

<b>System</b>	Nuclear Power Generation	<b>Potential Failure Mode and Effects Analysis (Design FMEA)</b>
<b>Subsystem</b>	Pressurized Water Reactor	
<b>Component</b>		
<b>Design Lead</b>		
<b>Core Team</b>	Katherine May, Keith Sherer, Kathleen Pacheco, Michael McCleary, Sharth Tadepalli	
		<b>Key Date</b> _____

Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	S e v	Potential Cause(s)/ Mechanism(s) of Failure	P r o b	Current Design Controls	D e t	R P N
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**Failure Modes, Effects and Causes taken from the Nuclear Power Plant Operating Experiences  
from the IAEA/NEA Incident Reporting System 1996-1999**

Coolant System	Loss of Coolant Casualty	Cease to generate power	5	Reactor Shutdown	2	Back up power generators	10	100
Coolant System	Loss of Coolant Casualty	Containment Breach	10	Poor Design	2	Adequate design relief valves and piping	10	200
Coolant System	Loss of Coolant Casualty	Containment Breach	10	Material	2	Material certification, understand thermal aging	10	200
Coolant System	Loss of Coolant Casualty	Plant Personnel Injured	9	Leak outside of reactor compartment, pipe burst	1	Redundant equipment, proper surveillance	10	90
Coolant System	Loss of Coolant Casualty	Plant Personnel Injured	9	Containment Failure	1	Redundant equipment, proper surveillance	10	90
Coolant System	Loss of Coolant Casualty	Plant Personnel Radioactively Contaminated	7	Leak outside of reactor compartment	2	Redundant equipment, proper surveillance	10	140
Coolant System	Loss of Coolant Casualty	Plant Personnel Radioactively Contaminated	7	Containment Failure	2	Redundant equipment, proper surveillance	10	140

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Coolant System	Loss of Coolant Casualty	Civilian Population Radioactively Contaminated	10	Containment Failure	1	Redundant equipment, proper surveillance	10	100
Coolant System	Loss of Coolant Casualty	Soil Contamination	10	Containment Failure	2	Redundant equipment, proper surveillance	10	200
Coolant System	Loss of Coolant Casualty	Ground Water Contamination	10	Containment Failure	2	Redundant equipment, proper surveillance	10	200
Steam Line	Steam line rupture	Cease to generate power	5	Material Failure	10	Design Margin, Inspection, material certification	10	500
Steam Line	Steam line rupture	Cease to generate power	5	Improper Valve Line up	10	Sensors, inspection	10	500
Steam Line	Steam line rupture	Plant Personnel Injury or Death	10	Material Failure	5	Design Margin, Inspection, material certification	10	500
Steam Line	Steam line rupture	Plant Personnel Injury or Death	10	Improper Valve Line up	5	Sensors, inspection	10	500
Steam Line	Steam line rupture	Damage to Equipment	5	Material Failure	7	Design Margin, Inspection, material certification	10	350
Steam Line	Steam line rupture	Damage to Equipment	5	Improper Valve Line up	7	Sensors, inspection	10	350

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Electrical Cabinets	Electrical Bus Fire	Equipment Damage	5	Material Failure	3	Design Margin, Inspection, material certification	4	60
Electrical Cabinets	Electrical Bus Fire	Equipment Damage	5	Condensation in Electrical Cabinet	2	Humidity sensors	4	40
Electrical Cabinets	Electrical Bus Fire	Equipment Damage	5	Improper Maintenance procedures	3	Review of procedures for maintenance, Operator training	4	60
Electrical Cabinets	Electrical Bus Fire	Personnel Injury	9	Material Failure	3	Design Margin, Inspection, material certification	4	108
Electrical Cabinets	Electrical Bus Fire	Personnel Injury	9	Condensation in Electrical Cabinet	2	Humidity sensors	4	72
Electrical Cabinets	Electrical Bus Fire	Personnel Injury	9	Improper Maintenance procedures	3	Review of procedures for maintenance, Operator training	4	108
Electrical Cabinets	Electrical Bus Fire	Cease to generate power	5	Material Failure	3	Design Margin, Inspection, material certification	4	60
Electrical Cabinets	Electrical Bus Fire	Cease to generate power	5	Condensation in Electrical Cabinet	2	Humidity sensors	4	40
Electrical Cabinets	Electrical Bus Fire	Cease to generate power	5	Improper Maintenance procedures	3	Review of procedures for maintenance, Operator training	4	60

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Turbines	Turbine Failure	Cease to generate power	5	Loss of Lubrication	2	Inspection, PM	2	20
Turbines	Turbine Failure	Cease to generate power	5	Material Failure	2	Design Margin, Inspection, material certification	8	80
Turbines	Turbine Failure	Cease to generate power	5	Auxiliary system failure	2		4	40
Turbines	Turbine Failure	Degraded Performance	3	Loss of Lubrication	2	Inspection, PM	2	12
Turbines	Turbine Failure	Degraded Performance	3	Material Failure	2	Design Margin, Inspection, material certification	8	48
Turbines	Turbine Failure	Degraded Performance	3	Auxiliary system failure	2		4	24
Steam Generator	Steam Generator leak	Cease to generate power	5	Material Failure	2	Material certification, Design Margin, Inspection	7	70
Steam Generator	Steam Generator leak	Cease to generate power	5	Poor Chemistry Control	1	Sensors	2	10
Steam Generator	Steam Generator leak	Secondary System contamination	6	Material Failure	2	Material certification, Design Margin, Inspection	7	84
Steam Generator	Steam Generator leak	Secondary System contamination	6	Poor Chemistry Control	1	Sensors	2	12

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Steam Generator	Steam Generator leak	Loss of coolant accident	8	Material Failure	2	Material certification, Design Margin, Inspection	7	112
Steam Generator	Steam Generator leak	Loss of coolant accident	8	Poor Chemistry Control	1	Sensors	2	16
Steam Generator	Steam Generator leak	Personnel Contamination	7	Material Failure	2	Material certification, Design Margin, Inspection	7	98
Steam Generator	Steam Generator leak	Personnel Contamination	7	Poor Chemistry Control	1	Sensors	2	14
Steam Generator	Steam Generator leak	Equipment Contamination	5	Material Failure	2	Preventative maintenance, inspection	7	70
Steam Generator	Steam Generator leak	Equipment Contamination	5	Poor Chemistry Control	1	Sensors	2	10
Containment Spray System	Safety system is unavailable	System could not perform safety function of cooling containment and lowering pressure in case of release of hot fluids from pipe or valve	7	Containment spray system was inoperable	2	Analyze technical documentation and personnel training	4	56

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Containment Spray System	Safety system is unavailable	System could not perform safety function of cooling containment and lowering pressure in case of release of hot fluids from pipe or valve	7	Deficiency in the power supply to the pump motor	2	Analyze technical documentation and personnel training	4	56
Containment Spray System	Safety system is unavailable	System could not perform safety function of cooling containment and lowering pressure in case of release of hot fluids from pipe or valve	7	Trains inoperable due to closed valves	3	Analyze technical documentation and personnel training	4	84
Control Rods in Reactor	Inadvertent control rod withdrawal	Rods would not be reinserted to decrease power resulting in serious safety concerns	1	Maintenance error in coupling the power to the bus that supplied the drive motors	1	Review maintenance procedures, Quality assurance program	4	4
Control Rods in Reactor	Control rod inserted only partly	Cracking of control rods	2	Fuel assemblies are deformed	2	Maintenance and replacement of rods	7	28

Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	S e v	Potential Cause(s)/ Mechanism(s) of Failure	P r o b	Current Design Controls	D e t	R P N
Control Rods in Reactor	Control rod inserted only partly	reduce rigidity and cause bowing in whole core	2	Fuel assemblies are deformed	2	Maintenance and replacement of rods	7	28
Control Rods in Reactor	Control rod inserted only partly	Reactor cannot be shutdown on demand	2	Fuel assemblies are deformed	2	Maintenance and replacement of rods	7	28
Control Rods in Reactor	Control rod inserted only partly	Cracking of control rods	2	Swelling of control rod	2	Maintenance and replacement of rods	7	28
Control Rods in Reactor	Control rod inserted only partly	reduce rigidity and cause bowing in whole core	2	Swelling of control rod	2	Maintenance and replacement of rods	7	28
Control Rods in Reactor	Control rod inserted only partly	Reactor cannot be shutdown on demand	2	Swelling of control rod	2	Maintenance and replacement of rods	7	28
Control Rods in Reactor	Control rod inserted too slowly	Cracking of control rods	1	Fuel assemblies are deformed	2	Maintenance and replacement of rods	7	14
Control Rods in Reactor	Control rod inserted too slowly	reduce rigidity and cause bowing in whole core	2	Fuel assemblies are deformed	2	Maintenance and replacement of rods	7	28
Control Rods in Reactor	Control rod inserted too slowly	Reactor cannot be shutdown on demand	2	Fuel assemblies are deformed	2	Maintenance and replacement of rods	7	28
Control Rods in Reactor	Control rod inserted too slowly	Cracking of control rods	1	Swelling of control rod	2	Maintenance and replacement of rods	7	14

Item / Function	Potential Failure Mode(s)	Potential Effect(s) of Failure	Sev	Potential Cause(s)/ Mechanism(s) of Failure	Pr ob	Current Design Controls	Det	R P N
Control Rods in Reactor	Control rod inserted too slowly	reduce rigidity and cause bowing in whole core	1	Swelling of control rod	2	Maintenance and replacement of rods	7	14
Control Rods in Reactor	Control rod inserted too slowly	Reactor cannot be shutdown on demand	1	Swelling of control rod	2	Maintenance and replacement of rods	7	14
Diesel generator	Diesel generator failed to start	Site could not cope with loss of power	1	valve failure in air start system	2	Preventative maintenance, redundant systems	7	14
Diesel generator	Diesel generator failed to start	Site could not cope with loss of power	10	Wrong fuel used	2	Review changes before implementation, redundant systems	9	180
Piping	Pipe Failures	Sudden rupture of the pipe leading to system degradation	9	Wall Thinning (flow assisted corrosion)	1	Design Margin, Inspection, Redundancy	3	27
Piping	Pipe Failures	Cracks and Leaks leading to system degradation	9	Thermal Fatigue	1	Design Margin, Inspection, Redundancy	3	27
Circuit Breakers	Circuit Breaker Explosion	Explosion of an oil and air mixture	10	Circuit Breaker did not open causing overheating in the housing	2	Heat sensors	10	200
Valves	Valve Failures	Improper flow control, isolation failures	9	Pressure locking due to thermal binding	2	Redundancy, operability tests at hot conditions	10	180

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Vessel head	Vessel Head penetration cracks	instantaneous failure at the connection to the vessel, loss of coolant, ejection of control rod	7	Material Fatigue	1	In-service inspections	5	35
Emergency Core Cooling System	Control operator blocked a safety circuit	All trains in a system are inoperative	10	Human Error	2	Procedures for operator training	2	40