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Ageing Lessons Learned from the Periodic Safety Review of BWR NPP

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Introduction

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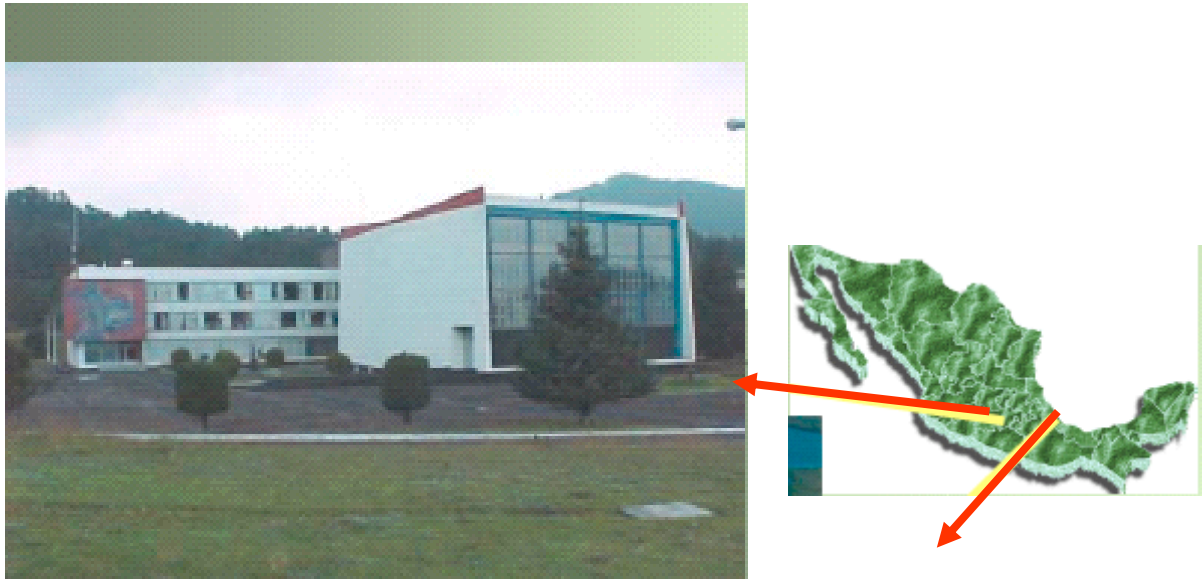
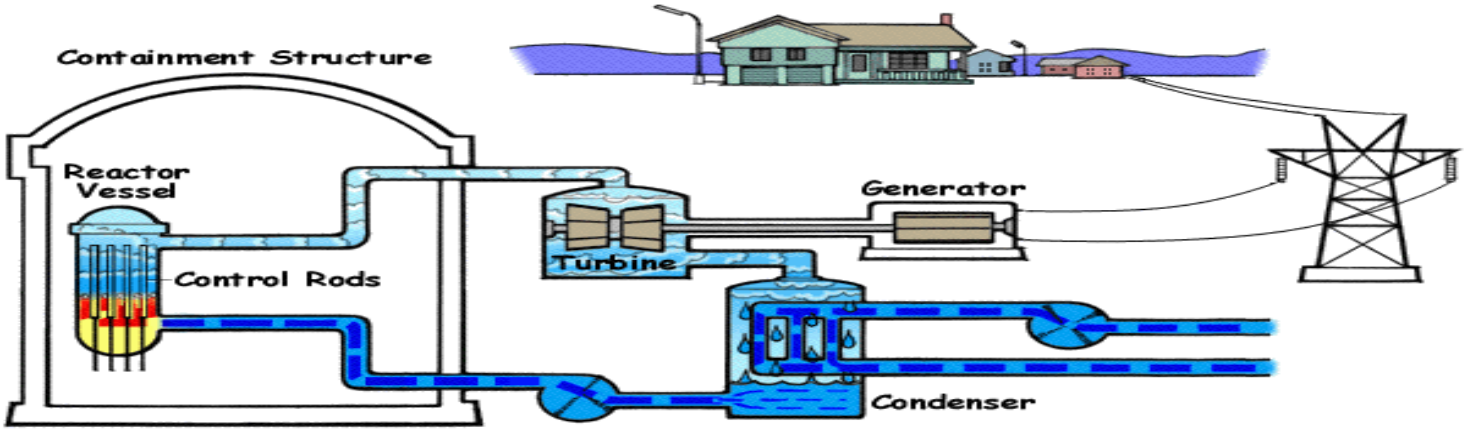


INININ performs R&D in nuclear sciences and techniques, and also provides support to the nuclear industry



Periodic Safety Review

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Mexico: in 2006 the regulatory body accepted the use of NS-G-2.10 safety guide to perform the PSR.

NS-G-2.10 guide assess fourteen safety factors, being Ageing one of them.

The PSR presented here was performed in 2008.

PSR - Ageing → Methodology

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- The scooping and screening of the SSC´s within PSR was realized by the Maintenance Rule and the Equipment Reliability Process.

- From a total of 85 systems, 33 systems were chosen to be reviewed as a representative sample.

- Meetings, interviews, questionnaires and search in the databases were used in order to evaluate the Ageing Management and the status of the equipment reliability process at the plant level.

PSR - Ageing → Process and Regulation

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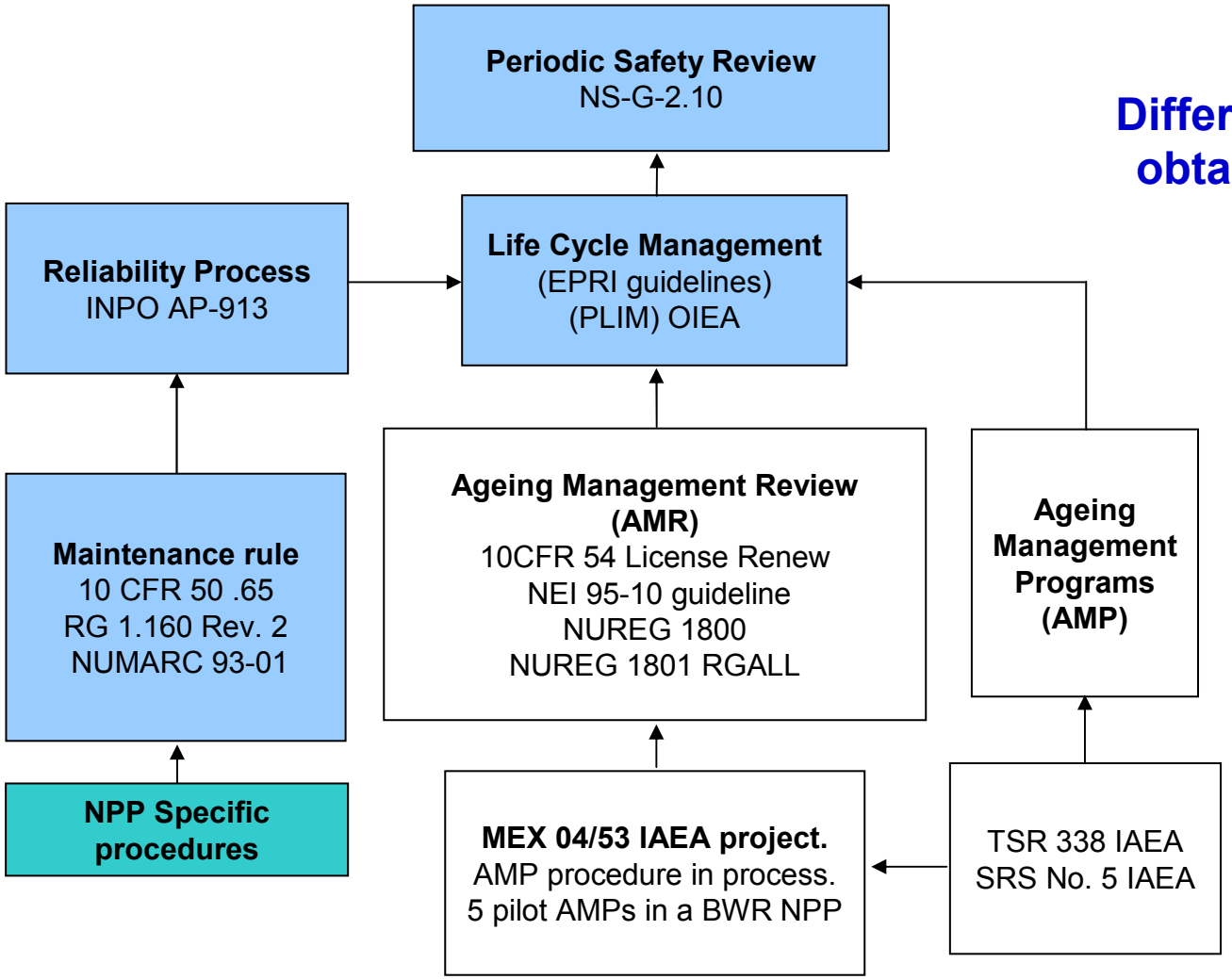

Different paths to obtain the PSR.

PSR - Ageing → Reliability Process

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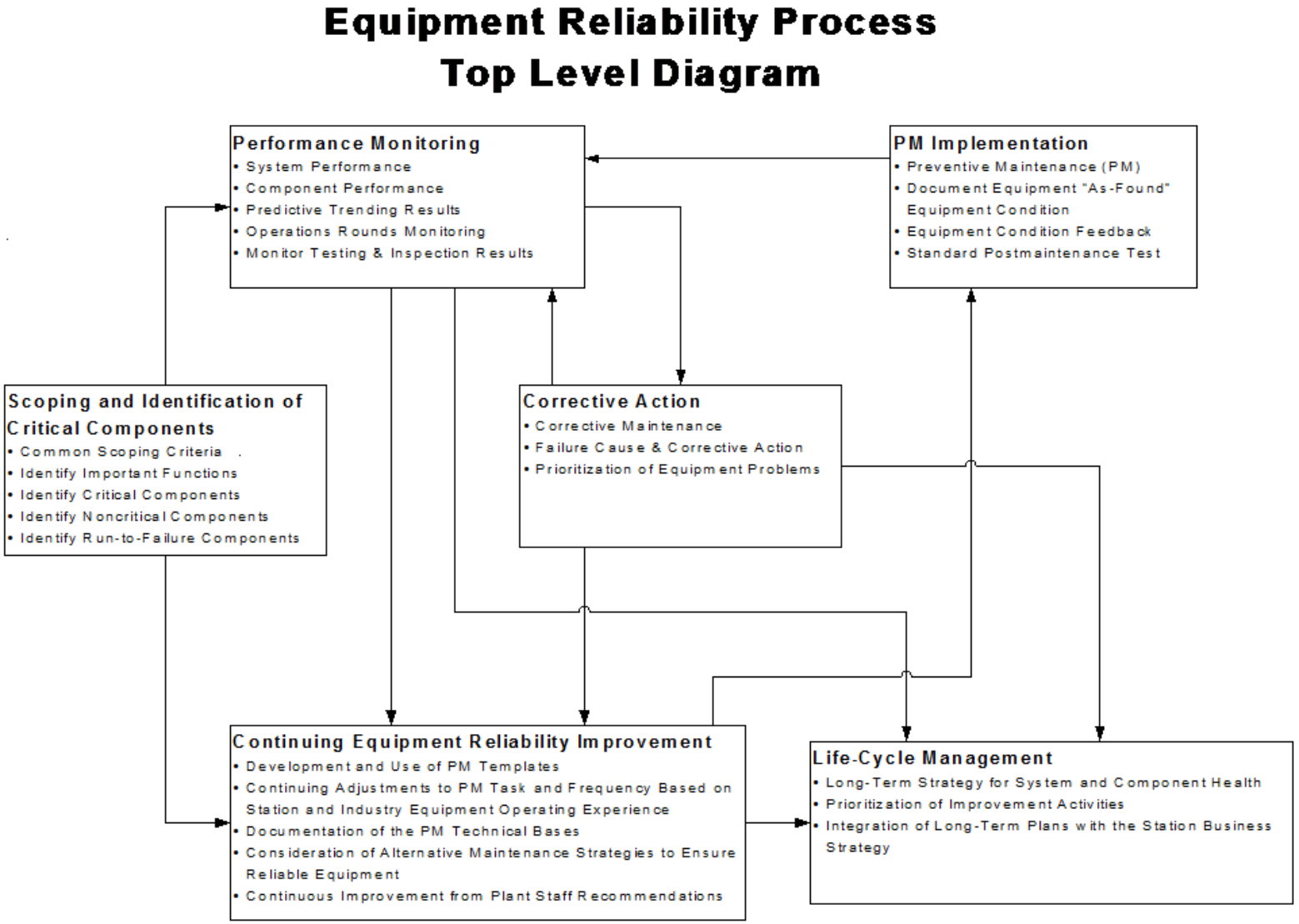

PSR - Ageing → Systems reviewed

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Acronym	System	Acronym	System	Acronym	System
CRD	Control rod drive (hydraulic)	LPCS	Low pressure core spray	FWC	Feed water control
HPCS	High pressure core spray	RHR-C	Residual heat removal	PRM	Process radiation monitors
NCCW	Nuclear closed cooling water	NSW	Nuclear service water	RSG	Reservation system of treatment of gas
RCIC	Reactor core isolation cooling	CHW	Chilled water	NS4	Insulation groups
MS	Main steam	RPV/ RPVIs	Reactor pressure vessel/ Reactor pressure vessel internals	PRNM	Power range neutron monitoring
COND	Condensate (nuclear steam)	RPS	Reactor protection system	RPS/MG	Reactor Protection System
SLC	Standby liquid control	NB	Nuclear boiler	OG/GY	Off gas / glycol
MS/TI	Main stream/ turbine	RHR-A	Residual heat removal-a	PDB	Power Distribution Board 125volt DC.
RFPT	Reactor feedwater pump turbine	RHR-B	Residual heat removal-b	PDC	Power Distribution Center 250 volt DC .
RRC	Reactor recirculation	DG III	Diesel generator	MGT	Main generator transformers
PHO	Hydrogen/oxygen recombine system	NS4	Insulation groups	REA/ROA/RMA	Air conditioner Secondary Containment

PSR - Ageing → Results

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✓The procedure to select the SSC's covered by the Ageing Program is being elaborated.

✓The ageing mechanisms are analyzed by using EPRI templates. There is neither an ageing mechanisms database, nor a statistic study of mechanism trends.

✓There are some plant programs related to ageing; some of them are in the development stage while others are in the implementation stage.

PSR - Ageing → Results: Ageing Programs

Check valve reliability program:

At present, this program only verifies the valves operability. If an abnormality is presented, a job order is opened. The software to monitor this program is being developed.

Pumps Program:

This program verifies the pumps operability. The software of this program is being developed.

Reactor vessel Materials Surveillance Program:

This is an AMP that uses mechanical tests (tension and impact) in order to verify the radiation induced embrittlement of reactor pressure vessel steels; according the test results, the Pressure-Temperature (PT) operating curves are modified with the aim to assure the safe operation of pressure vessels.

In vessel visual inspection program- IVVI:

This is an AMP based in the normative accepted by the American Nuclear Regulatory Commission (NRC). By means of susceptibility analyses, in vessel internals ageing is managed, and this program is modified taking in count the susceptibility to ageing mechanisms, in special to Intergranular Stress Corrosion Cracking (IGSCC). In this program, water conductivity ($\leq$0,15 μs/cm) is monitored, and non destructive testing (NDT) are performed in order to detect flaws, defects and IGSCC.

PSR - Ageing → Results: Ageing Programs

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Erosion corrosion program:

By using Erocor software, the pipe wall thickness of different systems is monitored, the lines that present the higher corrosion susceptibility are identified. By coupling structural integrity analysis and wall thickness evaluation, it is possible to continue the operation of some equipment with wall thickness below the minimum design thickness

Damper program:

This program evaluates damper in service life. This program performs functional tests and it is not directly related to ageing mechanisms.

Water Chemistry Program:

There is a specific procedure to control the chemical and radio-chemical analysis of reactor water. By this program? together with IVVI, the optimized water chemistry program was proposed: Noble Metal Chemical Addition (NMCA) to vessel internals and Hydrogen Water Chemistry (HWC) are coupled in order to mitigate IGSCC.

PSR - Ageing → Results: Ageing Programs

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Environmental qualification program:

This program has as objective to assure the qualification of the equipment related to the security, which are located in a severe environment and that have an assigned function before, during and after a design based accident. This program includes principally the evaluation, mitigation (replacement) and ageing monitoring of active components.

Heat exchanger program:

With the objective to know the heat exchangers capacity margin and their structural integrity, this program monitors the heat exchangers performance and their inspections. This program has four modules: monitoring, inspections, induced currents and failures. The inspections module is applied to erosion-corrosion susceptible systems. In the failure module there is a record of the failure type presented in each heat exchanger.

Pressurized recipients program:

This is a non destructive tests program which allows knowing the structural integrity of receipts submitted to pressure (tanks, batteries, boilers, etc.) in order to minimize the personal risks. The tests included in this program are: hydrostatic, pneumatic, ultrasound, etc. This program may detect leaks and any ageing mechanism that produce leaks can be detected (corrosion, pitting, cracking, pores, etc.).

PSR - Ageing → Results: Ageing Programs

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Fatigue Monitoring:

This program is limited to only one component, the High Pressure Cooling System nozzle. Every time that this component operates, the calculation to know the cumulated fatigue damaged is performed.

Snubbers program:

This program records the mechanical charges and the displacement suffered by snubbers at high or low temperature. It detects the ageing mechanisms that induce a loss of mechanical properties.

Underground pipelines program:

This program includes the inspection and maintenance of underground pipelines located at different places of the BWR NPP. The program detects pipeline and casing corrosion, paint and concrete degradation, etc.

Flexible Hose program:

By the means of the design and development of a database, this program is being developed. It is expected to include the flexible hoses into an AMP in order to avoid that the hoses are used beyond their life cycle. The flexible hoses ageing mechanisms are related to damage produced by inclemency, ultraviolet radiation and thermal effects.

PSR - Ageing → Results: Ageing Programs

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Cathodic Protection program:

This program is a measure to mitigate corrosion, and its application is a way to avoid this important ageing mechanism.

Concrete inspection and liners program (Primary container):

This program pretends to know, internally and externally, the primary container physical state in order to determinate the critical zones of the concrete and steel structures. With this program, ageing management of concrete and steel liner primary container will be performed.

Cables program:

A cable Ageing Management Program (AMP) methodology is being developed, it is taken into account the oxidation induced time, the thermal ageing, elongation tests and radiation damage.

Storage materials program:

This program specifies the expiration date and the shelf life of articles, consumables, lubricants, elastomeric, grease, etc; thus, it controls the ageing of these items, fulfilling the guide NS-G-2.10.

SYSTEM/COMPONENT		PROGRAM										
		VALVE	PUMPS	VESSEL MATERIALS SURVEILLANCE	EROSION CORROSION	DAMPER	WATER CHEMISTRY	ENVIRONMENTAL QUALIFICATION	PREVENTIVE AND CORRECTIVE MAINTENANCE	FATIGUE MONITORING	HEAT EXCHANGER	COMMENTS
CRD	Control rod drive (hydraulic)	X						X	X			
HPCS	High pressure core spray	X	X			X		X	X	X*		* Only when acting is the mouthpiece and survey report is generated
NCCW	Nuclear closed cooling water		X		X	X		X	X		X	
RCIC	Reactor core isolation cooling	X	X			X		X	X			
MS	Main steam				X							
SLC	Standby liquid control	X				X			X			
MS/TI	Main stream/ turbine				X							
FWC	Feed water control							X				
COND	Condensate (nuclear steam)				X							
RFPT	Reactor feedwater pumps turbine											
RRC	Reactor recirculation	X				X		X	X			
PHO	Hydrogen/oxygen recombine system	X				X			X			
LPCS	Low pressure core spray	X	X			X		X	X			
RHR-C	Residual heat removal	X	X			X		X	X		X	
NSW	Nuclear service water		X		X			X	X			
CHW	Chilled water	X	X						X			
RPV/RPVI	Reactor pressure vessel			X			X*					*RPVI's

PSR - Ageing → Results: Ageing Matrix

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System	Component	Degradation mechanisms in metals					Degradation mechanisms in non metals.		
		Erosion	Pitting	Corrosion	Cracking	Thermal ageing	Mechanical damage	Cracking	Other
Control rod drive (hydraulic)	Manually operated valve	1						1	
	Hydraulic Control Unit	1		2					
	Pump for the handling of the control rods	8							
	scram water accumulator / Hydraulic Control Unit	16	20	15					
High pressure core spray	Motor operated valve						3		
	Relief valve						1		
	Relief valve								
	Damper and spring						1		
	Steering valve						1		

PSR - Ageing → Results: Ageing Matrix

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System	Component	Degradation mechanisms in metals					Degradation mechanisms in non metals.		
		Erosion	Pitting	Corrosion	Cracking	Thermal ageing	Mechanical damage	Cracking	Other
Reactor recirculation	Pump A	2							
	Pump B	1							
	piping				1				
	Flexible hose / Flexible Connection		1	1					
	Relief valve	1							
	Manually operated valve	4							
	Motor operated valve	2			1				
Reactor core isolation cooling	Pump	1							
	Switch to high level b			1		1			
	Level control valve								1
	Manually operated valve	9				1			2
	Motor operated valve	2		1					2
	Pressure Control Valve	2							

PSR - Ageing → Conclusions

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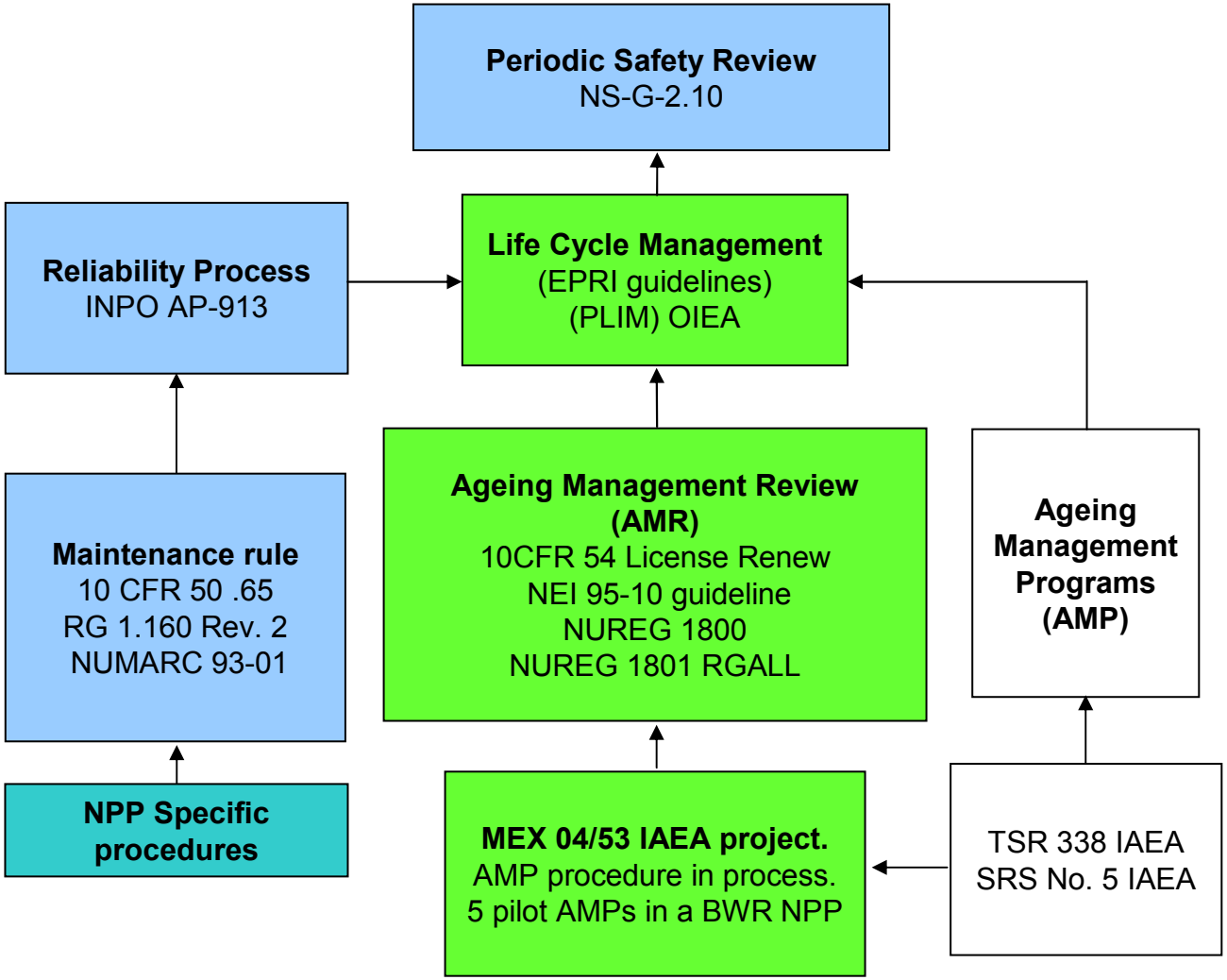

PSR - Ageing → Conclusions

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Now, after ~20 years of NPP operation: Extended Power Uprate (EPU) is planed.

After EPU, the tendency is Renewal License application, including:

- Scooping and Screening.
- AMP´s for SSC.
- TLAA
- PLiM´s and LR.