Fractal Solutions

Risk-Based Analysis

Evaluating the Risk of Failure

2004 Maintenance & Reliability Technology Summit

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Internet Downloads

MARTS papers and blank forms available for download at

www.FractalSolutions.com

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Or

See me for a CD of the two sessions

Risk-Based Analysis and *PM Optimization*

Introduction

- Risk Based Analysis is part of the RCM process
- Replaces RCM's Failure Mode and Effects Analysis (FMEA) step
- Risk Based Analysis is used to identify failure consequences and to prioritize equipment risk

Introduction

- Develops RPN, or “risk ranking”, of equipment within the system
- Equipment with high risk failures receive detailed analysis
- Remaining equipment receives less detailed analysis

Introduction

- Ranking equipment risk is useful when:
  - You have limited maintenance resources and
  - You want assurance that critical equipment is being properly maintained
  - You need a method to prioritize plant work

Key Terms and Definitions

- Failure Mode
  - Equipment's inability to meet a standard of performance with respect to its function
  - How equipment can fail in a general or overall sense
  - Examples:
    - Fails to run
    - Fails to close
    - Erratic output

Key Terms and Definitions

- Failure Effect
  - Defines the consequences of a equipment failure mode
  - Failure consequence in terms of:
    - Environmental
    - Health
    - Safety
    - Economic factors

Key Terms and Definitions

- Risk Priority Number (RPN)
  - Relative ranking of equipment failure against other equipment within that system
- Likelihood
  - A rating scale that defines the frequency of a failure mode

Key Terms and Definitions

- Detectability
  - A rating scale that defines the chances of detecting a failure or the effects of a failure before it occurs
- Weight
  - A rating scale that defines the severity of the effect of failure

Key Terms and Definitions

- Critical Failure
  - Equipment loss of function with undesirable consequences
  - Any failure vital to the operation of the plant, system, or safety

What You'll Need

- Equipment list
  - Maintenance management system
  - Plant drawings
  - Interviews
- List of standard Failure Modes
  - Dependent on Equipment Type
  - List is available on Fractal Solutions' web site

What You'll Need

Example Failure Mode list

Description
Misdistribution of air
Degraded performance
External leak
Erratic output
Fails as is
Insufficient agitation or mixing
Fails to fully charge
Fails high
Fails High/Low
Fails in last position
Fails low
Fails to open/close
Fails to operate
Fails to remain closed
Fails to remain open
Fails to close
Fails to filter
Fails to govern/regulate/control
Fails to open

What You'll Need

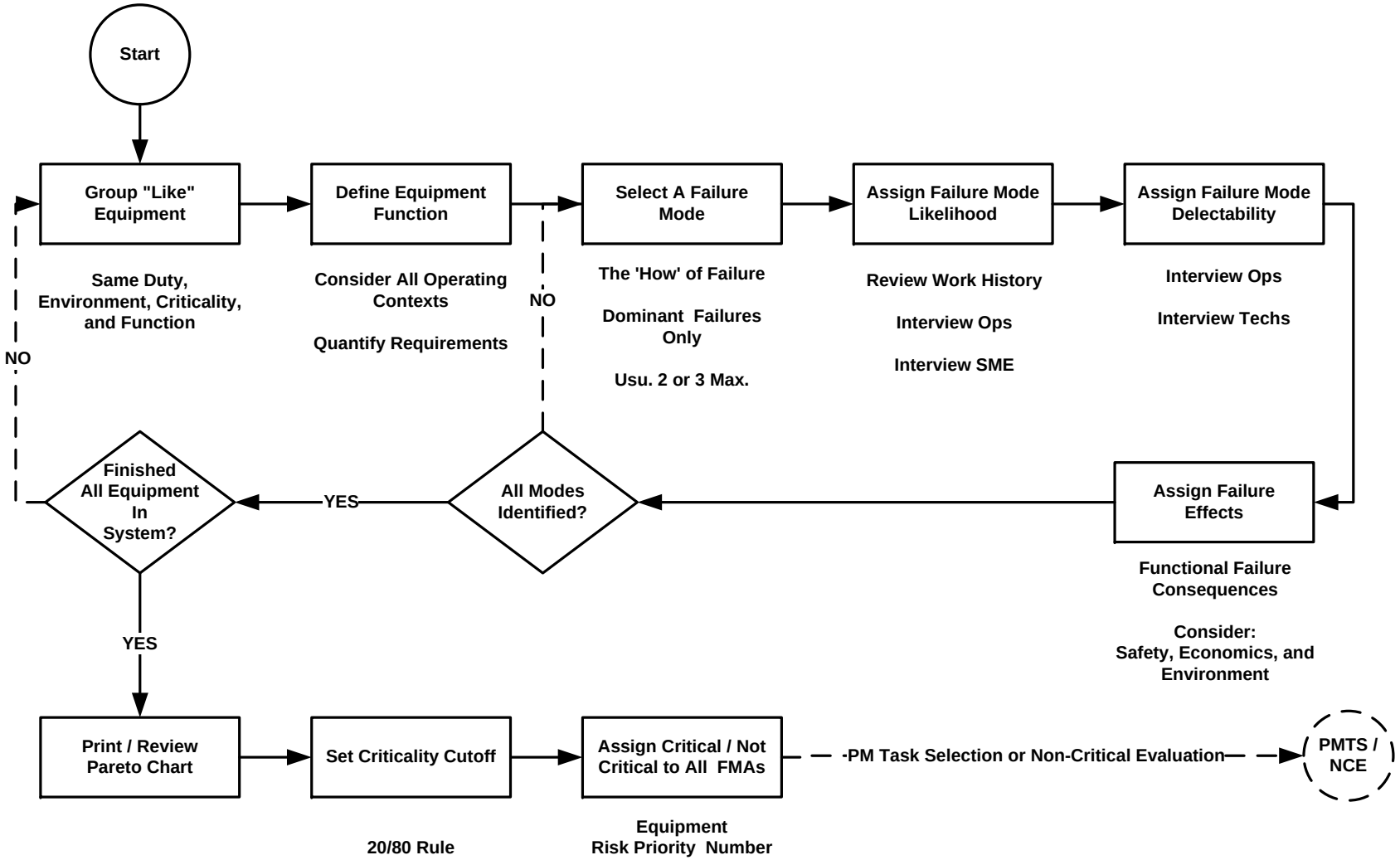
- List of Failure Effects with assigned Weight values
  - Reflects your company's strategic plan and objectives
  - Establishes logic for quantifying the impact of equipment failure
  - Effects typically cover environmental, safety, and economic issues
  - List usually contains 8 – 12 items

What You'll Need

Example Failure Effect list

Effect ID	Failure Effect	Weight
A01	Unit Shutdown	10
A03	Unit Throughput Loss	8
B01	Minor Throughput Loss	4
C01	Startup Delay	4
H01	Personnel Hazard	10
H02	Personnel Hazard - Low probability of injury	5
I01	Environmental Reg. Event - Major Incident	10
I02	Environmental Reg. Event - Incident	7
I03	Environmental Reg. Event - Near Miss	3
M01	No Effect	0

Getting Started - Overview



Step 1: Group Like Equipment

- Shortens evaluation time
- Must have same or similar:
  - Design
  - Environment
  - Duty
  - Functions
- Same Failure Likelihood

Step 2: Define Equipment Function

- Always relate to operating context
  - Startup, normal ops, shutdown, special, and emergency
- Has clearly defined conditional requirements
  - Supply….To…During…
- Has quantifiable conditions when possible
  - Pressure, temperature, flow, range, etc.

Step 3: Select a Failure Mode

- Describes how equipment fails at a “high level”
- Must be plausible, or dominant
- Typically between 2 and 3 failure modes per equipment
- Examples:
  - Fails to start
  - Fails to open
  - Fails to indicate

Step 4: Assign Failure Mode Likelihood

- For each failure mode:
  - Assign numerical value based upon actual and expected likelihood of failure
  - Exclude externally caused failures (e.g., motor failure is not pump failure)
- Information Sources:
  - Work order history
  - Operating/Incident reports
  - Interviews

Step 4: Assign Failure Mode Likelihood

- 1 → Very unlikely (has not happened to equipment or similar equipment)
- 2 → Unlikely (>2 times in 5-10 years to equipment or similar equipment)
- 3 → Likely (>3 times in last 5 years)
- 6 → Likely (>2 times in last year)
- 10 → Very Likely (many times to this equipment)

Step 5: Assign Failure Mode Detectability

- For each Failure Mode:
  - Assign numerical value based on how likely a failure mode can be detected
  - Based on operators ability to detect failure during normal operation
  - A high value indicates hidden failure, while a low value indicates an easily detected failure

Step 5: Assign Failure Mode Detectability

- 1 → Immediately observed
- 5 → Moderate detectability
- 10 → Hidden failure

Step 6: Assign Failure Effects

- For each Failure Mode:
  - Identify all effects for each selected failure mode
  - Consider full range of operation
    - start-up, operating, and shut down
  - Consider worst realistic case
  - Information sources:
    - System descriptions
    - Operating procedures
    - Interviews

Step 7: Interpret RPN Results

- Failure Mode RPN = Weight x Likelihood x Detectability
- Add up each equipment's Failure Mode RPN to get the total RPN
- Complete RBA for all equipment in the system
- Develop the Pareto chart
- Review chart and establish high cutoff

Example – Equipment List

Step 1 RBA

Equipment List

				Date:	**Page: 1 of 1**
Plant: Swimming Pool				**Plant ID:** SP	
System Name: Water Treatment				**System ID:** WT	
Analysts:					
Pumping		**Water Conditioning**		**Heating**	
ID Number	Name	ID Number	Name	ID Number	Name
	Main pump and motor		**Main (Vortex) filter**		**Gas heater**
	Pool sweep pump and motor		**Trap filters**		**Gas piping**
	Valves – alignment		**Chlorinator**		**Temp control / limit unit**
	Valve – drain		**Flush valve on main filter**		**Pool/spa switch**
	Mechanical timers		**Pressure gauge on main filter**		
	Piping				

Example – Equipment Function

Step 2 RBA

Equipment Functions

	Date: Oct 1, 2000	**Page:** 1 of 3
Plant: Swimming Pool	**Plant ID:** SP	
System / Subsystem Name: Water Treatment / Pumping	**System/Subsys ID:** WT / 1.0	
Analysts:		

Equip ID	Equip Description	Function
	Main pump and motor	Maintain 70 GPM water flow at specified times to the other subsystems.
	Pool sweep pump and motor	Maintain 50 GPM flow at specified times to pool sweep line.

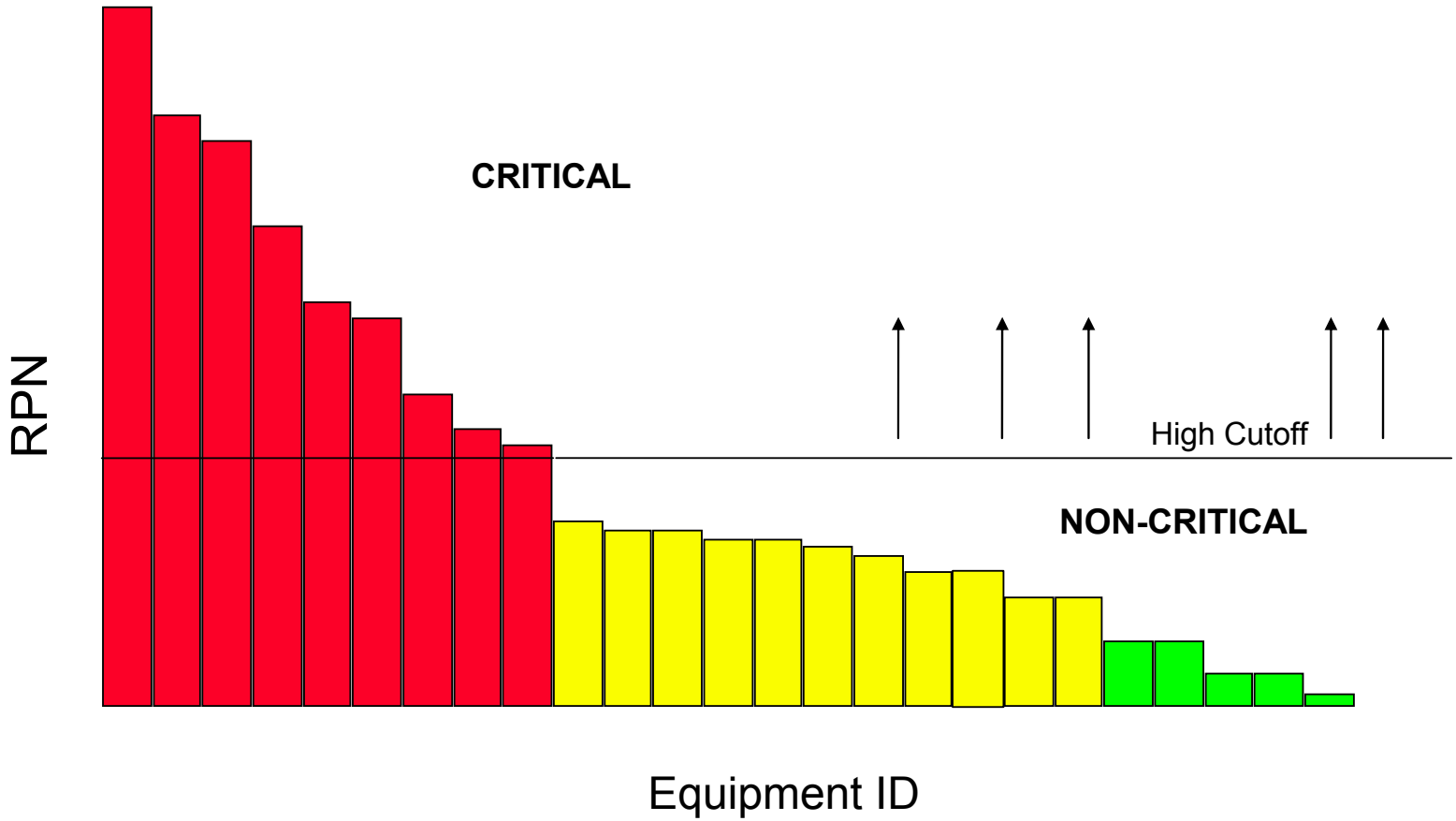
Example

Step 3 RBA

Failure Modes and Effects Analysis

				Date:		Page: 1 of 3		
Plant: Swimming Pool				**Plant ID:**				
System/Subsystem Name: Water Treatment				**Sys/Subsys ID:**				
Analysts:								
Equipment	**Failure Mode**	**Likelyhood** 1 — 10	**Detectability** 1 — 10	**Failure Effects**	**Weight** 1 — 10	**RPN**	**Total RPN**	
Main Pump and Motor	Fails to start	2	1	Major impact on water quality	6	12		
				Spa inoperative	7	14		
	Erratic output	4	1	Minor impact on water quality	3	12		
				Spa inoperative	7	28		
							66	
Pool sweep pump and motor	Fails to start	1	1	Minor impact on water quality	3	3		
	Erratic output	1	1	Minor impact on water quality	3	3		
	Fails to start	1	1	Minor impact on water quality	3	3		
	Erratic output	1	1	Minor impact on water quality	3	3		
							12	
Valves – pool/spa alignment	Fails to open/close	5	1	Pool or Spa inoperative	10	50		
							50	
Valve – drain	Fails to open	1	5	Spa inoperative	7	35		
							35	

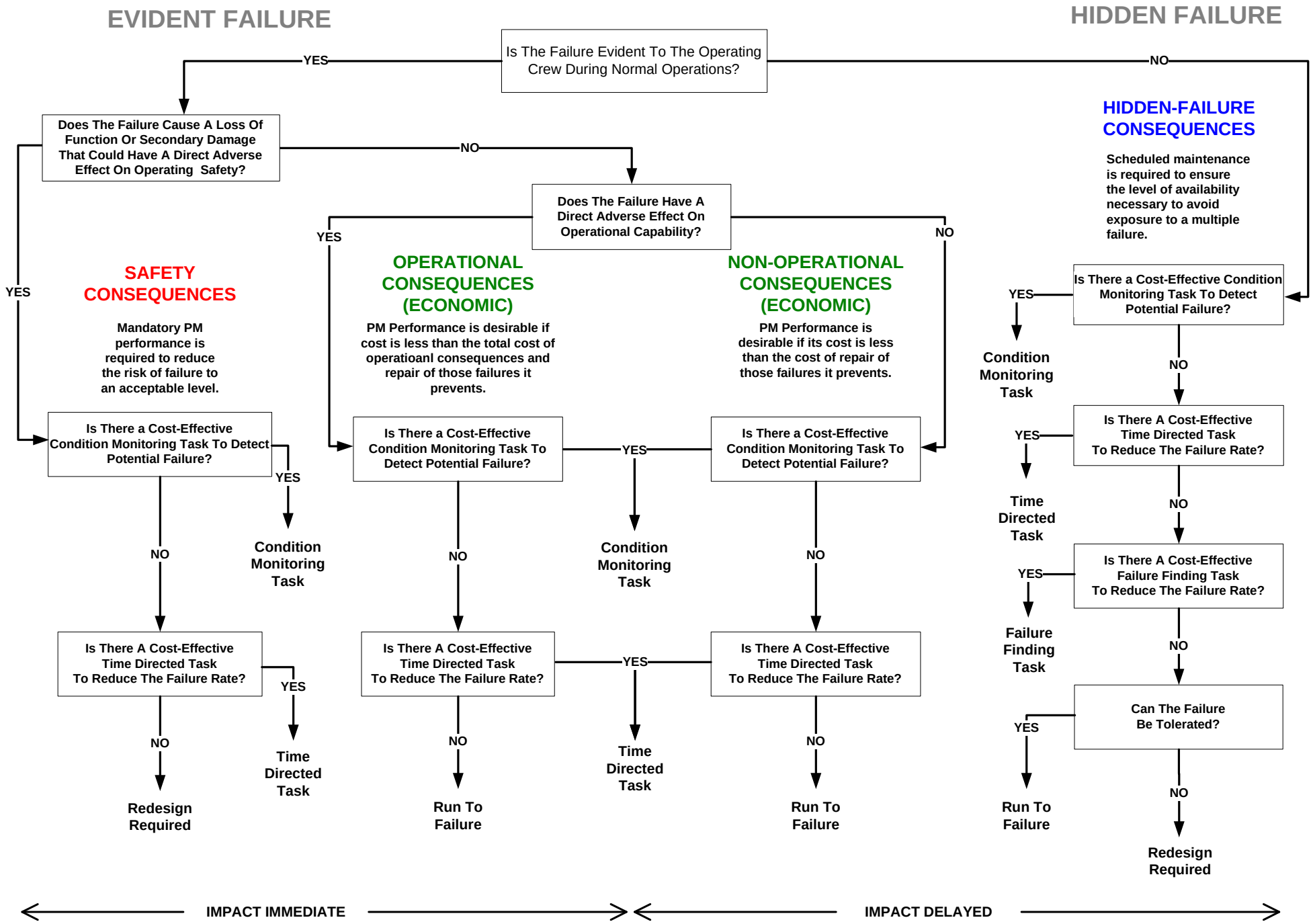
Step 7: Interpret RPN Results



Step 8: Assign Critical / Not Critical

- Critical equipment failure receives in-depth PM Task analysis via Logic Tree
- Non-critical equipment receives low-level review for factors other than Criticality that may drive PM assignment

Decision Logic for Task Selection



Example RBA Analysis Results (DOE Site)

- 2,200 components in first year
  - 760 approval pending
  - 342 approved
  - 375 implemented
  - Remainder in other stages of analysis
- 10,000 hour reduction in annual wrench time
- $450,000 annualized savings to-date

Cost Reductions Not Captured

- Operations
  - Lockouts and other support
- Radcon
  - RWP & coverage support
  - Waste generation/disposal
  - Personnel exposure
- Engineering
  - Maintenance support
  - Pre-Approved model work orders
- Administrative

Step 1 RBA

Equipment List

				Date:	**Page: of**
Plant:				**Plant ID:**	
System Name:				**System ID:**	
Analysts:					
ID Number	Name	ID Number	Name	ID Number	Name

Step 2 RBA

Equipment Functions

	Date:	**Page: of**
Plant:	**Plant ID:**	
System Name:	**System ID:**	
Analysts:		

Function No.	Description

Step 3 RBA

Risk-Based Analysis

					Date:			Page: of	
Plant:					Plant ID:				
System/Subsystem Name:					Sys/Subsys ID:				
Analysts:									
FMA ID	Equipment	Failure Mode	Likleyhood 1 -- 10	Detectability 1 -- 10	Failure Effects	Weight 1 -- 10	RPN	Total RPN	