Reliability Centered Maintenance (RCM) on Main Feedwater System

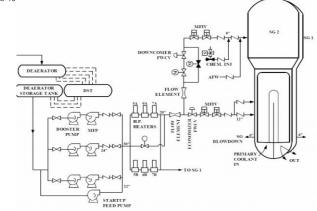
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RCM process on MFWS

1. System Selection

Importance in maintaining plant availability. Failure of the system or any major component can directly cause reactor/turbine trip or significant power reduction (>20%)



2. Functional Failure Analysis

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To supply feedwater to the steam generators at required pressure, temperature, flow rate, and water chemistry	 Total loss of feedwater (FW) flow FW flow rate exceeds required amount Insufficient FW flow at 100 % Rx power
To increase pressure and temperatu re of FW in the regenerative cycle	Supply FW at a lower pressure andtemperature
Control SG water level	 Unable to control the SG level SG level exceeds maximum level SG level below minimum level
Maintain SG level when Rx power is ≤5 %	Restricted FW flowSupply excess FW flow
Terminate feedwater flow in the event of a malfunction	• Unable to terminate the FW flow
Provide FW and containment isolation in the event of design basis accident	 Unable to isolate the containment and SG Partial isolation of SG and containment

3. Critical component selection

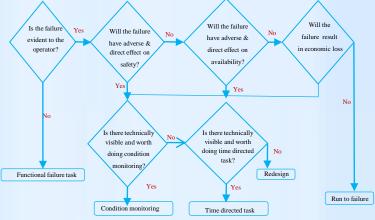
			Component	ΣF-V	RA	W	RRW	Rank
RAW > 2.0			MFWP	0.7004	10.9	15	1.305	HSS
RRW >1.005			FWPB	0.0406	10.9	15	1.014	HSS
Sum of $F-V > 0.00$)5		MFIV	0.0953	10.9	15	1.012	HSS
			FWDV	0.0547	10.9	15	1.010	HSS
			FWChV	0.0004	10.9	15	1.010	HSS
			FWCV	0.0376	10.9	15	1.009	HSS
4. FMECA			HP HX	0.0001	10.9	15	1.000	HSS
			SUP	0.0107	10.9	15	1.000	HSS
Measure of Criticality (MoC)		SUCV	0.0019	10.915		1.002	HSS	
= 0.5S + 0.3A + 0.2	2C				<u> </u>			C 11
= 0.5S + 0.3A + 0.2	2C		Component		Critic		MG	Class
= 0.5S+0.3A+0.2	2C Class			S	А	C	MoC	
			FWPps	S 1.8	A 3.4	С 2.6	2.4	F
MoC Range 1.0-1.5	Class		FWPps MFIV	S 1.8 2.9	A 3.4 3.4	C 2.6 3.0	2.4 3.1	F E
MoC Range 1.0-1.5 1.5-2.0	Class H G		FWPps MFIV FWDV	S 1.8 2.9 1.6	A 3.4 3.4 2.6	C 2.6 3.0 2.6	2.4 3.1 2.1	F E F
MaC Range 1.0-1.5 1.5-2.0 2.0-3.0	Class H G F		FWPps MFIV FWDV FWChV	S 1.8 2.9 1.6 1.2	A 3.4 3.4 2.6 2.3	C 2.6 3.0 2.6 2.1	2.4 3.1 2.1 1.7	F E F G
MoC Range 1.0-1.5 1.5-2.0	Class H G		FWPps MFIV FWDV FWChV FWCV	S 1.8 2.9 1.6 1.2 1.3	A 3.4 3.4 2.6 2.3 2.8	C 2.6 3.0 2.6 2.1 2.4	2.4 3.1 2.1 1.7 2.0	F E F G G
MaC Range 1.0-1.5 1.5-2.0 2.0-3.0	Class H G F		FWPps MFIV FWDV FWChV FWCV HP HX	S 1.8 2.9 1.6 1.2 1.3 1.4	A 3.4 3.4 2.6 2.3 2.8 3.0	C 2.6 3.0 2.6 2.1 2.4 2.4	2.4 3.1 2.1 1.7 2.0 2.1	F E F G G F
MaC Range 1.0-1.5 1.5-2.0 2.0-3.0	Class H G F		FWPps MFIV FWDV FWChV FWCV HP HX SUP	S 1.8 2.9 1.6 1.2 1.3 1.4 1.3	A 3.4 3.4 2.6 2.3 2.8 3.0 2.8	C 2.6 3.0 2.6 2.1 2.4 2.4 2.6	2.4 3.1 2.1 1.7 2.0 2.1 2.0	F E F G F F G
MaC Range 1.0-1.5 1.5-2.0 2.0-3.0	Class H G F		FWPps MFIV FWDV FWChV FWCV HP HX	S 1.8 2.9 1.6 1.2 1.3 1.4	A 3.4 3.4 2.6 2.3 2.8 3.0	C 2.6 3.0 2.6 2.1 2.4 2.4	2.4 3.1 2.1 1.7 2.0 2.1	F E F G G F

[1] IAEA, Application of Reliability Centred Maintenance to Optimize Operation and Maintenance in Nuclear Power

 [1] J. May Approximation relation of the month of the control of the matter of the control of the month of the control of the matter of the control of the con

ComponentEntitive effectMFWP• Loss of FW supply to SG • Insufficient FW flow to SG. • Reactor trip/ significant power • reduction.• Rotor fails to rotate • Shaft, impeller, and seal break • Thrust bearing failure • Coupling breakage • Over speed tripMFIV• Fail to isolate containment and • FW system• Loss internal parts • Failed seal rings • Seized bearings on valve shaft • Body wear • Internal corrosion • Seal deterioration • Fastener loosening• Loose internal parts • Seized bearings • Seized bearings • Seized bearings • Seized bearings • Seized bearings • Seized bearings • Seal deterioration • Fastener looseningFWDV FWChV• Fail to control SG level • Increase in FW flow leading to • reactor trip• Erosion of valve body • Vibration induced cracks • Normal wear • Seal deterioration • Blocked flow conditions • Thermal fatigue • Excess vibrationHP HX• Decrease in FW temperature • Loose efficiency of SGs • Reduce Rx power < 20%.• Blocked flow conditions • Thermal fatigue • Excess vibrationSUP• Fail to recirculate FW• Material lodging in rotor • Large vibrations • Thrust bearing failures • Coupling failures • Coupling failures	FMEC	A results	
MFWPLoss of FW supply to SG Insufficient FW flow to SG.Shaft, impeller, and seal break Thrust bearing failure Coupling breakage Over speed tripFWBP· Fail to isolate containment and · FW system· Loose internal parts · Failed seal rings · Seized bearings on valve shaftFWDV FWChV· Fail to direct the FW flow · Restricted FW flow · Increase in FW flow leading to · reactor trip· Body wear · Internal corrosion · Seal deterioration · Fastener looseningFWCVV· Fail to control SG level · Increase in FW flow leading to · reactor trip· Erosion of valve body · Vibration induced cracks · Normal wear · Seal deteriorationHP HX· Decrease in FW temperature · Loose efficiency of SGs · Reduce Rx power < 20%.	Component	Failure effect	Failure causes
MFIV • FW system • Failed seal rings FWDV • Fail to direct the FW flow • Body wear FWChV • Fail to control SG level • Internal corrosion FWCV • Fail to control SG level • Increase in FW flow leading to • Factor trip • Decrease in FW temperature • Blocked flow conditions HP HX • Decrease in FW temperature • Blocked flow conditions • Fail to recirculate FW • Material lodging in rotor Large vibrations • Thrust bearing failures		Insufficient FW flow to SG.Reactor trip/ significant power	Shaft, impeller, and seal breakThrust bearing failureCoupling breakage
FWDV • Fail to direct the FW flow • Internal corrosion FWChV • Restricted FW flow • Seal deterioration FWCV • Fail to control SG level • Failto control SG level • Increase in FW flow leading to • Erosion of valve body • reactor trip • Seal deterioration • Decrease in FW themperature • Blocked flow conditions • Loose efficiency of SGs • Reduce Rx power < 20%. • Fail to recirculate FW • Material lodging in rotor Large vibrations • Thrust bearing failures	MFIV		Failed seal rings
• Fail to control SG level • Vibration induced cracks • Increase in FW flow leading to • Vibration induced cracks • reactor trip • Seal deterioration • Decrease in FW temperature • Blocked flow conditions • Loose efficiency of SGs • Reduce Rx power < 20%. • Fail to recirculate FW • Material lodging in rotor • Large vibrations • Thrust bearing failures			Internal corrosionSeal deterioration
HP HX • Loose efficiency of SGs • Reduce Rx power < 20%. • Thermal fatigue • Excess vibration SUP • Fail to recirculate FW • Material lodging in rotor • Large vibrations • Thrust bearing failures	FWCV	Increase in FW flow leading to	Vibration induced cracksNormal wear
• Fail to recirculate FW • Large vibrations • Thrust bearing failures	НР НХ	 Loose efficiency of SGs 	Thermal fatigue
	SUP	Fail to recirculate FW	Large vibrations
S/UCV • Fail to control FW flow • Internal corrosion • Body wear	S/UCV	• Fail to control FW flow	internal correston

5. Maintenance task selection



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Component	Selected task		Component	Selected task		
			FWDV	Time directed tasks		
MFWP	Condition monitoring			• In-service, visual inspection		
	Vibration analysis		FWChV	Leak detection		
FWBP	 Lube oil analysis 			Failure finding task		
	Time directed task • Rotor binding check • Visual examination and • inspection • Coupling check		FWCV	Surveillance testing		
			SUCV	Failure finding tasks		
				Surveillance and leak rate		
				tests		
				• In-service inspection		
SUP	Failure finding tasks			Routine observation		
	Surveillance and leak rate testsIn-service inspection		HP HX	Condition monitoring		
				 Infrared thermography 		
	Condition monitoring	11		System engineer walkdowns		
	Ultrasonic noise detection Infrared thermography			Time directed task		
				Visual inspections		
	• System engineer walkdowns			Leak detection		
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Conclusion

RCM is successfully applied on the MFWS in which MFIV is found to be the most critical component. With the combination of criticality class and LTA, maintenance tasks namely condition monitoring, time directed, and functional analysis are recommended.

