China Nuclear Power EQ Testing

NPP standards

NPP standard system in China

1	2	3
Law, such as Decree of state council	**Regulation, Such HAF,HAD**	**National and industry Standards, such as GB,NB. Enterprise Standards**

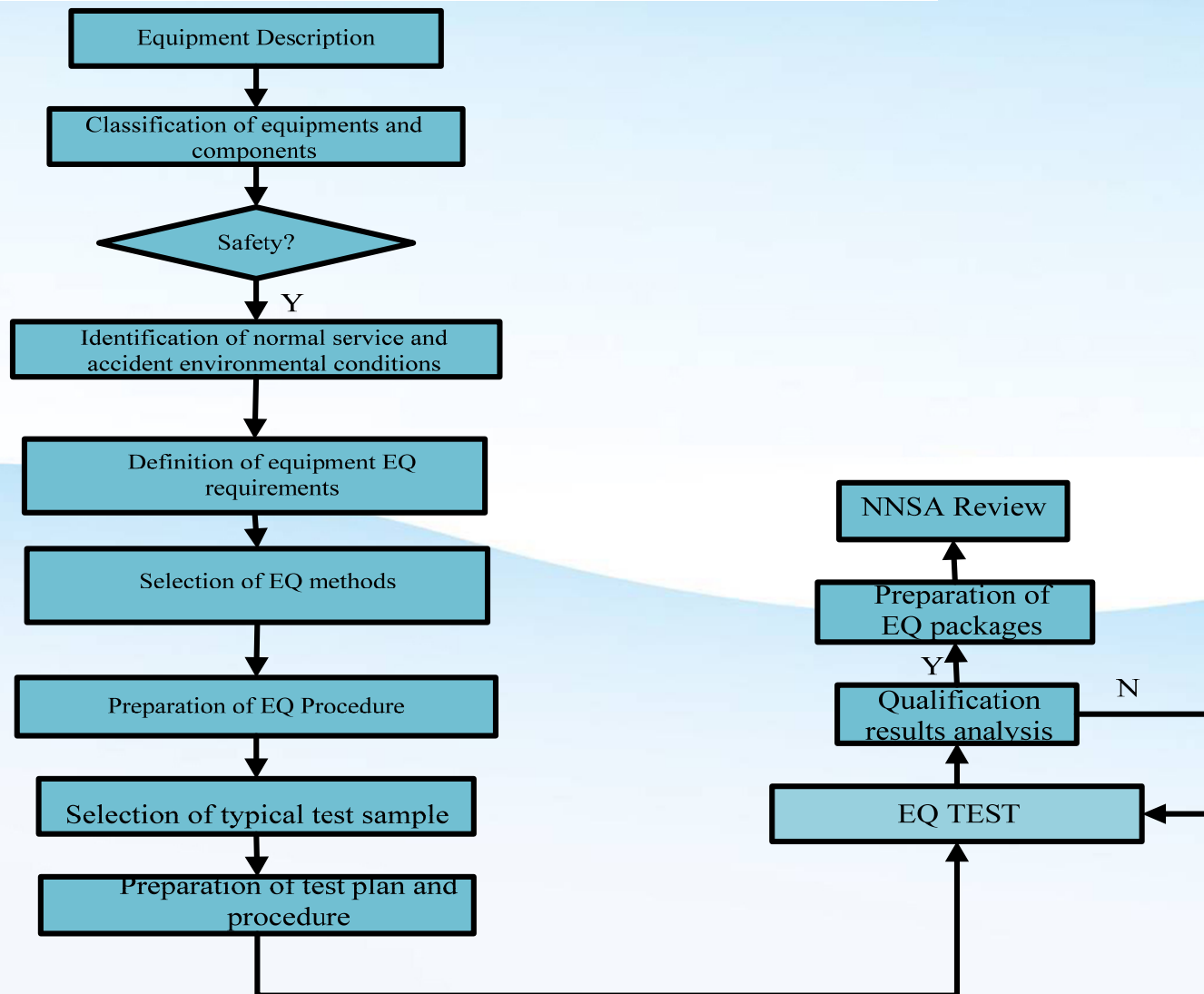Reference: IAEA, RCC, IEEE, IEC, ASME, ASTM

Regulation Related to License

- Decree 500 of State Council - Civil nuclear safety equipment supervision and management regulations

- HAF601 Civil nuclear safety equipment design, manufacture, installation and testing methods of supervision and management

- HAF602 Nondestructive inspection of civil nuclear safety equipment qualification management regulation

- HAF603 regulation and the schedules and annexes of civil nuclear safety equipment welder welding operation of grid management

- HAF604 supervision and management methods and accessories of Imports of civil nuclear safety equipment

Standard system in China

- In 2009 and 2010, Energy Bureau respectively released two nuclear power standard system table " the pressurized water reactor nuclear power plant nuclear standard system table" (covering 680 nuclear power standard) and" conventional island and BOP standard system table" (covering 162 nuclear power standards.).

- These tables cover eight areas, respectively general and basic, nuclear power preparatory work, engineering design, equipment, construction, commissioning, operation, retirement standards.
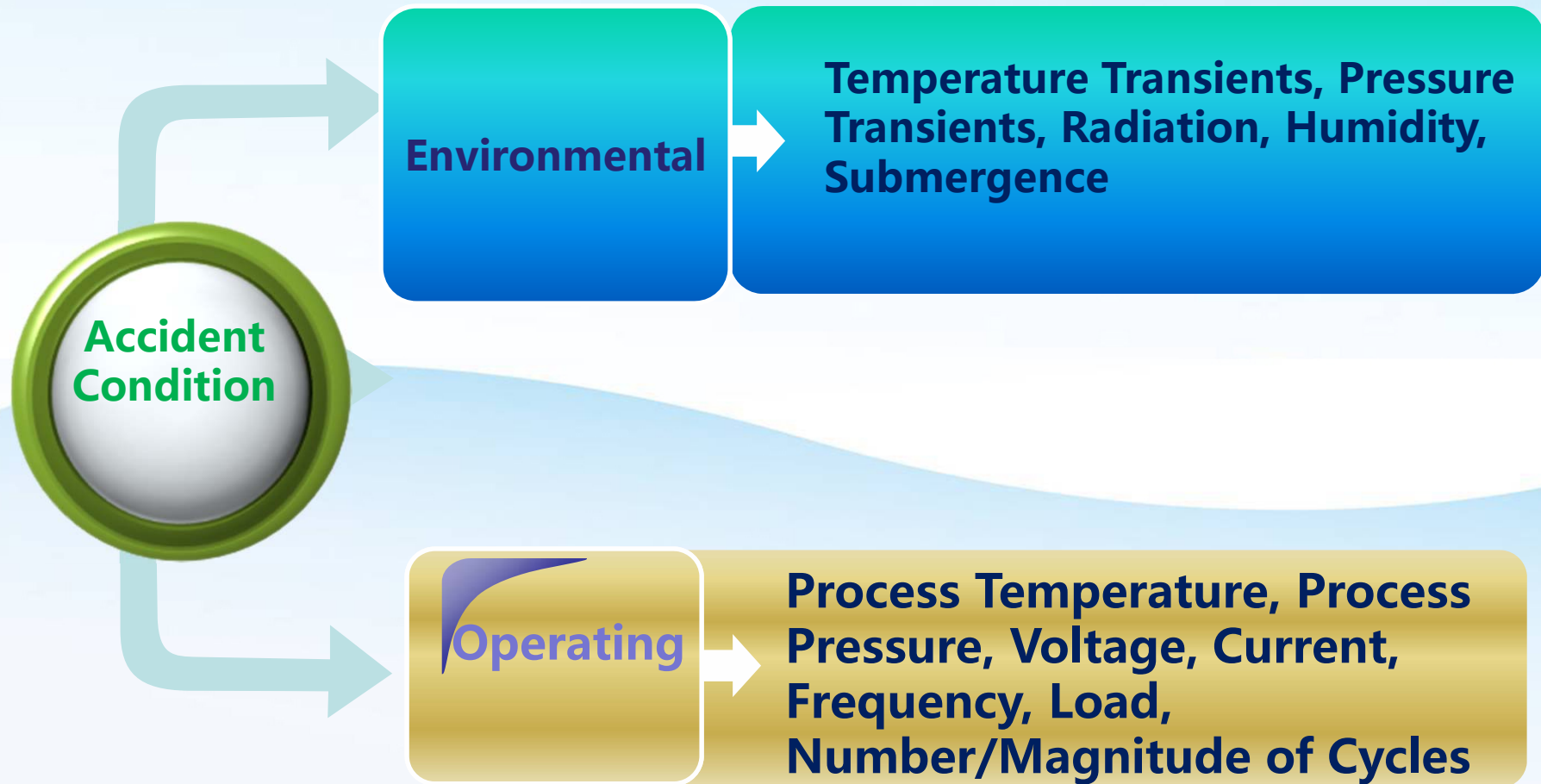
EQ Program Flowchart

Identification of Environmental Condition

Normal Service Condition

Environmental (Including Transient Conditions)

Temperature, Pressure, Radiation, Humidity, Vibration, Chemical Interactions, Dust, Corrosion

Operating

Process Temperature, Process Pressure, Voltage, Current, Frequency, Load, Number/Magnitude of Cycles

Identification of Environmental Condition

Accident Condition

Environmental → Temperature Transients, Pressure Transients, Radiation, Humidity, Submergence

Operating → Process Temperature, Process Pressure, Voltage, Current, Frequency, Load, Number/Magnitude of Cycles

EQ Test Sequence

Test Items	K1	K2	K3
Baseline Performance Test under normal operating conditions	▲	▲	▲
Limiting Test under normal operating conditions	▲	▲	▲
Aging test	▲	▲	△
Seismic test	▲	▲	▲
DBA test: Subject sample to simulated harsh environmental conditions	▲		
Post-DBA test	▲		

Thermal Aging Test

Challenge:
- Life evaluation

- Low temperature
- High temperature
- Humidity heat
- Temperature variation
- Thermal aging

EMC Test

Available EMC Standards in China：

CH GB/T11684《核仪器电磁环境条件与试验方法》

EU RCC-E(IEC/EN 61000-6-2和IEC/EN 61000-6-4)

US NRC RG1.180 (Ref.12): MIL-STD-461E (Ref.21)

US NRC RG1.180 (Ref.12): IEC 61000/CISPR series

New test building to be enabled in 2013
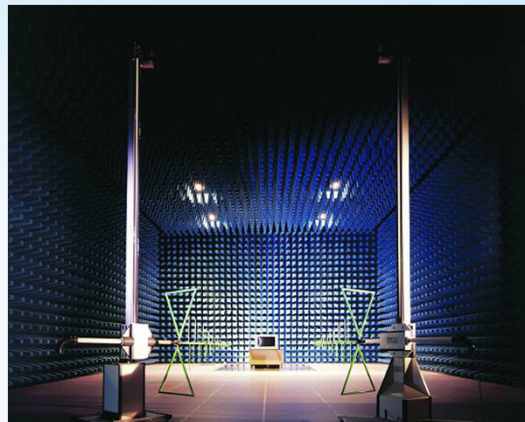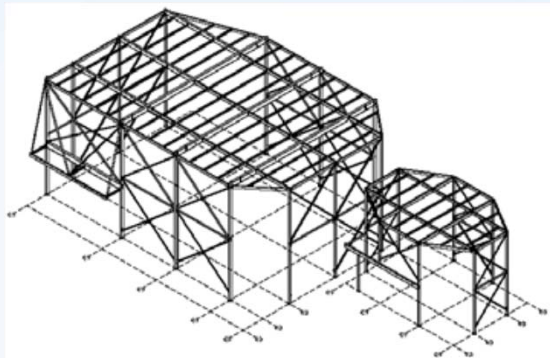
EMC Test

NRC RG1.180 (Ref.12): IEC 61000/CISPR Series Standards

【13 test items in total , including 2 Emission test items and 11 Immunity test 】

No.	EMC Test Items	Test Level	Application Port
1	Low-frequency conducted immunity	16Hz~2.4kHz,Level 2	Power Cables
2		15Hz~150kHz, Level 3	Power Cables/Signal Cables
3	Radio Frequency conducted field immunity test	150 kHz ~ 80 MHz Level3: 140 dBμV / (10V)	Power Cables/Signal Cables
4	Power Frequency Magnetic Field Immunity test	50Hz~60 Hz,Level4: 30 A/m	EUT
5		50/60Hz~50kHz,Level4: 300 A/m	EUT
6		100kHz~1MHz,Level4: 30 A/m	EUT
7	Radio Frequency Immunity Test	26MHz~1GHz,Level3: 10 V/m 1GHz~10GHz,10 V/m	EUT
8	Surge test (Combined Wave)	Power Supply:Level4 (4kV); Signal:Level3 (2kV)	Power Cables/Signal Cables
9	Surge test (Ring Wave)	Power Supply:Level4 (4kV); Signal:Level3 (2kV)	Power Cables/Signal Cables
10	Electrical Fast Transient Burst test	Power Supply:Level4 (4kV); Signal:Level3 (2kV)	Power Cables/Signal Cables
11	Electrostatic Discharge Test	Level 4: 8kVCD; 15kVAD	EUT
12	Conducted Emission	Frequency range：150kHz~30MHz	EUT
13	Radiated Emission	Frequency range：30MHz~1GHz	EUT

EMC Test

NRC RG1.180 (Ref.12): MIL-STD-461E (Ref.21)

[10 test items in total , including 4 Emission test items and 6 Immunity test]

No.	EMC Test Items	Test Level	Application Port
1	CE101	30 Hz ~ 10 kHz	Power Cables
2	CE102	10 kHz ~ 2 MHz	Power Cables
3	RE101	30 Hz ~ 100 kHz	部件/ EUT
4	RE102	2 MHz ~ 10 GHz	EUT
5	CS101	30 Hz ~ 150 kHz	AC/DC Power Cables
6	CS114	10 kHz ~ 30 MHz	Power Cables、interconnections
7	RS101	30 Hz ~ 100 kHz	Enclosure、interconnections
8	RS103	30 MHz ~ 10 GHz 10 V/m	Enclosure、interconnections
9	CS115	2A	Cable bench
10	CS116	10k Hz ~ 100 MHz	Power Cables、interconnections

EMC test
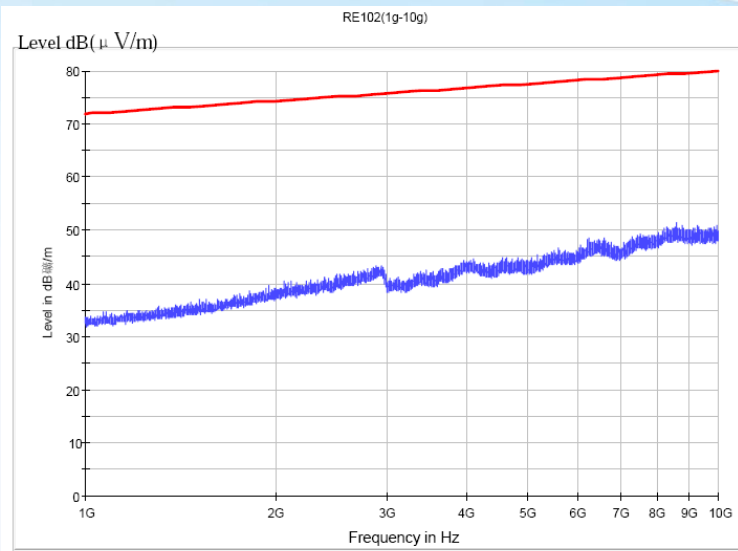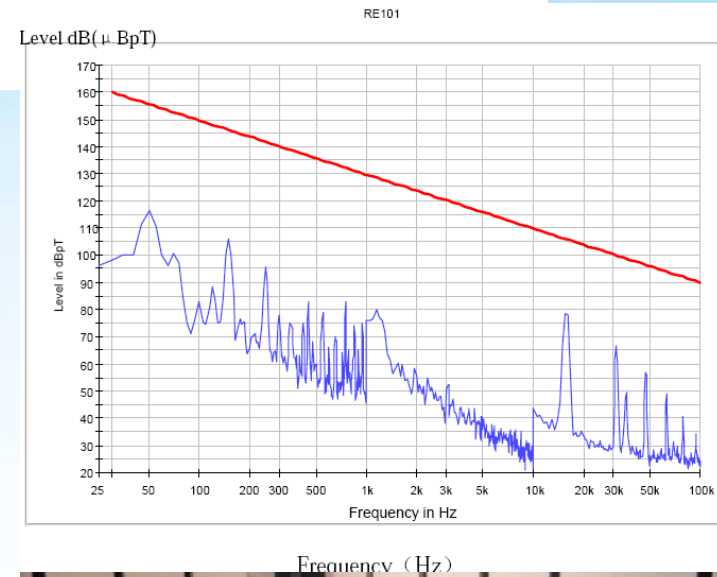
Challenges:
- EMC test on site
- EM Environmental Evaluation

Seismic Test

- **Capability Covers US IEEE, EU RCC-E, and CH GB/T12727**

- **Specifications：**
  - tri-axial 6DoF
  - Size：2.5m×2.5m
  - Rated load: 5T
  - Frequency: 0.1~100Hz
  - Horizontal/Vertical:
    displacement: ±190mm/ ±150mm
    speed: ±2.5m/s/ ±2.0m/s
    acceleration: ±10g/ ±10g

- **Functions：**
  - sine beat test, multi-frequency beat test, sine sweep test, shock response spectrum test and time-history test…
  - virtual seismic performance analysis and prediction based on FEM with the software of SAP2000 and ANSYS

NPIC
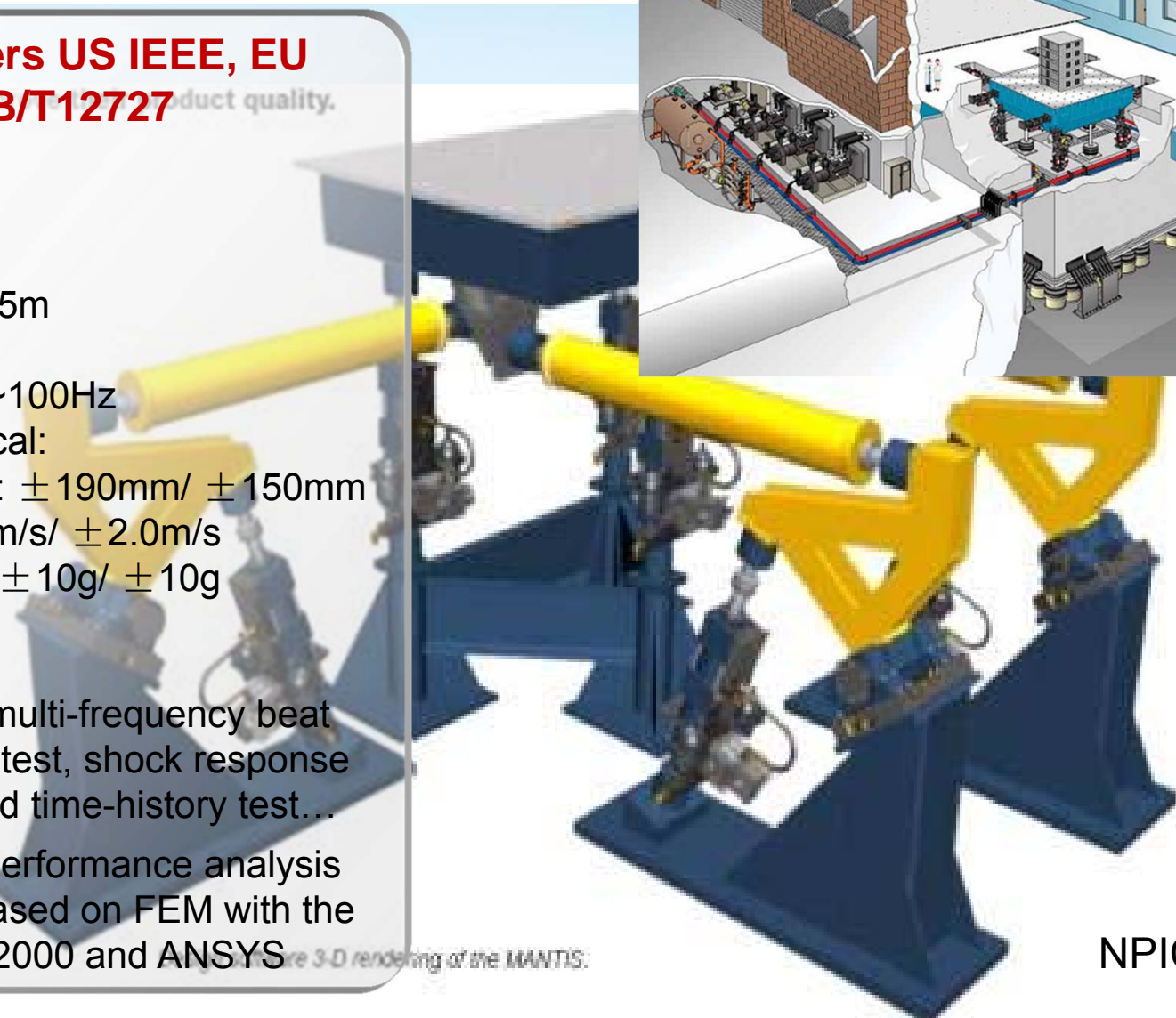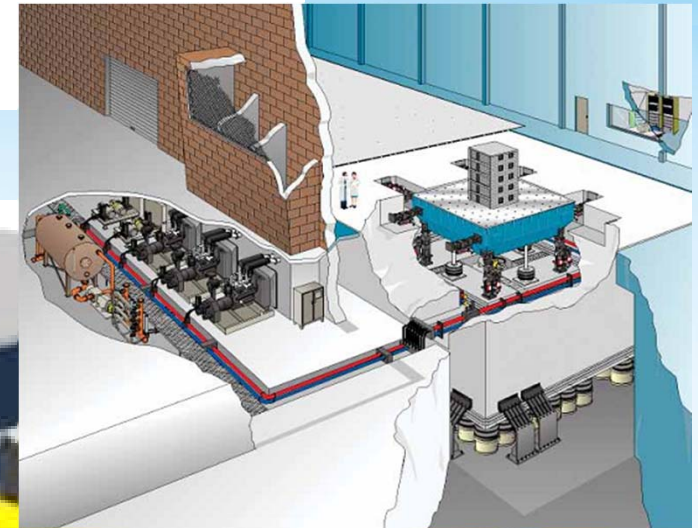
Seismic Test

Valve static test

Challenge:
- Dynamic test
- Large and heavy sample

LOCA Test

● Comply with the IEC, IEEE, GB/T12727.

■ **Specifications：**

- design Temp： 300℃
- design Pres：1.25MPa
- Spray liquid：1.5％ boronic acid ＋0.6％ NaOH, PH9.25
- Spray density：4.75 m³/s•m² （28.5L/min•m²）
- 7.5m³:bench： Φ2000×2900mm, cover RCC-E&GB
- 2m³ ：Φ1200×1200mm , cover AP1000&RCC-E&GB

Software V&V

● V&V flowchart

■ Standards：IEC 61508、IEC 60880、IEC 62138 and IEEE 1012 and so on；

■ *Independence requirements to safety* Software Verification and Validation (V&V)；

■ V&V activities throughout full lifecycle

■ Accuracy, traceability, reliability, completeness

V＆V Review Procedure
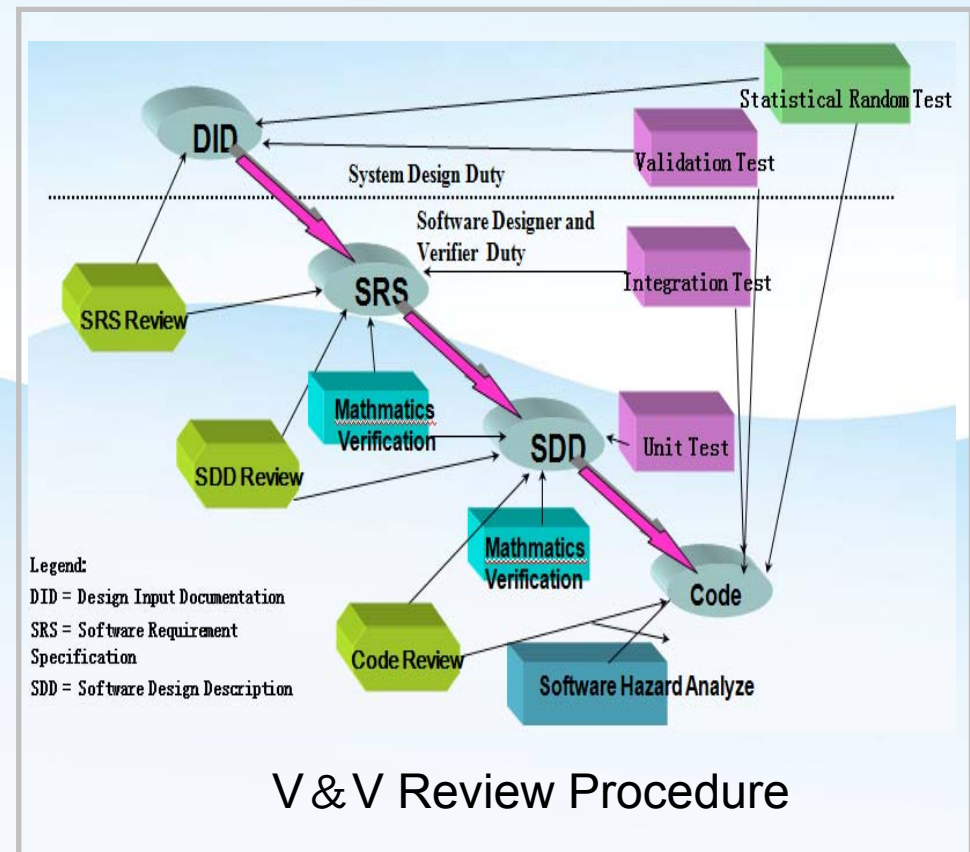
Software V&V

- **Software test tools in Software test lab**

Use famous software such as: Parasoft C++, Testbed

- Code Review（Code Rules）
- Quality Review（Analyse code complexity, density and testability）
- Design Review（Analyse interface, use of variable, control flowchart and so on）
- Unit Test（establish test driver and test vector automatically）
- Test Verification（Track test procedure and analyse code coverage）
- Test Management（Test case management, documentation management）

File Edit View Help

Static | Complexity | Data Flow | Cross Ref | Info Flow | Qual Report | Qualsys | LCSAJ | User Def | Section 3 | Section 4 | PDTMCSFVA

Rule Number	Default Strength	Description	CAST	CERT	CMSE	CONFORM	CWE	Customer Sample	DERA	EADS	GJB	HIS	JPL	MISRA	MISRA-C 2004	NET
1	C	Procedure name reused.	✓		✓				✓		✓	✓		✓	✓	
2	M	Label name reused.	✓		✓				✓		✓			✓	✓	
3	M	More than *** executable reformatted lines in file.			✓			✓		✓	✓					
4	M	Procedure exceeds *** reformatted lines.	✓		✓			✓		✓						
5	C	Empty then clause.	✓	✓	✓		✓		✓							
6	O	Procedure pointer declared.	✓		✓							✓				
7	C	Jump out of procedure.	✓		✓			✓								
8	C	Empty else clause.	✓		✓											
9	C	Assignment operation in expression.		✓	✓			✓		✓	✓	✓		✓	✓	
11	M	No brackets to loop body (added by Testbed).	✓		✓			✓		✓	✓	✓		✓	✓	
12	M	No brackets to then/else (added by Testbed).	✓	✓	✓			✓		✓	✓	✓		✓	✓	
13	M	goto detected.	✓		✓			✓		✓	✓	✓	✓		✓	
14	O	Procedural parameter declared.			✓				✓		✓					
15	M	Anonymous field to structure.			✓				✓		✓	✓				
16	O	Multiple labels declared.	✓		✓				✓		✓					
17	O	Code insert found.							✓					✓		
18	M	More than *** parameters in procedure.	✓		✓			✓		✓						
19	C	Procedural para used in an uncalled procedure.	✓		✓			✓		✓						
20	M	Parameter not declared explicitly.	✓	✓	✓			✓								
21	M	Number of parameters does not match.	✓	✓	✓	✓			✓		✓	✓		✓	✓	
22	C	Use of obsolete language feature (use = -).						✓	✓		✓	✓		✓		

Challenge:
- Complex Program development environment
- Simulation

Severe accident simulation

Simulation tests in military and marine fields:

- High temperature fire
- Immergence
- Wind tunnel
- Explosion

- *Key points:*
    - *Balance between safety and economy?*
    - *How to set a reasonable limit?*
    - *Hazard evaluation and risk assessment?*

Zhouzhuan, nearby Shanghai

Zhouzhuan, nearby Shanghai

XinTianDi Pub, Shanghai

River Bund,Shanghai

River Bund, Shanghai

Nanjing Road, Shanghai

Yuyuan Garden, Shanghai

pickled cabbage

xiao long bao

vegetarian dumplings

mixed appetizer

mini xiao long bao

fried rice

chicken soup with noodles

drunken chicken

steamed cake

Many thanks for your attention!

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