Nuclear Codes and Standards

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BUREAU VERITAS

Move Forward with Confidence

Codes and Standards

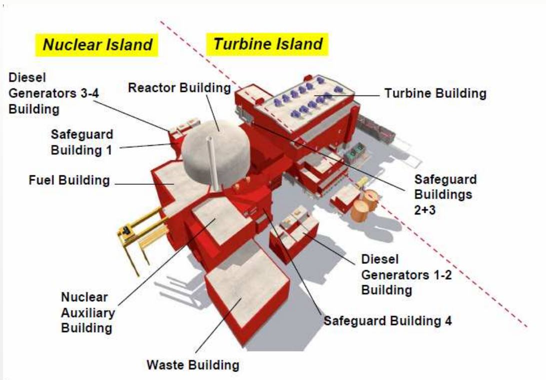
1. Introduction and background
2. Standards selected for EPR design
3. ASME vs RCC- M

Courtesy Areva NP

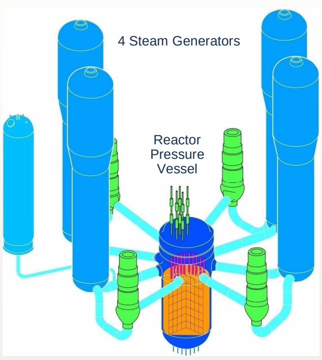
UK Experience

- To be licensable in UK all nuclear plant requires to be Designed, Manufactured and Installed to a recognised Nuclear code. The UK have never had a code specifically prepared for nuclear safety critical equipment.
- Most UK experience is with ASME
- Sizewell B
- Repairs to existing Nuclear plant
- Utilities and Regulator need to agree codes to be used
- ASME and RCC-M are the most widely recognised Nuclear Codes
- RCC-M will supplemented with a UK adaptation document.

Nuclear Island/ Turbine Hall



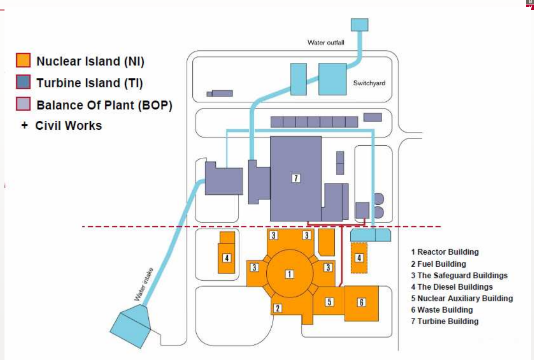
Reactor Cooling System Primary loops



•Pressurizer

4 Reactor Coolant Pumps

Nuclear Island & Balance of Plant



American Society of Mechanical Engineers - Boiler and Pressure Vessel Code

- **ASME Code** covers different Types of Boilers and Pressure Vessels
- Nuclear Facility Mechanical Components must comply with **ASME Section III**
- **Section III** of the Code, (ASME III) is divided into Divisions & Subsections
  - Subsection NCA General Requirements for Divs. 1 & 2 (including Quality Management Arrangements)
- Division 1
  - Subsection NB Class 1 Components
  - Subsection NC Class 2 Components
  - Subsection ND Class 3 Components
  - Subsection NE Class MC Components
  - Subsection NF Supports
- Division 2 Concrete Containment Vessels
- Other Relevant sections
- **Section II** Materials
- **Section V** Non Destructive Testing
- **Section IX** Welding

French - RCC Standards

- **Codes applicable to nuclear equipment construction**
  - **RCC-C Fuel**
  - **RCC-E Electrical equipment**
  - **RCC-G Civil works**
    - Prepared by EDF + FRA. Published by Afcen
  - ***RCC-M Mechanical Components of PWR Nuclear Islands***

  RCC-MR FBR mechanical components
  - **RCC-P System design and Safety classification**
    - Not published
    - Replaced by reference to safety analysis report
  - **RCC-I Fire protection**
    - Prepared by EDF + FRA. Not published
- In-Service Inspection
  - **RSE-M (mechanical components)**

History of Nuclear Standards

- ASME III, first issued in 1963, was the first PV code offering a consistent set of rules backed on structural analysis and an improved knowledge of material behaviour. More precisely it incorporated:
  - Design by stress analysis
  - Stress categorization
  - Thermal stress
  - Fatigue
  - Non ductile failure
  - Dynamic loadings (including earthquake)
- As far as RCC-M is concerned, codification works started in 1978 .

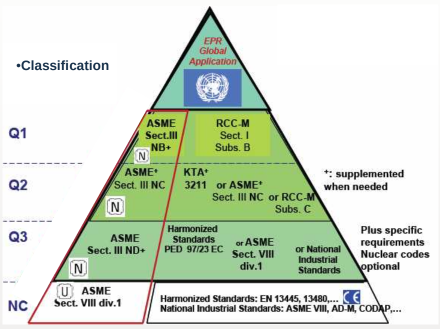
History of RCC-M

- ► First 900 and 1300 MW PWR plants built under Westinghouse licence
  - Design based on ASME III Code
  - Construction based on EDF specifications
  - 1974 French nuclear order issued
  - Technical specifications issued with adaptations and FRA + EDF approval needed
- ► In 1978
  - 30 plants in operation or under construction
    - 25 in France, 5 abroad
  - Practices well established and technical performances known
  - Needs for transfer of technology and localization of manufacturing
- ► 1980: First RCC-M edition
- ► 2000 Integration of French-German consensus
- ► 2007 is the latest edition, with addenda in 2008 & 2009. 2010 in Jul 2011

RCC-M covers the following equipment

- ► Nuclear boiler and ancillaries mechanical equipments:
  - Vessels
  - Heat exchangers
  - Piping
  - Pumps
  - Valves
  - Supports
  - Reactor internals
- ► RCC-M does not include the following:
  - Ventilation, compressors, HVAC
  - Penetration
  - Liners
  - Composite material vessels

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



Courtesy Areva NP

Standards for EPR for Nuclear Island, Safety class 1 main components

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 UK	RCC-M 2007 *	GDA submission to NII	UK regulations does not make mandatory code

Standards used in current EPR construction projects

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

Standards for EPR: Nuclear Island (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 UK	Will likely follow FL3	UK regulations does not make mandatory any code

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

Stucture of the code

Structure of the code

Applicable RCC-M subsections

Section I Nuclear Island Components

- Subsection A : General rules
- Subsection B : Pressure retaining components class 1
- Subsection C : Pressure retaining components class 2
- Subsection D : Pressure retaining components class 3
- Subsection E : Small Components
- Subsection G : Core support structures
- Subsection H : Supports
- Subsection J : Storage tanks (class 2 and 3)
- Subsection Z : Technical appendices

Structure of the code

Applicable RCC-M subsections

Section II : Materials

Section III : Examination methods

Section IV : Weldings

Section V : Fabrication

Structure of the code

RCC-M Code	ASME Code
Section 1 Nuclear Island Components	Section III
A General requirements	NCA
B Class 1 components	NB
C Class 2 components	NC
D Class 3 components	ND
E Small components	None
G Core support structure	NG
H Supports	NF
J Storage tanks	NC/ND 3800-3900
P Containment penetrations	NE
Z Technical appendices	Appendices
Section 2 Materials	Section II
Section 3 Examination methods	Section V
Section 4 Welding	Section IX
Section 5 Fabrication	Various parts of Section III

Structure of the code

Design

- Covers mechanical resistance
- Functional requirements out of scope

Materials

- Material selection
- Procurement
- Part qualification

Manufacturing

- Fabrication and welding
- Process and welders qualifications

Examinations

- Stage
- Methods
- Acceptance criteria

QA A 5000
Documents to be delivered A 3000
Surveillance to be dealt with in contractual documents

Structure of the code

Chapter A 3000

A.3100 Equipment specification

A.3200 General technical documents

- Layout, referencing documents
- Part lists
- Design and stress reports

A.3300 Procurement

A.3400 Fabrication processes

A.3500 Welding

A.3600 Examination

A.3700 Non-conformance and deviation reports

A.3800 Preparation, follow-up and final reports

- Initial state, follow-up, final phases
- End-of-manufacturing reports

End of manufacturing reports are self-supported documentation delivered to owner

Structure of the code

Mandatory Appendices

Appendix	Scope
ZI	**Material Properties to use for design**
ZII	**Experimental Stress Analysis**
ZIII	**Establishment of Allowable Stress Values**
ZIV	**Rules for Components Under External Pressure**
ZV	**Rules for Bolted Flange Connections**
ZVI	**Design Rules for Linear Supports**

Structure of the code

Non mandatory Appendices

+ ZY, ZZ related to French Regulation and PED

Appendix	Scope
ZA	**Rules for Reinforcement of Class 1 Vessel Openings**
ZD	**Analysis of Fatigue behaviour of zones with Geometrical Discontinuities**
ZE	**Alternative Rules for Analysis of Class 1 Piping Systems in the Situations For which Level A Criteria is required**
ZF	**Rules for Level D Criteria Components**
ZG	**Protection Against Fast Fracture**
ZH	**Acceptable Rules for Evaluation of the Usage Factor**
ZS	**Constructive Dispositions Associated With In Service Inspections**

ASME Organisational differences vs RCC-M

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. (follows NQA-1 code)**

ASME Organisational differences vs RCC-M

RCC - M

➢**Accreditation:**

- ***European Members States, China, … impose Third Parties for assessment of conformity and survey of manufacturing, through their regulation.***
- **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 requirement of assessment under Third Party survey (NB).**

➢ **Authorized Inspection and Code Symbol Stamps:**

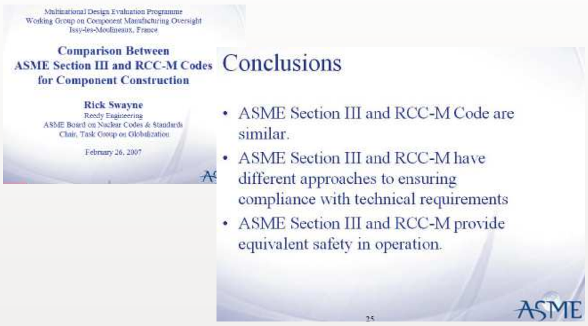
- **RCC-M does not require Code Symbol Stamping.**

➢**Quality Assurance:**

- **RCC-M uses ISO-9000/2000 with additional requirement of IAEA 50-C-QA (GS-R-3 in 2009).**
- **RCC-M requires 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**

ASME III vs RCC- M

Although regulatory contexts and industrial habits were different, the basic philosophy and goals are the same



Similar Design principles

Contrary to ordinary technical code (e.g. pressure vessel code), equipments intended to be used in a nuclear context are subject to a specific safety evaluation and demonstration process summarised in a Safety Report.

This Safety report gives a classification of components and the definition of situations to be investigated during design stage

The consequence is that:

- components are not only designed in nominal steady state situation but also in transient situations (start up and shut down, upset, incidents and emergency)
- a high level of quality of manufacturing is requested
- proof that a consistent safety strategy has been applied and that safety goals have been achieved must be given.
- coherence between various parts of the code (design, fabrication, examination, …)is to be ensured

These features are common to RCC-M and ASME III, but also to KTA

Main similarities concerning Design

- **Stress analysis and plastic design**

RCC-M (as well as KTA, and other non nuclear codes such as ASME IV Div 2, PD 5500, CODAP Div 2 EN 13445…) has adopted the stress categorization principles. RCC-M, EN 13445 and ASME III offer the possibility of elastic plastic analysis

- **Fatigue analysis**

Fatigue analysis is based on the same same SN curves.

- **Linear supports**

For both codes, linear supports design are based in both cases on AISC

- **Piping**

Piping design rules came for both codes from ANSI (now incorporated by ASME)

- **Resistance to buckling**

For both cases basic formulas and charts taken from ASME VIII, Div 1

- **Miscellaneous**

A lot of typical components are designed according to the same methods, e.g: Flanges = Taylor Forge, Valves= Kellogg….

Main differences concerning Design (not exhaustive)

However, even if basically the methods are the same, they differ in some respects:

- **Stress analysis**
  - Level B does not exist for Class 1 components (2007)
  - For Class 1 components RCC-M is less directive than ASME with respect to stress classification: all choice should be justified
  - Level 0 criteria applicable for normal + upset conditions
  - RCCM rules for class 2 vessels more stringent than the equivalent ASME rules for Class 2 vessels
- **Fatigue**
  - Transient combination rules developed (alternatives in App. ZH)
  - Alternative strain correction factor Ke depending on thermal / mechanical parts of primary + secondary stress range (ASME more conservative)
  - No fatigue exemption rules for class 1 components
  - Specific approach for crack-like discontinuities (ZD)

Main differences concerning Design (not exhaustive)

- **Openings**
  - Reinforcement not mandatory for RCC-M: reinforcement to be justified in detail. ASME code (NB-3334) does not require a detailed calculation but gives mandatory reinforcement rules
- **Small components**
  - Components classified as small must be justified according to specific rules
- **Dynamic Analysis Methods** (seismic, surge, flow induced vibrations)
  - In RCC-M, no chapter equivalent to Appendix N (but no incompatibility either!)
- **Piping**
  - Minor differences for Class 1 piping. Greater for Class 2 and 3
  - For level C and D allowable limits differs between RCCM and ASME

	RCC-M	ASME
Level C limit	1.9Sm	Min[2.25Sm, 1.8Sy]
Level D limit	3Sm	Min[3Sm, 2Sy]

Conclusions

- 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,…);
- New non-mandatory appendix in RCC- M makes the Code more user friendly : dedicated appendix for local regulation e.g. Europe, France, … and U K, the latest one still to be issued.
- For “Non nuclear” equipment existing regulations apply – i.e. Pressure Equipment Regulations, harmonised standards…

Nuclear Codes and Standards

Questions