Reliability Centered Maintenance for CVCS - Charging System

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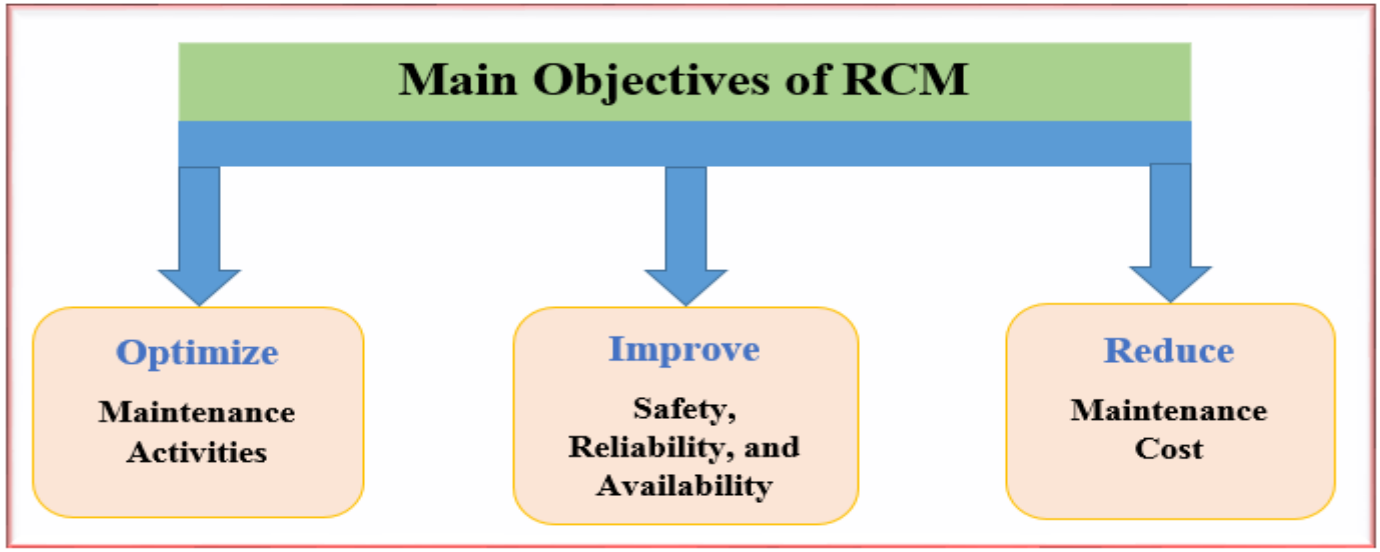
Introduction

- Chemical and volume control system (CVCS) is used to control the purity, volume, and boric acid content of the reactor coolant. The CVCS automatically adjusts the amount of reactor coolant in order to maintain a programmed level in the Pressurizer.
- CVCS is a critical system, needs to monitor its performance and develop maintenance plan to increase the reliability and availability of the system. So the maintenance plan for CVCS charging system will be developed by implementation of RCM Process.
- In this study RCM analysis is performed based on evaluation of Failure Modes Effects and Criticality Analysis (FME&CA) on the component, system and plant. The Logic Tree Analysis (LTA) is used to determine the optimum maintenance tasks.

Methodology (1/3)

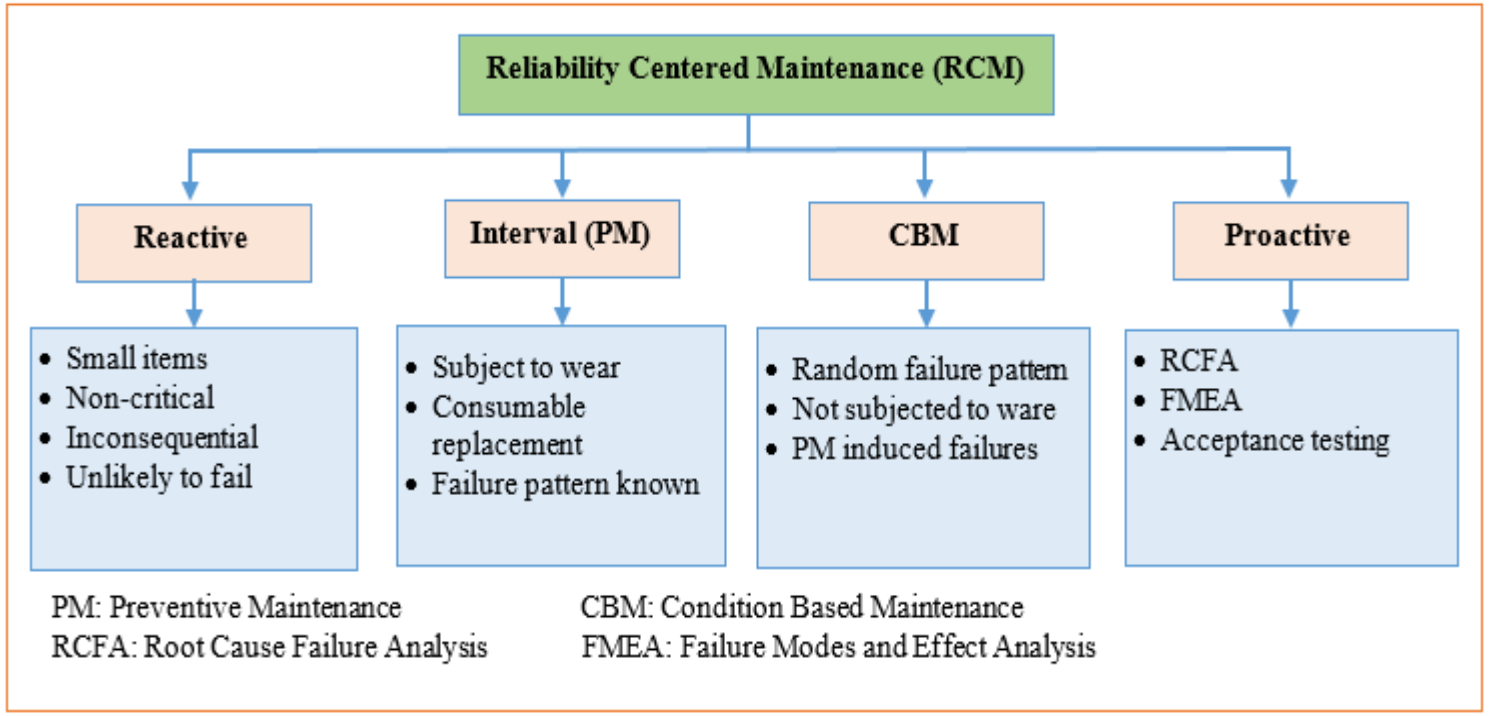
RCM:

- It is a systematic evaluation approach for developing or optimizing a maintenance programme, utilizes LTA to identify the maintenance requirements of equipment according to the safety and operational consequences of each failure and the degradation mechanism.



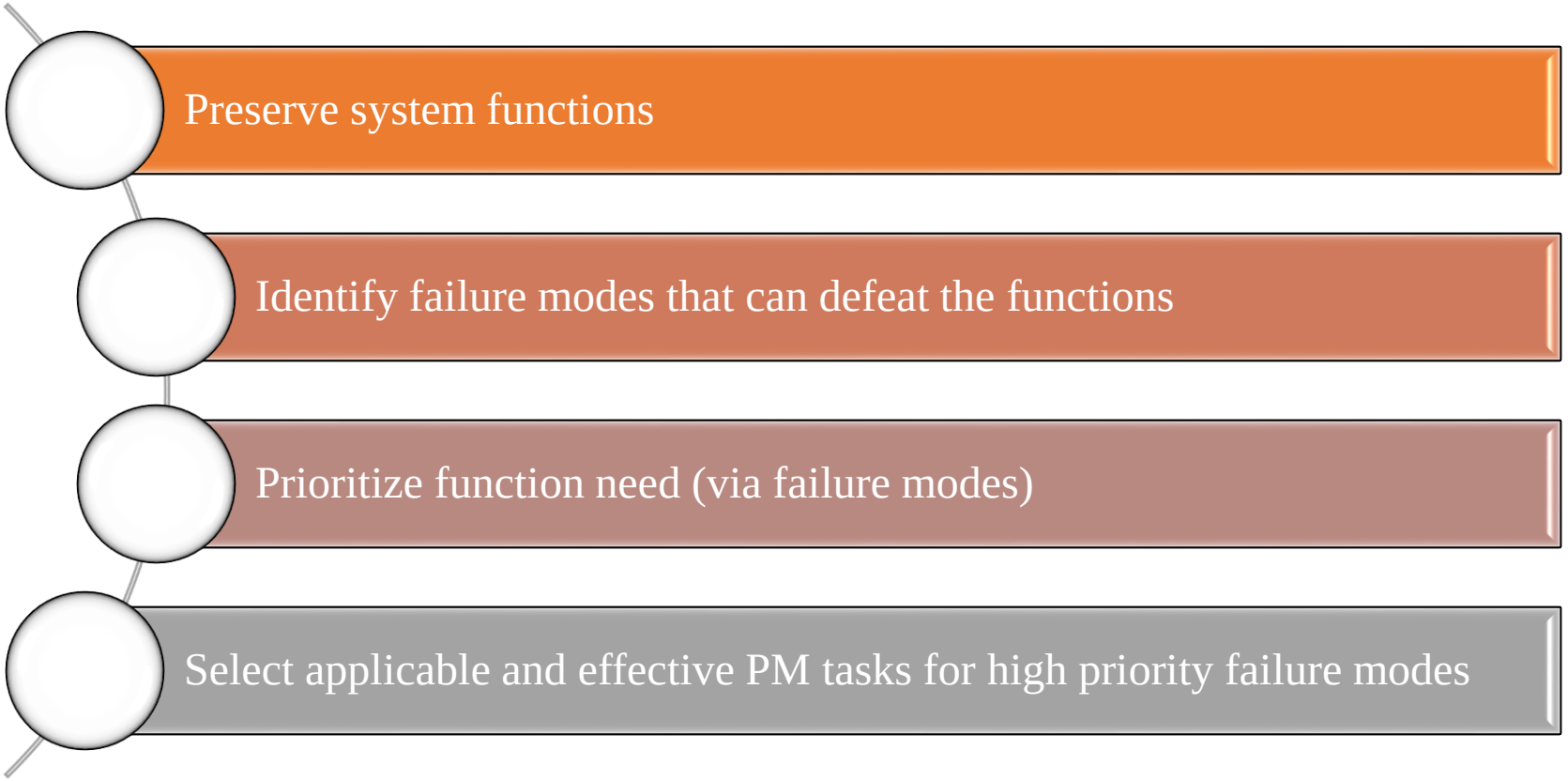
Methodology (2/3)

- RCM employs (PM), (PdM), (CBM), (RTF) and Proactive Maintenance techniques



Methodology (3/3)

- RCM Main Principles:

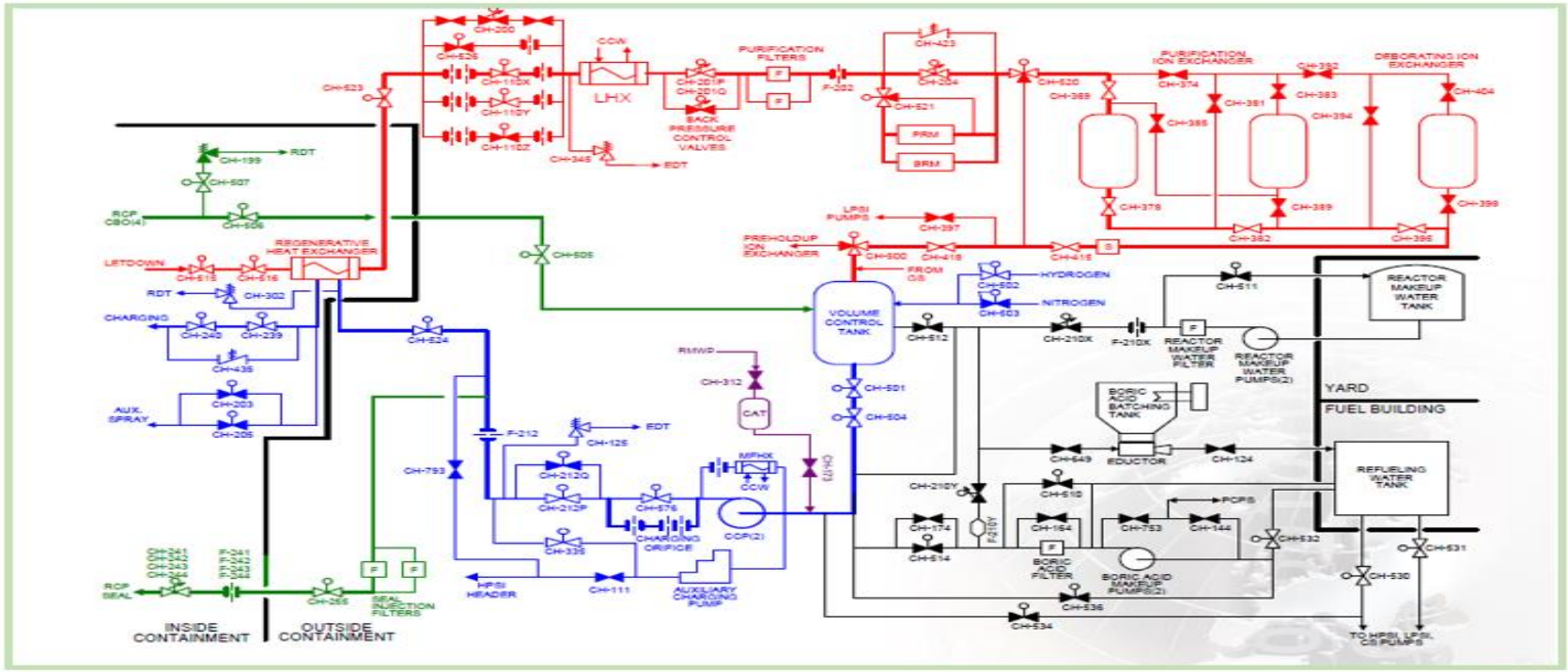


Reasons for selecting the CVCS

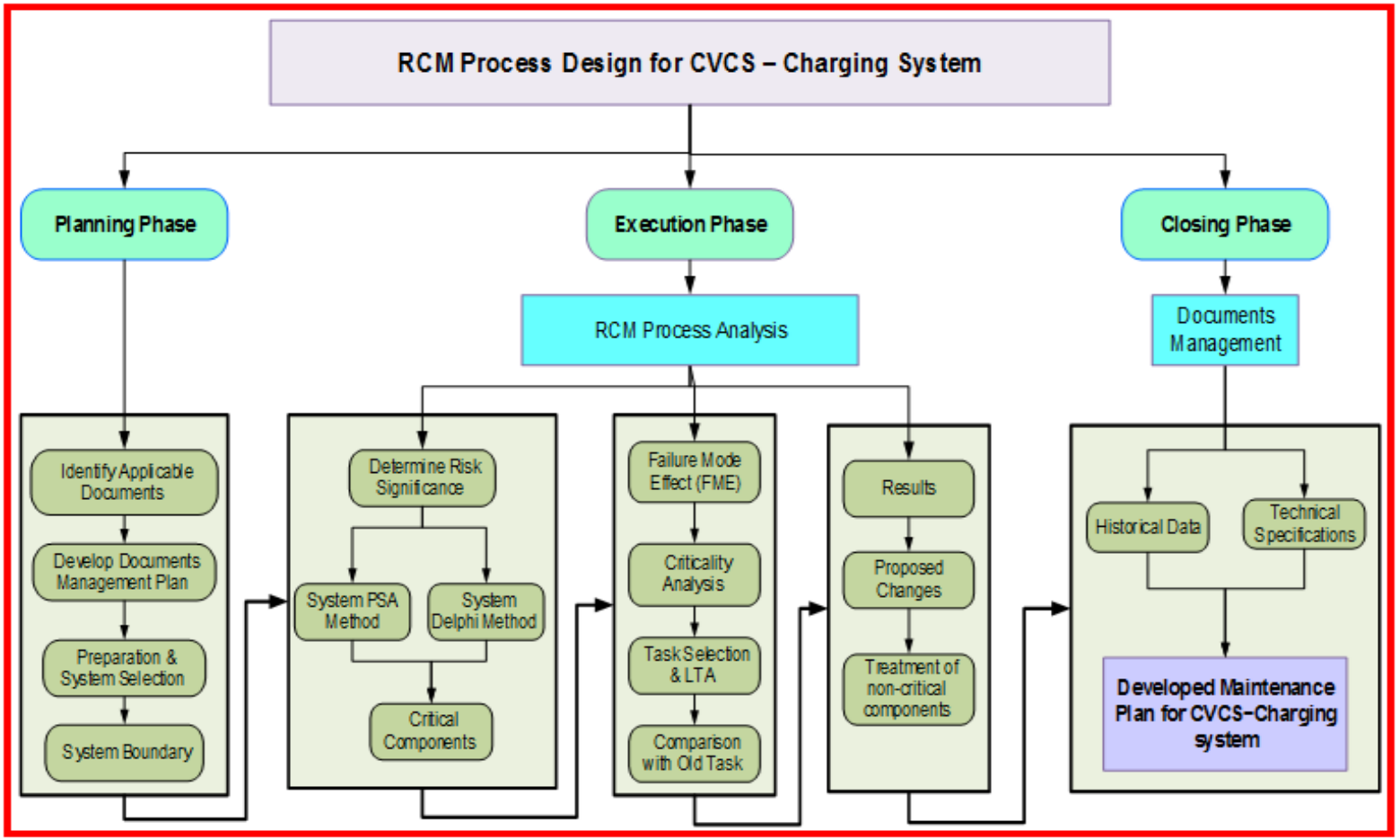
- CVCS is one of the systems that has issues in the nuclear power plant, troubles of CVCS reoccurred periodically, and CVCS is consist of various components which could possibly cause trouble.
- The integrity of the RCS and RCP and the safety of reactor are put at risk, If the following major CVCS functions cannot be performed;
  - ✓ Maintain the RCS inventory
  - ✓ Remove the dissolved oxygen in the RCS, control the pH, and purify the water
  - ✓ Control the reactor power using boron concentration
  - ✓ Supply seal injection water to the RCP
- Therefore, CVCS is a critical system and we need to monitor its performance and develop maintenance plan to increase the reliability and availability of the system.

System description

- The CVCS consists of the three subsystems :
  - ✓ Letdown System:- sends some coolant extracted from the RCS to the VCT.
  - ✓ Charging System:- sends water from VCT back to the RCS using the charging pump.
  - ✓ Seal Injection System:- injects seal water into the RCP shaft using charging water.



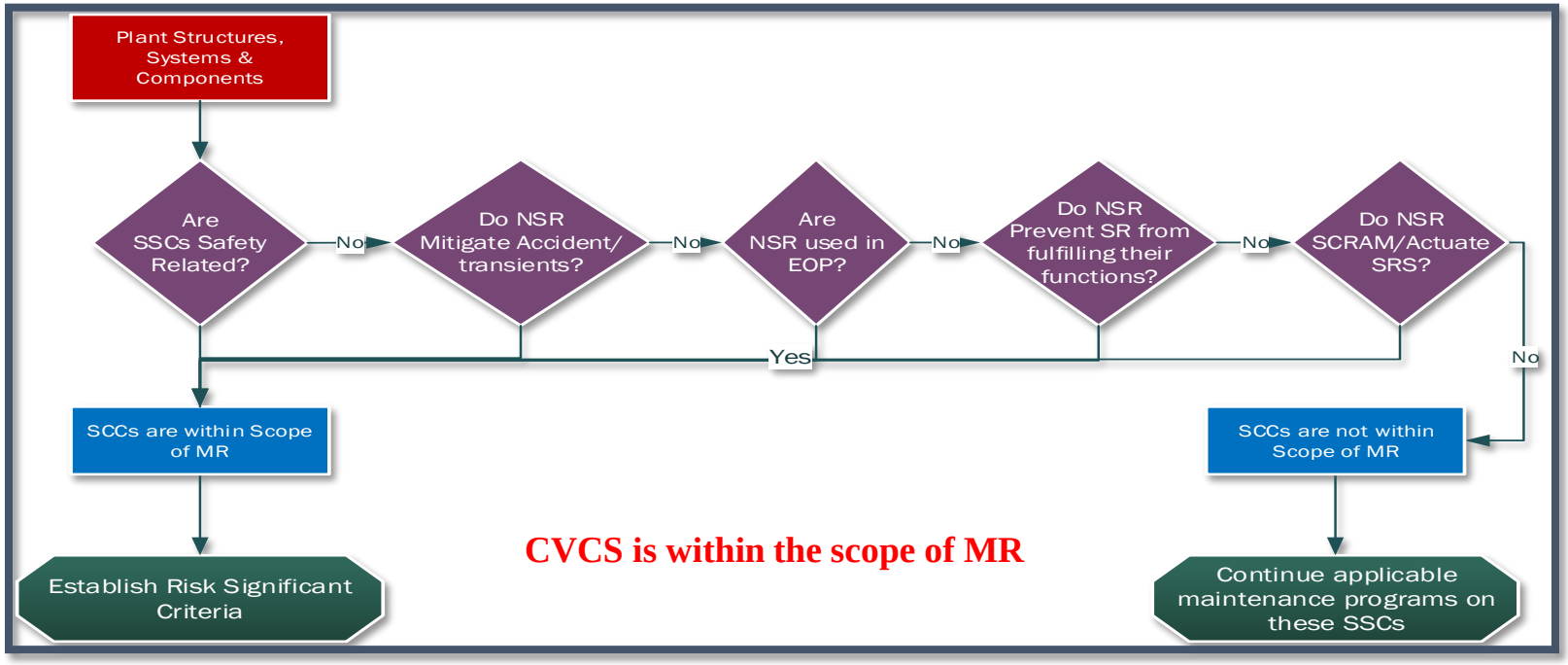
Implementation of RCM process for CVCS - Charging System (1/12)



Implementation of RCM process for CVCS - Charging System (2/12)

1- System Selection Process

- The scoping process identified the CVCS as a system that falls within the scope of maintenance rule



Implementation of RCM process for CVCS - Charging System (3/12)

2- System Functions

ID	Function Description
CV-01	Provide Reactivity Compensation
CV-02	Provide seal injection flow to RCPs and collect RCP seals controlled bleed-off
CV-03	Provide reactor makeup water supply to various auxiliary equipment
CV-04	Provide makeup flow for the losses from small leaks in the RCS piping
CV-05	Provide a means to add makeup water and adjust boron concentration of the IRWST
CV-06	Provide pressurizer auxiliary spray to control pressure of the pressurizer during the final stages of shutdown and pressurizer cooling
CV-07	Provide borated makeup to the spent fuel pool

CV-01,CV-02,CV-04,CV-07 In Scope

CV-03,CV-05,CV-06 out of Scope

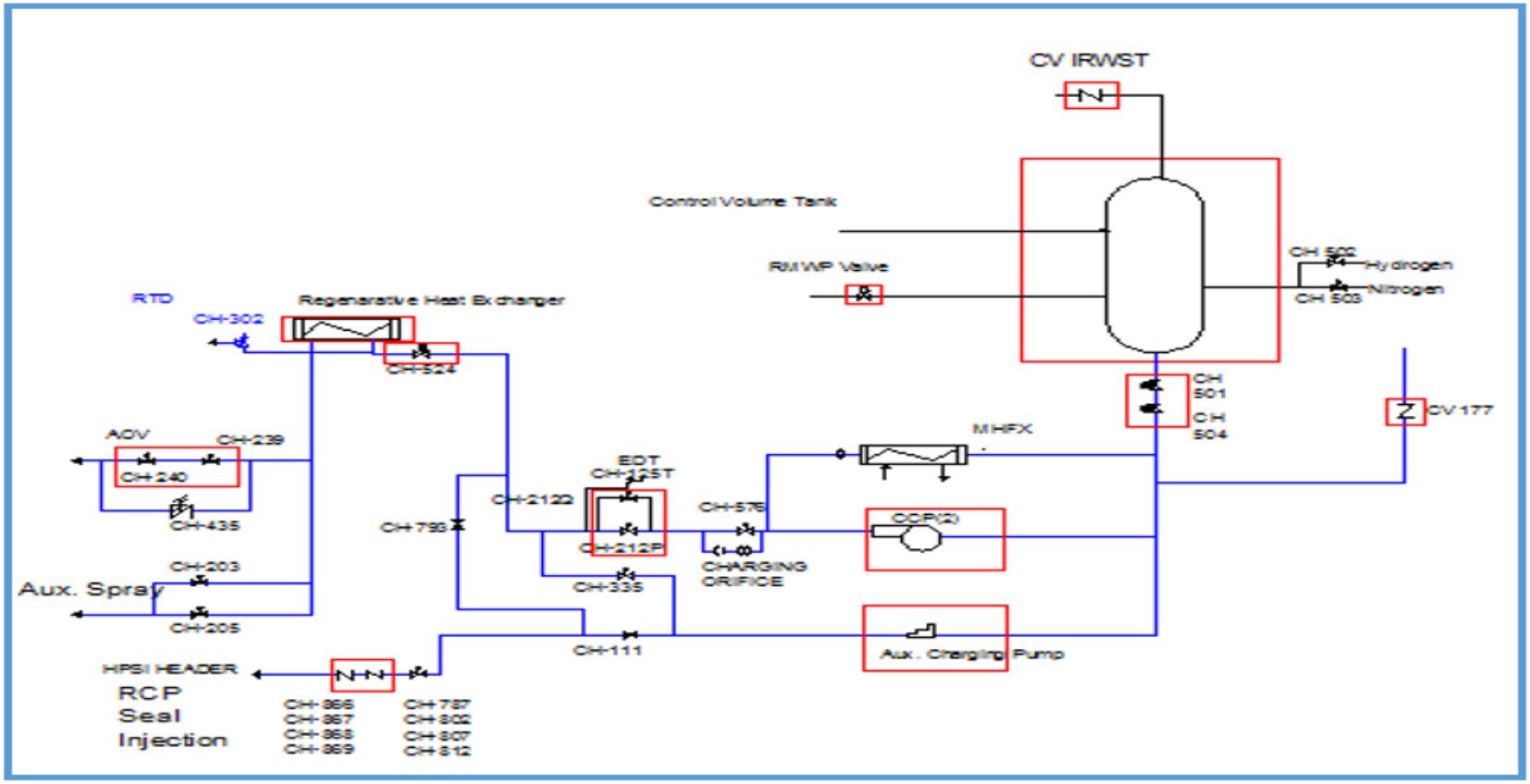
Implementation of RCM process for CVCS - Charging System (4/12)

3- Scoped Functions and Responsible Components

ID	Function Description	Responsible Components
CV-01	Provide Reactivity Compensation	- Volume Control Tank, - Charging Backpressure Control Valve (CH-240), - VCT outlet valves, - (Centrifugal) Charging Pumps, - Charging Flow Control Valves
CV-02	Provide seal injection flow to RCPs and collect RCP seals controlled bleed-off	- Volume Control Tank, - Seal Injection Flow Control Valves,
CV-04	Provide makeup flow for the losses from small leaks in the RCS piping	- Volume Control Tank, - Regenerative Heat Exchanger - (Centrifugal) Charging Pumps, - Charging Flow Control Valves (CH-241/242/243/244)
CV-07	Provide borated makeup to the spent fuel pool	- Volume Control Tank, - (Centrifugal) Charging Pumps, - Charging Flow Control Valves (CH-241/242/243/244)

Implementation of RCM process for CVCS - Charging System (5/12)

- CVCS Charging System Boundaries

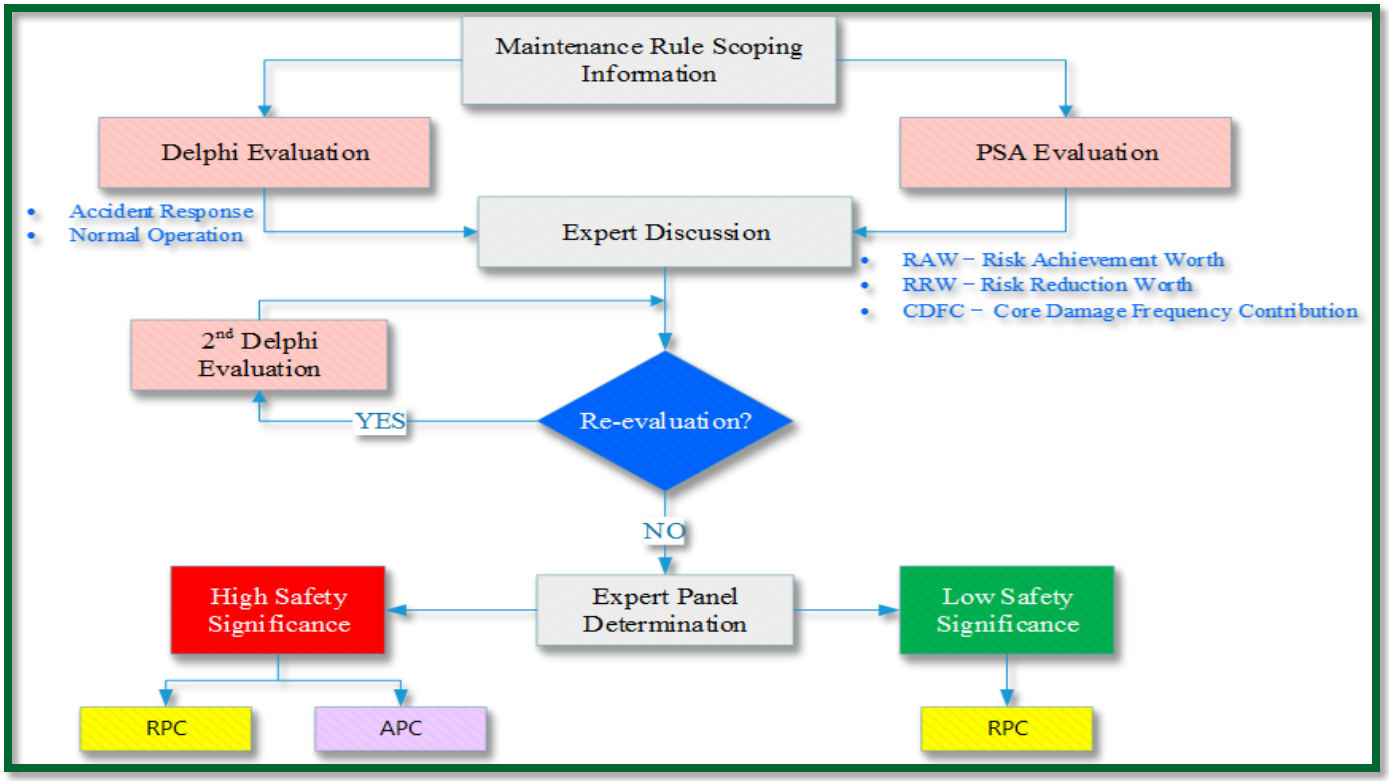


CVCS Charging System Modelling Diagram

Implementation of RCM process for CVCS - Charging System (6/12)

4-Risk Significance Determination

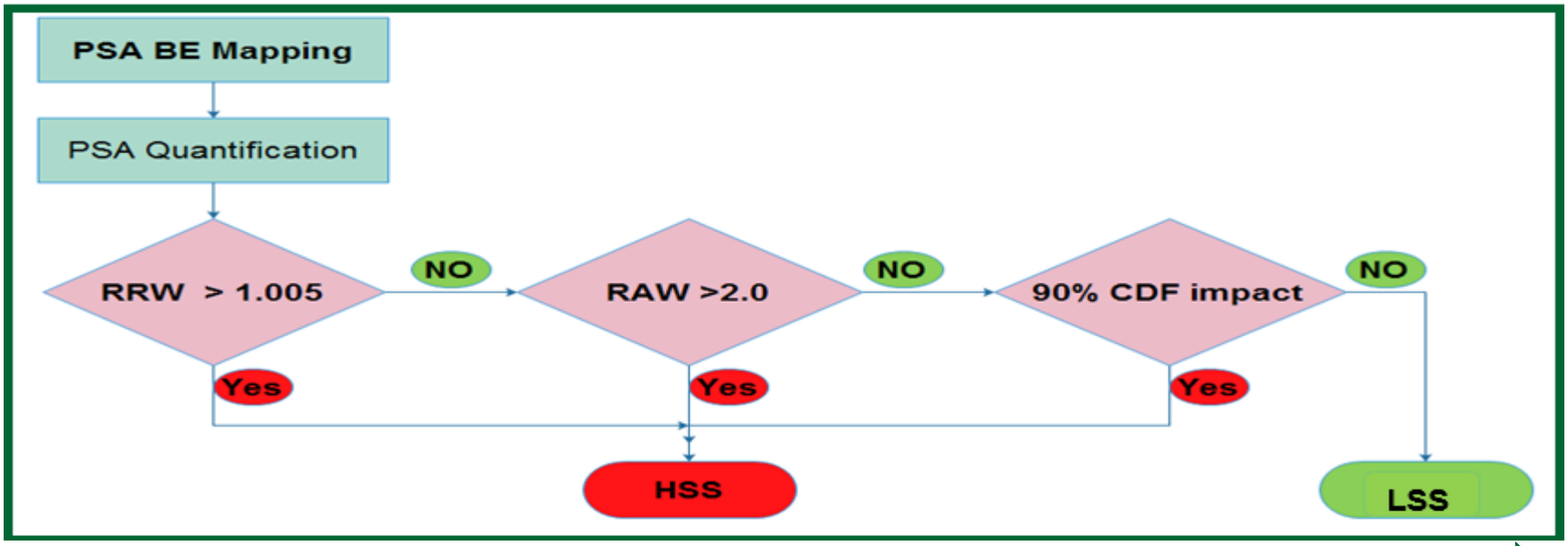
There are two method that are used to determine the safety significance. These include Delphi met hod and Probabilistic Safety Analysis method (PSA).



Implementation of RCM process for CVCS - Charging System (7/12)

a) PSA method

SAREX software developed by KEPCO E&C is used to model the SCS. SAREX is used to determine the safety significance of each component and identify the critical component by using the following flowchart.



PSA data from SAREX

HSS

Implementation of RCM process for CVCS - Charging System (8/12)

b) DELPHI method

- This method depend on the engineering judgment for the expert panel
- Using PSA & DELPHI method we can identify the critical components which are responsible of performing the critical function (The component flow path).

PSA Results	DELPHI Results	Identified Critical Components
- RCP Seal Injection - IRWST Replenish Line - Charging Back Pressure Valve - Containment Isolation Valve - Reactor Makeup Line Valve - VCT Outlet Isolation valve - Volume Control Tank - Regenerative Heat Exchanger	- Volume Control Tank - Charging Backpressure Control Valve - VCT outlet Isolation valves - (Centrifugal) Charging Pumps - Seal Injection Flow Control Valves - Charging Flow Control Valves (CH-241/ 242/ 243/244) - Regenerative Heat Exchanger	- Centrifugal Charging Pump - Volume Control Tank - Air Operated Valves - Motor Operated Valves - Check Valves - Regenerative Heat Exchanger - CCP Mini-Flow Heat Exchanger

Implementation of RCM process for CVCS - Charging System (9/12)

5- RCM analysis for critical components

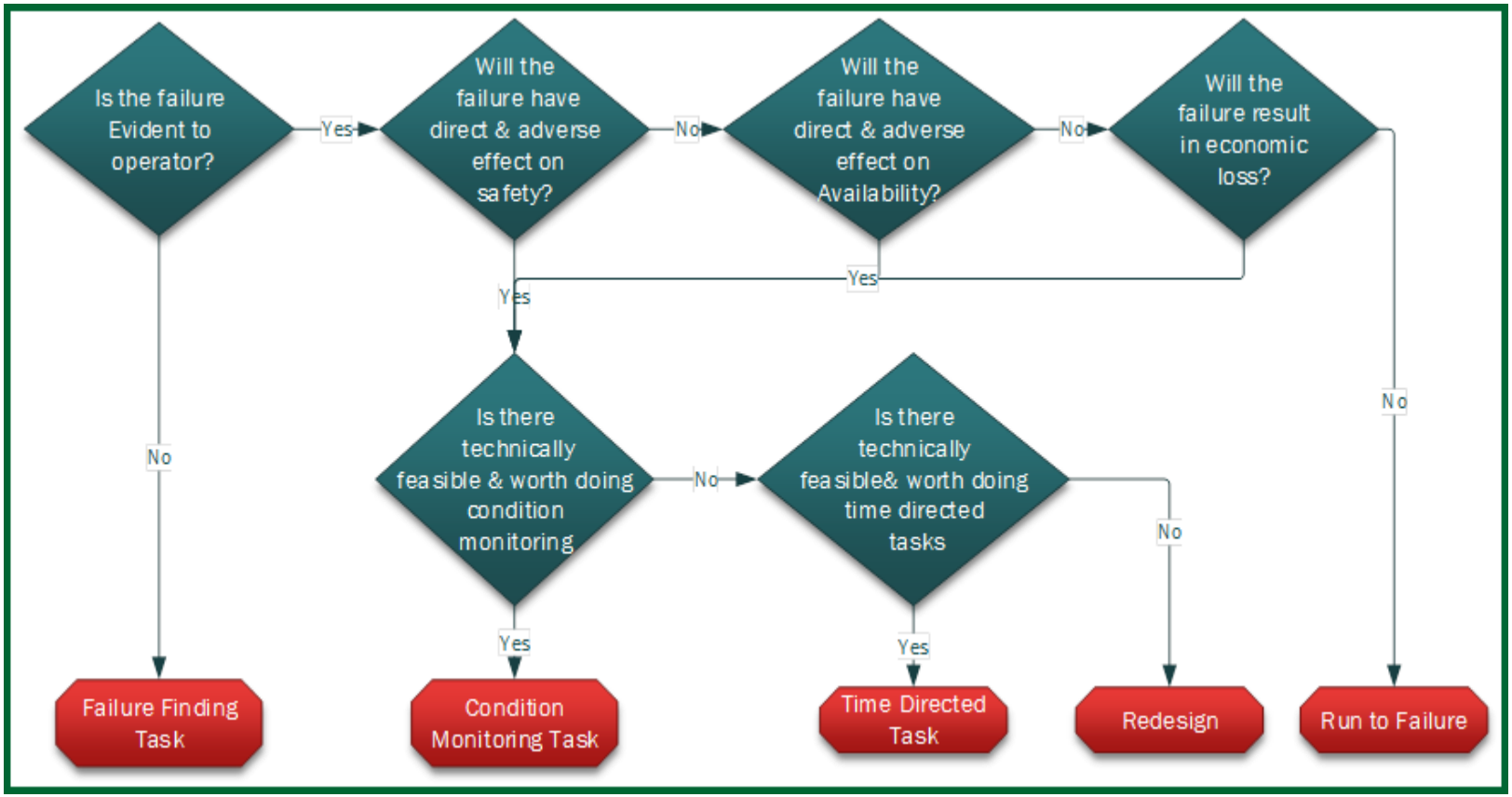
- Failure Mode Effect and Criticality Analysis (FME& CA)

  - Charging pump
  - Motor Operated Valves
  - Volume Control Tank
  - CCP Mini-Flow Heat Exchanger
  - Check Valve
  - Air Operated Valve
  - Regenerative heat exchanger

FME&CA

Implementation of RCM process for CVCS - Charging System (10/12)

6 - Tasks selection by LTA



Implementation of RCM process for CVCS - Charging System (11/12)

- Summary of tasks selection

Component	Number of CBM	Number of TB	Number of redesign	Failure Finding
Pump	40	10	1	2
	75%	18.8%	1.9%	3.7%
MOV	12	10	3	1
	46.2%	38.5%	11.5%	3.8%
VCT	14	0	0	0
	100%	0	0	0
Mini flow HX	4	1	2	0
	57.1%	14.3%	28.6%	0
CV	9	7	0	0
	56%	44%		
AOV	7	15	0	3
	28%	60%	0	12%
Regenerative HX	3	8	0	0
	27.3%	72.7%	0	0
Total Tasks	89	41	6	6
	62.7%	28.9%	4.2%	4.2%

Implementation of RCM process for CVCS - Charging System (1/12)

7 - Tasks comparison

- The new tasks exactly match the existing PM tasks. Retain
- The new tasks differ from the existing PM tasks. Modify
- The existing tasks may be replaced or deleted. Delete
- The new PM tasks should be added to prevent or mitigate identified failures for the components whose existing tasks do not provide this appropriately. Add

Results and discussions

- According to PSA data and DELPHI method Charging pump, Motor Operated Valves , Volume Control Tank , CCP Mini-Flow Heat Exchanger , Check Valve, Air Operated Valve, and Regenerative heat exchanger are the critical components in the CVCS - Charging System .
- The FME&CA carried out in this study investigated the possible failure modes for the major components in the system.
- Results showed that 62.2% of the potential failures can be detected and prevented by CBM, 28.9% of failure can be detected and prevented by TBM, 4.2% needs to redesign, 4.2% for failure finding and no run to fail for any failure modes.

Conclusion

- The RCM methodology is useful for improving the equipment reliability by strengthening the management of equipment condition, and leads to a significant decrease in the number of periodical maintenance, extended maintenance cycle, longer useful life of equipment, and decrease in overall maintenance cost.
- The results of RCM analysis shows that most of the potential failures in charging pump, VCT, MOV, CV, and Mini flow HX can be prevented by CBM tasks. CBM strategy will improve system and component performance without compromising nuclear safety or availability.

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여러분의 관심에 감사드립니다

Thank you for your attention