Reliability Centered Maintenance (RCM) on Main Feedwater System

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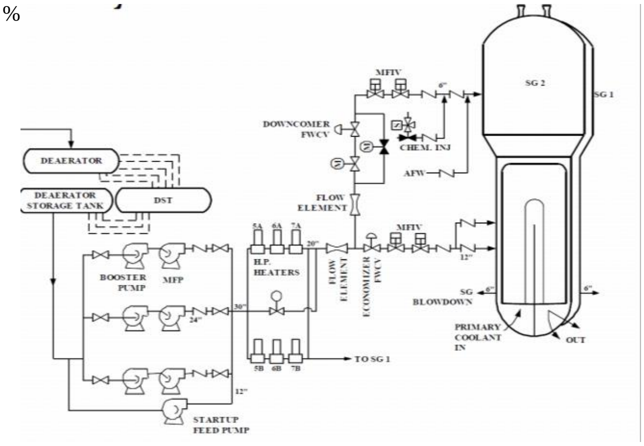
RCM process on MFWS

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

System functions	Functional failure
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 temperature of FW in the regenerative cycle	• Supply FW at a lower pressure and • temperature
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 flow • Supply 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

RAW > 2.0
RRW >1.005
Sum of F-V > 0.005

Component	ΣF-V	RAW	RRW	Rank
MFWP	0.7004	10.915	1.305	HSS
FWPB	0.0406	10.915	1.014	HSS
MFIV	0.0953	10.915	1.012	HSS
FWDV	0.0547	10.915	1.010	HSS
FWChV	0.0004	10.915	1.010	HSS
FWCV	0.0376	10.915	1.009	HSS
HP HX	0.0001	10.915	1.000	HSS
SUP	0.0107	10.915	1.000	HSS
SUCV	0.0019	10.915	1.002	HSS

4. FMECA

Measure of Criticality (MoC) = 0.5S+0.3A+0.2C

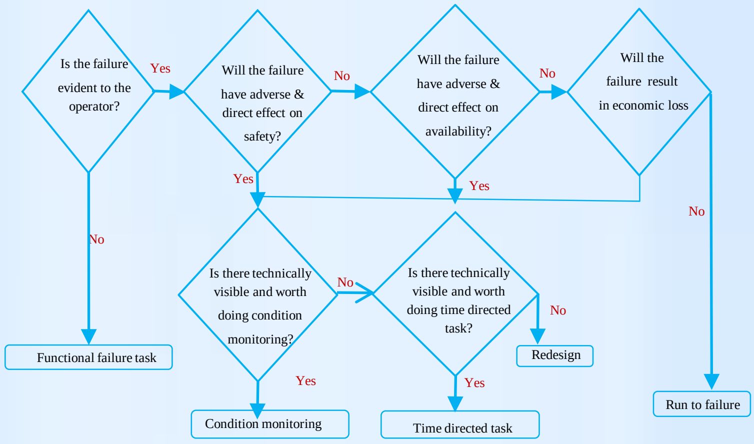
MoC Range	Class
1.0-1.5	H
1.5-2.0	G
2.0-3.0	F
3.0-4.0	E

Component	Criticality				Class
	S	A	C	MoC	
FWPps	1.8	3.4	2.6	2.4	F
MFIV	2.9	3.4	3.0	3.1	E
FWDV	1.6	2.6	2.6	2.1	F
FWChV	1.2	2.3	2.1	1.7	G
FWCV	1.3	2.8	2.4	2.0	G
HP HX	1.4	3.0	2.4	2.1	F
SUP	1.3	2.8	2.6	2.0	G
SUCV	1.3	2.9	2.1	1.9	G

FMECA results

Component	Failure effect	Failure causes
MFWP FWBP	• 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 trip
MFIV	• Fail to isolate containment and • FW system	• Loose internal parts • Failed seal rings • Seized bearings on valve shaft
FWDV FWChV	• Fail to direct the FW flow • Restricted FW flow	• Body wear • Internal corrosion • Seal deterioration • Fastener loosening
FWCV	• Fail to control SG level • Increase in FW flow leading to • reactor trip	• Erosion of valve body • Vibration induced cracks • Normal wear • Seal deterioration
HP HX	• Decrease in FW temperature • Loose efficiency of SGs • Reduce Rx power < 20%.	• Blocked flow conditions • Thermal fatigue • Excess vibration
SUP	• Fail to recirculate FW	• Material lodging in rotor • Large vibrations • Thrust bearing failures • Coupling failures
S/UCV	• Fail to control FW flow	• Internal corrosion • Body wear

5. Maintenance task selection



Component	Selected task
MFWP FWBP	Condition monitoring • Vibration analysis • Lube oil analysis Time directed task • Rotor binding check • Visual examination and • inspection • Coupling check
SUP	Failure finding tasks • Surveillance and leak rate tests • In-service inspection
MFIV	Condition monitoring • Ultrasonic noise detection • Infrared thermography • System engineer walkdowns

Component	Selected task
FWDV FWChV FWCV	Time directed tasks • In-service, visual inspection • Leak detection Failure finding task • Surveillance testing
SUCV	Failure finding tasks • Surveillance and leak rate • tests • In-service inspection • Routine observation
HP HX	Condition monitoring • Infrared thermography • System engineer walkdowns Time directed task • Visual inspections • Leak detection

Reference

[1] IAEA, Application of Reliability Centred Maintenance to Optimize Operation and Maintenance in Nuclear Power Plants, IAEA-TECDOC-1590, pp 2-5, 2007
[2] KHNP, APR1400 Design Certification Document Tier 2, Introduction and General Description of the plant, 2014
[3] NEI, 10 CFR 50.69 SSC Categorization Guideline, Nuclear Energy Institute, Washington, DC , pp 35-38, 2005

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.