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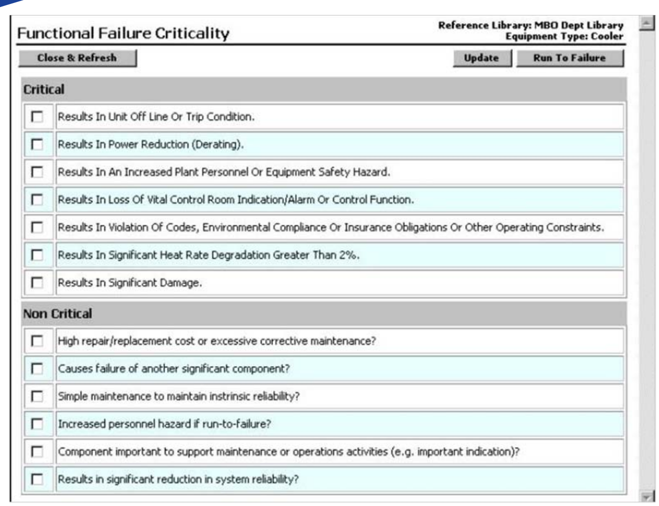
Guideline for Establishing Criticality Rankings for Fossil Power Plant Systems and Components



Guideline for Establishing Criticality Rankings for Fossil Power Plant Systems and Components

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Abstract

Organizations within the electric power generation industry are required to consistently make decisions regarding the priority of plant assets. This includes ranking and comparing plant systems and components with one another for various purposes, such as including them in an equipment reliability or equipment monitoring program, prioritizing maintenance activities, allocating resources, and many others. For each of these scenarios, a methodology is needed to characterize the criticality (or importance) of an asset. These methodologies can be basic and efficient or highly complex and resource intensive. This report is intended to serve as a resource for establishing the criticality of assets—specifically, plant systems and components. This report identifies various methodologies for developing system criticality ranking and component criticality ranking based on varying degrees of complexity. It also provides recommendations for appropriate applications of these methodologies and provides examples that illustrate how several utilities applied different approaches of system criticality ranking and component criticality ranking.

Keywords
Asset management
Components
Criticality
Prioritization
Ranking
Systems

Table of Contents

List of Figures

List of Tables

Section 1: Introduction

In today's utility environment where manpower and financial resources are limited, fossil power generation facilities are required to strategically target available resources to activities that provide the greatest return on investment. This driving need to appropriately allocate these resources to the most valuable assets has generated an increased interest by utilities to identify the criticality of plant systems and components. As a result utilities have developed various methodologies to establish asset criticality rankings for various applications and purposes.

Component criticality ranking (CCR) can enhance decision making associated with various equipment reliability related processes. These processes include:

- Daily maintenance work activity prioritization
  - Knowing the relative importance of all major assets at a plant can provide for daily and weekly work prioritization. If insufficient resources are available to perform all identified maintenance work, the CCR can be used to help identify the most valuable work as pertains to the overall station goals.
- Long-term asset management (LTAM)
  - CCR can be used as an input to assist the leadership team in making more informed decisions when planning and prioritizing long-term maintenance activities.
- System and component health management
  - As fossil generation utilities implement system health and component health management programs (SHM and CHM, respectively), resource limitations for implementing the processes will require prioritization of systems and components. System criticality ranking (SCR) and CCR can be utilized to establish the priorities and requirements for which systems and components to include.

- Maintenance basis optimization (MBO)
  - Many fossil generation utilities are implementing an MBO process to optimize the preventive maintenance (PM) tasks that will be performed. Understanding the relative system and component criticalities is paramount to the approach for this MBO process. Deciding on the PM strategy for an asset is dependent partially on its CCR; therefore, selecting components to be included in an MBO initiative is supported by effective SCR and CCR.
- Risk assessment
  - When a comprehensive set of system and component criticality rankings are developed, the consequence of failure (loss of the function of a system or component) is determined and used as part of the ranking process. The resulting CCR provide relative numbers representing the consequence of failure and, therefore, can be used as part of a risk assessment methodology. This process is discussed further in Section 2 of this guideline.

There are various approaches to identifying system and component criticality that have been applied in the power generation industry. These approaches can range from a simple method of binning each component (such as critical, non-critical, or run to failure) to a comprehensive approach where specific criteria associated with each of the organization's strategic goals are developed and applied to a ranking algorithm. Different situations and applications dictate which level of complexity is appropriate for conducting this ranking. This guideline will provide guidance on when and how to apply these different approaches. Examples are also provided that illustrate how various utilities have applied these different levels of complexity.

Section 2: Component Criticality Ranking Process

The component criticality ranking (CCR) process involves calculating the value of each component relative to other components within the plant (i.e., a transformer versus a boiler feed water pump). These CCR values can be calculated by various methods. The CCR process involves identifying an organization's set of goals and then determining the criticality of the component based upon these goals. The result of the process provides general component criticality categories or specific numerical values that represent the relative importance of each major component within a plant or across a fleet of plants. This chapter of the guideline provides an overview of the CCR process and describes the different methods for implementing a CCR process. Also discussed in this chapter is how CCR values and risk are related.

CCR Process Methodologies

Establishing component criticality can be performed using several different methods. Establishing component criticality is sometimes also referred to as the component's equipment reliability (ER) classification. Three distinct methodologies are described that range from a low complexity, simple approach to a high complexity approach that could support risk management.

Low Complexity Component Criticality Ranking Method

The ER classification process can be performed using different methods. The simplest ER classification method is to use experienced plant system engineers and/or operations personnel to review a master equipment list (MEL) and determine the ER classification of each piece of equipment. This simple approach is based solely on the system engineers' and/or operators' experience and knowledge of plant systems and equipment functions. An example of a low complexity method where the system engineers simply completed the ER classification field can be seen in Table 2-1.

Table 2-1
Example of a Low Complexity Component Classification

MASTER EQUIPMENT LIST		
UNID	**UNID Description**	**Equipment Reliability Component Classification (CC, NC, or, RTF)**
XYZ123-HC-CC-PMP-01PA	CCW PUMP 1A	CC
XYZ123-HC-CC-MTR-01PA	CCW PUMP 1A MOTOR	CC
XYZ123-HC-CC-PMP-01PB	CCW PUMP 1B	CC
XYZ123-HC-CC-MTR-01PB	CCW PUMP 1B MOTOR	CC
XYZ123-HC-CC-SNR-01FA	CCW INLET STRAINER 1A	NC
XYZ123-HC-CC-SNR-01FB	CCW INLET STRAINER 1B	NC
XYZ123-HC-CC-TNK-01TA	CCW HEAD TANK	CC
XYZ123-HC-CC-EXP-09MA	CCW PUMP 1A INLET EXPANSION JOINT	NC
XYZ123-HC-CC-EXP-09MB	CCW PUMP 1B INLET EXPANSION JOINT	NC
XYZ123-HC-CC-VLV-001A	CCW PUMP 1A INLET ISOLATION VALVE	RTF
XYZ123-HC-CC-VLV-001B	CCW PUMP 1B INLET ISOLATION VALVE	RTF
XYZ123-HC-CC-CKV-002A	CCW PUMP 1A DISCHARGE CHECK VALVE	NC
XYZ123-HC-CC-CKV-002B	CCW PUMP 1B DISCHARGE CHECK VALVE	NC
XYZ123-HC-CC-VLV-003A	CCW PUMP 1A DISCHARGE ISOLATION VALVE	RTF
XYZ123-HC-CC-VLV-003B	CCW PUMP 1B DISCHARGE ISOLATION VALVE	RTF

In Table 2-1, "CC" represents a critical component to maintaining an important system function. "NC" represents a non-critical component that is not critical to sustaining generation, safety or environmental compliance, but could result in a costly repair if failure occurs. Because of this a preventive maintenance (PM) strategy is warranted to protect against failure. "RTF" represents a run-to- failure component that is not critical to sustaining component or system functions, nor would failure result in costly repairs. These RTF components would not warrant any PM activities to prevent failure.

Medium Complexity Component Criticality Ranking Method

Another more typical and a somewhat more complex method of determining ER classification is to establish equipment criticality, along with the operating classification. This is often performed by an organization as part of a maintenance basis optimization (MBO) initiative. This method involves applying criteria by answering a series of questions to determine a component's criticality. An example of component criticality determination questions are shown in Figure 2-1.

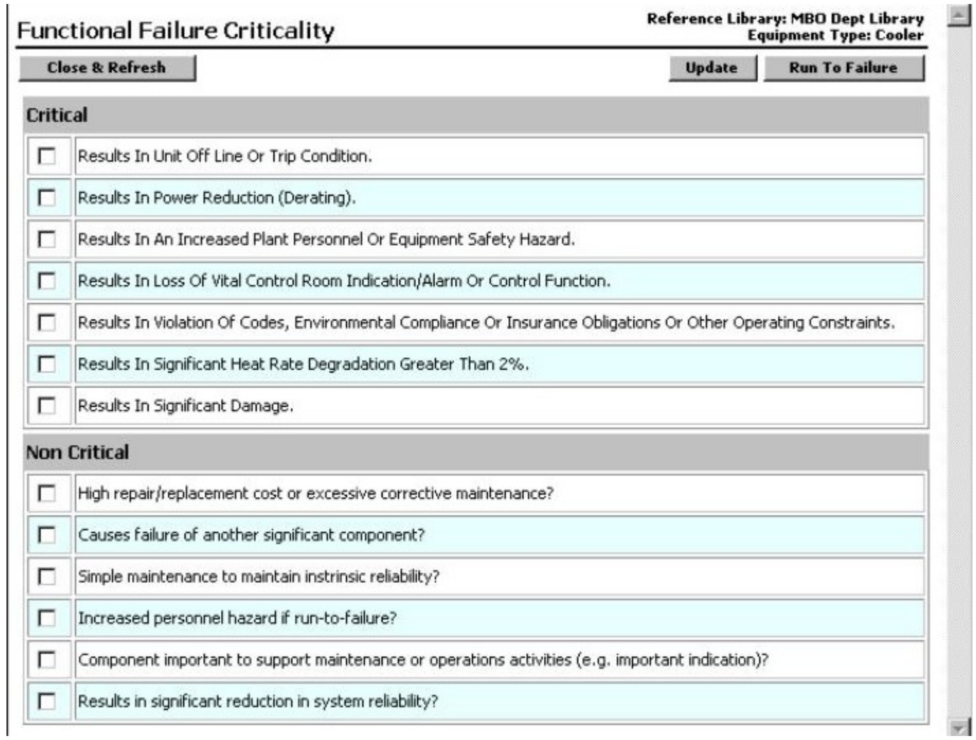


Figure 2-1
Example Criteria for a Medium Complexity Component Classification

An example of a medium complexity method is depicted in Table 2-2.

Table 2-2
Example of a Medium Complexity Component Classification

UNID	UNID Description	Equipment Reliability Component Classification
4-1 Boiler Feed Pump	SH-U4-FW-BFP-4-1-PUMPS	CRIT-1
4-1 Boiler Feed Pump Turbine	SH-U4-FW-BFP-4-1-TURB	CRIT-1
#4 Main Turbine	SH-U4-TU-TURB-4-MISC	CRIT-1
#4 Main Generator	SH-U4-GT-GEN-4-GENER	CRIT-1
4-1 Service Water Pump	SH-U4-SW-SWP-4-1-PUMPS	CRIT-2
4-1 Service Water Pump Motor	SH-U4-SW-SWP-4-1-MOTOR	CRIT-2
4-1 Circulating Water Pump	SH-U4-CW-CWP-4-1-PUMPS	CRIT-2

Table 2-2 (continued)
Example of a Medium Complexity Component Classification

UNID	UNID Description	Equipment Reliability Component Classification
4-1 Circulating Water Pump Motor	SH-U4-CW-CWP-4-1-MOTOR	CRIT-2
4-1 Condensate Pump	SH-U4-CD-CDP-4-1-PUMPS	CRIT-2
4-1 Condensate Pump Motor	SH-U4-CD-CDP-4-1-MOTOR	CRIT-2
4-1 Forced Draft Fan	SH-U4-CA-FDF-4-1-FANS	CRIT-2
4-1 Forced Draft Fan Motor	SH-U4-CA-FDF-4-1-MOTOR	CRIT-2
4-1 EHC Pump	SH-U4-EH-HFP-4-1-PUMPS	CRIT-2
4-1 EHC Pump Motor	SH-U4-EH-HFP-4-1-MOTOR	CRIT-2
Boiler Drain Valves & Traps	SH-U4-BP-VALVES	CRIT-6
North Steam Drum Safety Valve	SH-U4-BP-SV-40005-VALVE	CRIT-5
North Steam Drum Safety Valve	SH-U4-BP-SV-40006-VALVE	CRIT-5
G4 Generator Step-Up Transformer	SH-U4-GT-XFMR-4-XFORM	CRIT-1
423-4 Station Service Transformer	SH-U4-23K-XFMR-423-4-XFORM	CRIT-1
480V Motor Control Center 4EE	SH-U4-480-4EE	NON-CRIT1
480V Motor Control Center 4A	SH-U4-480-4A	NON-CRIT1
480V Motor Control Center 4AA	SH-U4-480-4AA	NON-CRIT1
480V Motor Control Center 4H	SH-U4-480-4H	NON-CRIT1
480V Motor Control Center 4J	SH-U4-480-4J	NON-CRIT1

This medium complexity method involved a fourteen step process to determine the ER component classification of CCR. An example of this approach in a real-world application is discussed in detail in Section 4 of this guideline.

High Complexity Component Criticality Ranking Method

The third method for determining CCR is a much more detailed and involved process. These complex approaches apply multiple weighting factors, input variables, and algorithms to produce more quantitative and granular assessments of CCR. An example of one such approach is known as the "System and Equipment Reliability Prioritization" (SERP) process. This is a systematic approach that can help consistently prioritize maintenance with respect to the relative importance of each component to the company's strategic goals and objectives. These priorities are typically based on a common set of factors across the generating facilities (e.g., safety, environmental, cost, and reliability). The rankings provide a foundation upon which priority decisions can be made. Other criteria that indicate the current condition of the equipment, such as engineering risk assessments and immediate needs for production, should be integrated with this priority ranking to make day-to-day decisions regarding asset management. The rankings are established as consensus input from operations, maintenance, technology specialists, craft, and management.

The SERP process ranks each individual system to generate a system criticality ranking (SCR) value for each system. The SERP process also ranks the importance of each piece of equipment to the function of the system, which results in an operational criticality ranking (OCR) value. The overall component criticality ranking (CCR) value is established as a product of SCR and OCR:

Component Criticality (CCR) = System Criticality (SCR) x Operational Criticality (OCR)

The CCR values can be used with the associated probability of failure or the asset failure probability factor (AFPF) to create the component's corresponding maintenance priority index (MPI).

Maintenance Priority Index (MPI) = CCR x AFPF (Assets Failure Probability Factor)

A component's MPI is essentially a number that identifies the components that warrant the highest priority of maintenance resources at a given point in time relative to other components. Figure 2-2 provides an example of the SERP process results.

System Criticality Ranking (SCR)
= SQRT (Sum of (Strategic Criteria^2))

Operational Criticality Ranking (OCR)
= SQRT (Sum of (Component Criteria^2))

Asset Criticality Ranking (ACR)
= SCR * OCR

Asset Failure Probability Factor (AFPF)
(Indicative of the Probability of Failure)

Maintenance Priority Index (MPI)
= ACR * AFPF

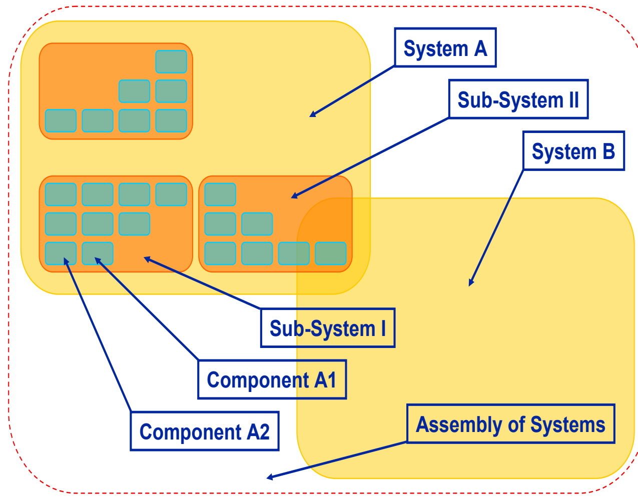


Figure 2-2
SERP Process Calculations and Results

The SERP process begins with developing a team that consists of system and component subject matter experts (SMEs). These experts are typically complied from all disciplines at a plant site, including:

- Operations
- Engineering
- Maintenance
- Supply Chain
- Work Control

The level of required involvement of each of these plant personnel can range from formal meetings to simple phone calls or e-mail exchanges. These experts review the utility goals and objectives (e.g., safety and environmental compliance, cost, and reliability) and use these to help develop SERP criticality criteria at the system and component levels. Management approval is typically required for the established criticality criteria. A SERP analysis is performed that assigns values to each system and component based on the defined criteria. This analysis process usually will involve many SMEs. Once the SCR and OCR values have been determined the CCR value can be calculated by multiplying the SCR value by the OCR value resulting in the CCR value. If it is desired to develop a MPI value, the AFPF will have to be determined. The MPI value is then determined by multiplying the CCR value by the AFPF. All of these calculated results are typically captured within a spreadsheet. An example SERP spreadsheet can be seen in Table 2-3 below.

Table 2-3
Example of a High Complexity Component Classification

Asset ID #	Asset Description	Parent System Name	SCR	OCR	CCR	AFPF	MPI
3-22P01	1A 345 Transformer	Avon	15.133	18.16	274.81	1	274.81
3-23P02	1B 345 Transformer	Avon	15.133	18.16	274.81	1	274.81
3-23P01	1C 345 Transformer	Avon	15.133	18.16	274.81	1	274.81
3-21P06	1A OCB	Avon	15.133	15.19	229.87	1	229.87
3-32A41	1B OCB	Avon	15.133	15.19	229.87	1	229.87
3-22E12	1C OCB	Avon	15.133	15.19	229.87	1	229.87
3-22K11	1A-H Bushing	Avon	15.133	236.84	236.84	2	473.68
3-22K12	1A-L Bushing	Avon	15.133	236.84	236.84	2	473.68
3-22E11	1A Voltage Regulator	Avon	15.133	15.96	241.65	4	966.61
3-22K13	1B Voltage Regulator	Avon	15.133	15.96	241.65	4	966.61
3-22E13	1C Voltage Regulator	Avon	15.133	15.96	241.65	4	966.61
3-31E01	1A 345 Transformer Lightning Arrestor	Avon	15.133	5.83	88.22	1	88.22

The final step of the SERP process is to enter the CCR and MPI values into the CMMS so they can be used to help prioritize daily work orders and backlog work orders and to support decision making associated with many other Equipment Reliability and Asset Management processes/activities. Figure 2-3 provides an overview of the entire SERP process.

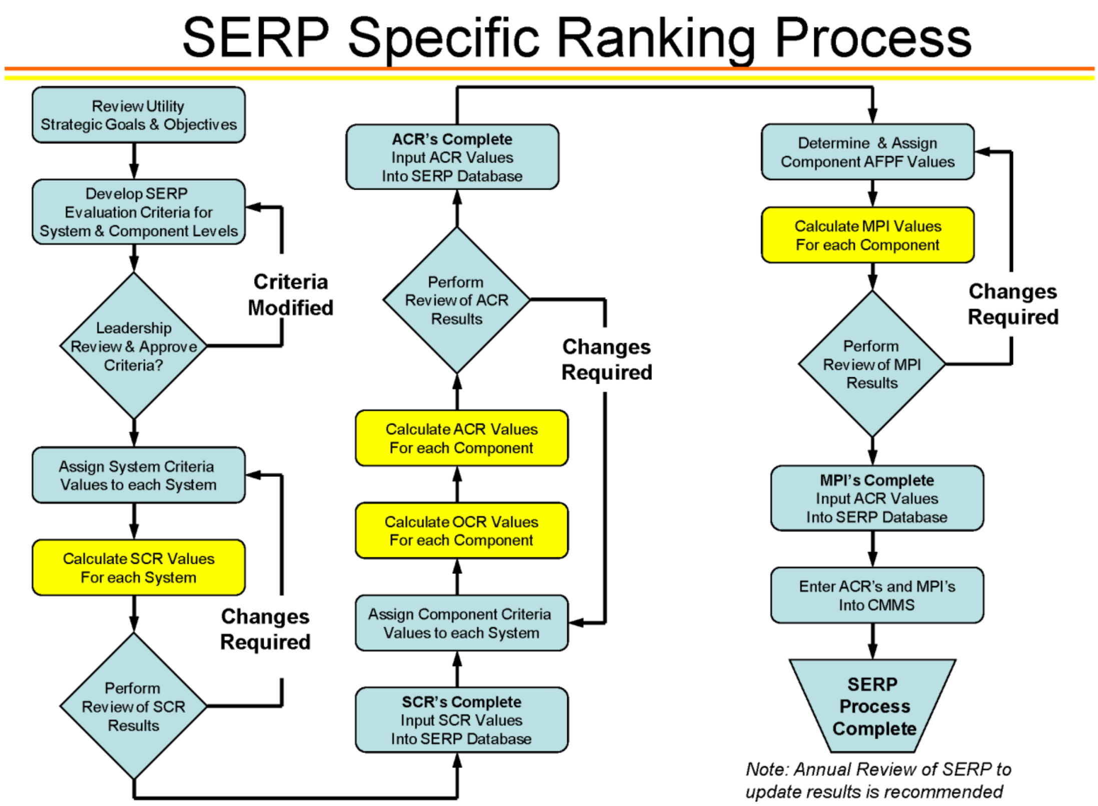


Figure 2-3
SERP Process Diagram

CCR and Risk Management

In today's power generation environment, it has become necessary not only to predict if a problem exists for a component, but what risk is involved if that component is not repaired immediately. Risk is defined as the consequence of asset or component failure multiplied by the probability of failure of that component.

Risk = Consequence of Asset Failure x Probability of Asset Failure

There is a direct relationship between a component's CCR value and risk or risk management. When the CCR process is implemented, the criteria used to quantify the potential consequences of failure of a system and/or a component typically considers:

- Personal safety impacts
- Generation capacity (or commercial availability) loss
- Costs for repair of failed equipment
- Environmental events and impact

These criteria represent the specific consequences that an organization is trying to mitigate or eliminate. Therefore, once a CCR number is calculated based on the criteria identified above, the "rational consequence of failure" for a component is established. Essentially, the CCR value becomes the quantified consequence of component failure. This can be applied to the risk equation, along with the component probability of failure, to determine the current risk.

CCR = Consequence of Component Failure

Component Risk = Consequence of Component Failure x Probability of Component Failure

Component Risk = CCR x Component Probability of Failure

The most challenging and sometimes most subjective part of calculating an accurate risk value is determining a component's "current" probability of failure. Some utilities perform studies of failures on major components over a long history (e.g. 30 years) and then develop failure curves of components (e.g., transformers and breaker types) over the estimated useful life (30, 40, or 60 years). Creating failure curves that identify the probability of failure over the useful age of a component allows an organization to calculate risk associated with a component.

Another method for determine probability of failure is using data from sources such as the North American Electric Reliability Corporation (NERC) Generation Availability Data System (GADS) risk tables available on the NERC website. The GADS risk tables are the risk assessment product that provides historical information obtained from GADS. The information is presented in a table as a product of "total megawatt-hour loss" and "total number of occurrences". A point of diminishing returns can be chosen based on an examination of the data for business planning. An example of a risk assessment grid can be seen in Appendix A.

Section 3: Assigning Criticality Rankings to Systems

Simple Approach

The simplest approach of assigning levels of importance to power generation systems is to break the systems or sub-systems into tier levels. This system criticality tier classification segregation can be defined as follows:

- Tier 1 - critical to generation
- Tier 2 - important to generation
- Tier 3 - support generation
- Tier 4 – other

An example of system tier ranking can be seen below in Table 3-1:

Table 3-1
Example of a System Tier Ranking

System Criticality Tier Level	1	BP		BALANCE OF PLANT SYSTEMS
Tier 1		**BP**	CA	Compressed Air System
Tier 3		**BP**	LK	Lakes System
Tier 2		**BP**	CP	Cathodic Protection System
Tier 2		**BP**	WS	Water System
Tier 3		**BP**	PW	Potable Water System
Tier 2		**BP**	WW	Wastewater System
Tier 3		**BP**	WT	Water Treatment System
Tier 3		**BP**	AP	Ash Pond System
Tier 2		**BP**	FP	Fire Protection System
	2	**BH**		**BAG-HOUSE SYSTEMS**
Tier 1		**BH**	CM	Bag-house System
Tier 1		**BH**	FH	Fly Ash Handling System
Tier 1		**BH**	RA	Bag-house Cleaning System
Tier 1		**BH**	BF	Booster Fans System
Tier 1		**BH**	DX	Bag-house Duct System
	3	**HB**		**BOILER & HEAT RECOVERY STEAM GENERATOR (HRSG) SYSTEMS**
Tier 1		**HB**	BB	Boiler Air System
Tier 2		**HB**	BC	HRSG & Boiler Chemistry System
Tier 1		**HB**	FG	Boiler Flue Gas System

Assigning tier values to systems is typically accomplished by organizing a meeting among the plant engineering, operations and maintenance leadership and other plant knowledgeable individuals to assign a value to each system. These system tier values can help the organization with prioritizing equipment reliability and asset management activities. For example, when implementing system health reporting, these system tier values van be used to decide which plant systems will be included for developing system health reports.

SERP Approach

The SERP process begins with reviewing the utility goals and objectives to develop SERP criticality criteria at the system level. Decision criteria for each criticality criteria level is typically broken down into descriptions specifically related to each overall criticality criteria category and ranked with values from 1 to 10. An example of typical system level criticality criteria and decision criteria descriptions are shown below in Table 3-2:

Table 3-2
SERP System Level Criticality

Criteria	Criteria Value	Criteria Description
Safety		
	10	High Safety Concern, possible fatality…injuries occur to personnel
	8	High Safety Concern, possible injuries occur to personnel….lost time
	5	Safety concerns, possible doctor attended injuries
	3	Low Safety Concern, action taken to secure area
	1	No Safety Concern
Environmental		
	10	Shut Down
	8	Fine
	5	Notice of Violation
	3	Close Call (Non-Reportable)
	1	No Effect
System Cost		
	10	Major O&M Cost > $100,000
	6	Medium O&M Cost $100,000 > X >$50,000
	4	Minor O&M Cost < $50,000
	1	No Effect
Commercial Availability		
	10	Plant (all units) Shutdown
	9	Long Term Unit Shutdown (> 1 week)
	8	Short Term Unit Shutdown (< 1 week)
	7	Long Term Boiler Shutdown (> 1week) for dual boiler units only

Table 3-2 (continued)
SERP System Level Criticality

Criteria	Criteria Value	Criteria Description
	6	Short Term Boiler Shutdown (< 1week) for dual boiler units only
	5	Long Term Unit Load Reduction (> 1 week)
	4	Short Term Unit Load Reduction (< 1 week)
	3	Future Potential Loss of MW's
	1	No Effect
Efficiency		
	10	> 100 BTU's
	5	< 100 BTU's and > 25 BTU's
	1	< 25 BTU's

When assigning system criteria values, some assumptions must be made and are as follows:

- The unit is operating normally at full load.
- All systems are operating normally except the system being examined.

The analysis includes querying the involved personnel on consequences if the facility loses the functionality of the system being analyzed for each identified criteria. Examples include:

- Safety - What is the most probable safety impact if the system loses its functionality?
- Environmental - What is the most probable impact to the environment if the system loses its functionality?
- Cost - Assuming the system loses it functionality, what is the most probable cost impact as a consequence of losing the system (additional costs to operate, damage to other systems, etc.)?
- Commercial availability - What is the most probable impact to unit availability if the system loses its functionality?
- Efficiency - What is the most probable impact to unit efficiency if the system loses its functionality?

The plant personnel involved in performing the SERP SCR are asked to provide a 1 – 10 ranking for each criterion based on the approved decision criteria descriptions. Those values are then squared and summed and the square root taken of that sum to produce the SCR value. This process is continued until each system within the scope of the SERP project is completed. Using the SERP results identified in Table 3-3, an example System Criticality Ranking calculation is provided.

Table 3-3
Example of a System Criticality Ranking Calculation

System Name	Safety	Environ	Cost	Comm Avail	Heat Rate Efficiency	System Criticality Ranking SCR
SITE FIRE PROTECTION	8	3	10	9	1	15.97
$SCR = \sqrt{8^2 + 3^2} + 10^2 + 9^2 + 1^2$ = **15.97**						

In conclusion, it is important in today's environment for fossil power generation utilities to determine system criticality to enhance their ability to prioritize various work activities. The approach that an organization applies to determine system criticality should depend on the intended application of the values. For example, if an organization is simply using the SCR values to decide what systems will be included for system health reporting, then the simpler system tiered approach would suffice. If the organization is planning to deploy a risk management process where system and then component failure consequence will be required, then the more complex SERP SCR methodology may be the best option.

Section 4: Assigning Criticality Rankings to Components (Equipment)

Equipment Reliability (ER) Classification Approach

As stated in Section 2, the simplest component CCR approach is to perform ER classification using experienced plant system engineers and/or operations personnel to review an established master equipment list (MEL), and determine the component's ER classification based solely on experience and knowledge of plant systems and equipment. Components are typically assigned a criticality level such as:

- Critical (CC)
- Non-critical (NC)
- Run-to-failure (RTF)

A second approach of medium complexity is to develop equipment classification values for components as part of an overall maintenance basis optimization (MBO) project. Similar ER classifications are used, such as CC, NC, and RTF; however, these are determined using an approach that utilizes specific criteria. An example is a numerical priority value from 1 to 9 that describes the effects or consequences of a component failure on the plant. Table 4-1 describes priority values 1 through 5. These represent critical equipment.

Table 4-1
Definitions for Equipment Classification Priorities for Critical Equipment

Value	Description
Importance 1	Results in Unit Trip or full load loss.
Importance 2	Results in a 40 percent power de-rate below normal full load.
Importance 3	Results in a significant de-rate 20 percent below normal full load.
Importance 4	0 percent de-rates but possible generation loss due to extended asset failure.
Importance 5	Potential Loss of generation due to failure of redundant equipment.

Table 4-2 describes the priority values 6 through 9. These represent non-critical equipment.

Table 4-2
Definitions for Equipment Classification Priorities for Non-Critical Equipment

Value	Description
Importance 6	Loss of asset causes loss of auto function to multiple equipment and or systems.
Importance 7	Loss of asset causes significant operational inconvenience.
Importance 8	Loss of asset precludes normal system or equipment operation.
Importance 9	No effect.

Equipment that does not affect safety, reliability, or environmental regulation and is more economical to run-to-failure than to perform PM is designated as RTF. RTF equipment should not be part of a PM program; however, the decision to make equipment RTF is part of the analysis process and is documented.

An alternative to this approach that provides slightly more detailed criticality determination is a process that breaks down the classifications further as seen in Table 4-3.

Table 4-3
Multi-step Process for Criticality Determination

Value	Description
CRIT-1	Results in Unit off line or Trip Condition
CRIT-2	Results in Power Reduction (De-rating)
CRIT-3	Results in an Increased Plant Personnel or Equipment Safety Hazard
CRIT-4	Results in Loss of Vital Control Room Indication/Alarm or Control Function
CRIT-5	Violation of Codes, Environmental Compliance OR Insurance Obligations OR Other Operating Constraints.
CRIT-6	Results in Significant Heat Rate Degradation Greater Than 2%
CRIT-7	Results in Significant Damage
NON-CRIT1	High repair/replacement cost or excessive corrective maintenance
NON-CRIT2	Causes failure of another significant component
NON-CRIT3	Simple maintenance to maintain intrinsic reliability
NON-CRIT4	Increased personnel hazard in run-to-failure
NON-CRIT5	Component important to support maintenance or operations activities (e.g. important indication)
NON-CRIT6	Results in significant reduction in system reliability
RTF	Run to Failure

As part of the CCR process, utilities will often determine a component's "operating classification" based on its service conditions and duty cycle. These operating classifications are very useful when optimizing or developing the maintenance bases for plant components.

The operating classification is an assessment of two operating parameters in which a component performs its function. These parameters include:

Service Condition

- Harsh – Harsh environments could include one or more of the following conditions:
  - Temperature extremes
  - Toxic or caustic medium
  - High pressure fluids
  - Prevalent coal dust
  - Salt water
  - High humidity
  - Dirty or greasy environments

- Non-Harsh – Non-harsh environments include:
  - Heated or cooled enclosures
  - Clean environments, or sheltered from external atmospheric conditions.

Duty Cycle

- Frequent – Numerous start/stop cycles or continuous duty service
- Seldom – Infrequent use, usually only during plant startup or shutdown

SERP Approach

When executing the SERP process for determining component ranking, essentially the same criticality criteria is used as was used for system ranking. One key difference involves replacing system cost criteria with component cost criticality criteria. An example of the component cost criticality criteria is provided in Table 4-4 below:

Table 4-4
SERP Component Level Criticality

Criteria	Criteria Value	Criteria Description
Component Cost		
	10	Major O&M Cost > $1,000,000
	9	$500,000 - $1,000,000
	8	$250,000 - $500,000
	7	$100,000 - $250,000
	6	$75,000 - $100,000
	5	$50,000 - $ 75,000
	4	$25,000 - $50,000
	3	$5,000 - $25,000
	2	$1,000 - $5,000
	1	No Effect - $1,000

When assigning component criteria values, the same assumptions are used as were used for systems with the following changes:

- The unit is operating normally at full load.
- All equipment is operating normally except the equipment being examined.

The analysis includes asking the personnel involved what will happen if the facility loses the functionality of the equipment being analyzed for each criteria included in the analysis. Examples of this include:

- Safety - What is the most probable safety impact if the equipment loses its functionality?
- Environmental - What is the most probable impact to the environment if the equipment loses its functionality?
- Component Cost - Assuming the equipment loses it functionality, what is the most probable cost impact as a consequence of losing the equipment? What is the rational for catastrophic failure (i.e., not just a pump oil leak, but a failure of seals and bearings; or not just a motor bearing, but a winding failure requiring re-insulation along with bearing replacements)? Estimate the cost of the most likely rational catastrophic failure and any collateral damage caused by the failure.
- Commercial availability - What is the most probable impact to unit availability if the equipment loses its functionality?
- Efficiency - What is the most probable impact to unit efficiency if the equipment loses its functionality?

A plan will need to be developed to review the system rankings and identify the subject matter experts (SMEs) that will be needed for ranking the equipment within those systems (e.g., a turbine specialist for turbine lube oil, chemists for water systems, etc.). Begin with the highest-ranking system and rank the components within that system. The personnel involved are asked to provide a 1 – 10 ranking for each criterion based on the approved decision criteria descriptions. Those values are then squared and summed and the square root taken of that sum to produce the operating criticality ranking (OCR) value. This process is continued until to each component within the scope of the SERP project is completed. An example of a SERP calculation result is depicted in Table 4-5.

Table 4-5
Example of a Component Criticality Ranking Calculation

Component Name	Safety	Environ	Cost	Comm Avail	Heat Rate Efficiency	Operating Criticality Ranking OCR
HP TURBINE OUTER SHELL	3	1	9	9	1	13.15
$OCR = \sqrt{3^2 + 1^2} + 9^2 + 9^2 + 1^2$ = **13.15**						

In conclusion, the approach that an organization applies to determine component criticality should depend on the intended application of the values. For example, if an organization is simply using the component criticality ranking (CCR) values to support the prioritization of daily maintenance work activities, then the simple approach yielding critical, non-critical, run-to-failure would suffice. If the goal is to use the CCR values to prioritize an MBO project application or to deploy a risk management process, then the medium complexity or complex method should be deployed to provide additional CCR granularity to support these processes.

Section 5: Examples of Implementation in the Electric Power Generation Industry

In recent years, utilities have been more active with defining component criticality. Component criticality ranking (CCR) results from a few recent EPRI member experiences are provided in this section of the guideline. Examples of varying complexity (low, medium and high) are included to help illustrate which approaches are more applicable and appropriate for various situations and applications.

Low Complexity Component Criticality Ranking Example

An example of a low complexity CCR process can be taken from what Arizona Public Service (APS) initially performed as part of their Material Condition Improvement Initiative. An important enabler for implementing the new equipment reliability (ER) processes as part of their Material Condition Improvement Initiative was identification of component criticality. APS system engineers were tasked with determining component ER classifications based solely on their experience and knowledge of plant systems and equipment. The component criticality ranking process yielded criticality rankings of critical (CC), non-critical (NC), and run-to-failure (RTF). An example of the results is included in Table 5-1.

Table 5-1
APS Example of a Low Complexity Component Classification

APS PLANT / UNIT: Redhawk		
System Name: Heat Cycle		
Sub-System Name: Closed Cooling Water		
COMPONENT - UNID - MASTER EQUIPMENT LIST		
New MAXIMO UNID		
UNID	**UNID Description**	**Equipment Reliability Component Classification (CC, NC, or, RTF)**
RH1STM-HC-CC-TEU-TE223B	COND PUMP MOTOR 1B COOL WTR TEMPERATURE ELEMENT	NC
RH1STM-HC-CC-TNK-019M	CCW CHEMICAL ADD TANK	NC
RH1STM-HC-CC-HTX-01AA	CCW HEAT EXCHANGER 1A	NC
RH1STM-HC-CC-HTX-01AB	CCW HEAT EXCHANGER 1B	NC
RH1STM-HC-CC-PMP-01PA	CCW PUMP 1A	CC
RH1STM-HC-CC-MTR-01PA	CCW PUMP 1A MOTOR	CC
RH1STM-HC-CC-PMP-01PB	CCW PUMP 1B	CC
RH1STM-HC-CC-MTR-01PB	CCW PUMP 1B MOTOR	CC
RH1STM-HC-CC-SNR-01FA	CCW INLET STRAINER 1A	NC
RH1STM-HC-CC-SNR-01FB	CCW INLET STRAINER 1B	NC
RH1STM-HC-CC-TNK-01TA	CCW HEAD TANK	CC
RH1STM-HC-CC-EXP-09MA	CCW PUMP 1A INLET EXPANSION JOINT	NC
RH1STM-HC-CC-EXP-09MB	CCW PUMP 1B INLET EXPANSION JOINT	NC
RH1STM-HC-CC-VLV-001A	CCW PUMP 1A INLET ISOLATION VALVE	RTF
RH1STM-HC-CC-VLV-001B	CCW PUMP 1B INLET ISOLATION VALVE	RTF
RH1STM-HC-CC-CKV-002A	CCW PUMP 1A DISCHARGE CHECK VALVE	NC
RH1STM-HC-CC-CKV-002B	CCW PUMP 1B DISCHARGE CHECK VALVE	NC

As the Material Condition Improvement Initiative proceeds, APS has intentions to perform a comprehensive MBO analysis within the next one to two years. These criticality rankings will be validated as part of the more detailed MBO analysis process.

Medium Complexity Component Criticality Ranking Example

The criticality determination method used by the Hawaiian Electric Company (HECO) is a good example of a medium complexity implementation of determining CCR values for utility components. HECO developed an Importance/Criticality Matrix (Table 5-2) as part of the Power Supply Reliability Optimization (PSRO) initiative. This approach applied nine (9) CCR levels to each plant component.

Table 5-2
HECO Criticality Matrix

Priority	Reliability Capacity	Efficiency	Environment	Safety
1	Full Load Loss		Immediate Non-Compliance	Asset Required to Protect Life/Property
2	Major De-Rating 40% or more		Imminent Violation	
3	Significant De-Rating 20% or more	Heat Rate Effect Significant		
4	0% De-Rating but possible generation loss due to extended asset failure		Prevents Effective Management	Redundant Safety System
5	Potential Loss of Generation due to failure of redundant equipment	Heat Rate Effect Moderate		
6	Loss of Asset Causes Loss of Auto Function to Multiple Equipment or System		Detracts from Improvement Goals	Protects equipment from Damage
7	Loss of Asset Causes Significant Operational Inconvenience	Heat Rate Effect Minimal		
8	Loss of Asset Precludes Normal System or Equipment Operation			
9	No Effect	No Effect	No Effect	No Effect

The nine (9) priority levels developed and applied were based on four (4) criteria associated with HECO's high-level business objectives:

- Reliability capacity
- Efficiency
- Environment
- Safety

Subsequently, HECO associated the nine (9) CCR levels with their work control priority system. Table 5-3 provides the relationship between CCR priority levels 1 – 9 and the High, Medium, and Low work control priority definitions.

Table 5-3
HECO Asset Criticality Code for Work Control Prioritization System

HECO		**PSRO**
High	Causes a Unit De-Rate of more than 10 MW	1
	Places more than 2 units on 100% Risk Condition	2
	Has an immediate impact on personnel safety or environmental compliance	3
Medium	Places a single unit on 100% risk for more than 5 days	4
	Places a unit on risk for 1 day	5
	Has potential to impact on personnel safety or environmental compliance	6
Low	Plant system problems that do not immediately impact unit operation or reliability	7
	Non-Plant related systems that may have short term impacts on unit operation or reliability	8
	Non-Plant related systems that may have little impact or no impacts on unit operation or reliability	9
Examples		
High – 1	Boiler Feed Pump	
High – 2	Auxiliary Cooling Water or Station Service Water Pumps	
High – 3	Opacity Meter OOS, Broken Handrail	
Medium – 1	Circulating Water Pump Bearing	
Medium – 2	Fuel Oil Pump, Mechanical Seal	
Medium – 3	Calibrate Waste Water Overboard Meter Before July 31	
Low – 1	Boiler Wash Pump #31 Foot Valve Stuck Open	
Low – 2	Batch Tank Influent Pump #2 Seized	
Low – 3	Admin. Bldg. Toilet Flush Valve Leaking	

Table 5-4 represents HECO's desire for future work order priority coding with the correlation to the CCR values.

Table 5-4
HECO Future Work Order Priority Codes

Priority Codes	Descriptions
H1	**VITAL** - Failure will result in an immediate loss of Full Generating Capacity. Failure has an immediate impact on Plant / Personnel Safety or results in an Environmental Non- Compliance. Failure will result in an Unexpected Large Capital Expenditure, Long Lead Time for Replacement of Asset or Parts.
H2	**URGENT** - Failure will result in a Partial Loss of Generation, 40% or Greater. Has a Potential of causing Environmental Non- Compliance or Unsafe Condition.
H3	**SIGNIFICANT** - Failure will result in a Partial Loss of Generation, 20% up to 40% or has significant Heat Rate Effect implications.
M1	**SERIOUS** - Extended failure will result in a serious condition, eventually leading to a Loss of Generation. Usually requires manual control or system could become unstable and result in a loss of function of the component, failure of component, manual operation or de-rating event.
M2	**MODERATE** - Failure of Redundant Equipment will result in a Loss of Generation or Moderate Heat Rate Effect.
M3	**MILD** - Failure will have a significant impact on normal Operating Activities. Automatic Control is lost and Manual Control is required or additional monitoring is required to maintain equipment within specification limits.
L1	**MINIMAL** - Failure will not immediately impact unit operation / reliability.
L2	**DEFERABLE** - Failure may have a short term impact on unit operation I reliability or results in an inconvenience to Plant Operating Activities.
L3	**NO EFFECT** - Failure will have little impact or no impacts on unit Operation / Reliability.

High Complexity Component Criticality Ranking Example

System and equipment reliability prioritization (SERP) is an example of a high complexity approach to determining CCR. The SERP process was performed at Progress Energy's Sutton Plant in June of 2007. Sutton Plant is a three unit, 575 megawatt total capacity, coal-fired generating facility that was commissioned in 1954. The SERP process at Sutton Plant required 12 days and involved the following plant personnel full commitment to complete:

- Operations department, 1 person
- Predictive maintenance (PdM) technician, 2 persons
- Work management specialists, 2 persons
- Craft, 1 person from each discipline
- Maintenance supervision

Progress Energy applied the following criticality criteria to perform their SERP analysis:

- Safety
- Environmental
- System costs
- Component cost
- Commercial availability
- Heat rate – efficiency

Depicted in Table 5-5 is the Sutton Plant SERP analysis results spreadsheet. This table represents a sort of the top 41 SCR values for Unit 3 systems and is sorted from the highest to the lowest rankings.

Table 5-5
Progress Energy Sutton Plant SERP Example - Sorted by SCR

FAC	Unit	System Code	System Name	Safety	Envir	Cost	Comm Avail	Heat Rate / Eff	System Criticality Ranking SCR
SUT	3	6175	Site Fire Protection	8	3	10	9	1	15.97
SUT	3	5090	48 VDC Distribution	8	3	10	9	1	15.97
SUT	3	5245	125 VDC Distribution	8	1	10	9	1	15.72
SUT	3	5240	125 VDC Battery Charger	8	1	10	9	1	15.72
SUT	3	5235	125 VDC Battery	8	1	10	9	1	15.72
SUT	3	5020	Turbine Lube Oil	5	1	10	9	1	14.42
SUT	3	7040	Precipitator	3	10	1	8	1	13.23
SUT	3	4080	Closed Cooling Water	3	1	10	8	1	13.23
SUT	3	5265	Heat Tracing	3	1	6	8	1	10.54
SUT	3	5060	Hydrogen Seal Oil	5	1	4	8	1	10.34
SUT	3	3070	Condensate	3	1	1	8	5	10.00
SUT	3	3060	Heater Vents, Drains & Level Controls	3	1	1	8	5	10.00
SUT	3	3055	Feedwater Heaters	3	1	1	8	5	10.00
SUT	3	3050	Feedwater	3	1	1	8	5	10.00
SUT	3	5145	Start-Up And Auxiliary	3	1	1	9	1	9.64
SUT	3	5135	230 Kv Switchyard System	3	1	1	9	1	9.64
SUT	3	5040	Generator System	3	1	1	9	1	9.64
SUT	3	5005	Turbine	3	1	1	9	1	9.64
SUT	3	2140	Pulverizers	3	1	1	9	1	9.64
SUT	3	2130	Coal Distribution After Crusher	3	1	1	9	1	9.64

Table 5-5 (continued)
Progress Energy Sutton Plant SERP Example - Sorted by SCR

FAC	Unit	System Code	System Name	Safety	Envir	Cost	Comm Avail	Heat Rate / Eff	System Criticality Ranking SCR
SUT	3	1020	Furnace	3	1	1	9	1	9.64
SUT	3	1015	Boiler	3	1	1	9	1	9.64
SUT	3	6175	480 VAC Distribution	3	1	4	8	1	9.54
SUT	3	5050	Generator Gas	3	1	4	8	1	9.54
SUT	3	5035	Turning Gear	3	1	4	8	1	9.54
SUT	3	5025	Gland Seal	3	1	4	8	1	9.54
SUT	3	4015	Circulating Water	3	1	4	8	1	9.54
SUT	3	3105	Boiler Chemical treatment	3	1	4	8	1	9.54
SUT	3	2160	Combustion Controls	3	3	1	8	1	9.17
SUT	3	2145	Combustion Air	3	3	1	8	1	9.17
SUT	3	7050	Flue Gas	3	1	1	8	1	8.72
SUT	3	6135	Instrument Air	3	1	1	8	1	8.72
SUT	3	6010	Main Control Board	3	1	1	8	1	8.72
SUT	3	6005	Process Computer	3	1	1	8	1	8.72
SUT	3	5195	Uninterruptible Ac	3	1	1	8	1	8.72
SUT	3	5175	480 VAC Distribution	3	1	1	8	1	8.72
SUT	3	5170	4 kV Ac Distribution	3	1	1	8	1	8.72
SUT	3	5065	Generator Isolated Bus	3	1	1	8	1	8.72
SUT	3	5045	Generator Exciter	3	1	1	8	1	8.72
SUT	3	5030	Exhaust Hood Spray	3	1	1	8	1	8.72
SUT	3	5015	Electro-Hydraulic Control	3	1	1	8	1	8.72

Depicted in Table 5-6 is the Sutton Plant SERP analysis results spreadsheet. This figure represents a sort of the top 20 operating criticality ranking (OCR) values for Unit 3 components and is sorted from the highest to the lowest rankings.

Depicted in Table 5-7 below is the Sutton Plant SERP analysis results spreadsheet. This table represents a sort of the top 20 CCR values for Unit 3 and is sorted from the highest to the lowest rankings. The SERP CCR ranking represents the relative importance of that specific asset at Sutton Plant to all other assets.

Table 5-6
Progress Energy Sutton Plant SERP Example - Sorted by OCR

FAC	UNIT	SYS NUM	SYST DESC	EQUIP TYPE	EQUIPT DESC	EQUIP NUMBER	Safety	Envir	Cost	Comm Avail	Heat Rate/ EFF	Operating Criticality Ranking OCR	System Criticality Ranking SCR	Asset Criticality Ranking CCR	Asset Failure Probability Factor AFPF	Maint. Priority Index MPI
SUT	3	2130	Coal Distribution After Crusher	DLV	Valve, Deluge (Fire Prot.)	DLV	8	3	10	9	1	15.97	9.64	154.00	1	154.00
SUT	3	6175	Site Fire Protection	CON	Controls	Fenwal Alarm	8	3	10	9	1	15.97	9.54	152.33	4	609.33
SUT	3	6175	Site Fire Protection	CON	Controls	Fire Detection	8	3	10	9	1	15.97	9.54	152.33	4	609.33
SUT	3	6175	Site Fire Protection	DLV	Valve, Deluge (Fire Prot.)	Fire Deluge	8	3	10	9	1	15.97	9.54	152.33	1	152.33
SUT	3	6175	Site Fire Protection	CON	Controls	Fire Det Panel	8	3	10	8	1	15.43	9.54	147.17	4	588.67
SUT	3	5005	Turbine	RTR	Rotor	HP/IP Rotor	3	3	10	9	1	14.14	9.64	136.38	1	136.38
SUT	3	5005	Turbine	RTR	Rotor	LP Blading	3	3	10	9	1	14.14	9.64	136.38	1	136.38
SUT	3	5005	Turbine	RTR	Rotor	LP Rotor	3	3	10	9	1	14.14	9.64	136.38	1	136.38
SUT	3	5020	Turbine-Generator Lube Oil	MOT	Motors	Mot-Exv	3	1	10	9	1	13.86	14.42	199.84	1	199.84
SUT	3	5020	Turbine-Generator Lube Oil	PMP	Pumps	Pmp-Eyo	3	1	10	9	1	13.86	14.42	199.84	1	199.84
SUT	3	5040	Generator	GEN	Generator	Gen Stat Rotor	3	1	10	9	1	13.86	9.64	133.63	1	133.63
SUT	3	5005	Turbine	TRB	Turbines	Hp Outer Shell	3	1	9	9	1	13.15	9.64	126.84	1	126.84
SUT	3	5065	Generator Isolated Phase Bus	TRN	Transformer	Main Xfmer	3	1	9	9	1	13.15	8.72	114.66	1	114.66
SUT	3	5145	Startup & Aux Transformer	TRN	Transformer	Aux Xfmer	3	3	8	9	1	12.81	9.64	123.50	1	123.50
SUT	3	5145	Startup & Aux Transformer	TRN	Transformer	Start-Up Xfmer	3	3	8	9	1	12.81	9.64	123.50	1	123.50
SUT	3	5005	Turbine	BRN	Assemblies, Bearing	No.1 Turb Brg	3	1	8	9	1	12.49	9.64	120.45	1	120.45
SUT	3	5005	Turbine	BRN	Assemblies, Bearing	No.2 Turb Brg	3	1	8	9	1	12.49	9.64	120.45	1	120.45
SUT	3	5005	Turbine	BRN	Assemblies, Bearing	No.3 Turb Brg	3	1	8	9	1	12.49	9.64	120.45	1	120.45
SUT	3	5005	Turbine	BRN	Assemblies, Bearing	No.4 Turb Brg	3	1	8	9	1	12.49	9.64	120.45	1	120.45
SUT	3	5005	Turbine	BRN	Assemblies, Bearing	Thrust Bearing	3	1	8	9	1	12.49	9.64	120.45	1	120.45

Table 5-7
Progress Energy Sutton Plant SERP Example - Sorted by CCR

FAC	UNIT	SYS NUM	SYSTEM DESC	EQUIP TYPE	EQUIPT DESC	EQUIP NUM	Safety	Envir	Cost	Comm Avail	Heat Rate/ EFF	Operating Criticality Ranking OCR	System Criticality Ranking SCR	Asset Criticality Ranking CCR	Asset Failure Probability Factor AFPF	Maint. Priority Index MPI
SUT	3	5020	Turbine-Generator Lube Oil	MOT	Motors	Mot-Exv	3	1	10	9	1	13.86	14.42	199.84	1	199.84
SUT	3	5020	Turbine-Generator Lube Oil	PMP	Pumps	Pmp-Eyo	3	1	10	9	1	13.86	14.42	199.84	1	199.84
SUT	3	7040	Precipitators	TRC	Xfmer / Rectifiers Set	T/R Ge 115kva	3	3	7	9	1	12.21	13.23	161.48	1	161.48
SUT	3	5245	125 V Dc Distribution	DP-	Panels, Distribution	3A VDC Dist Pan	3	1	5	8	1	10.00	15.72	157.16	1	157.16
SUT	3	5245	125 V Dc Distribution	DP-	Panels, Distribution	3B VDC Dist Pan	3	1	5	8	1	10.00	15.72	157.16	1	157.16
SUT	3	2130	Coal Distribution After Crusher	DLV	Valve, Deluge (Fire Prot.)	Dlv	8	3	10	9	1	15.97	9.64	154.00	1	154.00
SUT	3	6175	Site Fire Protection	CON	Controls	Fenwal Alarm	8	3	10	9	1	15.97	9.54	152.33	4	609.33
SUT	3	6175	Site Fire Protection	CON	Controls	Fire Detection	8	3	10	9	1	15.97	9.54	152.33	4	609.33
SUT	3	6175	Site Fire Protection	DLV	Valve, Deluge (Fire Prot.)	Fire Deluge	8	3	10	9	1	15.97	9.54	152.33	1	152.33
SUT	3	6175	Site Fire Protection	CON	Controls	Fire Det Panel	8	3	10	8	1	15.43	9.54	147.17	4	588.67
SUT	3	5020	Turbine-Generator Lube Oil	PIP	Piping	PIP	5	3	2	8	1	10.15	14.42	146.37	1	146.37
SUT	3	7040	Precipitators	ELC	Electrode	Elc	3	3	6	8	1	10.91	13.23	144.31	1	144.31
SUT	3	5020	Turbine-Generator Lube Oil	RSV	Reservoir	Rsv	3	1	4	8	1	9.54	14.42	137.58	1	137.58
SUT	3	5020	Turbine-Generator Lube Oil	RSV	Reservoir	001	3	1	4	8	1	9.54	14.42	137.58	1	137.58
SUT	3	5005	Turbine	RTR	Rotor	HP/IP Rotor	3	3	10	9	1	14.14	9.64	136.38	1	136.38
SUT	3	5005	Turbine	RTR	Rotor	LP Blading	3	3	10	9	1	14.14	9.64	136.38	1	136.38
SUT	3	5005	Turbine	RTR	Rotor	LP Rotor	3	3	10	9	1	14.14	9.64	136.38	1	136.38
SUT	3	5040	Generator	GEN	Generators	Gen Stat Rotor	3	1	10	9	1	13.86	9.64	133.63	1	133.63
SUT	3	5005	Turbine	TRB	Turbines	Hp Outer Shell	3	1	9	9	1	13.15	9.64	126.84	1	126.84
SUT	3	5145	Startup & Aux Transformer	TRN	Xfmer	Aux Trn	3	3	8	9	1	12.81	9.64	123.50	1	123.50

The Sutton Plant SERP analysis used asset failure probability factor (AFPF) values that ranged from 1 to 10 and were based on the criteria identified in Table 5-8.

Table 5-8
Progress Energy Sutton Plant SERP Results - AFPF Criteria

AFPF Value	Criteria Description
1	None or very infrequent failure frequency in number of years
4	Few Problems – failure frequency once a year
7	Frequent attention needed – failure frequency in months (several per year)
10	Many problems – Biggest man-hour consumer

Depicted in Table 5-9 is the Sutton Plant SERP analysis results spreadsheet. This table represents a sort of the top 25 maintenance priority index (MPI) values for Unit 3 components and is sorted from the highest to the lowest rankings. The MPI number combines the CCR with the AFPF of the specific asset. This provides a relative number that allows the organization to identify the components that have the highest priority for maintenance to the lowest priority for maintenance.

Table 5-9
Progress Energy Sutton Plant SERP Example - Sorted by MPI

FAC	UNIT	SYS NUM	SYSTEM DESC	EQUIP TYPE	EQUIPT DESC	EQUIP NUM	Safety	Envir	Cost	Comm Avail	Heat Rate/ EFF	Operating Criticality Ranking OCR	System Criticality Ranking SCR	Asset Criticality Ranking CCR	Asset Failure Probability Factor AFPF	Maint. Priority Index MPI
SUT	3	6175	Site Fire Protection	CON	Controls	Fenwal Alarm	8	3	10	9	1	15.97	9.54	152.33	4	609.33
SUT	3	6175	Site Fire Protection	CON	Controls	Fire Detection	8	3	10	9	1	15.97	9.54	152.33	4	609.33
SUT	3	6175	Site Fire Protection	CON	Controls	Fire Det Panel	8	3	10	8	1	15.43	9.54	147.17	4	588.67
SUT	3	7050	Flue Gas	DUC	Ductwork	Duct-LWZ	1	1	1	1	5	5.39	8.72	46.95	7	328.63
SUT	3	7050	Flue Gas	DUC	Ductwork	Duct-LXA	1	1	1	1	5	5.39	8.72	46.95	7	328.63
SUT	3	7020	Fly Ash Removal - Wet	PIP	Piping	Pip	3	1	2	1	1	4.00	7.75	30.98	10	309.84
SUT	3	6175	Site Fire Protection	PIP	Piping	Xfmer Piping	3	1	3	1	1	4.58	9.54	43.71	7	306.00
SUT	3	7040	Precipitators	CSG	Casing	CSG	3	3	2	3	1	5.66	13.23	74.83	4	299.33
SUT	3	7040	Precipitators	MIN	I&C, Misc	Precip Rap Ctr	1	3	2	4	1	5.57	13.23	73.65	4	294.62
SUT	3	4080	Component/Closed Cooling Water	HTX	Heat Exchangers	3A CCW Ht Exch	1	1	3	4	1	5.29	13.23	70.00	4	280.00
SUT	3	4080	Component/Closed Cooling Water	HTX	Heat Exchangers	3B CCW Ht Exch	1	1	3	4	1	5.29	13.23	70.00	4	280.00
SUT	3	4080	Component/Closed Cooling Water	MOT	Motors	003	1	1	3	4	1	5.29	13.23	70.00	4	280.00
SUT	3	4080	Component/Closed Cooling Water	MOT	Motors	010	1	1	3	4	1	5.29	13.23	70.00	4	280.00
SUT	3	4080	Component/Closed Cooling Water	MOT	Motors	3A CCW Pmp Mtr	1	1	3	4	1	5.29	13.23	70.00	4	280.00
SUT	3	4080	Component/Closed Cooling Water	MOT	Motors	3B CCW Pmp Mtr	1	1	3	4	1	5.29	13.23	70.00	4	280.00
SUT	3	4080	Component/Closed Cooling Water	PMP	Pumps	3A CCW Pump	1	1	3	4	1	5.29	13.23	70.00	4	280.00
SUT	3	4080	Component/Closed Cooling Water	PMP	Pumps	3B CCW Pump	1	1	3	4	1	5.29	13.23	70.00	4	280.00
SUT	3	5235	125 V Dc Battery	BAT	Batteries	Batteries	3	1	2	1	1	4.00	15.72	62.86	4	251.46
SUT	3	5245	125 V Dc Distribution	FIX	Fixtures, Light, And, Lights	Emerg. Lights	3	1	1	1	1	3.61	15.72	56.67	4	226.66
SUT	3	3045	Reheat	STV	Valve, Stop	RH spray Reg vlv	3	1	2	1	5	6.32	8.72	55.14	4	220.54
SUT	3	7060	Continuous Emission Monitoring	MON	Monitor	Flow Monitor	1	3	2	3	1	4.90	6.00	29.39	7	205.76
SUT	3	7060	Continuous Emission Monitoring	MON	Monitor	Opacity Monitor	1	3	2	3	1	4.90	6.00	29.39	7	205.76
SUT	3	5020	Turbine-Generator Lube Oil	MOT	Motors	Mot-Exv	3	1	10	9	1	13.86	14.42	199.84	1	199.84
SUT	3	5020	Turbine-Generator Lube Oil	PMP	Pumps	Pmp-Eyo	3	1	10	9	1	13.86	14.42	199.84	1	199.84
SUT	3	2160	Combustion / Process Control	ANL	Analyzer	O2 Cab A/C	1	3	1	3	1	4.58	9.17	42.00	4	168.00

As you can see the various sorts provide differing results as far as highest rankings to lowest rankings for components, systems, CCR values, and the overall MPI values. The reason for the differences between CCR values and MPI values are the AFPF that were applied to the various components.

Sutton Plant's use of a subjective scale of 1 to 10 provided only a guideline as to what the absolute MPI should be for a piece of equipment; however, when the risk management process is implemented, it provides a more objective failure rate for components than AFPF. The value and validity of the MPI can be used with greater assurance within the CCR process. In the future Sutton Plant plans to develop the probability of failure that will be calculated each year as part of the risk management process.

Section 6: References

1. *Developing and Implementing an Asset Health Management Program.* EPRI, Palo Alto, CA: 2011. 1023067
2. Progress Energy – Fossil Condition Assessment Process procedure, EGR-FGDX-00150
3. Progress Energy – Maintenance Basis Optimization (MBO) and System and Equipment Reliability Prioritization (SERP) Procedure, ADM-FGDX-00044
4. NERC – 2011 Risk Assessment of Reliability Performance Report – July 2011
5. NERC – 2011 Long Term Reliability Assessment Report – November 2011

Section 7: Glossary

Asset – A tangible component that a utility owns and uses to produce income. An asset is commonly considered to be any component of a plant or its equipment. Synonymous with equipment and components.

Component Criticality Ranking (CCR) – The calculated criticality value of a component relative to other components within the plant. This value is calculated by multiplying the component value to the system by the value of the system to the plant.

Asset Failure Probability Factor (AFPF) – A value placed on the actual failure rate for each component/asset type. This probability can be based on industry failure rate data, actual in-house component failure rate data, or craft experience. This factor is the likelihood that each component will fail to provide its designed function and, therefore, require maintenance. This factor represents the probability of failure. Synonymous with component failure probability.

Critical Issues – Plant concerns that pose a risk to reliability or costs. These issues require substantial funding, engineering assistance, or upper management attention. Generally, these issues cannot be simply addressed with a routine work order and can lead to intolerable consequences.

Consequences – The level of impact that results from an unwanted event or condition. Its impact may result in future expenditures, equipment reliability reduction, loss of generation, loss of efficiency, or safety and environmental issues.

Critical Component (CC) – Those components for which an organization has zero tolerance for unplanned failures. Critical components are components whose function is so important that efforts are made to prevent all failures that are known to occur and are expected to occur at least once in the life of the component. Critical components must, therefore, be subject to sufficient design control and design change rigor. They must have sufficient monitoring and maintenance coverage in frequency and scope to address a wide spectrum of possible failure mechanisms.

Functional Failure – A failure in which a device or system loses its ability to perform its intended design functions.

GADS (Generating Availability Database System) – The system used by NERC (North American Electric Reliability Council) that collects, records, and retrieves operating information about the performance of electric generating equipment. Megawatt-hour (MWh) losses are recorded by cause code.

GADs Risk Table – The risk assessment product that provides historical information obtained from GADS. The information is presented in a table as a product of "total megawatt-hour loss" and "total number of occurrences".

Importance Level – A numerical priority value (e.g., 1 to 9) assigned to a specific component that describes the plant effects or consequences of a component failure.

Maintenance Basis (MB) – A strategy that defines the specific PM tasks, scope, and frequencies to protect a component from functional failure. The Maintenance Basis contains the documented rational for performing the specific tasks and for the recommended frequency of performance. The Maintenance Basis includes both time based restore or replacement tasks (PM-RR) and equipment condition data collection and inspection tasks (PM-CMT). "Component Maintenance Strategy" is sometimes used synonymously with the term Maintenance Basis as it pertains to a specific plant component.

Maintenance Basis Failure (MBF) – Occurs when a functional failure occurs on a component that is protected by the Maintenance Basis. Although sometimes the failure may not be directly linked to a failure of the process established by the MBO analysis and implementation, all such failures indicate that the protected component has lost its function. Attending to MBFs enables the determination of corrective actions that drive the continuous improvement process.

Maintenance Basis Optimization (MBO) – A process used for establishing or reviewing the maintenance basis for plant production equipment. This process typically compares existing PMs to best practice PM Templates and makes the appropriate adjustments (e.g., PM task additions, PM task deletions, or PM task frequency changes) to establish new component maintenance strategies.

Maintenance Priority Index (MPI) – Places an absolute value on the maintenance requirements of each asset within the enterprise indicative of the current condition of the equipment as well as the importance or criticality of the equipment. It is calculated by multiplying the criticality of the component (CCR) by the Asset Failure Probability Factor (AFPF) to provide a value that is relative to the maintenance priority of all other assets.

Preventive Maintenance Templates – A set of maintenance criteria for a combination of condition based, timed based, usage based, and/or operations surveillances that defines a maintenance strategy for a specific type of equipment. The templates may have several scenarios for the severity of conditions the equipment is operating in (e.g., severe or mild), the use of the equipment (e.g., high or seldom used) and the criticality of equipment (e.g., critical or non-critical).

Non-Critical (NC) – A component that falls between the two extremes of critical and run-to-failure. These are components for which cost-effective time based or condition based monitoring tasks are utilized to extend the component integrity and useful life. An aggressive maintenance strategy to eliminate all individual failures is not utilized for Non-Critical components.

Operational Criticality Ranking (OCR) – Calculated value of a component relative to any other component within a system relative to any other component within the same system. This value is calculated utilizing the component level decision criteria (factors) developed from the strategic goals and objectives of the utility.

Risk – The possibility of experiencing loss or injury. Risk is calculated by multiplying the consequence of the loss or injury by the probability that the event will occur.

Risk Assessment – Process used to determine the risk level of critical issues. Information is obtained and analyzed from various sources. The products of a risk assessment are the critical issues list, risk grid, GADS risk table, and any inspection recommendations.

Risk Grid – The risk assessment product that graphically communicates the risk level of critical issues.

Run-to-Failure (RTF) – Components that do not meet the requirements for critical or non-critical criteria. These components do not affect safety, reliability, or environmental compliance. It is more economical to allow these components to run-to-failure than to perform condition-based maintenance (CBM) or PM tasks.

System Criticality Ranking (SCR) – The calculated value of a system relative to other similar systems in the overall fleet or individual plant. This value is calculated utilizing decision criteria (factors) developed from the strategic goals and objectives of the utility.

Section 8: Acronyms

ACR – Asset Criticality Ranking

AECI – Associated Electric Cooperative, Inc.

AFPF – Asset Failure Probability

APS – Arizona Public Service

CC – Critical Component

CMMS – Computerized Maintenance Management System

EPRI – Electric Power Research Institute

ER – Equipment Reliability

GADS – Generating Availability Data System

HECO – Hawaiian Electric Company

MB – Maintenance Basis

MBF – Maintenance Basis Failure

MBO – Maintenance Basis Optimization

MEL – Master Equipment List

MPI – Maintenance Priority Index

NERC – North American Electric Reliability Corporation

NC – Non-Critical

OCR – Operational Criticality Rank

PM – Preventive Maintenance

PM-CMT – Preventive Maintenance-Condition Monitoring Task

RTF – Run-To-Failure

SCR – System Criticality Ranking

SERP – System and Equipment Reliability and Prioritization

SME – Subject Matter Expert

SOCO – Southern Company

TVA – Tennessee Valley Authority

WO – Work Order

Appendix A: Example Risk Assessment Grid

RISK ASSESSMENT - RISK GRID

Probability			Very Low 1 ≤12 hrs	Low 2 13 - 24 hrs	Moderate 3 25 - 48 hrs	High 4 49 - 96 hrs	Very High 5 >96 hrs
≤1 year	5	Very High	Low	Moderate	High	High	High
≤2 years	4	High	Very Low	Low	Moderate	High	High
≤3 years	3	Moderate	Very Low	Low	Moderate	Moderate	High
≤4 years	2	Low	Very Low	Low	Low	Low	Moderate
≤5 years	1	Very Low	Very Low	Very Low	Very Low	Very Low	Low

Current Reliability

Consequences

RISK ASSESSMENT RANKING DEFINITIONS

Consequences

Rank	Safety	Environmental	Reliability (Equivalent Hours Down)[1]
1 Very Low			≤12 hours
2 Low			≤24 hours
3 Moderate	Work-Around	Could exceed limits or possible exposure.	≤48 hours
4 High			≤96 hours
5 Very High	No Work-Around	Exceeds limits or human exposure.	>96 hours

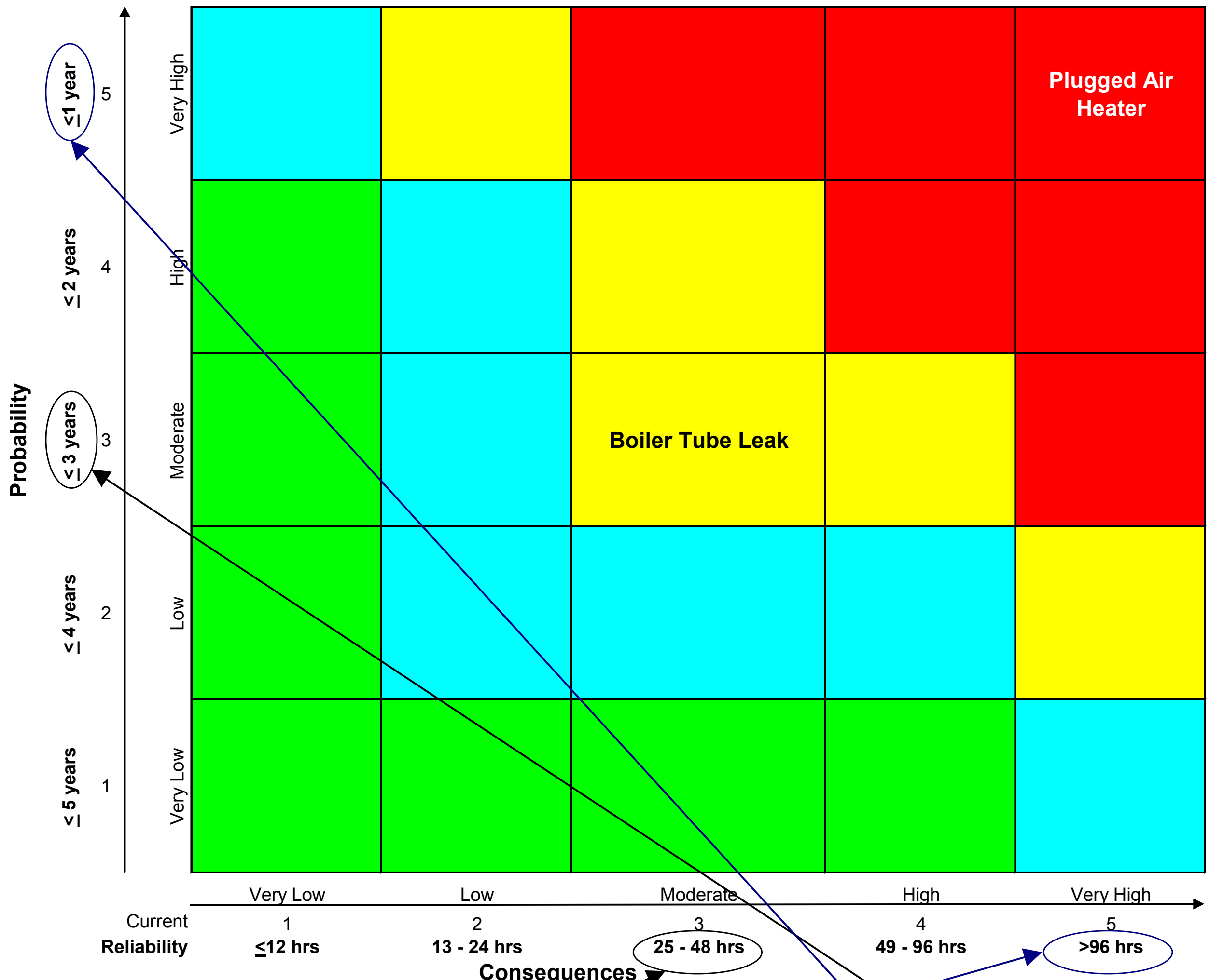
Probability

Rank	Safety Event Occurs within	Environmental Event Occurs within	Reliability Event Occurs within
1 Very Low	5 yrs	5 yrs	5 yrs
2 Low	4 yrs	4 yrs	4 yrs
3 Moderate	36 months	36 months	36 months
4 High	24 months	24 months	24 months
5 Very High	12 months	12 months	12 months

Note: 1. Equivalent Hours Down - The number of equivalent full load hours lost during the time period that the event occurs.

Figure A-1
Risk Assessment Grid Definitions

RISK ASSESSMENT - RISK GRID (Example)



Issue	Consequences	Probability
Boiler Tube Leak	Unit down for 40 hours.	Occur within 3 years.
Plugged Air Heater	1/30 of full load (8,760/30 = 292 equivalent hours)	Currently Plugged

Figure A-2
Risk Assessment Grid Examples

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