中广核 CGN 核能 Nuclear Power

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CPR1000 Equipment Survivability Assessment under Severe Accident

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善用自然的能量
Natural Energy Powering Nature

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2. Equipment Survivability and Equipment Qualification
3. Progress of ES in CGNPC
4. ES Assessment Method
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1.INTRODUCTION

1.Introduction

- 《 HAF102 - Safety of Nuclear Power Plants : Design 》
  - “To the extent possible, equipment (such as certain instrumentation) that must operate in a severe accident should be shown, with reasonable confidence, to be capable of achieving the design intent.”
- Definition
  - The equipment survivability assessment is to evaluate the availability of equipment and instrumentation used during a severe accident to achieve a controlled, stable state after core damage under the unique containment environments.

2.Equipment Survivability and Equipment Qualification

2.ES and EQ

- American :
  - EQ : Design Basis ;
  - ES : AP1000、ESBWR , Severe Accident ;
- France :
  - EQ : Design Basis、Beyongd Design Basis ;
- Compare based on concept of American EQ and ES.

2.ES and EQ

ES

- BDBA
- safety & non-safety
- state assess
- rely test already done

EQ

- DBA
- safety equipment
- ensure available
- specific test

3.PROGRESS OF ES IN CGNPC

3.Progress of ES in CGNPC

2010, start research on ES assessment method

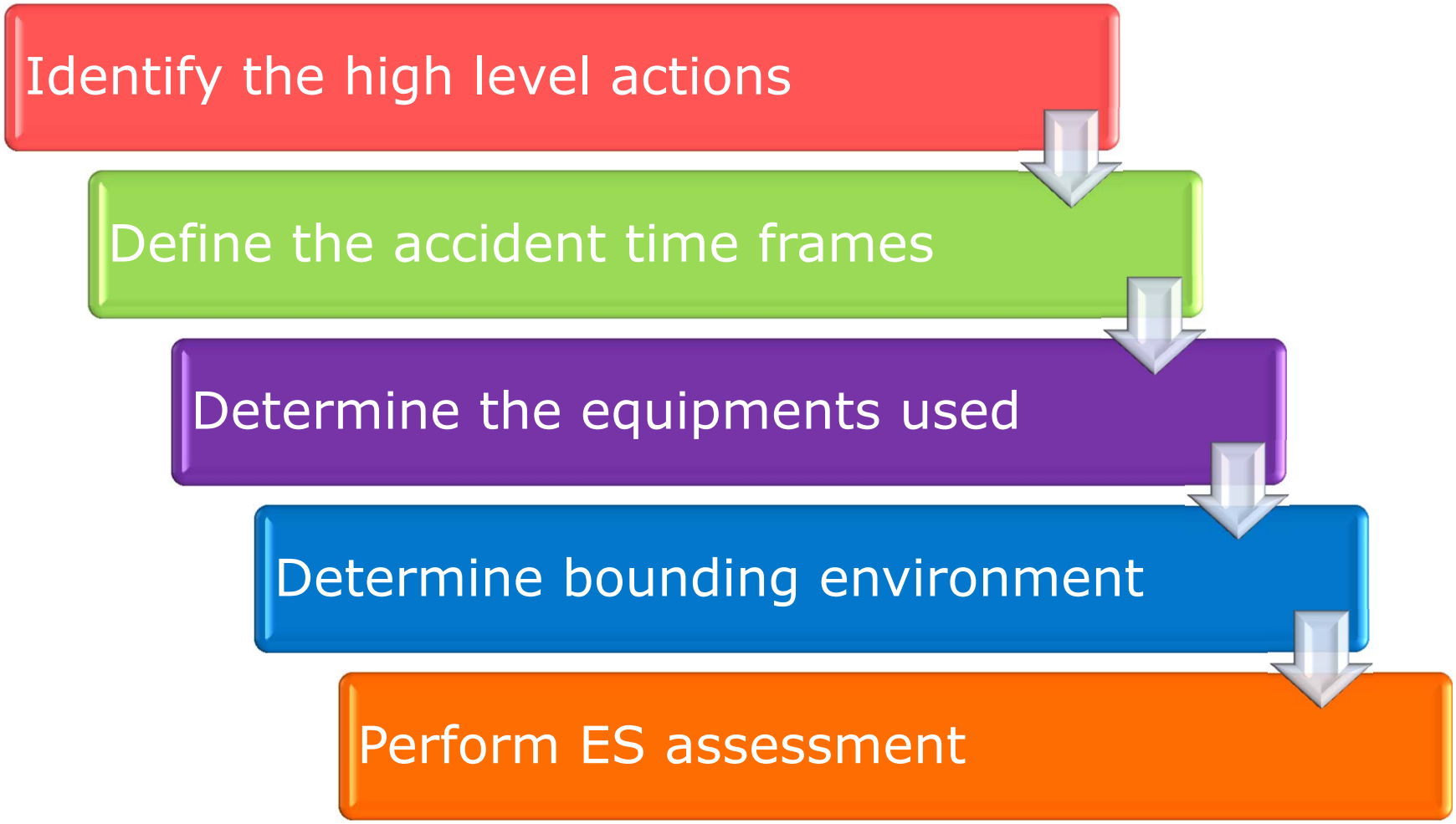
2011, finish LA2 ES, this is the 1st ES assessment for CPR1000 in China

2012, HongYanHe, NingDe, YangJiang

2013, Daya Bay, LingAo, FangCheng Gang

4.ES ASSESSMENT METHOD

4.ES Assessment Method



4.1.Identify the high level actions

- The high level actions are actions used to maintain the steady control state, that would achieve three object:
  - Heat could be removed from containment ;
  - Containment boundary protection ;
  - Safety state in primary and containment ;
- The high level actions for CPR1000 are defined by SAMG.

4.1.Identify the high level actions

主控室

严重事故初始响应导则
（SACRG-1）

严重事故瞬态导则
（SACRG-2）

技术支持中心（TSC）

严重事故诊断流程图
（DFC）

严重事故威胁状态树
（SCST）

严重事故导则		严重威胁导则
-SAG-1	-SAG-5	-SCG-1
-SAG-2	-SAG-6	-SCG-2
-SAG-3	-SAG-7	-SCG-3
-SAG-4	-SAG-8	-SCG-4

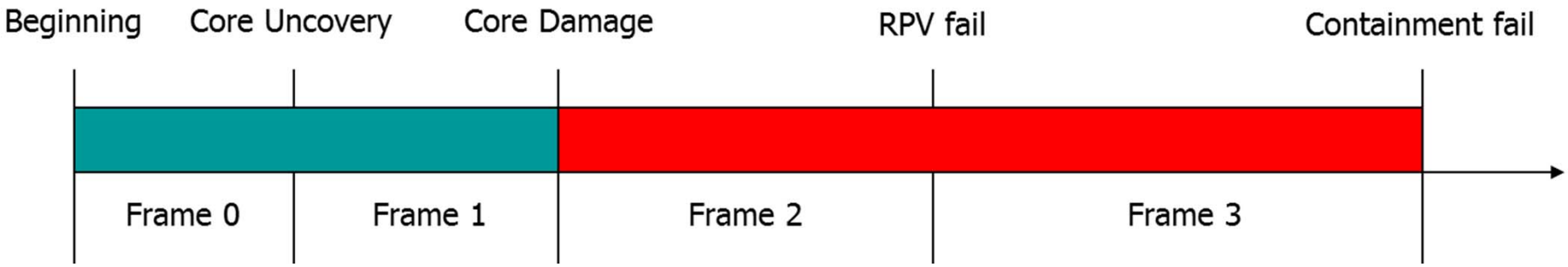
计算辅助（CA1-7）

技术支持中心
长期监督（SAEG-1）

SAMG终止（SAEG-2）

4.2.Define the accident time frames

- Time frames :
  - Time Frame 0 - Pre-Core Uncovery ;
  - Time Frame 1 - Core Heatup ;
  - Time Frame 2 - In-Vessel Severe Accident ;
  - Time Frame 3 - Ex-Vessel Severe Accident。



4.3.Determine the equipments used

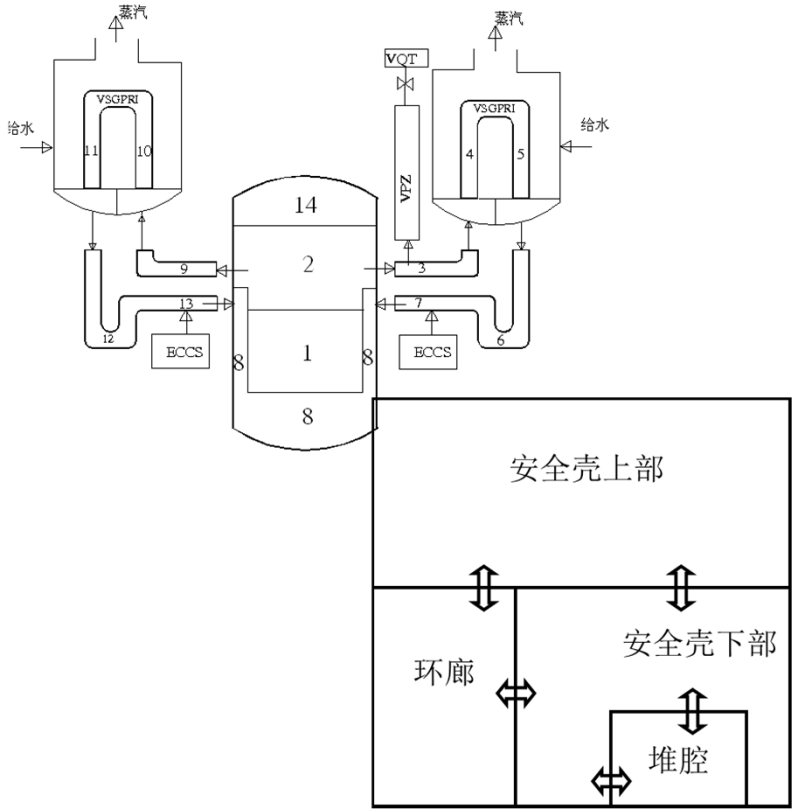
- According to the high level actions and plant character, 62 groups of equipments are listed;
- Additional equipments to be considered :
  - Instrument for SAMG enter, exit, long term;
  - Containment;
- Screen:
  - Inside Containment ;
  - Main/Important equipment ;

4.4.Determine bounding environment

- Condition for primary/secondary side:
  - According to the accident analysis:
    - Core outside thermocouple;
    - Pressurizer safety valves;
    - Secondary safety/relief valves ;
- Condition in Containment
  - Temperature
  - Pressure
  - Humidity
  - Dose
  - Aerosol

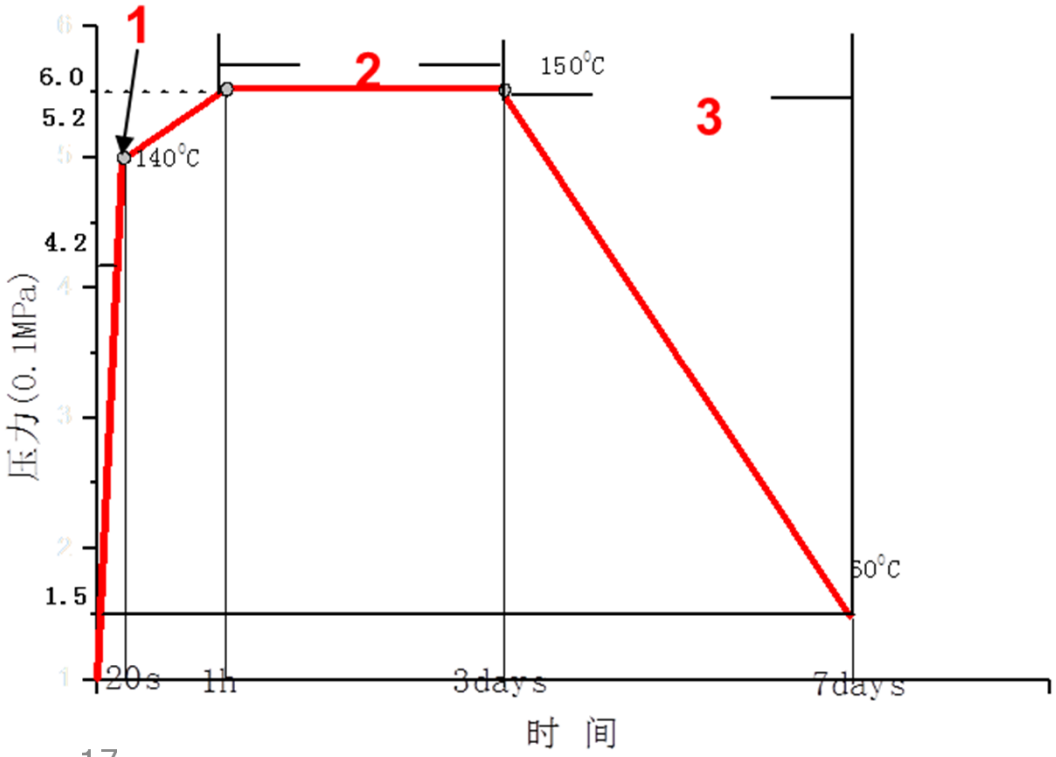
4.4.Determine bounding environment

- SA analysis code MAAP, simulate the response of light water reactor power plants:
  - a) response for primary
  - and secondary
  - b) response for cont.
  - c) behavior of core melt
  - d) movement of FP
  - e) hydrogen behavior



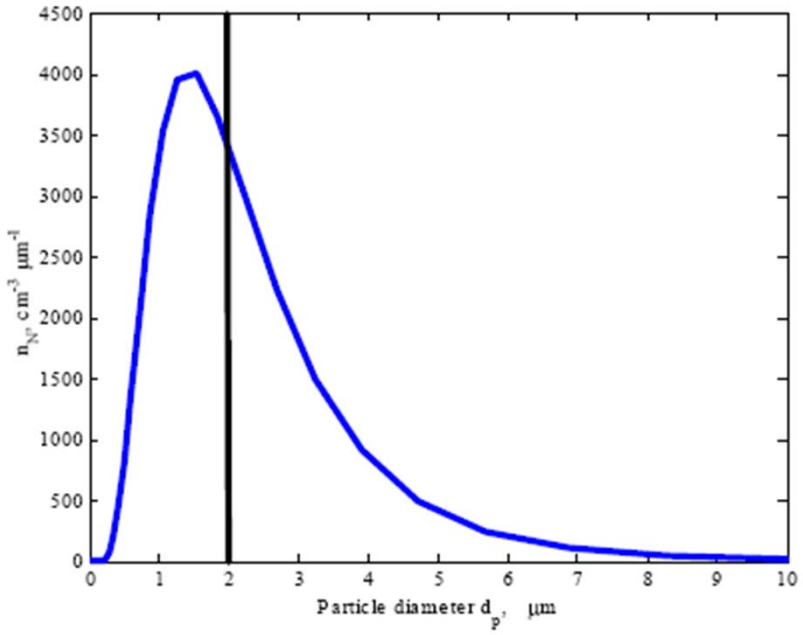
4.4.Determine bounding environment

- Temperature、Pressure
  - Cont. environment defined by SA analysis;
  - LBLOCA、SBO、ATWS。
  - Stage1 : LOCA accident;
  - Stage 2 : non-LOCA accident, feed-bleed, hydrogen burn;
  - Stage 3 : Cont. filter release, heat removal。



4.4.Determine bounding environment

- Aerosol——size
  - The size of aerosol usually comes from test, test of FPT showed the size is between 0.65 - 5.0 μm , average value is 2μm。

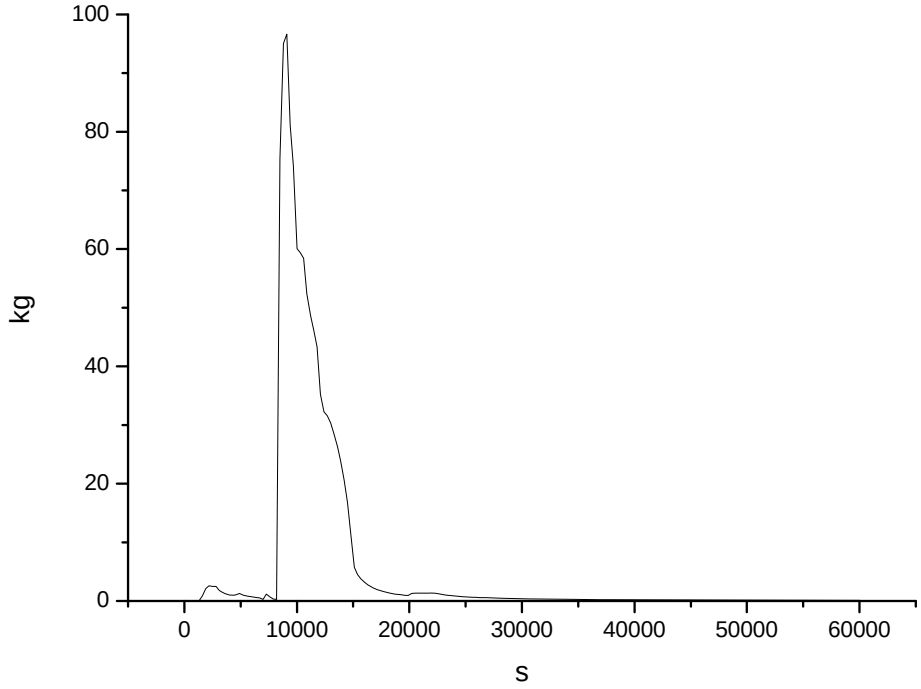


4.4.Determine bounding environment

- Aerosol——concentration
  - Calculated by MAAP code;
  - LOCA sequence
  - None HPSI, LPSI, ACC
  - None containment spray
  - Boundary FP mass

4.4.Determine bounding environment

- Aerosol——concentration
  - The peak mass of aerosol is about 100kg
  - Cont. vol. 49400m³
  - Under accident, the peak concentration is about 2 g/m³, average 1 g/m³



4.4.Determine bounding environment

- Humidity
  - Consider LOCA sequence , 100% ;
- Dose
  - A value of 1×10^{6}Gy (7 Days) is used, according to RG1.183.

4.5.Perform ES assessment

- Assessment method :
  - Compare equipment test condition with SA condition;
  - Containment use CFD method;
- Conclusion :
  - Completely satisfied;
  - Partly satisfied;
  - Can't decided;
  - Can’t be used;

5.RESULTS FROM LA2

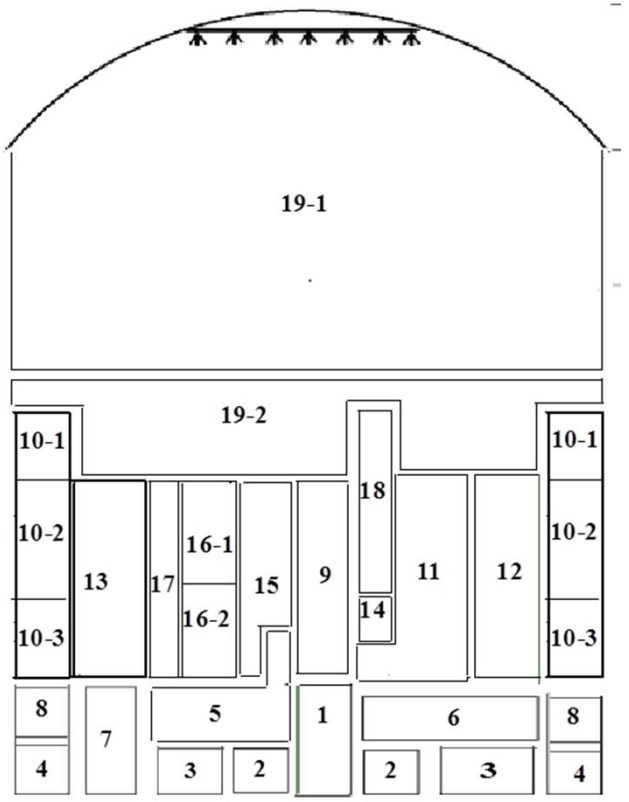
5.Results from LA2

- More than half of the equipments used under severe accident are out of containment;
- Some equipments could satisfy the harsh environment in a short period, but can’t stand for long period;
- Some equipments could satisfy the harsh environment in the whole accident;
- Some dedicated equipments already have been tested under severe accident environment;

6.FUTURE WORK

6. Future Work

- There are still some detailed work could be done in the future:
  - More realistic environment could be defined based on detailed analysis in detailed containment Room;
  - The conclusion for equipment survivability will be considered in Level 2 PSA for CPR1000;



谢谢 Thanks

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