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ASME NUCLEAR CODES AND STANDARDS

Supporting New Build and

Nuclear Manufacturing in South Africa

Session 3: ASME Section III, Component Design and Construction, Including

Application to the AREVA EPR

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- **AREVA welcomes you in Session 3**

- **1.Present situation: which Code for EPR components ?**
- **2. Principles of Code selection**
- **3. Origin of RCC-M rules and recent evolutions**
- **4. ASME vs RCC-M : puzzles and overlappings**
- **5. Conclusions**

1. Which code for AREVA EPR for NI, safety class 1 main component?

EPR Olkiluoto 3 Finland	RCC-M 2005	Started, in progress	Finnish regulation refers to ASME Sect.III or *other equivalent Code*
EPR Flamanville 3	RCC-M 2007	Started, in progress	French regulation does not make mandatory any Code
EPR Taishan	RCC-M 2007	Started	Chinese regulation does not make mandatory any Code
EPR USA	ASME III	Pre-licencing phase	US regulation makes ASME consistent with any licence

1. Which code for AREVA EPR: NI (SC2 & SC3 & NC), BOP, CI ?

EPR Olkiluoto 3 Finland	RCC-M 2005, ASME Sect. III , Sect. VIII, KTA, EN 13445, EN 13480,…		YVL:Finnish regulation, includes CE assessment for nuclear Not Classified (NC) equipment.
EPR Flamanville 3	RCC-M 2007, ASME Sect. III and Sect. VIII, KTA, EN 13445, EN 13480,…		French regulation includes CE assessment for nuclear Not Classified (NC) equipment
EPR Taishan	RCC-M 2007 level 2 and 3, ASME Sect. III and Sect. VIII, EN 13445, EN 13480, Chinese standards		Chinese regulation does not make mandatory any Code
EPR USA	ASME Sect. III, Sect. VIII,		US regulation makes ASME consistent with any licence

NI: *Nuclear Island* ***CI:*** *Conventional Island*
BOP: *Balance of Plant* ***CE****: Stamp witnessing the conformity to European Regulations*

2. Principles for Code selection

- **Principles applied as a function of safety classification: Safety Report of the Owner is the base**
- **Needs**
  - **High level of Safety**
  - **High availability factor during 60 years**
  - **Reasonable equipment and maintenance costs**
  - **Low radiation exposure of workers**
  - **Standardization to benefit from experience**
- **Industrial context**
  - **Equipment requirements from Contractor Engineering departments**
  - **Consideration of Suppliers experience: market opening**
  - **Evolutionary Pressurized Water Reactor first developed in a French-German context. Today ready for US and deployment anywhere in the world.**

2.Approach for specifying Equipment

- **Global Safety Approach**
  - **Careful selection of Materials**
  - **Optimized System and Equipment design**
  - **Low probability of Defect**
  - **Careful Non-Destructive Examinations**
  - **Implementation of QA System (Regulation RD 0034 in RSA)**
  - **When needed (regulations), measures allowing a "break preclusion concept" to be used**
  - **When needed (regulations), severe accidental conditions to be considered (Finland).**
- **Classification of Equipment**
  - **As a function of Safety class (SC1, SC2, SC3)**
  - ***As a function of Nuclear Pressure Equipment Regulations (« N1, N2, N3 » in the context of the French Regulation)***

As a result, equipment are classified in "Quality Classes" Q1, Q2, Q3

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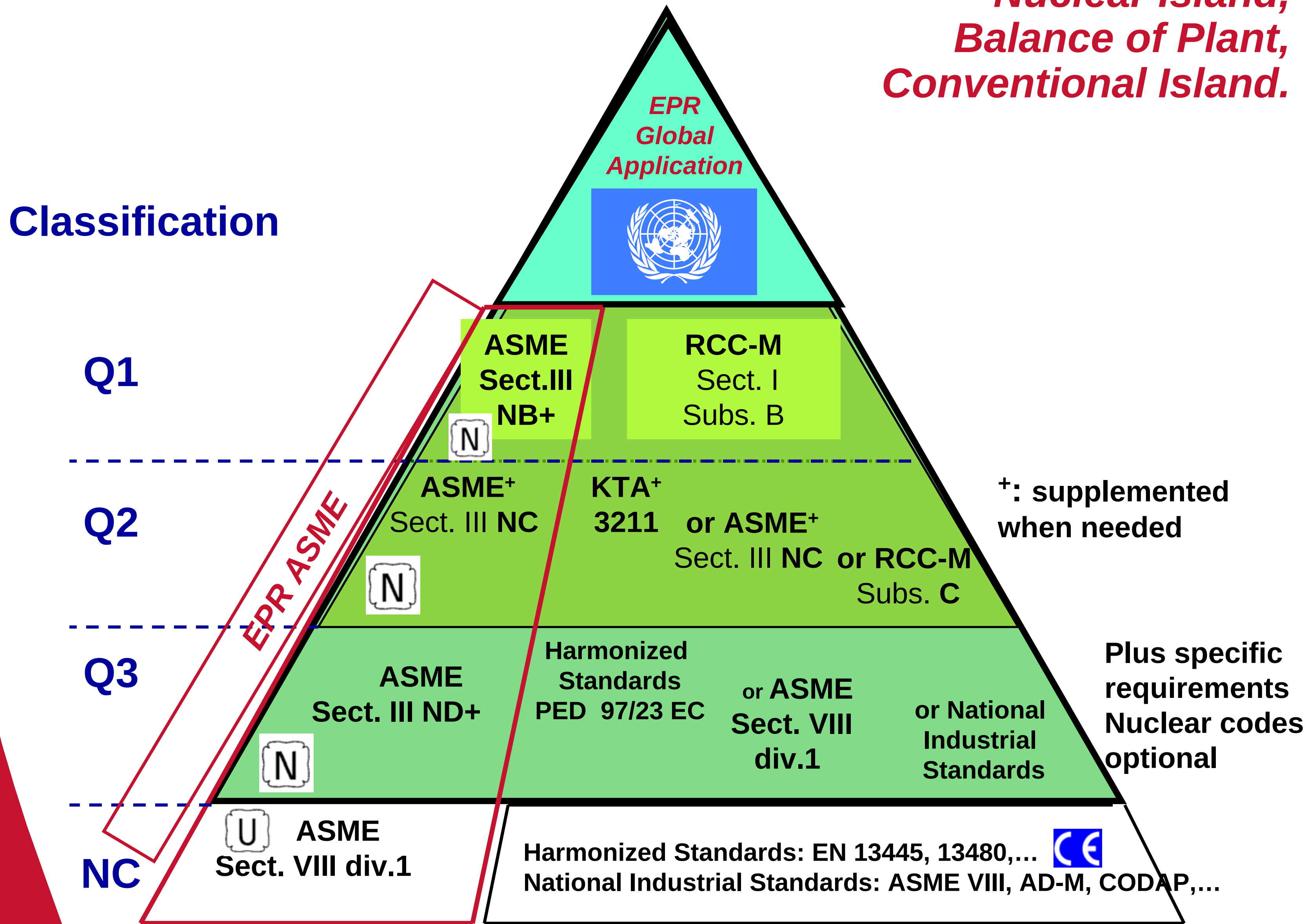
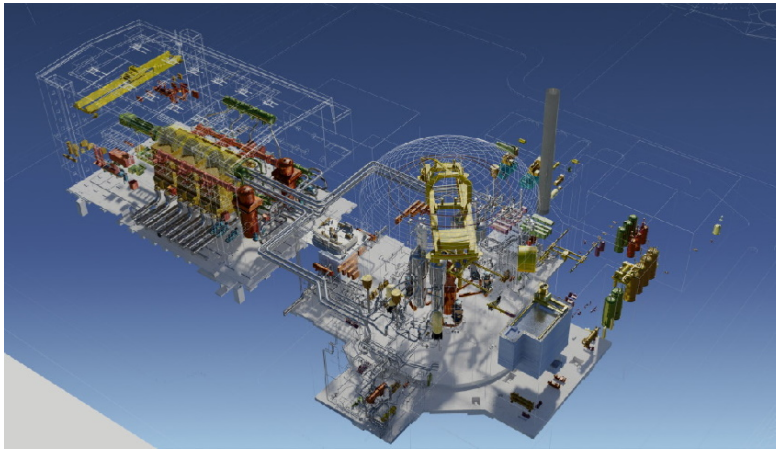
2. General strategy for EPR Codes and Standards selection: Nuclear Island, Balance of Plant, Conventional Island.



2. Consequences on Q2/Q3,NC Equipment Specifications

- Necessity to adapt equipment specifications with
  - Provisions in addition to the code



- Philosophy
  - Supplement with adequate provisions the applicable codes and/or standards
  - Reach an equivalent global quality level

- Compatibility conditions whenever several codes are used
  - Compatibility on dimensions
  - Compatibility with hypotheses on general system design
  - Consideration of fatigue risks
  - Specification of applicable criteria levels
  - Consideration of inspection liable to affect design
  - Consistency of materials and range of approval of qualifications
  - Pressure tests, Cleanliness…

2. Established conclusions for Nuclear Codes approach

Not only from AREVA' point of view…

Multinational Design Evaluation Programme
Working Group on Component Manufacturing Oversight
Issy-les-Moulineaux, France

Comparison Between ASME Section III and RCC-M Codes for Component Construction

Rick Swayne
Reedy Engineering
ASME Board on Nuclear Codes & Standards
Chair, Task Group on Globalization

February 26, 2007

ASME

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Conclusions

- ASME Section III and RCC-M Code are similar.
- ASME Section III and RCC-M have different approaches to ensuring compliance with technical requirements
- ASME Section III and RCC-M provide equivalent safety in operation.

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ASME

3.Historical Aspects : origin of RCC rules

US regulations, codes and standards for the general design of systems and components

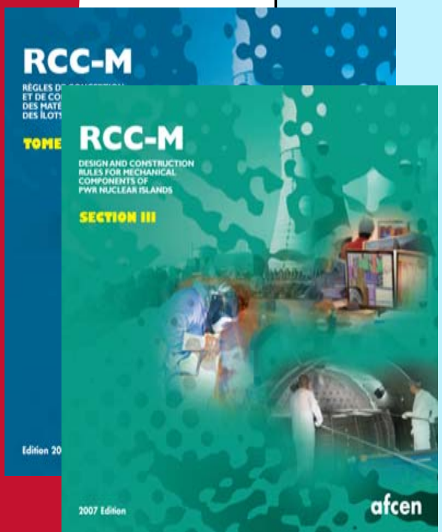
French and European rules, regulations and practices for the construction of components

PWR technology progressively adapted to French and European industrial and regulatory context

First RCC-M was picture of practices in 80's

Pragmatic approach: more than 60 NPP designed, manufactured, with rules set up in RCC

3. RCC-M vs ASME general organization



RCC-M Code

Section 1 Nuclear Island Components

- A General requirements
- B Class 1 components
- C Class 2 components
- D Class 3 components
- E Small components
- G Core support structures
- H Supports
- J Storage tanks
- P Containment penetrations
- Z Technical appendices

Section 2 Materials

Section 3 Examination methods

Section 4 Welding

Section 5 Fabrication

ASME Code

Section III

- NCA
- NB
- NC
- ND
- None
- NG
- NF
- NC/ND 3800-3900
- NE
- Appendices

Section II

Section V

Section IX (Qualifications)

Various parts of Sect. III

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3. How are established RCC requirements: in Afcen

- **BOARD** — **General Secretary**
  - **Editorial committee**
    - **RCC-C Sub committee**
      - Working Group
    - **RCC-E Sub committee**
      - General
      - Qualification
      - Design
      - Software
      - Installations
      - Examination
    - **RCC-M Sub committee**
      - Design
      - Materials
      - Technology
      - Examination
    - **RCC-MR Sub committee**
      - General
      - Design
      - Materials
      - Fabrication
    - **RSE-M Sub committee**
      - Inspection
      - NDE
      - Flaw Analysis
      - Repair

EDF, AREVA,CEA, DCN, Nuclear approved Inspection Bodies involved in RCC-M assessment through regulations

3. Main points of RCC-M approach and evolutions

- **RCC codes are Tools**
  - **Integrating construction and operation experience**
  - **Open to different regulatory contexts**
- **RCC-M is continuously evolving as a function of**
  - **Contractor and Supplier experience and research,**
  - **Projects needs**
  - **Evolution of International standards: calculations,…**
  - **Regulatory evolutions**
- **RCC-M 2007 edition integrates**
  - **EPR project needs**
  - **Standards updating**
  - **Regulatory evolutions resulting from European PED and French ESPN Order:** ***example for materials requirements***
- **Integration of appendices covering other regulatory contexts under consideration:** ***example***

No drastic changes

Continuous adaptations

4. RCC-M technical diffences vs ASME III

	Technical differences *
Design	
Mechanical resistance	2,4,7,8
Functional requirements out of scope	
Materials	
Materials selection	3,5,6
Procurement	
Part qualification	1
Manufacturing	
Fabrication and welding	9,13
Process and welders Qualifications	10,
Examinations	
Stage	
Methods	11
Extent	12
Acceptance criteria	
Hydrostatic tests	14
Overpressure protection	
Issued in 2007	

* : source: MDEP ASME presentation

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4. RCC-M technical scope vs ASME III: Technical differences

Equivalent but not identical! Reconciliation needed for the manufacturer

1 Material: ASME uses generic prequalification/ RCC-M uses prototype qualification (M140)

2 Material Stress Limits: ASME Section III, Class 2 and 3 allowable stresses are now up to 15% higher than those of the RCC-M Code, because Section III stress limits are now based on a design factor of 3.5 rather than 4

3 Material: RCC-M permits use of only very low carbon stainless steels with nitrogen limits. Determination of sensitivity to IGSCC, by corrosion testing, is required if the carbon content exceeds specified limits (0.03-0.04%). ASME Section III leaves material selection and IGSCC concerns to the Owner or Fabricator.

4 Material: RCC-M requires elevated-temperature tensile testing (base metal, weld metal, procedure qualifications) to confirm the elevated-temperature tensile and yield strengths for each heat/lot and welding procedure/ ASME relies on properties from representative heats to establish allowable stresses at elevated temperatures. Design factors compensate for unknowns and variations

5 Material: RCC-M requires impact testing with little regard for material composition or experience. It requires impact testing of materials that are exempted from testing by ASME Section III because of their inherent high toughness, such as austenitic stainless steel filler metal. These tests are not required by ASME Section III.

6 Material: RCC-M imposes a delta ferrite limit of 5-15%. The Section III limit is 5FN minimum. Section III does not have a maximum limit. High delta ferrite has not resulted in failure./ RCC-M requires corrosion testing if the carbon content exceeds 0.035%. ASME Section III does not require corrosion testing.

7 Design: Reinforced Openings, Class 1 Vessels - Same design approach, but RCC-M requires full stress analysis of openings, in addition to reinforcement calculations./ ASME Class 1 Piping - Same design approach, but RCC-M requires full stress analysis.

8 Design: Fatigue at Discontinuities - Same basic approach in both Codes, but RCC-M has add new detailled conditions of use of fatigue curves.

9 Welding qualification: RCC-M requires production weld test coupons. In most cases, one coupon per component, per WPS, per welder. ASME Section III does not require such coupons.

RCC-M welding procedure qualification for repair welds in castings must be performed using cast material. ASME Section III permits use of other product forms, such as plate. For Asme, procedure qualification product form has not been associated

10 Welding Qualification and Examination: RCC-M requires the welding procedure qualification test coupon to be examined in accordance with the production weld joint NDE requirements and to meet the applicable acceptance criteria. ASME Section III does not require this examination. ASME considers taht examination of the production joint proves weld quality.

RCC-M permits no undercut. ASME Section III permits 1/32 in. (1 mm). ASME considers that undercut has not been associated with weld failure.

11 Examination: RCC-M requires liquid penetrant examination of all Class 1 weld preparation surfaces prior to welding. In addition, the root pass of all welds not requiring final volumetric examination (e.g., fillet or partial-penetration welds) is to be examined using the liquid penetrant method. These examinations are not required by ASME Section III. ASME considers that absence of such exams has not been associated with weld failure.

12 Examination: the RCC-M Code requires radiographic and surface examination of piping butt welds in all Classes. ASME Section III requires the same for Class 1, but less examination for Class 2 and 3 piping butt welds. ASME considers that higher design factor for Classes 2 and 3 compensates the reduced examination requirements.

13 Non-pressure-retaining Items: RCC-M specifies some requirements for non-pressure-retaining items, such as pump shafts and impellers, which are exempted from the ASME Section III requirements because they do not affect pressure boundary integrity. ASME considers that examination of these items have to be specified by the Owner or designer.

14 Hydrostatic Testing: RCC-M specifies higher hydrostatic test pressures than ASME Section III, especially for castings. Because the hydrostatic test does not exceed the material yield strength, the higher pressure adds no benefit. For cast components, RCC-M requires a hydrotest at 1.5 times design pressure times the ratio of the yield strength at the test temperature to the yield strength at the design temperature, up to 1.8 times design pressure. For forgings, the required test pressure is 1.25 times the yield strength ratio, not to exceed 1.5 times design pressure. The ASME Section III test pressure is 1.25 times design pressure. No failures have been attributed to a lower test pressure.

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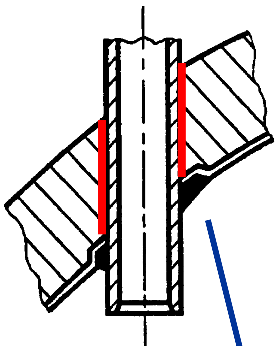
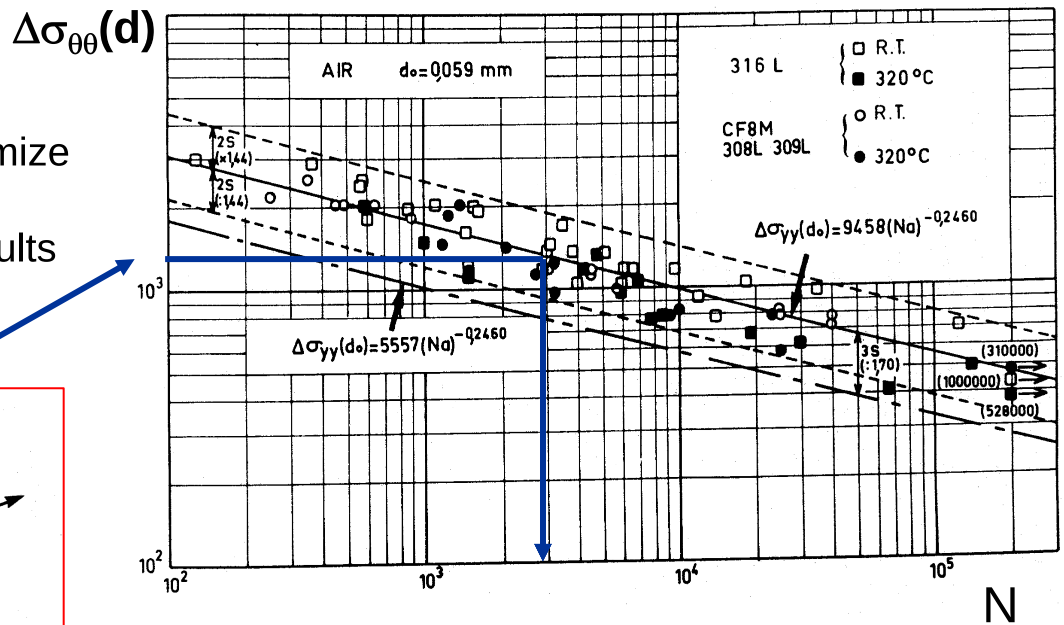
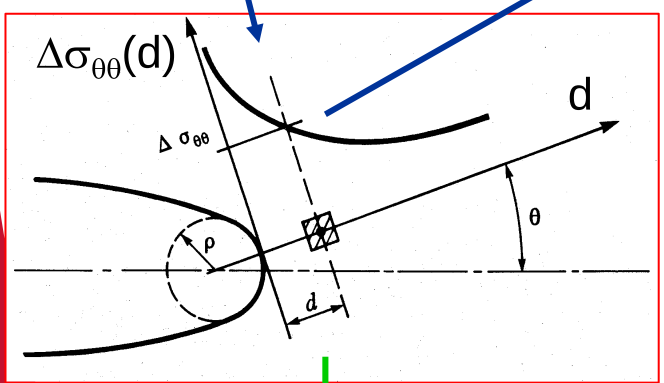
4. Fatigue analysis of crack-like discontinuities in RCC-M 2007

➢ **Introduction of dedicated fatigue curves based on experiments (Appendix ZD 2300)**



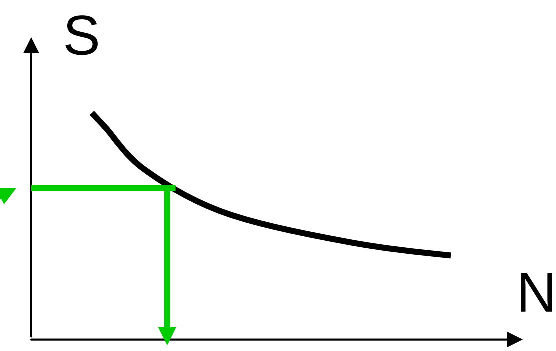
d chosen to minimize dispersion of Experimental results





➢ **Alternative ZD.3000 introduced:**

- application of Neuber rule ($\Delta\sigma\Delta\varepsilon$=cste)
- division by 1,5 before comparing to S-N curve (to take into account the fact that surface and size effects are integrated in the analysis)



4. ASME Organisational differences vs RCC-M or Industrial Codes or Standards

ASME:

Accreditation:

The ASME Sect. III standardized program for accreditation of manufacturers and fabricators provides great uniformity of acceptance of these organizations and therefore a great reliability on their assurance of product quality.

RCC-M does not have a generic standardized program for accreditation of manufacturers and fabricators, but relies on regulatory oversight of fabricators and technical qualification of the production workshop.

Authorized Inspection and Code Symbol Stamps:

ASME enhances reliability through use of the Authorized Nuclear Inspector (ANI or AI for Sect VIII).

Quality Assurance:

ASME Section III is similar to RCC-M. (NQA-1). ASME Section III is more technically-oriented than RCC-M and is based on US NRC requirements.

4. ASME III Organisational differences vs RCC-M or Industrial Codes or Standards

RCC-M or Industrial Codes or Standards :

European Members States, China, …impose Third Parties for assessment of conformity and survey of manufacturing, through their regulation.

Accreditation:

RCC-M or European Standards (EN 13445…) do not required accreditation.

Only for Industrial Codes or Standards ,European Regulation (PED 97/23/EC), CE marking is the testimony of assessment under Third Party survey.

Authorized Inspection and Code Symbol Stamps:

RCC-M does not require Code Symbol Stamping.

Only for Industrial Codes or Standards CE marking is the testimony of assessment under Notified Body survey.

Quality Assurance:

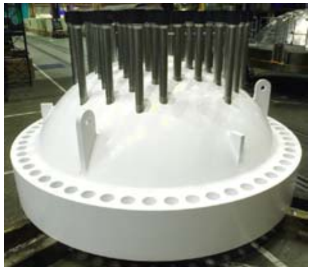
RCC-M uses ISO-9000/2000 with additional requirement of IAEA 50-C-QA (GS-R-3 in 2009). RCC-M to require that the documentation package include shop travelers, which are not specifically addressed by ASME Sect. III and are not usually included in the final documentation package for Section III components

4. Third parties in EPR applied Regulation

EPR Olkiluoto 3 Finland	RCC-M 2005, Level 1 level 2 and 3, ASME Sect. III and Sect.VIII, KTA, EN 13445, EN 13480,…		SC1&2: Finnish Nuclear Authority (STUK) SC3&4: Inspecta, Polartest, Bureau Veritas, EIRA « CE »: European Notified Bodies
EPR Flamanville 3	RCC-M 2007 level 2 and 3,ASME Sect. III and Sect.VIII, KTA, EN 13445, EN 13480,…		SC1: French Nuclear Authority (DEP or delegation). SC2, SC3: APAVE, AIB, Bureau Veritas, ASAP, HSB, CEIDRE « CE »:European Notified Bodies
EPR Taishan	RCC-M 2007 ,ASME Sect. III and Sect. VIII, EN 13445, EN 13480, Chinese standards		SC1: Chinese Nuclear Authority (NNSA), and EIRA SC2, SC3: NNSA, Third parties Non nuclear pressure equipment: third parties recognised by Chinese Authority
EPR USA	ASME Sect. III, Sect. VIII,		AIA

5.Conclusions

- ***AREVA' needs for EPR can be satisfied both by ASME III or by RCC-M,***
- ***Existing EPRs under construction follow RCC-M for the main safety class 1 components; for other safety class and non nuclear equipment , other codes are also used (ASME, KTA,…); however USEPR design is entirely based on ASME***
- ***New non-mandatory appendix in RCC-M makes the Code « user friendly »: dedicated appendix for local regulation, like Europe, France, …and U K, the latest one in progress.***
- ***The first EPR to be built in RSA can take advantage of the opening of EPR to the Codes: all South African manufacturers having experience in ASME/ RCC-M/ KTA/ EN can be involved in a partnership for EPR construction.***



Thank you for your attention

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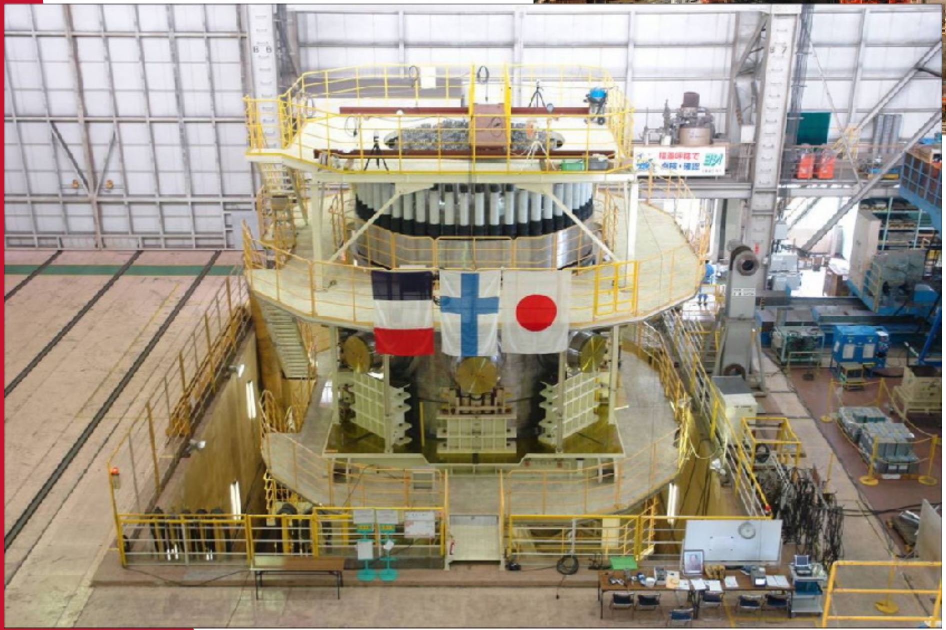
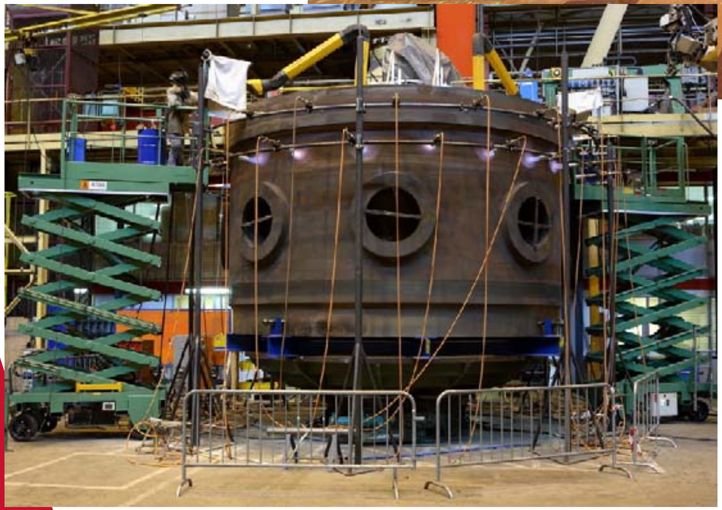
Olkiluoto 3 site
In September 2008

Hydrostatic test
of RPV in Japan

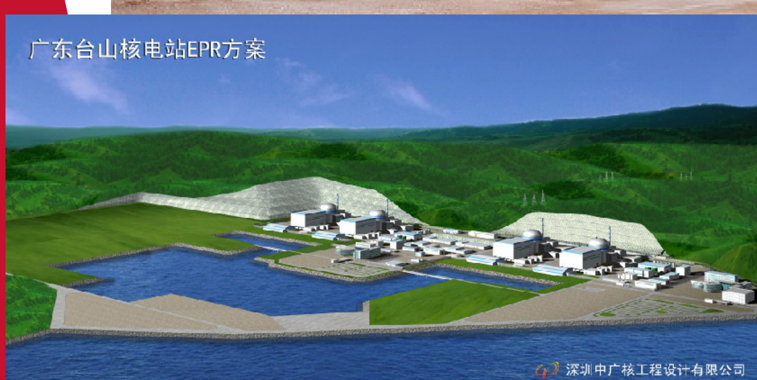


Flamanville 3 site in August 2008

RPV nozzle shell of RPV in France



Taishan site in August 2008



Example: Materials and Procurement Regulatory requirements

- **Section II updated according to recognized best practices and French regulation**

Equipment class		N1	N2	N3
A% Minimum elongation at fracture	**Ferritic** material **Austenitic** material **Martensitic** material **Bolting**	**20%** **35% *** **14%** **12%** with **Z% ≥ 0,45**	**14%** **25%** **12%** with **Z% ≥ 0,45**	**14%**
KV Minimum toughness	**Ferritic** material **Austenitic** material **Martensitic** material **Bolting**	**40 J** at **0°C** (**60 J** if Rm>600 MPa) **100 J** at **20°C *** **40 J** at **0°C** **40 J** at **0°C**	**27 J** at **0°C** **60 J** at **20°C** **40 J** at **0°C**	**27 J** at **20°C**
R_m **Max.**		**800 MPa**	-	-

Note: *: **25%** and **60 J for filler materials** at procurement stage

- **Limitation of Cobalt content**

Example: Introduction of new appendices to be in compliance with European and French Regulation

- **On the correspondence between Regulatory provisions and RCC-M chapters**
  - **Appendix ZU and ZZ for European Pressure Equipment Directive (97/23/EC)**
  - **Appendix ZT and ZY for Nuclear Pressure Equipment French Order**

- **Content of Appendices**
  - Content of Hazard analysis
  - Action by notified bodies and recognized third parties
  - Operating instructions
  - Identification of equipment
  - Equipment and Assemblies
  - Materials documents and quality system
  - Small components
  - Radiation protection