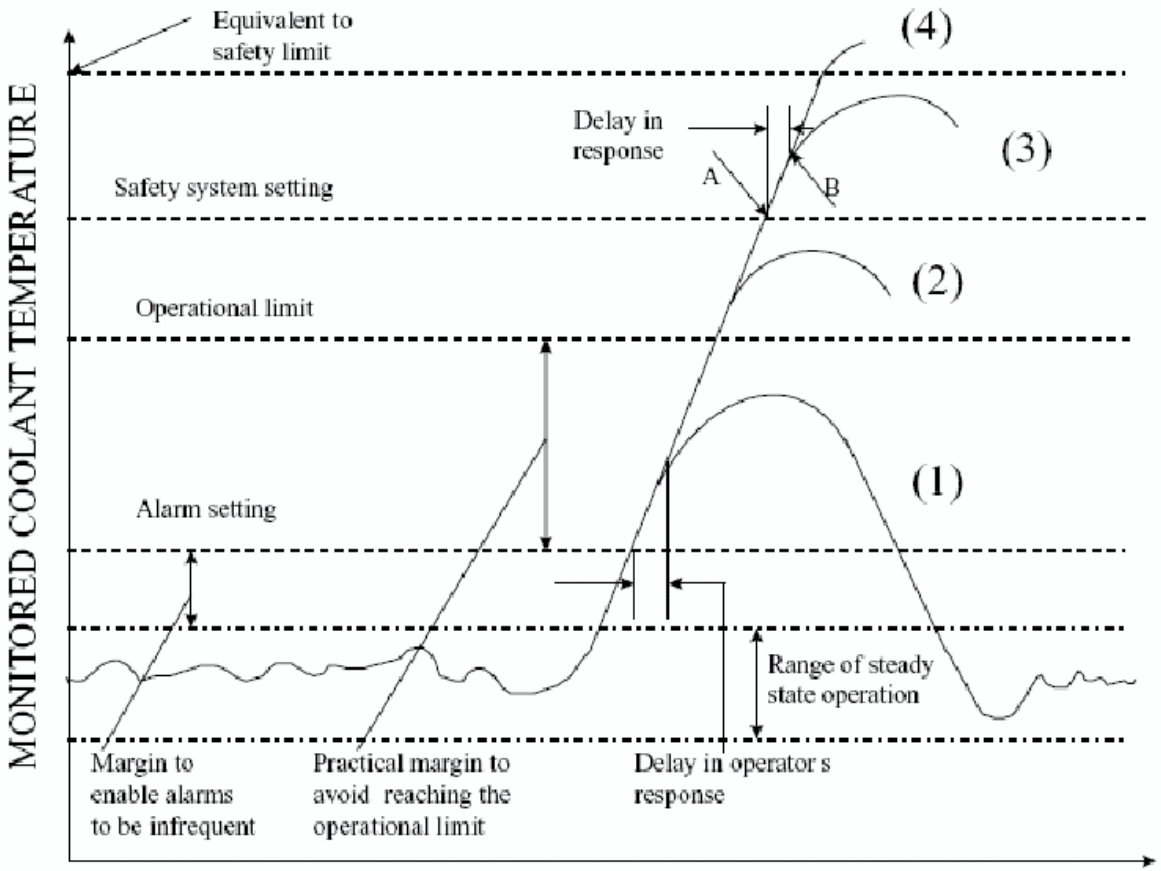


FIG. A–1. Interrelationship between a safety limit, a safety system setting and an operational limit.

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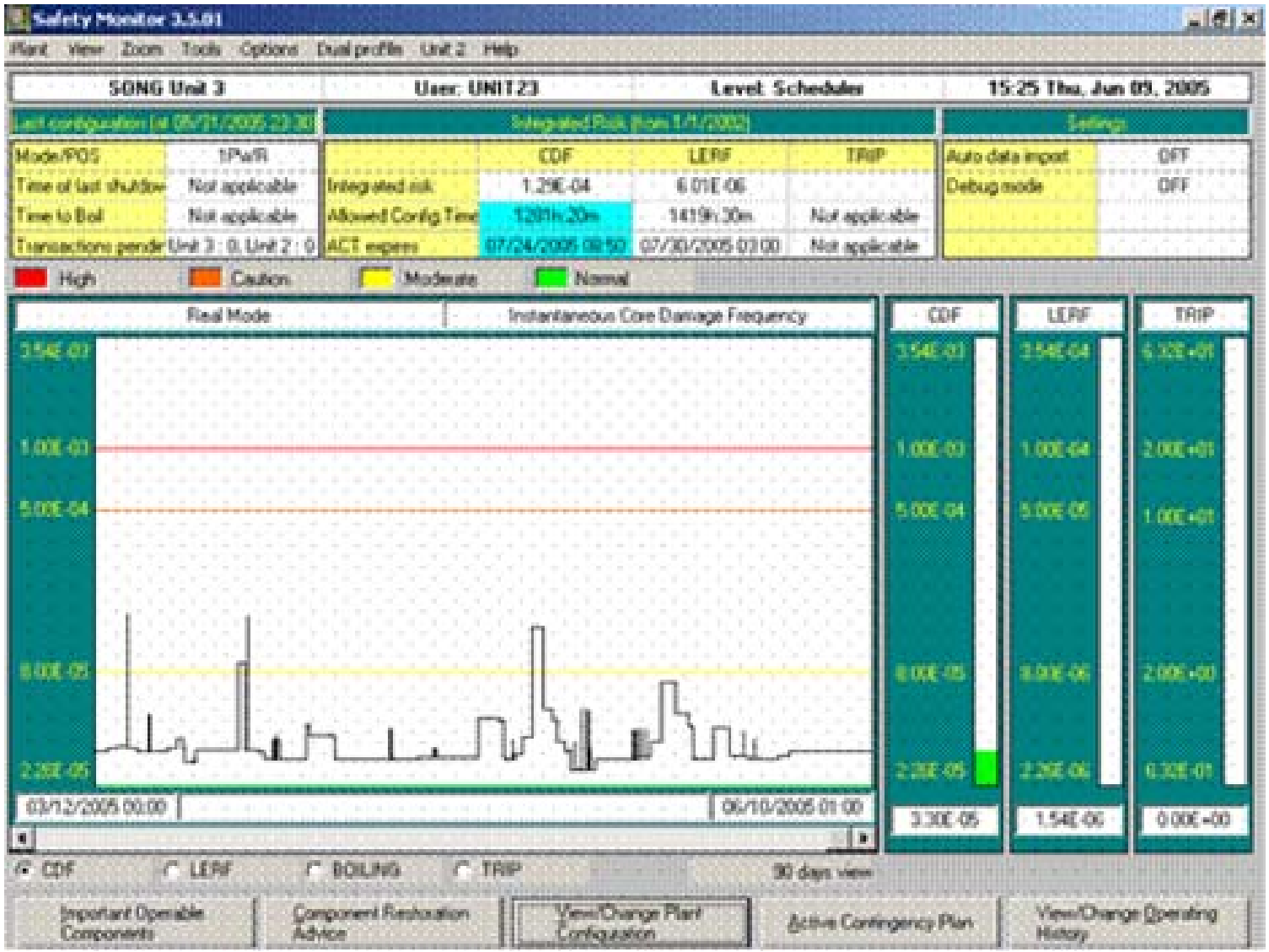
Control Room

- Tools include
  - Automatic Trips
  - Safety Parameter Display System of Critical Safety Functions
  - Risk Monitors
  - Key Process and control parameters

Risk Monitor



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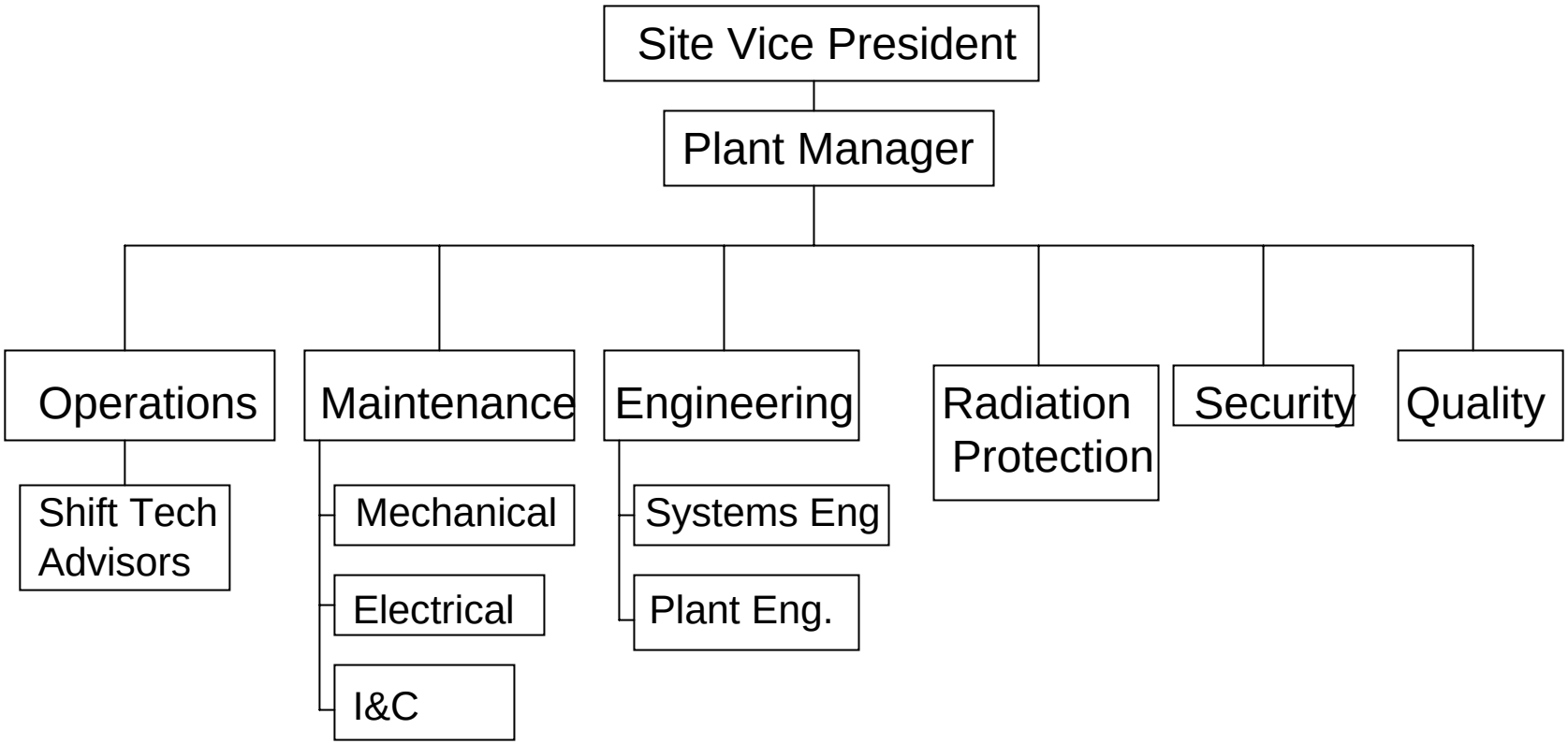
Organizational Structure



Some companies have a centralized engineering and support organization that provides technical support to a number of plants.

A Typical Non-Outage Day

- Morning call – what happened yesterday, overnight – issues – operability status – days since last human error - LCOs
- Risk monitor status – Plant vulnerabilities
- Plan for the day shift – maintenance, tests surveillances
- Electric Generation

Plant Oversight Processes

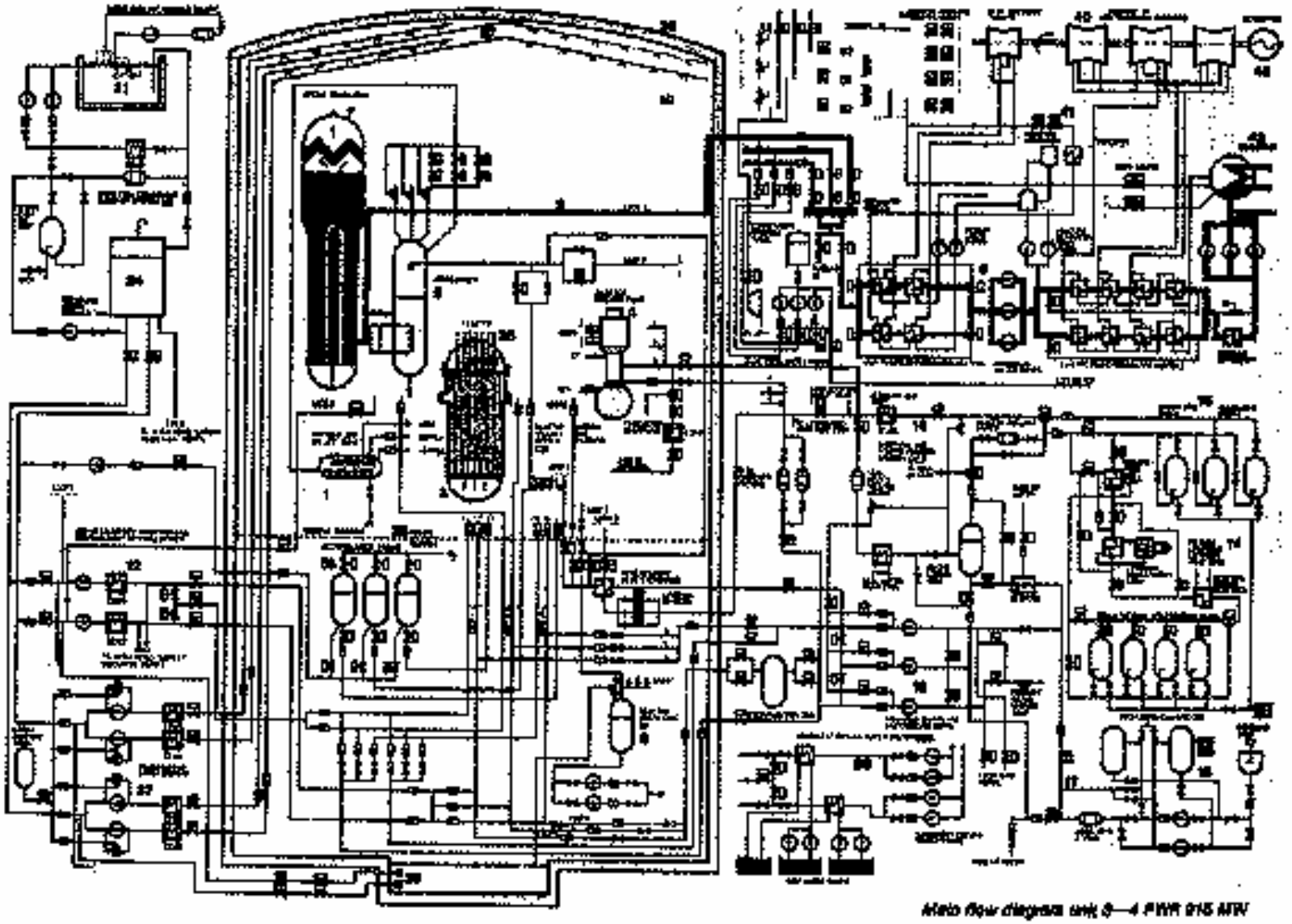
- Corrective Action Program
  - Corrective Action Review Board
- Quality Assurance Department Plant Operations Review Committee
- Nuclear Safety Advisory Review Com.
- External Review Boards
- Institute of Nuclear Power Operations

Key Success Safety and Performance Factors

- Safety Culture
- Basic Design of Plant – Fault tolerant
- Training – Operations, Engineering, Mgt.
- Quality Assurance – Self Assessment
- Organizational Factors – Sustain Safety
- Regulations – Motivate Safety (Risk Informed Regulations)

Homework Assignment

1. Use the Reactor Oversight Process site and identify the key safety issues in the last 2 quarters of the reactor nearest your home.
2. Based on the review of the performance indicators, identify the particular NRC inspection reports upon which the finding is based.
3. Summarize your review in a two page memo to me about the condition of this plant and the corrective actions being taken.
4. Are you satisfied with the safety of this plant?



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Spring 2008

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