Facilities Management
The University of Iowa

University of Iowa:
Single-Point Failure Analysis
RAM Program

RMF Engineering
Reliability. Efficiency. Integrity.

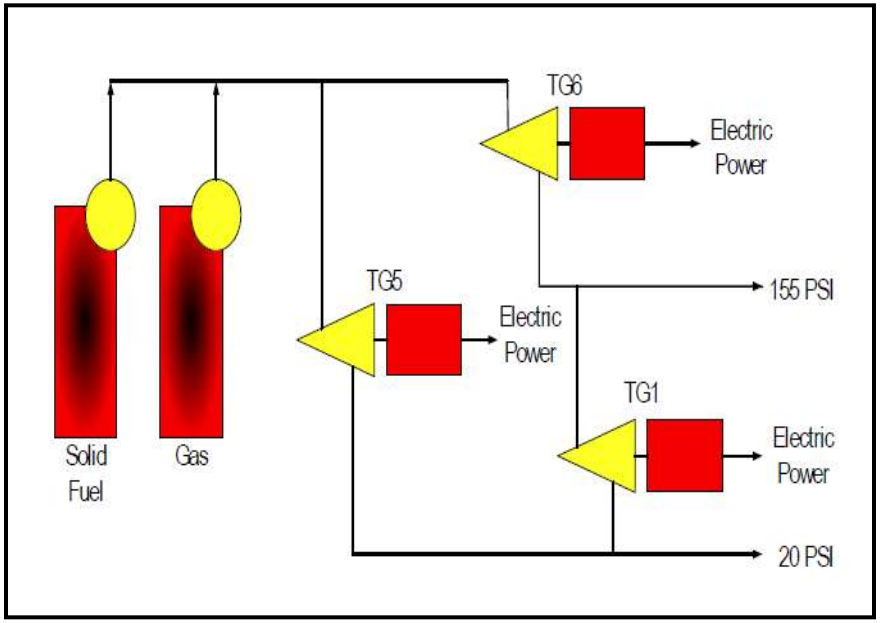
Agenda

- **University of Iowa**
  - Power Plant Overview and Single-Point Failure event
- **Reliability Engineering**
  - Tools of mitigating risk
- **ASME RAM-1 Standard**
  - Providing the Framework and Process

Overview

- **University of Iowa – Main Power Plant**
  - **4 Boilers: 600+ klb/hr, 3 Turbine Generators - 24.7 MW**

Boiler	Installed	Fuel	Capacity	Emmissions Control
7	1991	gas	135,000 PPH	Lox NOx Burners
8	1991	gas	140,000 PPH	Lox NOx Burners
10	1975	coal/gas/ biomass	170,000 PPH	Electrostatic Precipitator
11	1987 (1996)	coal/biomass	170,000 PPH	Baghouse and SO2 Emmissions Control



  - **Provides a critical steam load to University Hospital**
  - **Highly flexible in fuels and modes of operation**

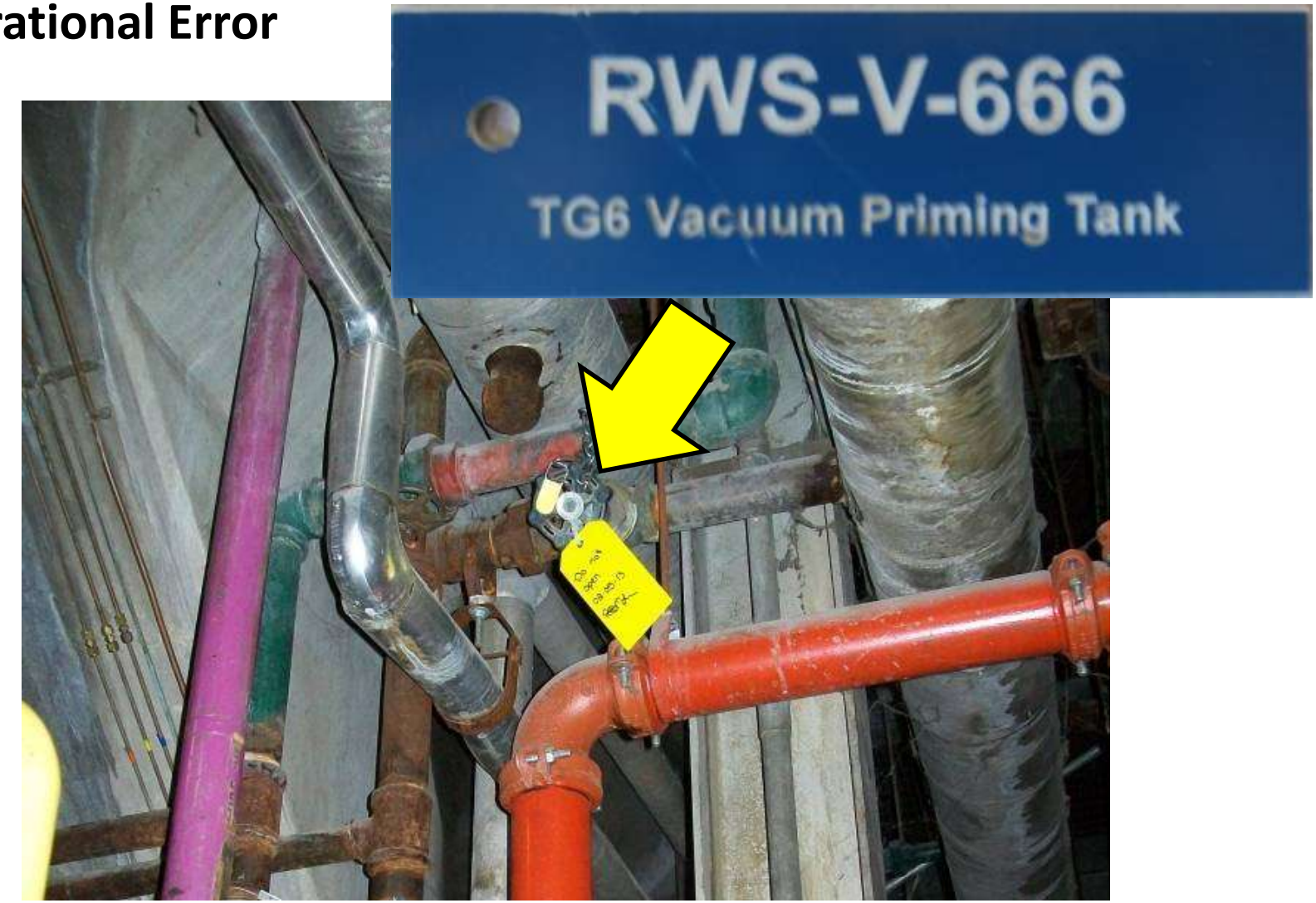
UI Steam Outage – February 5, 2013

Chronology

15:58 Boiler 11 trips on ash screw high temp and air compressors trip on high temp.
16:00 Operations troubleshoot CCW system and no root cause found.
16:30 TG6 and other equipment secured.
17:00 Mechanical distribution isolates west and east campus steam lines.
17:54 WCB 1 and 2 trip due to low water flow. Booster pump started and boilers re-started.
17:52 Plant instrument air established.
18:03 Boiler 7 and 8 online after stable CCW flow and instrument air
18:40 Steam introduced into North MPS and LPS sideline and pressure slowly increased.
19:00 PP personnel determine that CCW leak source was TG6 gland condenser to river water valve
20:42 Boiler 11 start-up attempted and SUB issue discovered.
23:14 West campus MPS steam line at normal header pressure.
23:30 Steam to campus fully restored.
00:58 Boiler 11 SUB online.
04:35 500 psi header at normal pressure.

UI Steam Outage 2013

- **Operational Error**



Reliability Engineering

- **A need for a *Single-Point Failure (SPF) Analysis***
  - **One tool in the toolbox…**
- **Reliability is a field of engineering.**
  - **Single Point Failure (SPF)**
  - **Failure Modes Effects and Criticality Analysis (FMECA)**
  - **Root Cause Analysis (RCA)**
  - **Fault Tree Analysis (FTA)**
  - **Reliability-Centered Maintenance (RCM)**
  - **Etc…**
- **ASME RAM-1 Compliance.**

Approach – PHASE 1

1. **Program Statement**

   Identify the power plant's functional requirements.

2. **Existing P&ID**

   Provide accurate drawings of the plant.

3. **OM&R Analysis**

   Identify effectiveness of existing of OM&R procedures.

4. **SPF**

   Identify the criticality of the equipment.

5. **FMECA**

   Identify how equipment can fail.

6. **ASME RAM-1 Compliance**

   RAM Program Manual

Approach – PHASE 2

7. **RCM**

   Match appropriate maintenance to modes of failure.

8. **OM&R**

   Establish highly effective OM&R procedures.

9. **Specification Guidelines**

   Incorporate reliability and OM&R into a set of spec guidelines.

10. **Training**

    Provide plant personnel training on the new system/processes.

11. **Audit**

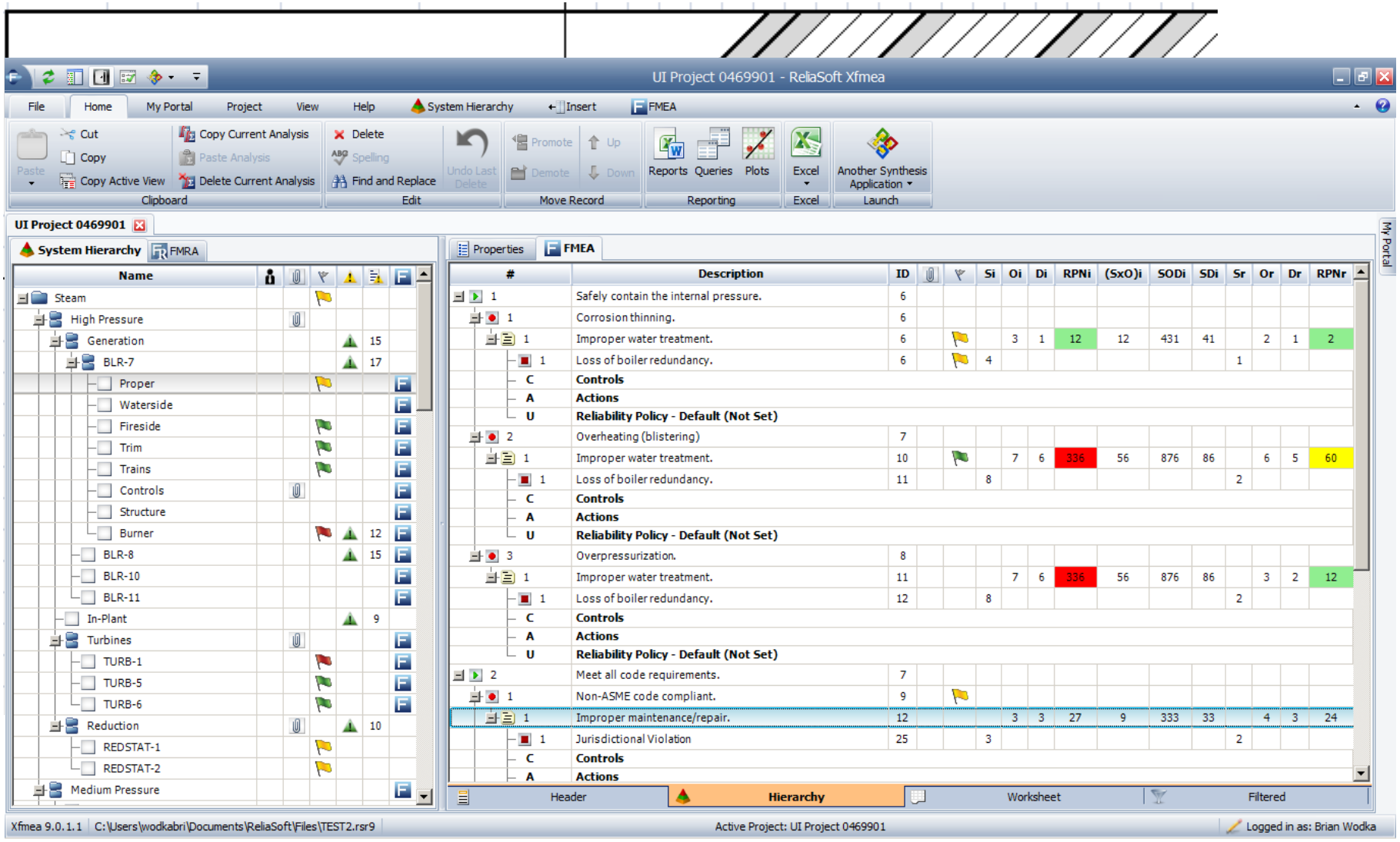
    Periodically provide examination of the RAM Program.

Phase 1 - Status

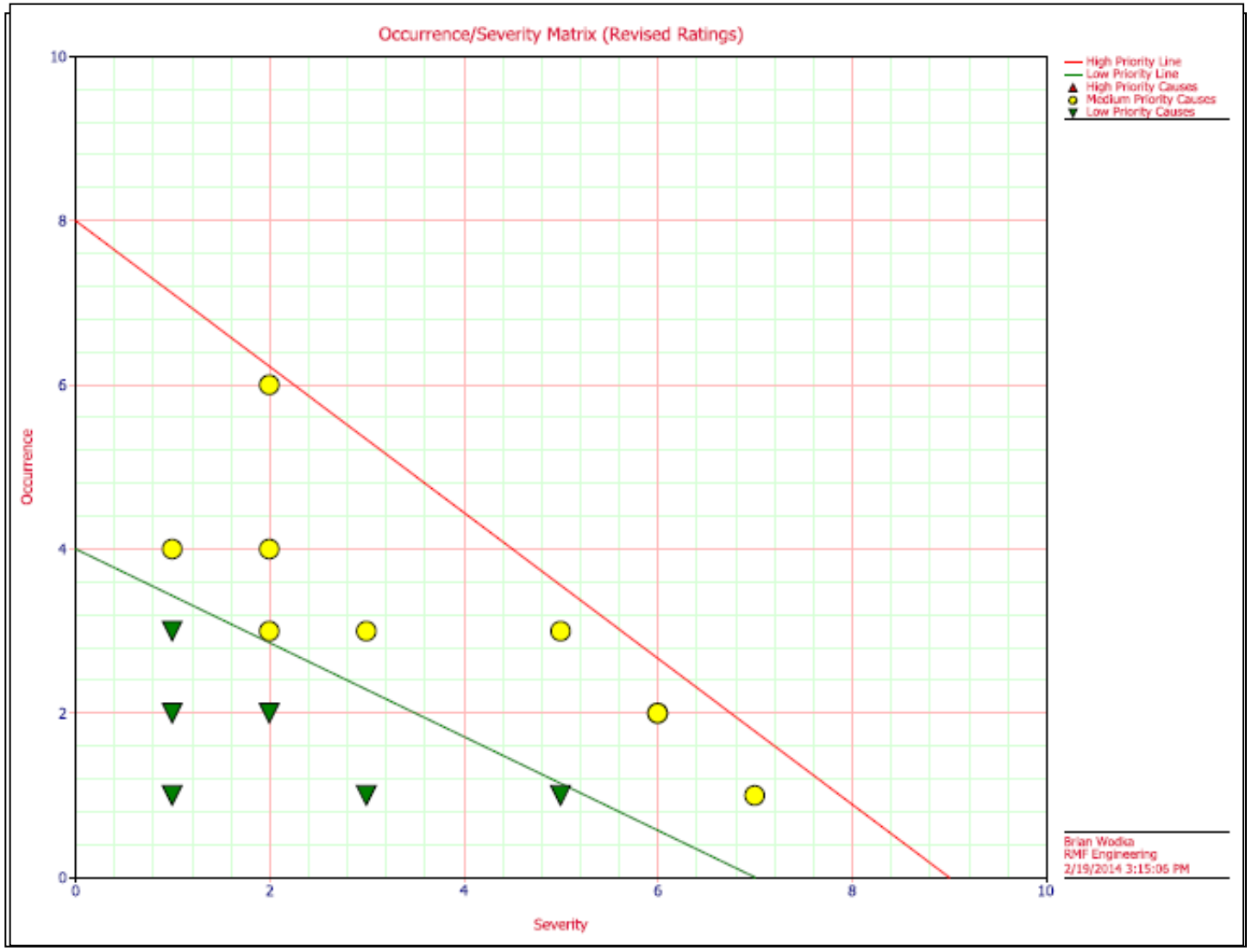
- Existing Drawings
  - Scope
  - Plan/Schematic
- 66 Mechanical Drawings
  - Concensus
- 14 Electrical Drawings

PLANT	SYSTEM	DRAWING TITLE	DRAWING NUMBER	FIELD WORK	FIELD INTO CAD	ENG QC	Submitted To Client	FINAL QC	Submitted After Comments
MPP	AIR	BASEMENT- NORTH END	150.1	100%	0%	0%		0%	
MPP	AIR	BASEMENT- SOUTH END	150.2	100%	0%	0%		0%	
MPP	AIR	NORTH END	150.3	100%	0%	0%		0%	
MPP	AIR	FIRE ISLE-NORTH END	150.4	100%	0%	0%		0%	
MPP	AIR	FIRE-ALLEY-SOUTH	150.5	100%	0%	0%		0%	
MPP	AIR	BOILER 11 BUILDING	150.6	100%	0%	0%		0%	
MPP	AIR	BUNKERS AND SILO 3 DRAWING	150.7	100%	0%	0%		0%	
MPP	AIR	OAT GULL, LIME ,AND ASH SILOS	150.8	100%	0%	0%		0%	
MPP	AIR	BOILER 11 BUILDING	150.9	100%	0%	0%		0%	
MPP	ASH	ASH SYSTEM	161.1	50%	0%	0%		0%	
MPP	BIOMASS	OAT HULL BIOMASS SYSTEM	102	0%	0%	0%		0%	
MPP	BLOWDOWN	BOILER BLOWDOWN SYSTEM	131.1	100%	85%	85%	Yes	0%	
MPP	BLOWOFF	BOILER BLOWOFF SYSTEM	129.1	100%	85%	85%	Yes	0%	
MPP	BOILER 7	BOILER 7 SYSTEM	132.1	80%	0%	0%		0%	
MPP	BOILER 8	BOILER 8 SYSTEM	132.2	0%	0%	0%		0%	
MPP	BOILER 10	BOILER 10 SYSTEM	132.3	0%	0%	0%		0%	
MPP	BOILER 11	SHEET 1 P& ID	132.4	0%	0%	0%		0%	
MPP	BOILER 12	SHEET 2 P&ID	132.5	0%	0%	0%		0%	
MPP	CO2	CO2 SYSTEM	151	100%	85%	50%	For Next Week	0%	
MPP	COAL HANDLING	COAL SYSTEM	160.1	0%	0%	0%		0%	
MPP	COAL HANDLING	COAL SYSTEM (FROM SILO TO BOILER)	160.2	0%	0%	0%		0%	
MPP	CONDENSATE	MAIN CONDENSATE	113.1	25%	0%	0%		0%	
MPP	CONDENSATE	C FLOOR RECEIVING TANKS	113.2	100%	85%	85%	Yes	0%	
MPP	CONDENSATE	MAIN CONDENSATE	113.3	25%	0%	0%		0%	
MPP	CONDENSATE	IN-PLANT RETURN SOUTH END	113.4	0%	0%	0%		0%	
MPP	CONDENSATE	COAL BUILDING RETURN	113.5	0%	0%	0%		0%	
MPP	CONDENSATE	RIVER WATER ROOM AND CONDENSER ROOM	113.6	0%	0%	0%		0%	
MPP	CONDENSATE	FLASH TANKS	113.7	10%	0%	0%		0%	
MPP	CONDENSATE	TG1 HOTWELL	113.8	100%	0%	0%		0%	
MPP	CONDENSATE	TG5 HOTWELL	113.9	100%	0%	0%		0%	
MPP	CONDENSATE	TG6 HOTWELL		100%	0%	0%		0%	
MPP	CONDENSATE	MAIN BASEMENT		0%	0%	0%		0%	
MPP	COOLING WATER	COOLING WATER SYSTEM		0%	0%	0%		0%	
MPP	COOLING WATER	COOLING WATER SYSTEM		0%	0%	0%		0%	
MPP	COOLING WATER	COOLING WATER SYSTEM		0%	0%	0%		0%	
MPP	COOLING WATER	COOLING WATER SYSTEM		0%	0%	0%		0%	
MPP	DESUPERHEATER	DESUPERHEATER SPRAY SYSTEM	115.1	100%	85%	85%	1.5.13	0%	
MPP	ELECTRO-HYDRAULIC CONTROL	ELECTRO-HYDRAULIC CONTROL SYSTEM		0%	0%	0%		0%	
MPP	FEEDWATER	WEST SIDE	112.1	100%	85%	80%	Yes	0%	
MPP	FEEDWATER	EAST SYSTEM	112.2	100%	85%	85%	Yes	0%	
MPP	FEEDWATER	FEEDWATER HEATER AND BOILERS	112.3	100%	85%	85%	Yes	0%	
MPP	FEEDWATER	CHEMICAL FEED		100%	0%	0%		0%	
MPP	GAS FUEL	GAS FUEL SYSTEM	152.1	100%	85%	85%	Yes	0%	
MPP	LIME	LIME SYSTEM		0%	0%	0%		0%	
MPP	MAKE-UP WATER	MAKE-UP WATER SYSTEM	111.1	100%	85%	85%	1.5.13	0%	
MPP	MAKE-UP WATER	DEMINERALIZERS	111.2	100%	0%	0%		0%	
MPP	MAKE-UP WATER	MAKE-UP WATER SYSTEM	111.3	100%	0%	0%		0%	
MPP	MAKE-UP WATER	MAKE-UP WATER SYSTEM	111.4	100%	85%	85%	Yes	0%	
MPP	MAKE-UP WATER	MAKE-UP WATER SYSTEM	111.5	100%	85%	85%	1.5.13	0%	
MPP	MAKE-UP WATER	PUMPS TO DEAERATERS	111.6	100%	85%	85%	1.5.13	0%	
MPP	POTABLE-NONPOTABLE	POTABLE-NONPOTABLE WATER SYSTEM	110.1	100%	85%	85%	For Next Week	0%	
MPP	POTABLE-NONPOTABLE	POTABLE-NONPOTABLE WATER SYSTEM	110.2	100%	85%	85%	For Next Week	0%	
MPP	RIVER WATER	RIVER WATER SYSTEM	119 [MISSING]	0%	0%	0%		0%	
MPP	STEAM	TURBINE AND CONDENSER ROOMS		0%	0%	0%		0%	
MPP	STEAM HIGH	HPS (NEW DRAWING)	120.1	100%	85%	50%	For Next Week	0%	
MPP	STEAM HIGH	MPS(NEW DRAWING)	120.2	100%	85%	50%	For Next Week	0%	
MPP	STEAM MEDIUM	MPS(NEW DRAWING)	120.3	100%	85%	50%	For Next Week	0%	
MPP	STEAM MEDIUM	LPS(NEWDRAWING)	120.4	100%	85%	50%	For Next Week	0%	
MPP	STEAM MEDIUM	LPS(NEW DRAWING)	120.5	100%	85%	50%	For Next Week	0%	
MPP	STEAM	BOILER 11, ANNEX, SILOS	120.6	100%	85%	50%		0%	
MPP	STEAM	BOILER STEAM	120.7	100%	85%	50%		0%	
MPP	TURBINE OIL	TURBINE GENERATORS #1 & #5		0%	0%	0%		0%	
MPP	TURBINE OIL	TURBINE GENERATOR #6		0%	0%	0%		0%	
MPP	TURBINE GENERATOR 1	TURBINE GENERATOR #1		0%	0%	0%		0%	
MPP	TURBINE GENERATOR 5	TURBINE GENERATOR #5		0%	0%	0%		0%	
MPP	TURBINE GENERATOR 6	TURBINE GENERATOR #6		0%	0%	0%		0%	

Phase 1 - Status



Risk Plots


Occurrence/Severity Matrix (Revised Ratings)
High Priority Line
Low Priority Line
High Priority Causes
Medium Priority Causes
Low Priority Causes
Occurrence
Severity
0
2
4
6
8
10
Brian Wodka
RMF Engineering
2/19/2014 3:15:06 PM

ASME RAM-1 Standard

RELIABILITY, AVAILABILITY, AND MAINTAINABILITY OF EQUIPMENT AND SYSTEMS IN POWER PLANTS

1 INTRODUCTION

A RAM program is a structured methodology to identify and deliver the reliability, availability, and maintainability (RAM) requirements of a power plant in the most cost-effective manner. This document is an assurance standard to govern the master planning process for a power plant RAM program. It is intended to provide a methodology to develop and implement a comprehensive availability assurance program for the design, construction, and operation phases of the RAM project. This Standard is applicable to both new and existing facilities.

2 SCOPE

This Standard provides the requirements to establish a RAM program for any power-generation facility. The program process includes

(a) establishment of RAM goals

(b) requirements for design, construction and commissioning, and operations

This Standard identifies the required RAM program elements and responsibilities.

3 PURPOSE

The purpose of this Standard is to meet the owner's power plant RAM performance goals. This Standard identifies program requirements that support effective reliability processes in design, construction and commissioning, and operations. It requires a risk-based approach to design and provides requirements to optimize performance effectively throughout the life cycle of the power plant.

4 DEFINITIONS

basis of design (BOD): the underlying assumptions and requirements that support the physical plant design.

criticality: the relative importance of equipment attributes that range from physical materials and hardware to design functions.

reliability, availability, and maintainability (RAM):

(a) the process of addressing all the associated concepts of reliability, availability, and maintainability and integrating them to meet the owner's performance objectives

(b) a set of requirements imposed on a plant, system, or component to ensure that it

(1) will be ready for use when required

(2) will successfully perform assigned design-intended functions

(3) can be maintained operationally over its specified life

5 RAM PROCESS

This process provides a procedure to develop and implement a program that is a written, defined, verifiable, and living document that will enable the owner to meet his/her performance goals. The steps in the RAM process are given in paras. 5.1 through 5.4 (see Fig. 5-1).

5.1 Predevelopment

The owner shall establish needs by defining required criteria that shall serve to develop objective requirements, goals, validation parameters, and acceptance criteria.

5.2 Program Development

The owner shall select a project delivery method, designer, and constructor to build the power plant to the designed program criteria described in para. 5.1.

5.3 Program Implementation

The owner shall periodically review the program performance of the plant to determine if the plant is achieving the objectives and goals described in para. 5.1.

5.4 Program Revision

The owner shall modify the program described in paras. 5.2 and 5.3 to achieve the goals described in para. 5.1 or with new criteria that the owner establishes. Any owner-established criteria shall at least meet, or exceed, the criteria outlined in this Standard.

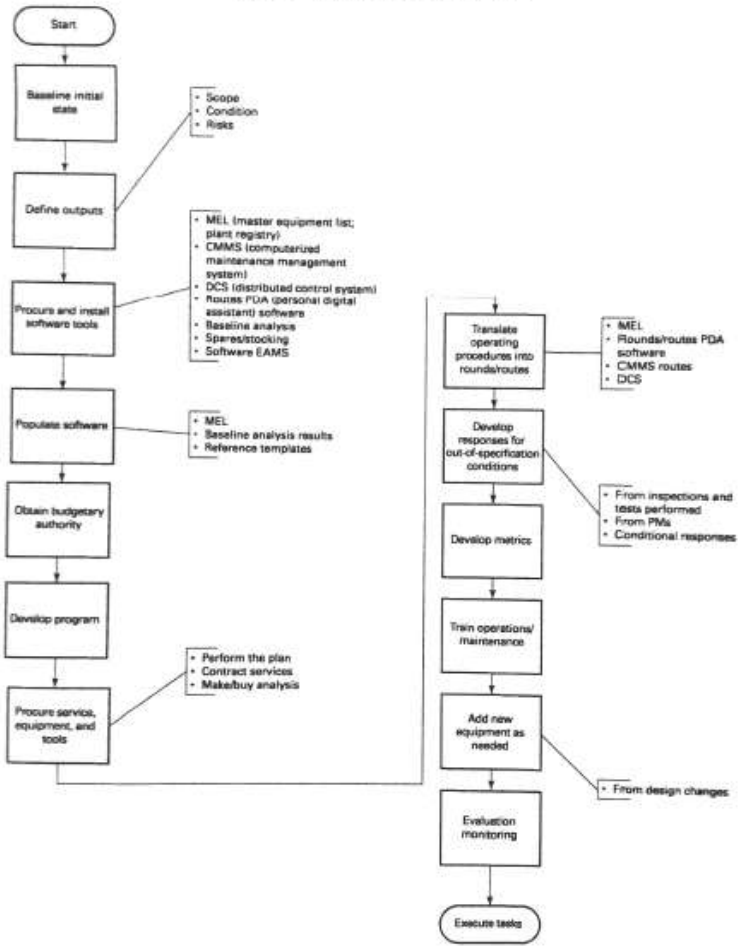
6 RAM DESCRIPTION

The following describes the steps in the RAM process.

6.1 Predevelopment Phase (See Fig. 6.1-1)

The owner shall define the top-level functional requirements for the plant. The output of the predevelopment phase is the BOD document, which will be used

Fig. 6.3-1 RAM Program Implementation



Conclusion

- **Risk Mitigation**
  - The Goal
- **Reliability Engineering**
  - The Tools
- **ASME RAM-1 Standard**
  - The Process

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