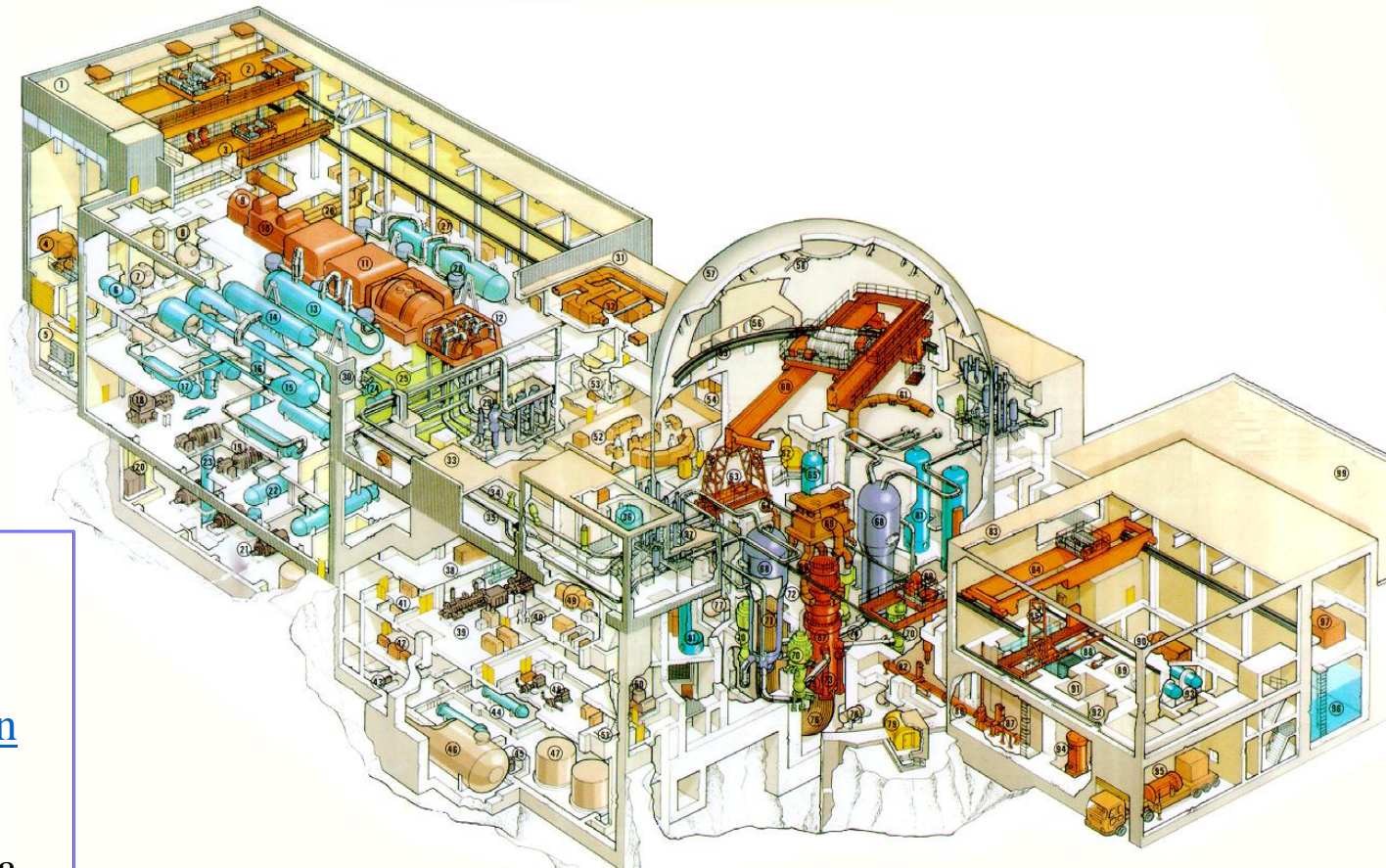


APR1400 Pressurizer System Performance Criteria



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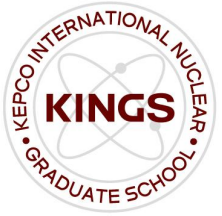
KINGS, Ulsan, Korea



Establishment Performance Criteria of APR1400 Pressurizer System

Contents

- ❖ Introduction
- ❖ Performance Criteria Establishment Process and Results for APR1400 PRZ System
- ❖ Conclusion



Introduction

- Maintenance rule at NPPs is required to:
 - Clear link between effective maintenance and safety as it relates to the number of transients and challenges to safety systems and the associated need for operability, availability, and reliability of safety equipment
 - Ensure that failure of other than safety related SSCs that could initiate or adversely affect a transient or accident is minimized
 - Ensure that design assumptions and margins in the original design basis are maintained and are not unacceptably degraded
- Establishment of SSCs performance criteria for maintenance rule implementation is one of the most parts to satisfy MR
- The establishment of specific performance criteria for APR1400 Pressurizer system such as RPC, APC, and CMC are to provide a basis for determining whether the function is under satisfactory performance (a)(2) or need goal setting (a)(1) of MR.

Performance Criteria Establishment Process for APR1400 PRZ System

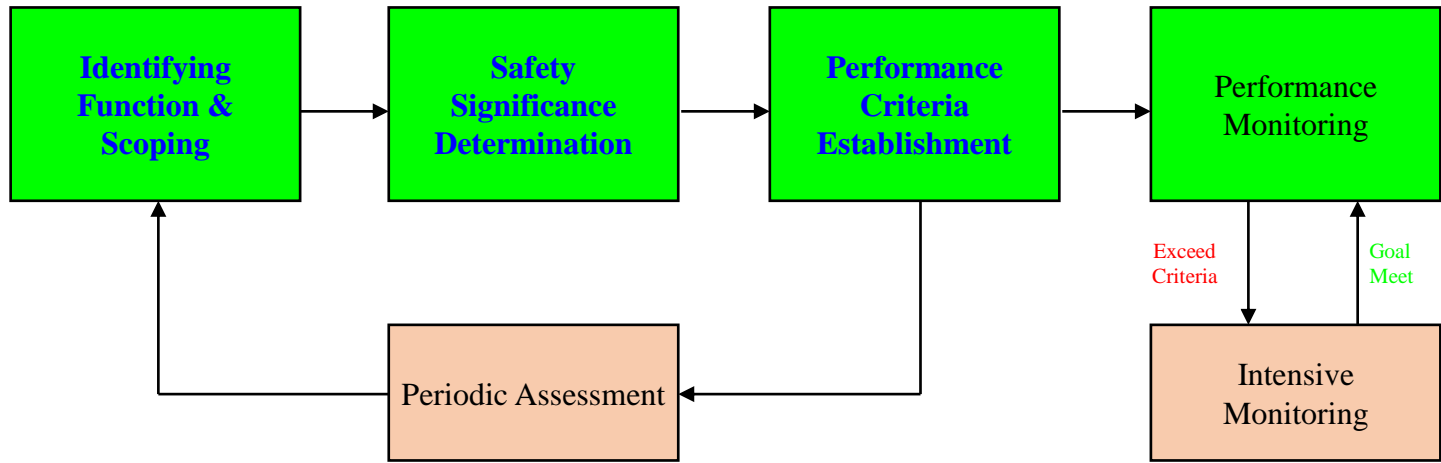


Fig. 1 Process for the maintenance effectiveness monitoring program development

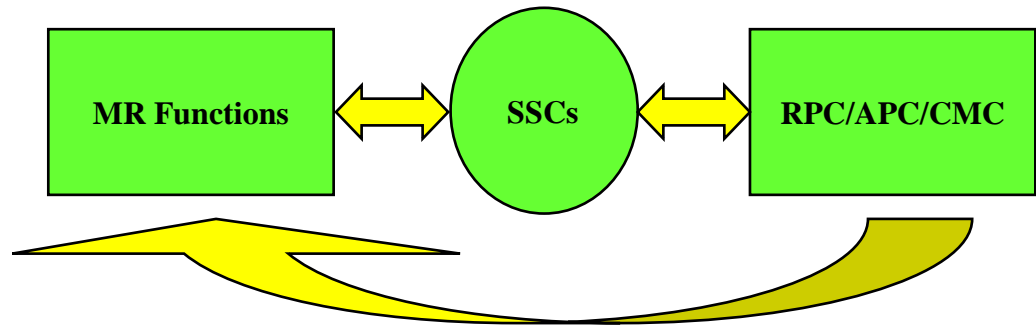


Fig. 2 Interactions of Functions/SSCs and PC

Identifying Function & Scoping of APR1400 PRZ System

Functional Analysis (1/3)

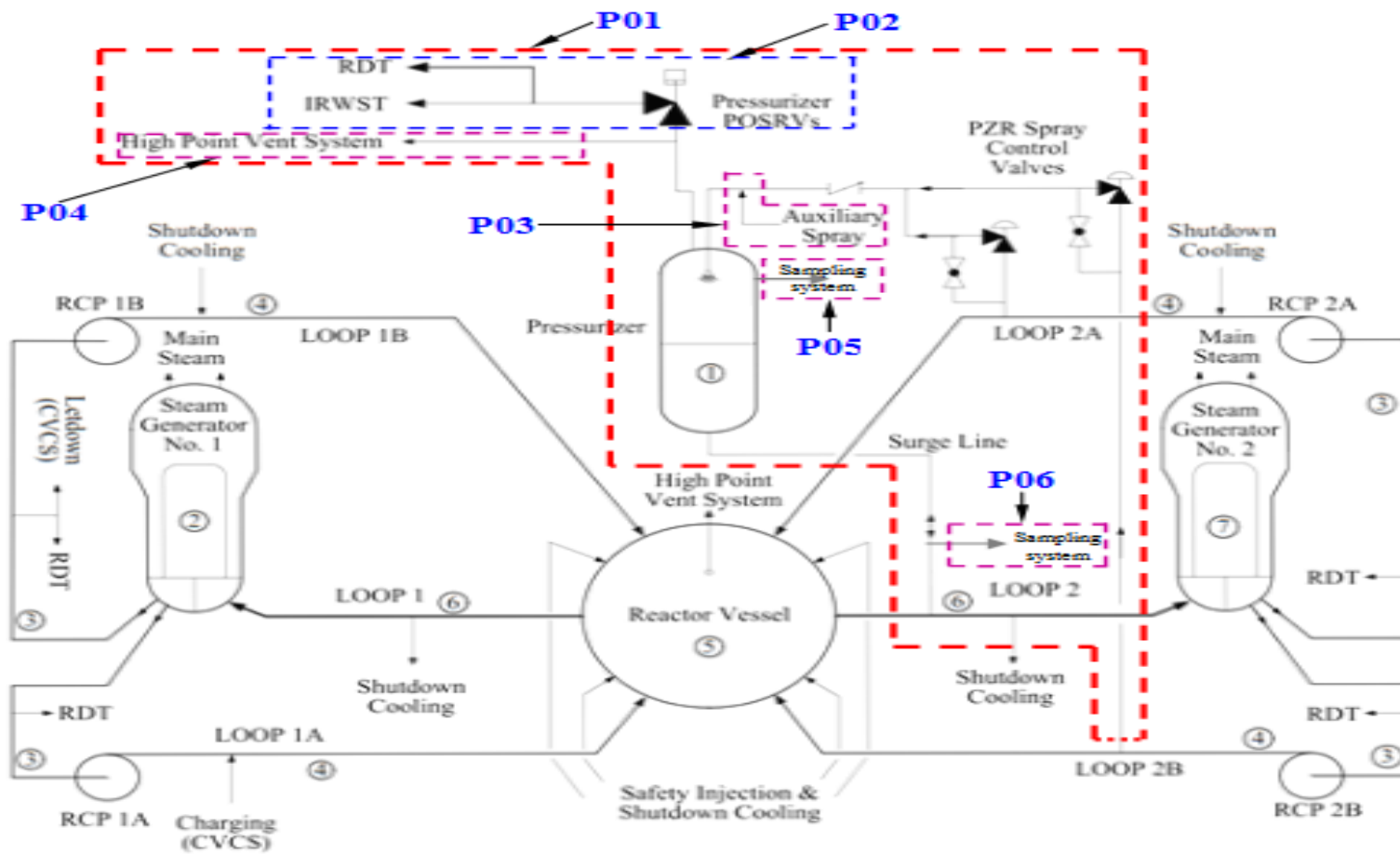


Fig. 3 Reactor Coolant system Schematic Flow Diagram

*** RDT: Reactor Drain Tank; IRWST: In-Containment Refueling Water Storage Tank; POSRV: Pilot Operated Safety Relief Valve; RCGVS: Reactor Coolant Gas Vent System

Identifying Function & Scoping of APR1400 PRZ System

Functional Analysis (2/3)

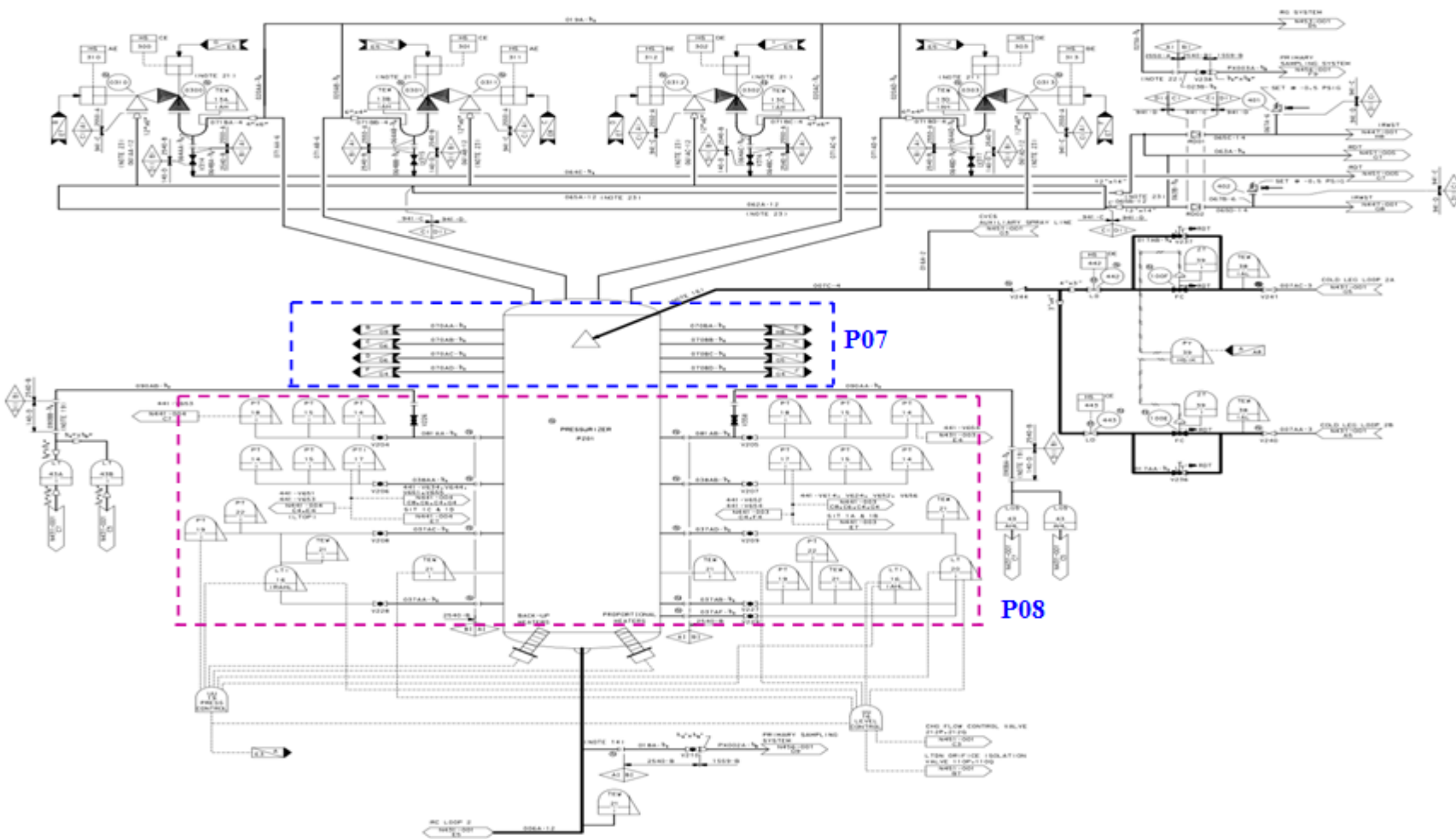


Fig. 4 Pressurizer and POSRV P&ID



Identifying Function & Scoping of APR1400 PRZ System

Functional Analysis (3/3)

Table 1 Functions list of APR1400 Pressurizer system

FID	Function Description
P-01	To maintain RCS operating pressure and compensate for changes in reactor coolant volume during load changes
P-02	To provide overpressure protection for the reactor coolant pressure boundary
P-03	To permit Pressurizer spray during plant heat-up, or to allow cooling if the reactor coolant pumps are shutdown
P-04	To allows non-condensable gases to be vented to the RCGVS during post-accident operations when these gases may be collected in the PZR steam space
P-05	To provide gaseous samples for analysis in order to provide a basis for control of the RCS chemistry and radiochemistry during normal operation
P-06	To provide liquid samples for analysis in order to provide a basis for control of the RCS chemistry and radiochemistry during normal operation
P-07	To generate input signal for reactor protection when high or low Pressurizer pressure
P-08	To generate input signal for controlling Pressurizer pressure and level

Identifying Function & Scoping of APR1400 PRZ System

SSC Scope Analysis in MR (1/2)

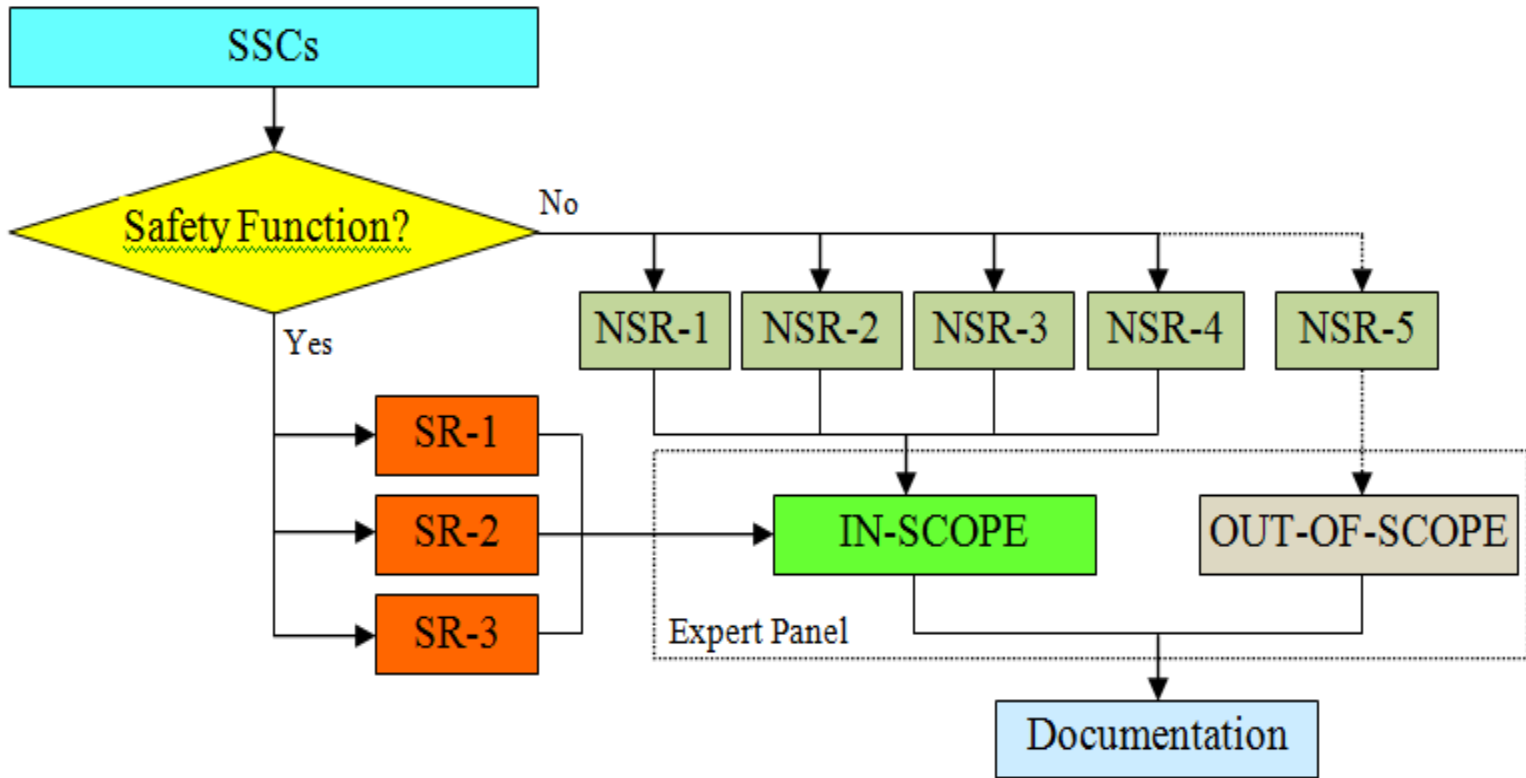


Fig 5. MR scoping determination process diagram



Identifying Function & Scoping of APR1400 PRZ System

SSC Scope Analysis in MR (2/2)

Table 2 APR1400 PRZ SSC In or Out scope of MR

FID	SR-1	SR-2	SR-3	NSR-1	NSR-2	NSR-3	NSR-4	Scope In/ Out
P-01	Y	Y	Y	N	N	N	N	In
P-02	Y	N	N	N	N	N	N	In
P-03	N	Y	N	N	N	N	N	In
P-04	Y	N	N	N	N	N	N	In
P-05	N	N	N	N	N	N	N	Out
P-06	N	N	N	N	N	N	N	Out
P-07	Y	N	N	N	N	N	N	In
P-08	Y	Y	Y	N	N	N	N	In

Safety Significance Determination

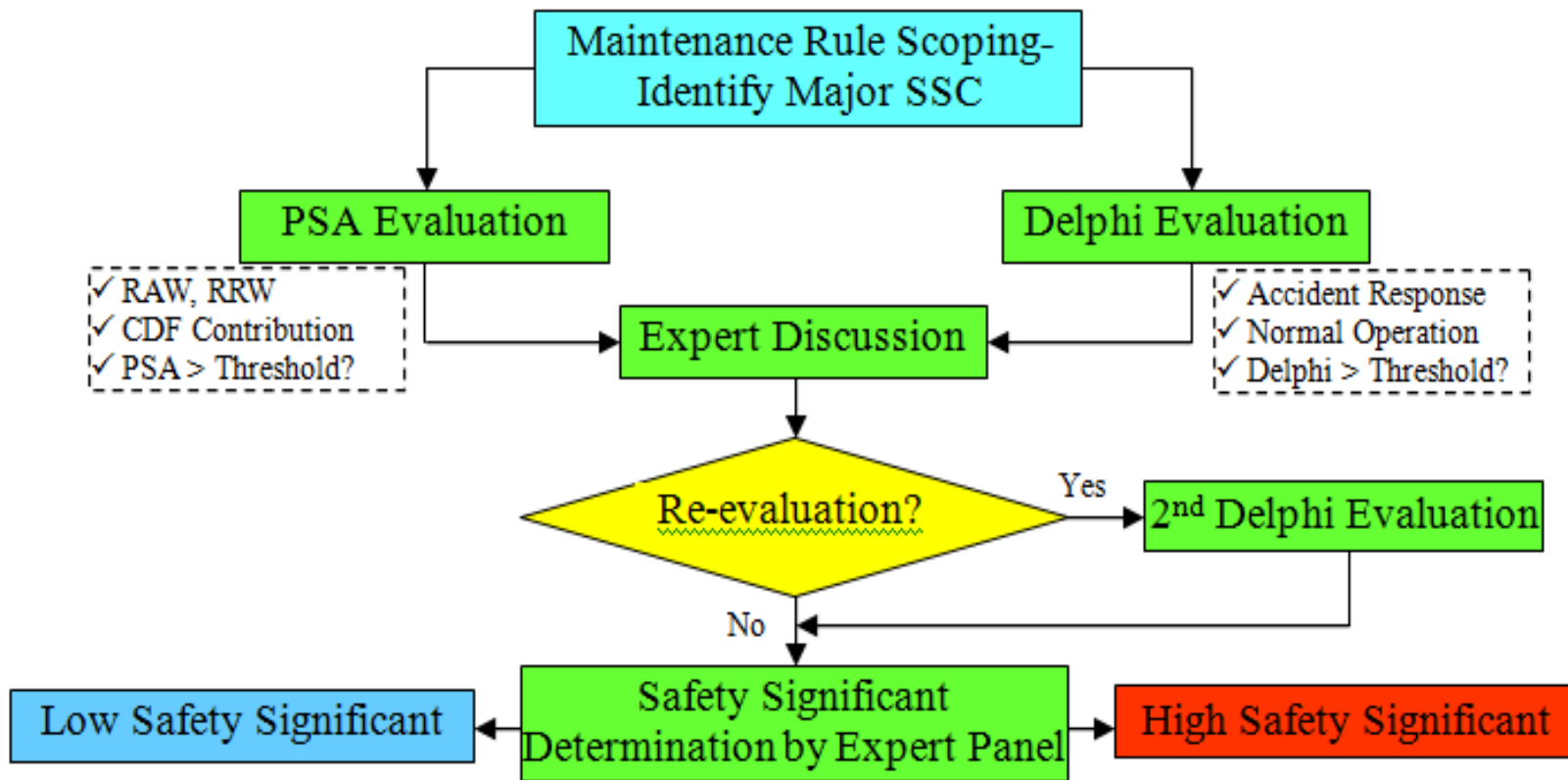


Fig. 6 Safety significance determination process



Safety Significance Determination

Delphi Method

Table 3 Delphi method survey result for safety significance determination of APR1400 Pressurezer system

FID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total Score	Safety Significance (HSS/ LSS)
P-01	110	213	22.5	28.5	7.1	7.8	5.5	6.7	7.7	5.7	414	HSS
P-02	110	213	22.5	143	7.1	7.8	5.5	6.7	7.7	5.7	528	HSS
P-03	175	213	22.5	28.5	21.3	7.8	5.5	6.7	7.7	5.7	494	HSS
P-04	175	170.4	22.5	28.5	7.1	7.8	5.5	6.7	7.7	5.7	437	HSS
P-07	153	213	22.5	28.5	7.1	7.8	5.5	6.7	7.7	5.7	458	HSS
P-08	153	170.4	22.5	28.5	7.1	7.8	5.5	6.7	7.7	5.7	415	HSS
Threshold: $-15\% \leq \text{Threshold (404)} \leq +5\%$												

Safety Significance Determination

PSA Method

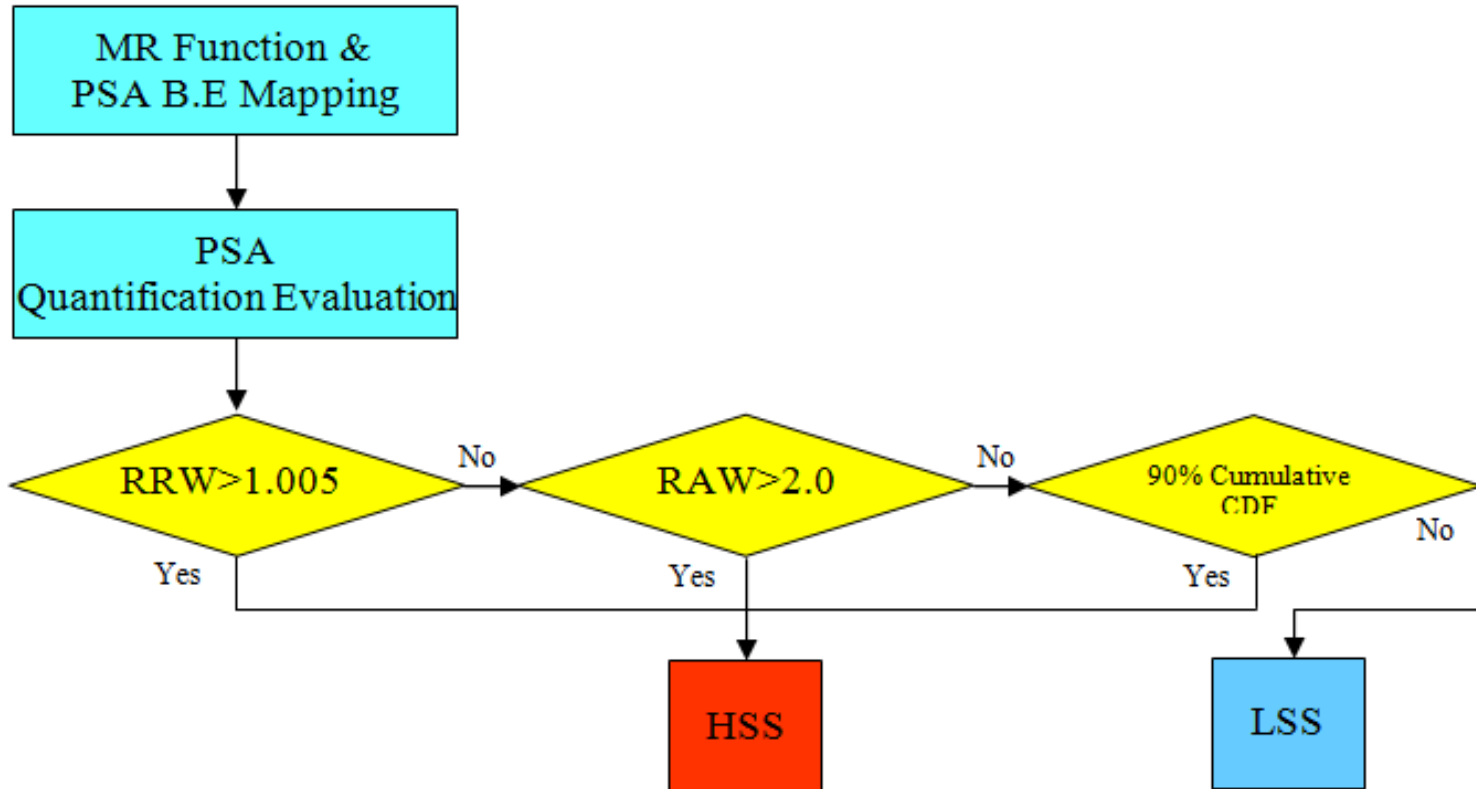


Fig. 7 PSA for risk significance determination process



Safety Significance Determination

Table 4 Safety significance determination results using PSA

ID Component	Event	PROB.	PSA Result		Threshold		Safety Significance (HSS/ LSS)
			RAW	RRW	RAW≥2	RRW≥1.005	
PZR heaters	HXY	1.100E-05	2.412E+01	1.000E+00	High	Low	HSS
CV244	CVO	2.000E-04	3.625E+03	3.635E+00	High	High	HSS
	CVC	2.380E-04	2.412E+01	1.011E+00	High	High	
MV242, MV243	MVO	9.630E-04	2.412E+01	1.047E+00	High	High	HSS
	MVC	9.630E-04	2.412E+01	1.047E+00	High	High	
	MVT	8.140E-07	2.412E+01	1.000E+00	High	Low	
	MVFC	1.590E-06	2.412E+01	1.000E+00	High	Low	
	MVSO	7.870E-14	2.412E+01	1.000E+00	High	Low	
AV100F, AV100E	AVO	2.220E-05	3.625E+03	1.087E+00	High	High	HSS
	AVG	7.000E-05	2.412E+01	1.195E+00	High	High	
V237, V241; V236, V240	VVO	1.920E-04	2.412E+01	1.004E+00	High	Low	HSS
	VVC	1.920E-04	2.412E+01	1.004E+00	High	Low	
	VVT	2.020E-06	2.412E+01	1.000E+00	High	Low	
PV200, PV201, PV202, PV203	PVO	1.700E-05	2.810E+02	1.005E+00	High	Low	HSS
	PVC	2.160E-07	2.412E+01	1.000E+00	High	Low	
	PVSO	1.050E-12	2.412E+01	1.000E+00	High	Low	
MV385, MV386	MVO	9.630E-04	2.412E+01	1.047E+00	High	High	HSS
	MVC	9.630E-04	2.412E+01	1.047E+00	High	High	
	MVT	8.140E-07	2.412E+01	1.000E+00	High	Low	
	MVFC	1.590E-06	2.412E+01	1.000E+00	High	Low	
	MVSO	7.870E-14	2.412E+01	1.000E+00	High	Low	
RV300, RV301; RV302, RV303; RV304, RV305; RV306, RV307	RVC	2.530E-07	2.412E+01	1.000E+00	High	Low	HSS
	RVO	2.540E-06	2.412E+01	1.000E+00	High	Low	
	RVSO	7.210E-13	2.412E+01	1.000E+00	High	Low	
SV203	SVO	2.280E-05	3.625E+03	1.090E+00	High	High	HSS
	SVC	2.280E-05	3.625E+03	1.090E+00	High	High	
	SVFC	1.120E-05	2.412E+01	1.001E+00	High	Low	
	SVSO	3.350E-14	2.412E+01	1.000E+00	High	Low	
	SVT	4.030E-05	2.412E+01	1.002E+00	High	Low	
V431	CVO	2.000E-04	3.625E+03	3.635E+00	High	High	HSS
	CVC	2.380E-04	2.412E+01	1.011E+00	High	High	
SV410, SV411, SV412, SV413, SV419, SV420, SV418	SVO	2.280E-05	3.625E+03	1.090E+00	High	High	HSS
	SVC	2.280E-05	3.625E+03	1.090E+00	High	High	
	SVFC	1.120E-05	2.412E+01	1.001E+00	High	Low	
	SVSO	3.350E-14	2.412E+01	1.000E+00	High	Low	
	SVT	4.030E-05	2.412E+01	1.002E+00	High	Low	
RV1430, RV1421	RVC	2.530E-07	2.412E+01	1.000E+00	High	Low	HSS
	RVO	2.540E-06	2.412E+01	1.000E+00	High	Low	
	RVSO	7.210E-13	2.412E+01	1.000E+00	High	Low	
PT-101A, PT-101B, PT-101C, PT-101D, PT-102A, PT-102B, PT-102C, PT-102D	PTOP	1.970E-05	2.412E+01	1.001E+00	High	Low	HSS
PT199X, PT199Y	PTOP	1.970E-05	2.412E+01	1.001E+00	High	Low	HSS
TEW19A, TEW19B, TEW19C, TEW21A, TEW21B	TTOP	2.020E-05	3.625E+03	1.079E+00	High	High	HSS
LT18, LT14(2), LT40A(2), LT40B(2)	LTOP	2.450E-06	2.412E+01	1.000E+00	High	Low	HSS
PT12(4), PT13(4), PT15(2), PT16(2), PT17(2), PT20(2)	PTOP	1.970E-05	2.412E+01	1.001E+00	High	Low	HSS

PSA analysis of RRW and RAW was done using SAREX models/code, input data used was the component failure basic events and their probabilities



Safety Significance Determination

Table 5 Final result for SSC safety significance determination of APR1400 PRZ system

FID	SSCs	PSA B.E Mapping	PSA Result	Delphi Result	Final Result
P-01	Heaters	PZR heaters	HSS	HSS	HSS
	PZR Spay	CV244	HSS	HSS	HSS
		MV242, MV243	HSS	HSS	HSS
		AV100F, AV100E	HSS	HSS	HSS
		V237, V241; V236, V240	HSS	HSS	HSS
P-02	POSRVs	PV200, PV201, PV202, PV203	HSS	HSS	HSS
P-03	Aux. Spray	SV203	HSS	HSS	HSS
		V431	HSS	HSS	HSS
P-04	RCGVS	SV410, SV411, SV412, SV413, SV419, SV420, SV418	HSS	HSS	HSS
		RV1430, RV1421	HSS	HSS	HSS
P-07	PT	PT-101A, PT-101B, PT-101C, PT-101D, PT-102A, PT-102B, PT-102C, PT-102D	HSS	HSS	HSS
		PT199X, PT199Y	HSS	HSS	HSS
P-08	PT, TT, LT	TEW19A, TEW19B, TEW19C, TEW21A, TEW21B	HSS	HSS	HSS
		LT18, LT14(2), LT40A(2), LT40B(2)	HSS	HSS	HSS
		PT12(4), PT13(4), PT15(2), PT16(2), PT17(2), PT20(2)	HSS	HSS	HSS

Performance Criteria Establishment

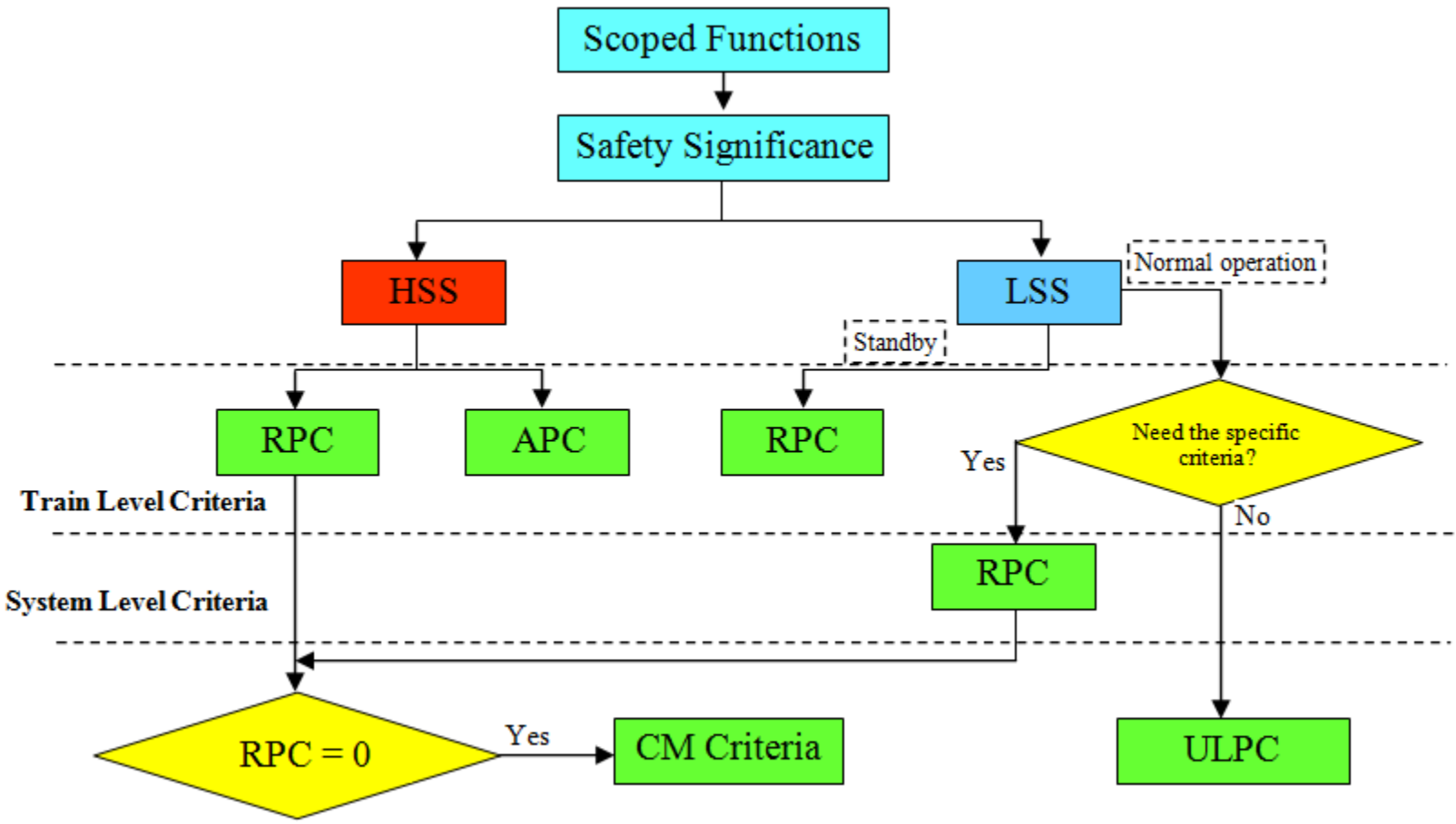


Fig. 8 PC selection establishment process

Performance Criteria Establishment

RPC Calculation

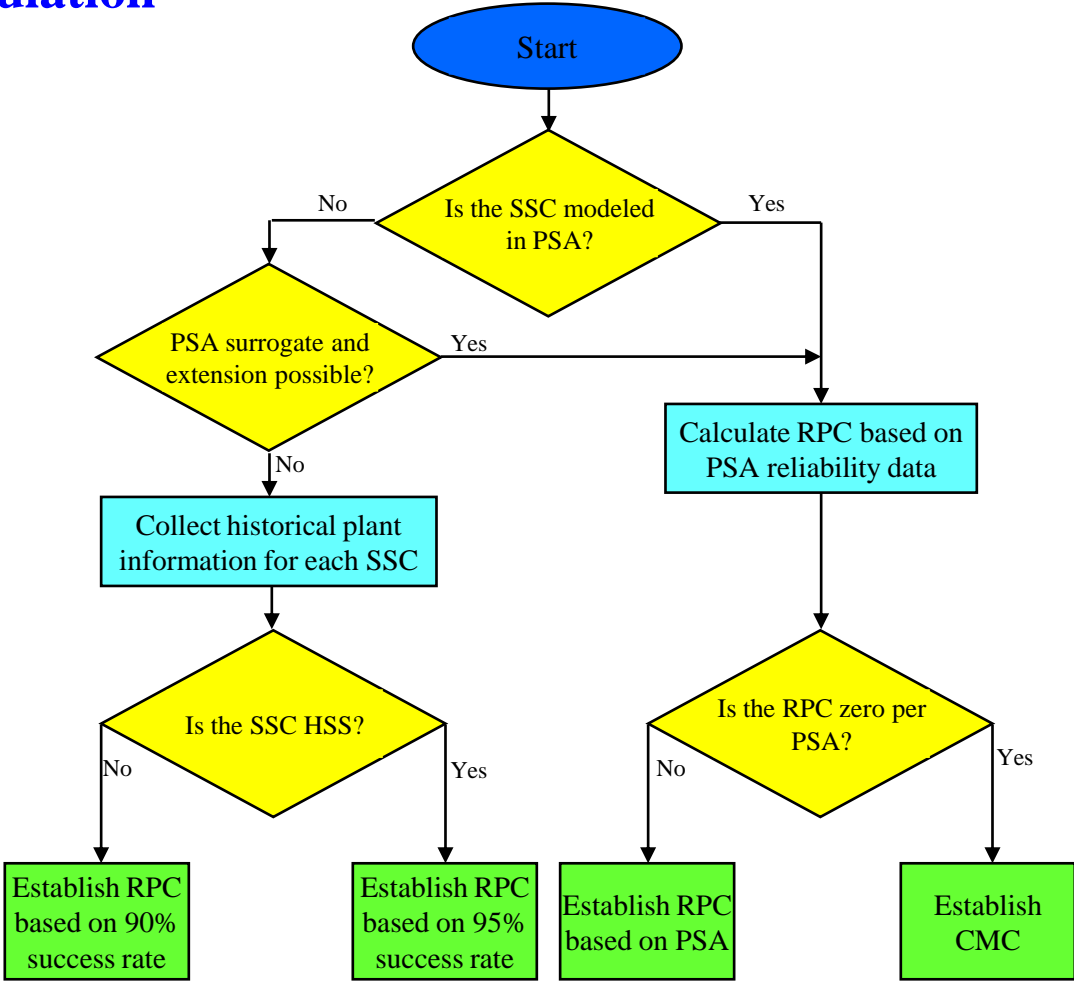


Fig. 9 RPC development process



Performance Criteria Establishment

RPC Calculation

- RPC were determined using EPRI methodology for the case of SSCs modeled in PSA and for the case in which PSA extended application is possible
- Data sources for significance determination results using PSA reference to APR1400 DCD Tier2, APR1400 SSAR, and NUREG/CR-6928
- The time period or mission time are considered every refueling cycle (18 months).

Performance Criteria Establishment

APC Calculation

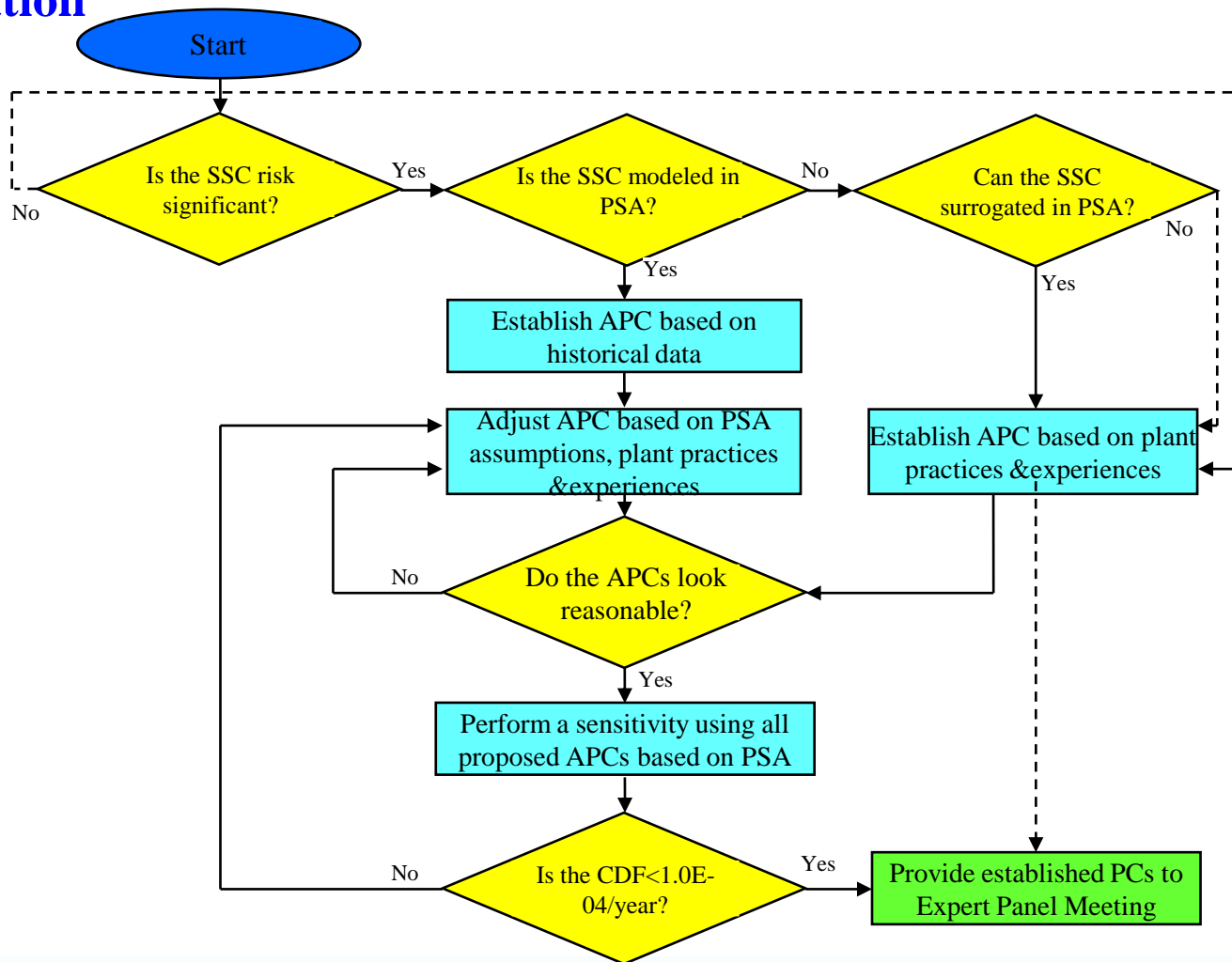
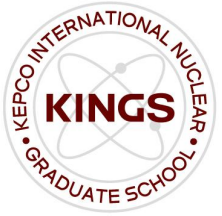


Fig.10 APC development process



Performance Criteria Establishment

APC Calculation

- APC is established for HSS SSCs
- If functions of SSCs are modeled in the probabilistic safety assessment, APC will determine based on the PSA data
- Another situation, APC will determine referring to Allowable Out-of-service Time (AOT) or maintenance hours if functions of SSCs are not modeled in the probabilistic safety assessment ($APC = RPC \times AOT$)

Performance Criteria Establishment

Table 6 Performance criteria of APR1400 PZR System

FID	SSCs	Key SSC	Failure Mode	Safety Significance	RPC (number of failures)	AOT	APC	CL	ML
P-01	Heaters	PZR heaters	HXY	HSS	0	72 hr	0 hr	Train	Train
	PZR Spray	CV244	CVO	HSS	0	4 hr	0 hr	Train	Train
			CVC	HSS	1		4 hr	Train	Train
		MV242, MV243	MVO	HSS	1	4hr	4 hr	Train	Train
			MVC	HSS	1		4 hr	Train	Train
			MVT	HSS	0		0 hr	Train	Train
			MVFC	HSS	0		0 hr	Train	Train
			MVSO	HSS	0		0 hr	Train	Train
		AV100F, AV100E	AVO	HSS	0	4 hr	0 hr	Train	Train
			AVG	HSS	0		0 hr	Train	Train
		V237, V241; V236, V240	VVO	HSS	0	4 hr	0 hr	Train	Train
	VVC		HSS	0	0 hr		Train	Train	
P-02	POSRVs	PV200, PV201, PV202, PV203	PVO	HSS	0	0.25 hr	0 hr	Train	Train
			PVC	HSS	0		0 hr	Train	Train
			PVSO	HSS	0		0 hr	Train	Train
P-03	Aux. Spray	SV203	SVO	HSS	0	4 hr	0 hr	Train	Train
			SVC	HSS	0		0 hr	Train	Train
			SVFC	HSS	0		0 hr	Train	Train
			SVSO	HSS	0		0 hr	Train	Train
			SVT	HSS	0		0 hr	Train	Train
	V431	CVO	HSS	0	4 hr	0 hr	Train	Train	
		CVC	HSS	0		0 hr	Train	Train	
P-04	RCGVS	SV410, SV411, SV412, SV413, SV419, SV420, SV418	SVO	HSS	0	72 hr	0 hr	Train	Train
			SVC	HSS	0		0 hr	Train	Train
			SVFC	HSS	0		0 hr	Train	Train
			SVSO	HSS	0		0 hr	Train	Train
			SVT	HSS	0		0 hr	Train	Train
	RV1430	RVO	HSS	0	72 hr	0 hr	Train	Train	
		RVSO	HSS	0		0 hr	Train	Train	
P-07	PT	PT-101A, PT-101B, PT-101C, PT-101D, PT-102A, PT-102B, PT-102C, PT-102D, PT199X, PT199Y	PTOP	HSS	0	72 hr	0 hr	Chanel	Chanel
P-08	PT, TT, LT	TEW19A, TEW19B, TEW19C, TEW21A, TEW21B	TTOP	HSS	0	72 hr	0 hr	Chanel	Chanel
		LT18, LT14(2), LT40A(2), LT40B(2)	LTOP	HSS	0	72 hr	0 hr	Chanel	Chanel
		PT12(4), PT13(4), PT15(2), PT16(2), PT17(2), PT20(2)	PTOP	HSS	0	72 hr	0 hr	Chanel	Chanel



Conclusion

- The APR1400 Pressurizer system performance criteria establishment for MR implementation is done with purpose to provide a basis for determining whether the function is under satisfactory performance (a)(2) or need goal setting (a)(1) of MR
- Most of APCs are less than or equal to 4 hours, and dominant RPCs are 0 or 1 time
- The results is necessary to review by expert panel with reflection of plant experiences and practices
- PC can be changed when PM base is changed and PSA results changed