afcen

Shaping the Rules for a Sustainable Nuclear Technology

Quality Management System
Certified ISO 9001:2008

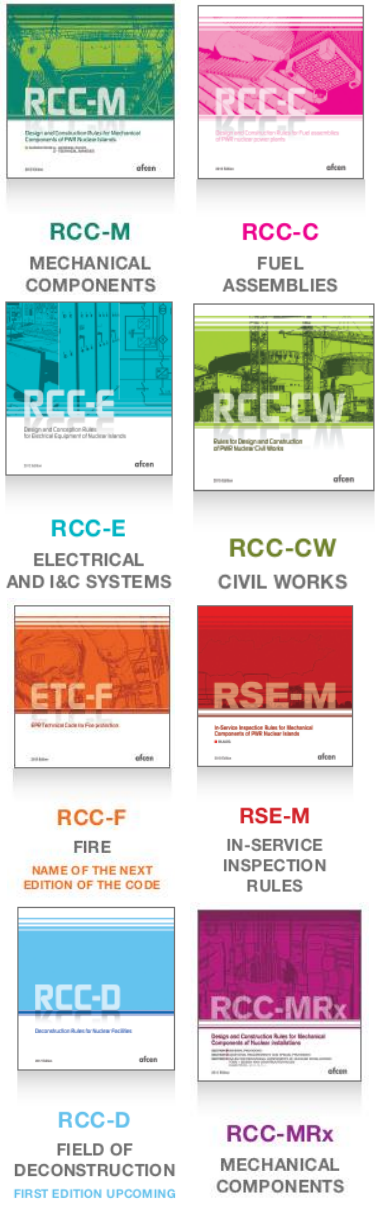
RCC-MRx code: context, overview, on-going developments

C PETESCH
RCC-MRx Sub-Committee Chairwoman

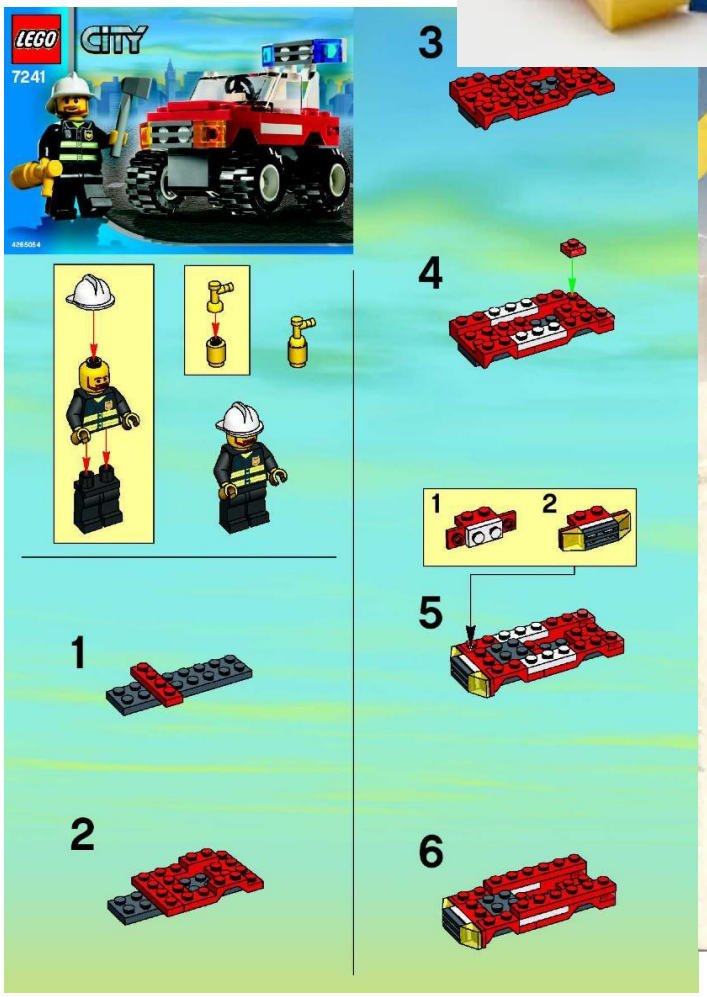
MatISSE/JPNM workshop on cross-cutting issues in structural materials R&D for future energy systems
JRC, Petten, 25-26 November,2015

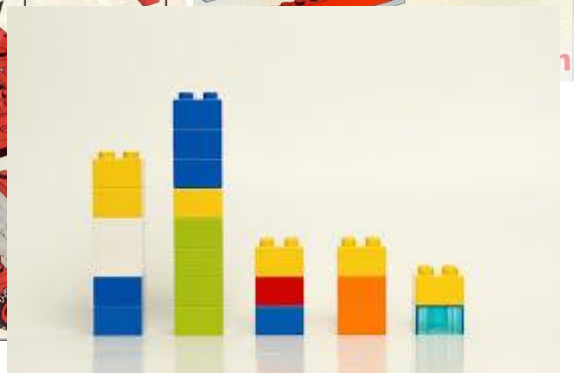
Outline of the Presentation

- ✓ Definitions: code, RCC-MRx, AFCEN…
- ✓ General methodology for a Design Code
- ✓ A particular case: RCC-MRx
  - ➢ Structure
  - ➢ Content: what does the code include and not include
  - ➢ How it is managed
- ✓ RCC-MRx future developments
- ✓ Conclusion

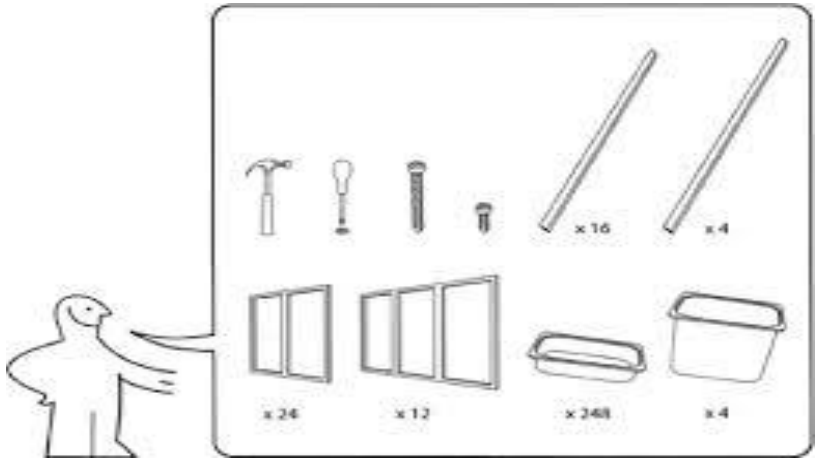


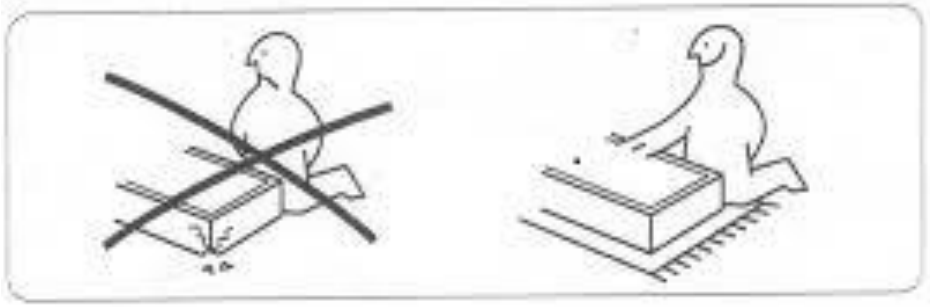
In a simple way…

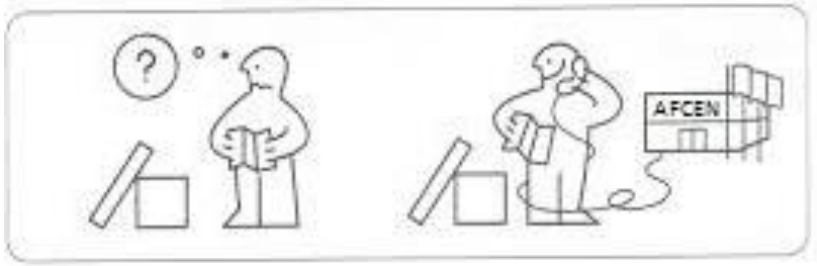




In a simple way…







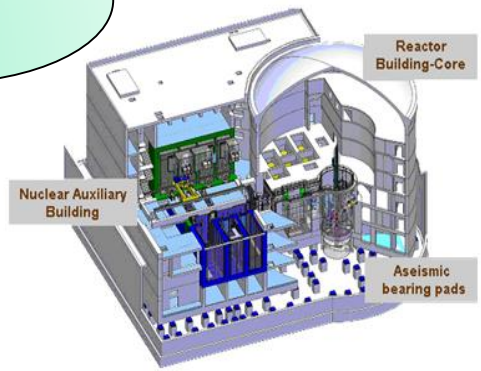
In a simple way…

- ✓ **A code or a standard:**
  - ➢ **A set of technical rules**
  - ➢ **A creation tool**
    - **Equipment sizing**
    - **Taking into account industrial experience**
  - ➢ **Guide for the designer**
    - **Check list of all necessary verifications**

- ✓ **The RCC-MRx code**
  - ➢ **Design and construction rules for mechanical components of nuclear installations: Sodium Fast Reactors (SFR), Research Reactors (RR) and Fusion Reactors (FR - ITER)**

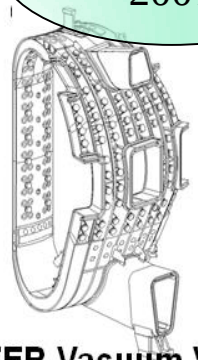
Main projects using RCC-MRx Code

RCC-MX 2008



Jules Horowitz Reactor

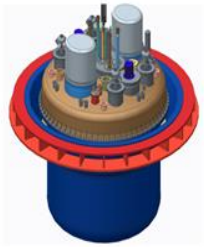
RCC-MR 2007



ITER Vacuum Vessel

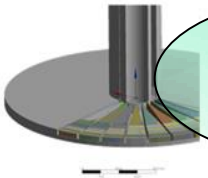
RCC-MR 2002

Indian PFBR



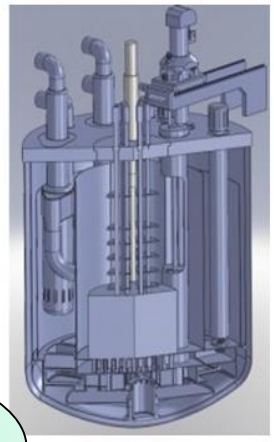
MYRRHA primary system

RCC-MRx 2012



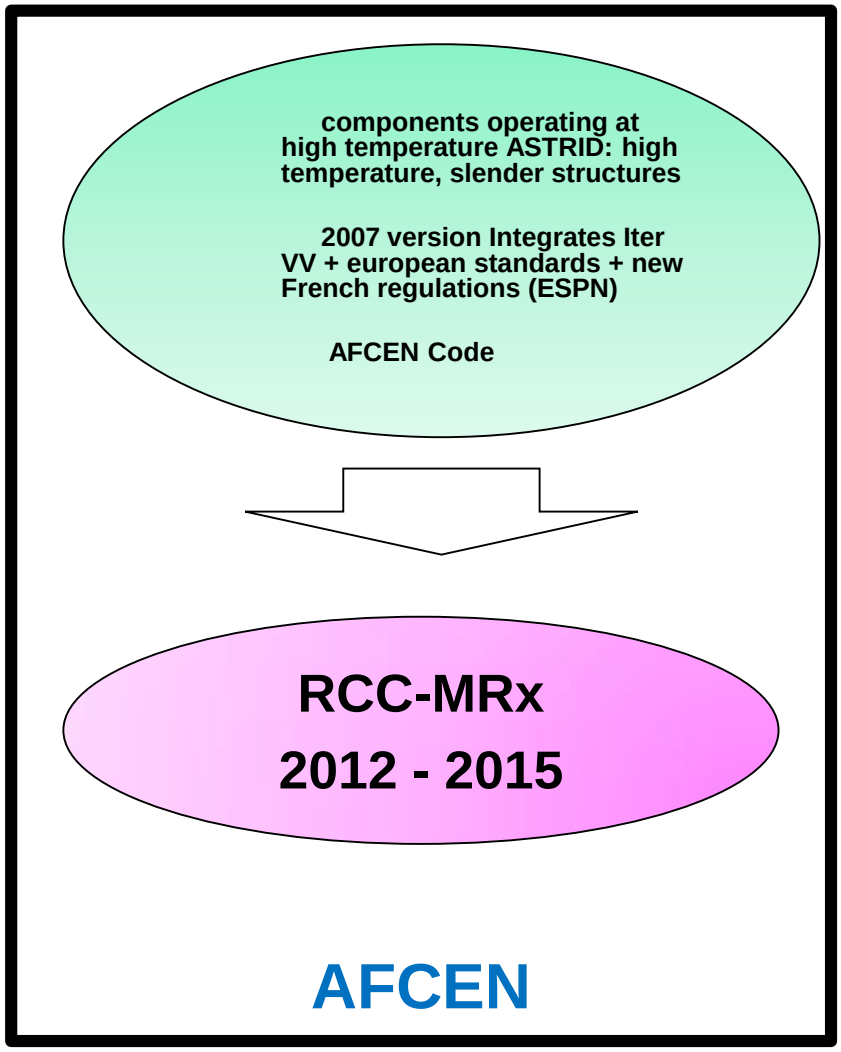
RCC-MRx 2012

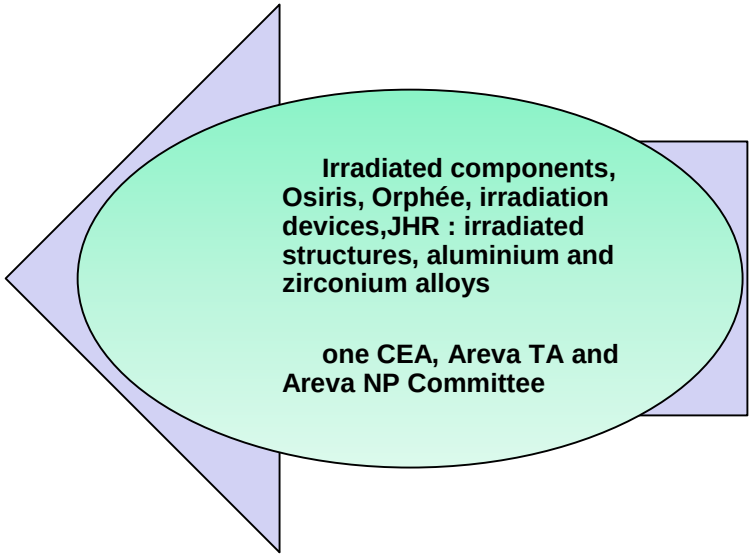
European Spallation Source target



ASTRID

RCC-MRx 2012



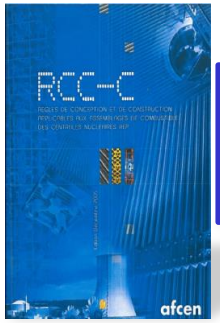


ETC-F

Fire protection

RCC-E

lectrical – I&C
ystems and
omponents



RCC-C

Fuel Assemblies

BOARD &

Executive Committee

Editorial committee

Training committee

RSE-M

In-Service Inspection rules PWR Mechanical components

ETC-C

Civil Engineering

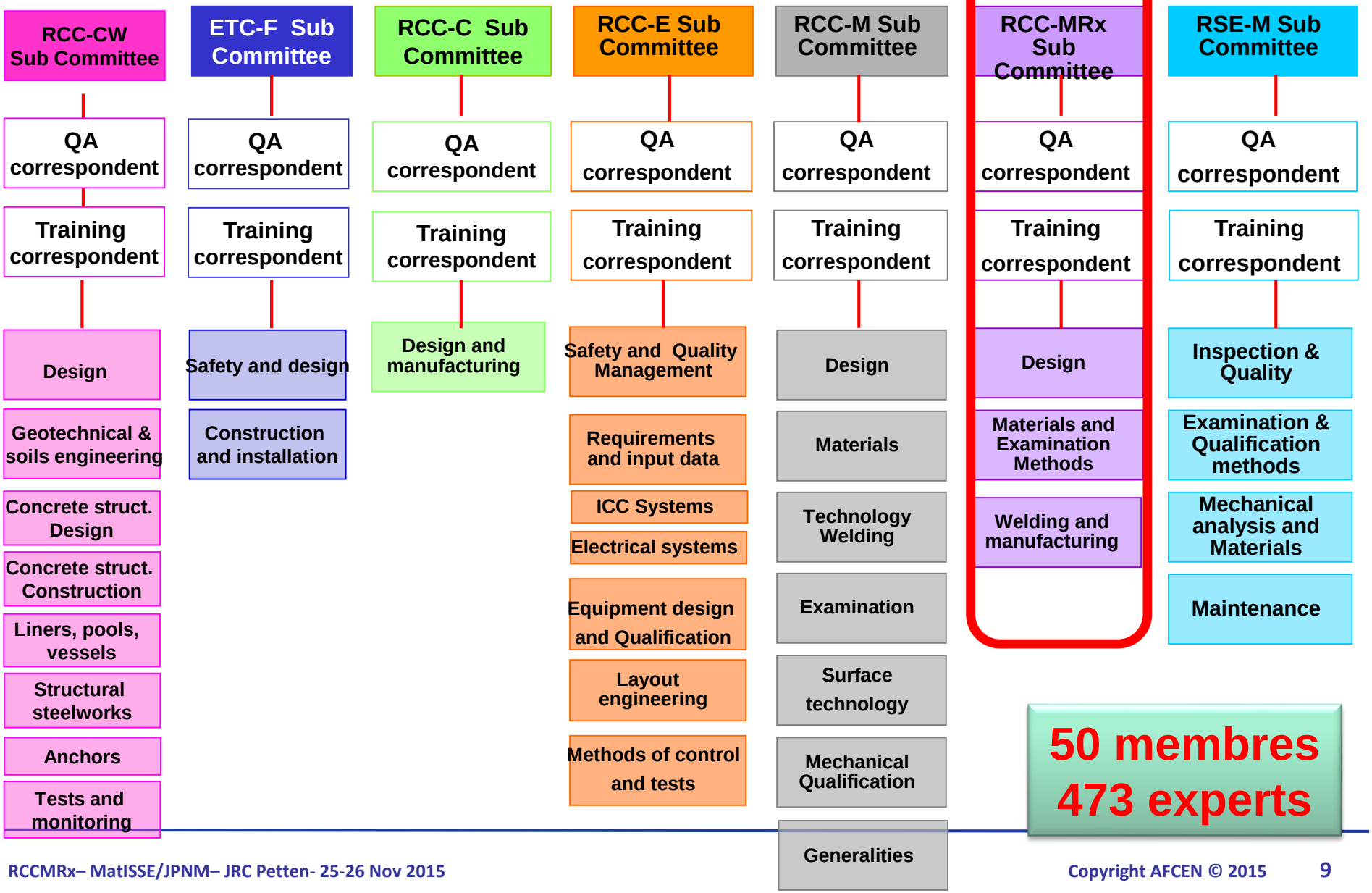
tructures

RCC-MRx

Design and Construction Rules HT/Irr. Mechanical Components

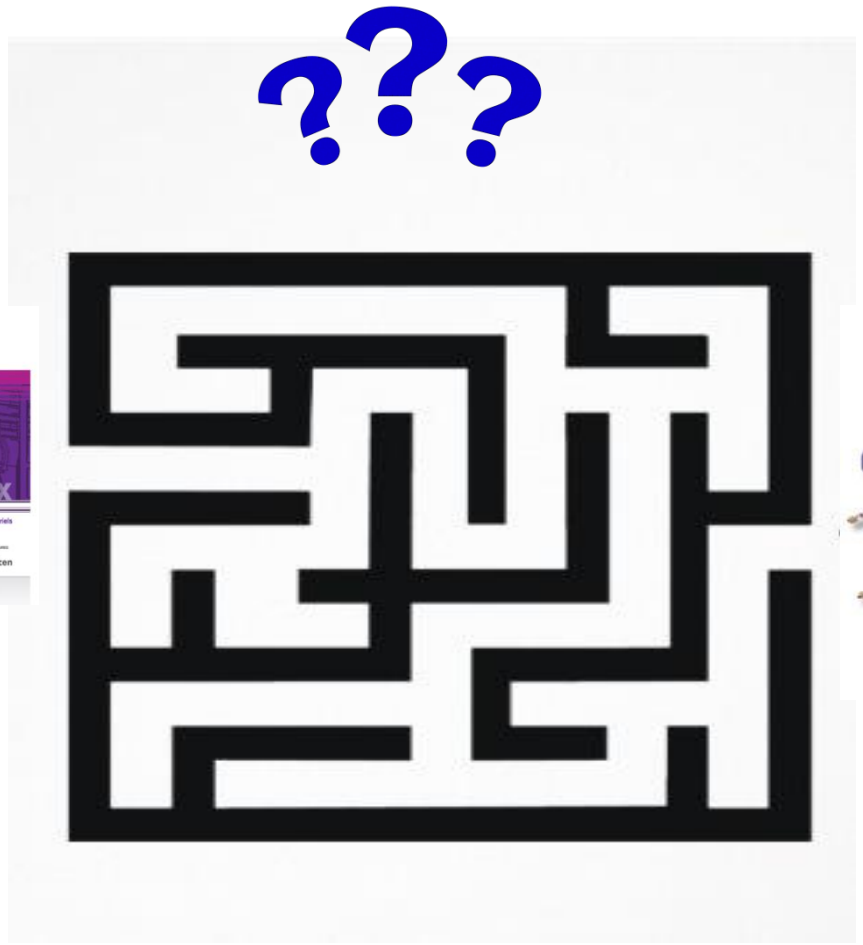
RCC-M

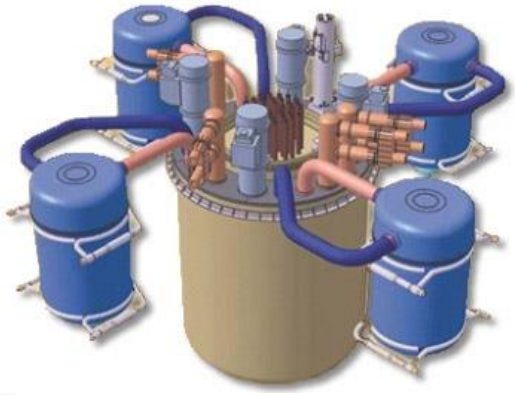
Design and construction of PWR Mechanical components



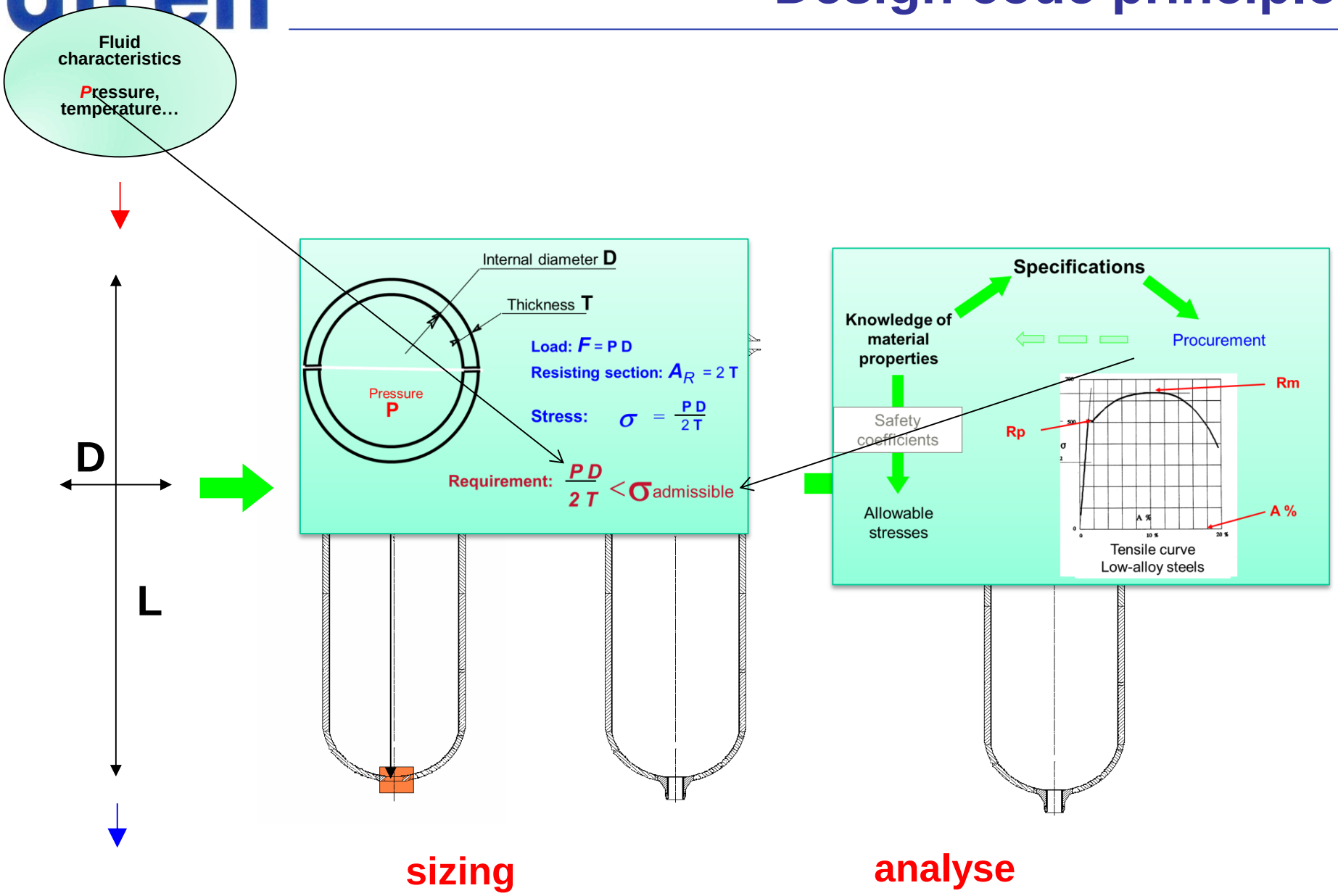
50 membres
473 experts

Design code principles





Design code principles



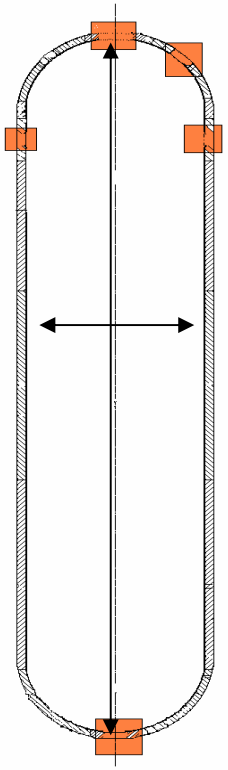
Design code principles

Fluid characteristics

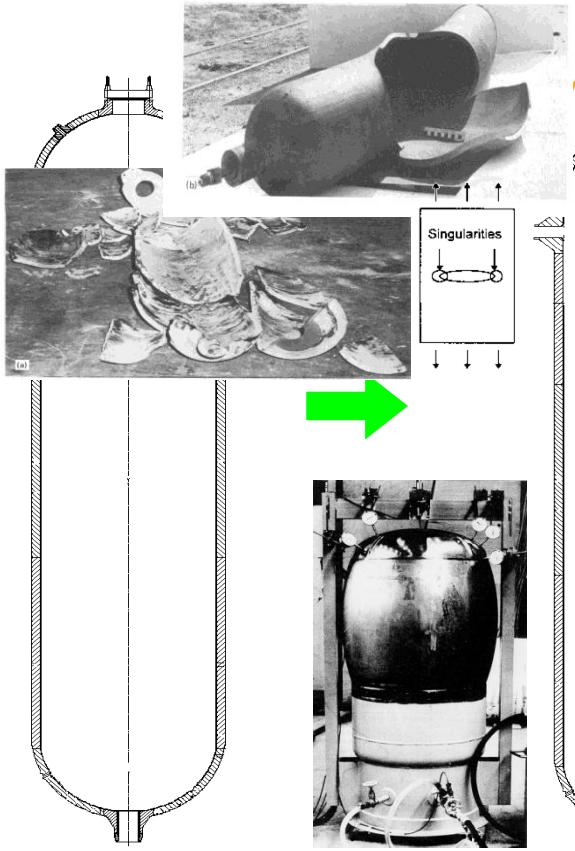
*P*ressure, temperature…

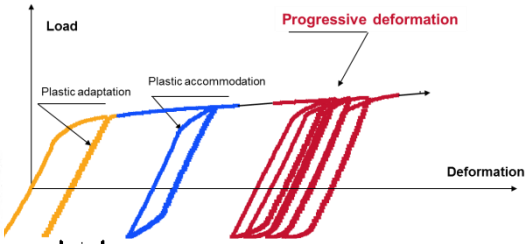
D

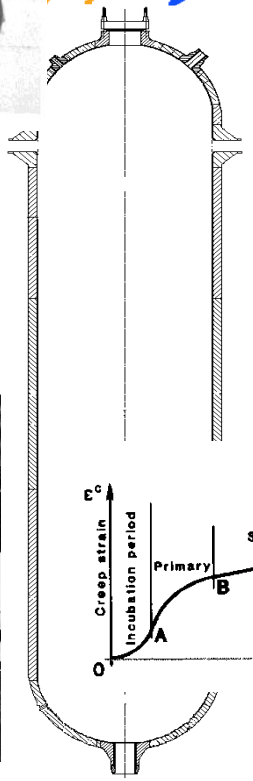
L

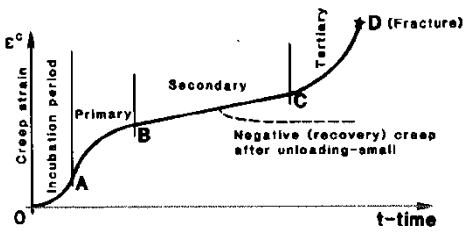


sizing



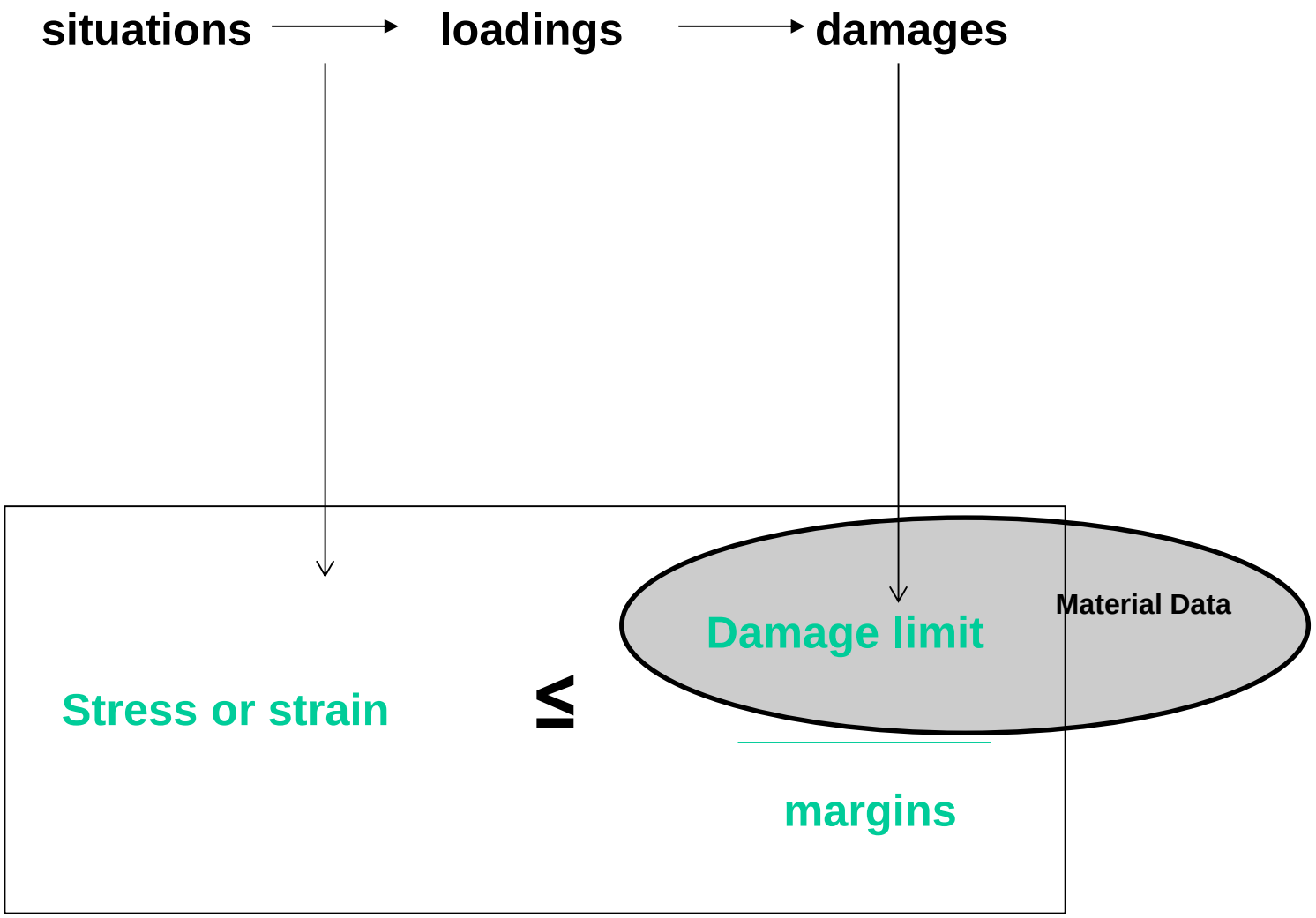






analyse

Design code principles



Design code principles

Loading	**≤**	**Loading corresponding to Damage**
Stresse or strain	**≤**	**Limit corresponding to damage / margin**

Prevention of:

- Excessive deformation
- Plastic instability
- Creep
- Progressive deformation
- Fatigue
- Fast fracture
- Corrosion
- Stress corrosion

Tensile properties
Yield strength Rp
Tensile strength Rm
Choice of material

Material File

Defects Elaboration modes
Examinations
Toughness Transition temperature
KV energy
Chemical composition
(toughness, ageing)

Chemical composition (avoid crack Creation and activation of corrosion Products)

Design code principles

RCC-MRx subsection Z - Appendix A3 or Probationary *Phase Rules*	*A3.4 : Basic data*	*A3.5 : Creep data*	*A3.6 : Irradiation data*	*A3.8 : Fracture Mech. data*
Non Alloy Steels (13 RPS in Tome 2)				
A3.10NAS : P235GH	X			
A3.11NAS : P265GH	X			X
A3.12NAS : P295GH	X			X
Alloy Steels (16 RPS in Tome 2, 4 RPS in RPP))				
A3.11AS : 25CrMo4, 42CrMo4, 30CrNiMo8	X			
A3.13AS : 16MND5	X and Bolts			
A3.14AS : 10CrMo9-10 fully annealed	X	X		
A3.15AS : 13CrMo4-5 quenched and tempered	X	X		
A3.16AS : 2.25% Cr, 1% Mo normalised tempered or quenched tempered	X	X		
A3.17AS : X10CrMoVNb9-2 quenched tempered	X	X		
A3.18AS : X10CrMoVNb9-1 normalised tempered or quenched tempered	X	X		X
A3.19AS : Eurofer X10CrWVTa9-1 normalised tempered	X			
Stainless Steels (25 RPS in Tome 2)				
A3.1S : X2CrNiMo17-12-2(N) solution annealed	X	X	X	X
A3.2S : X6CrNi18-10 et X5CrNi18-10 solution annealed	X	X		
A3.3S : X2CrNiMo17-12-2, 17-12-3, X2CrNiMo18-14-3	X	X	X	
A3.4S : X2CrNi18-9, X2CrNi19-11	X	X		
A3.6S : X15CrNiW22-12 solution annealed followed by aging	X	X		
A3.7S : X2CrNiMo17-12-2 around 20% work hardening	X and Bolts	X	X	
A3.8S : X4CrNiMo16-05-01 quenched and annealed	X and Bolts			
A3.10S : X6NiCrTiMoVB25-15-2 heat treated structural hardening	X and Bolts	X		
Special Alloys Ni-Cr-Fe (5 RPS in Tome 2)				
A3.5SA : X5NiCrTiAl33-21 after annealing heat treatment at 980°C	X	X		
Aluminium alloys (7 RPS in Tome 2, 1 RPS in RPP)				
A3.1A : 5754-O	X	X	X	
A3.2A : 6061-T6	X	X	X	
Zirconium alloys (4 RPS in Tome 2)				
A3.1Z : Zircaloy 2	X	X	X	
A3.2Z : Zircaloy 4	X	X	X	

RCC-MRx General Overview

Vessels
Pumps
Valves
Pipes
Bellows
Boxes
Heat exchangers

***Section I* (RDG)**

- **General provisions**
- **Entrance Keys – Appli**
- **Equipment specification**
- **Management system**

Section III

TOME 1 : DESIGN

Subsection A (RA): general provisions and entrance keys
Subsection B (RB): class $N1_{Rx}$ components and supports
Subsection C (RC): class $N2_{Rx}$ components and supports
Subsection D (RD): class $N3_{Rx}$ components and supports
Subsection K (RK): Examination and handling mechanisms
Subsection L (RL) : Irradiation devices
Subsection Z (Ai) : Appendixes (properties of materials etc.)

TOME 2 (RM): MATERIAL PROCUREMENT SPECIFICATIONS

TOME 3 (RMC) : TESTING AND EXAMINATION METHODS

TOME 4 (RS) : WELDING

TOME 5 (RF) : FABRICATION

TOME 6 (RPP) : PROBATIONARY PHASE RULES

***Section II* (REC)**

Additional requirements

For class 3 components

- application of Standard NF EN 13445
- application of Standard NF EN 13480
- Eurocode 3

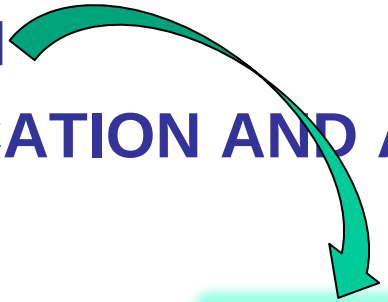
Special requirements

- European regulation ESP
- French regulation ESPN
- European regulation REACH

RCC-MRx General Overview

TOME 1

- ✓ RB 1000 GENERAL
- ✓ RB 2000 MATERIALS
- ✓ RB 3000 DESIGN
- ✓ RB 4000 FABRICATION AND ASSOCIATED EXAMINATIONS
- ✓ RB 5000 TESTS



- GENERAL
- ANALYSIS RELATED TERMS
- SIZING RULES
- ANALYSIS METHODS
- RULES FOR PREVENTION OF TYPE P DAMAGES
- RULES FOR PREVENTION OF TYPE S DAMAGES

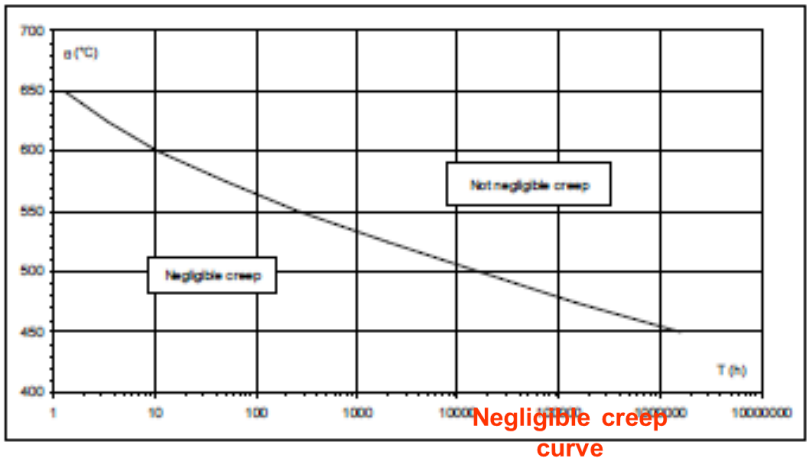
RULES FOR BOLTS, BOLTED ASSEMBLIES AND MECHANICAL

CONNECTORS

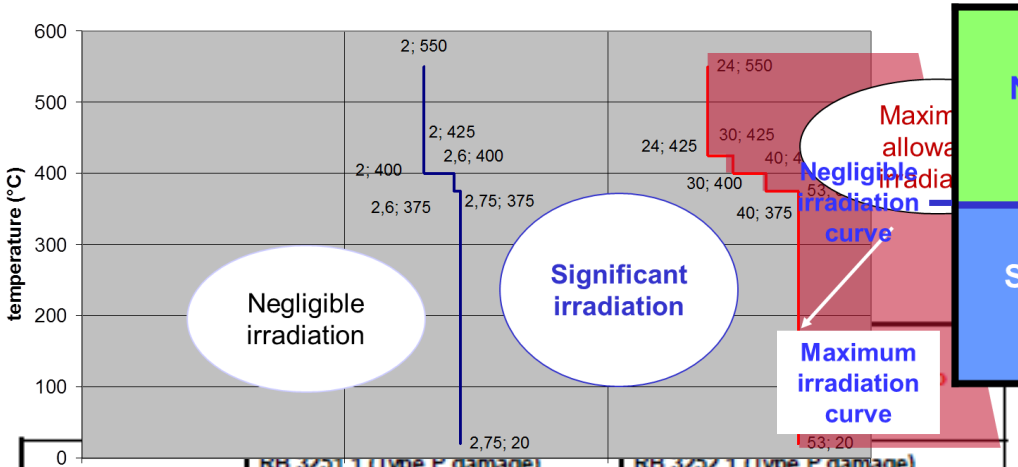
DESIGN RULES FOR SUPPORTS

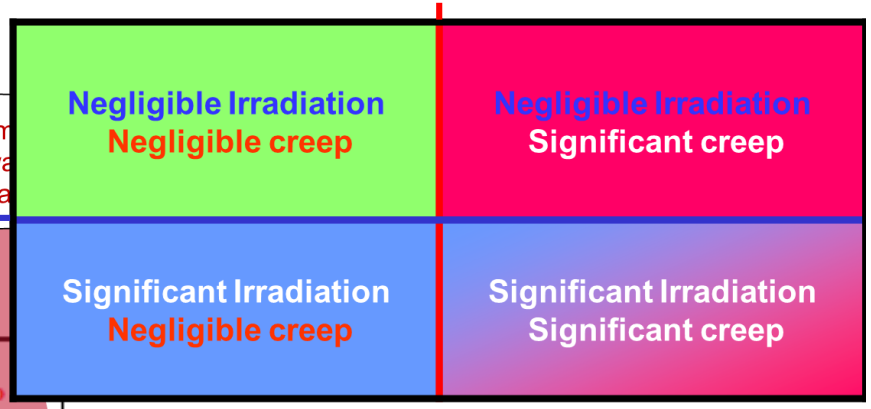
RCC-MRx General Overview

- ✓ **Materials and Design rules hav class 1 or 2 nuclear component**
  - ➢ **in creep conditions (significant**
  - ➢ **in irradiated conditions (signifi**



Example of negligible creep curve A3.1S





NEGLIGIBLE IRRADIATION	RB 3251.1 (Type P damage) RB 3261.1 (Type S damage) RB 3271.1 (Buckling)	RB 3252.1 (Type P damage) RB 3262.1 (Type S damage)
SIGNIFICANT IRRADIATION	RB 3251.2 (Type P damage) RB 3261.2 (Type S damage)	RB 3252.2 (Type P damage) RB 3262.2 (Type S damage)

Probationary Phase Rules

PPR	Title	Paragraph(s)	Purpose	Status
RPP1-2012-RA5000	Management system	RA 5000	Establishment and use of a quality management system	Renewal 2012-2015
RPP2-2012-9%Cr	Properties of chrome alloy steels from Annex A3.18AS	A3.18AS	Properties of chrome alloy steels from Annex A3.18AS – cyclic behaviour and creep	Renewal 2012-2015
RPP3-2012-RM 243-2	RM 243-2 thick plates	RM 243-2 and A3.18AS	Extension of application of RM 243-2 to thick sheets (up to 250 mm)	Renewal 2012-2015
RPP4-2012-Eurofer	Eurofer	RM 242-6, 243-3 and 244-3, appendix A3.19S	Introduction of Eurofer	Renewal 2012-2015
RPP5-2012-STR-S Casing 6061-T6	RM 522-7 casing 6061-T6	RM 522-7, appendix A3.GEN and A3.2A	S-RPS: Type 6061 T652 Al-Si-Mg alloy forged blanks for the core casing and additional information in associated Appendices A3.GEN and A3.2A	Renewal 2012-2015
RPP6-2012 aluminium welds	US inspection of welds on aluminium alloys	RS 7714.4 RS 7724.4	Introduction of measures for US inspection of welds on aluminium alloys	Renewal 2012-2015
RPP7-2012-A16	A16 – Locating defects	A16.2122	Definition of a general procedure for locating defects	Renewal 2012-2015
RPP8-2013-SMC2	Use of the SMC2 method for prevention of type S damages	RB 3645.82 RB 3661.1 RB 3661.24	Extension of the method of Seismic Moments Classification SMC2 to type S damages	Renewal 2013-2015
RPP9-2013-800H	800H Alloy	RM 412-4 RM 414-3 A3.6SA	Introduction of bars and tubes RPS in alloy 800H and the associated appendix A3	Renewal 2013-2015
RPP10-2015-A3.2A.69	6061-T6 swelling	A3.2A.69	New swelling law for 6061-T6	Introduction 2015

Code management

BOARD of GOVERNORS

Chairman of Afcen, Presidents of the Committees, General Secretary and Administrators

EXECUTIVE COMMITTEE

- **Training Committee**
- **Publishing Committee**
- **General Secretary**
- **Quality Committee**

Other Subcommittees

- Fire
- Electricty
- Civil Work
- Fuel

RCC-M Subcommittee
(Design and construction PWR)
S Marie Areva

1. Design
2. Materials
3. Examination
4. Technology
5. Fabrication

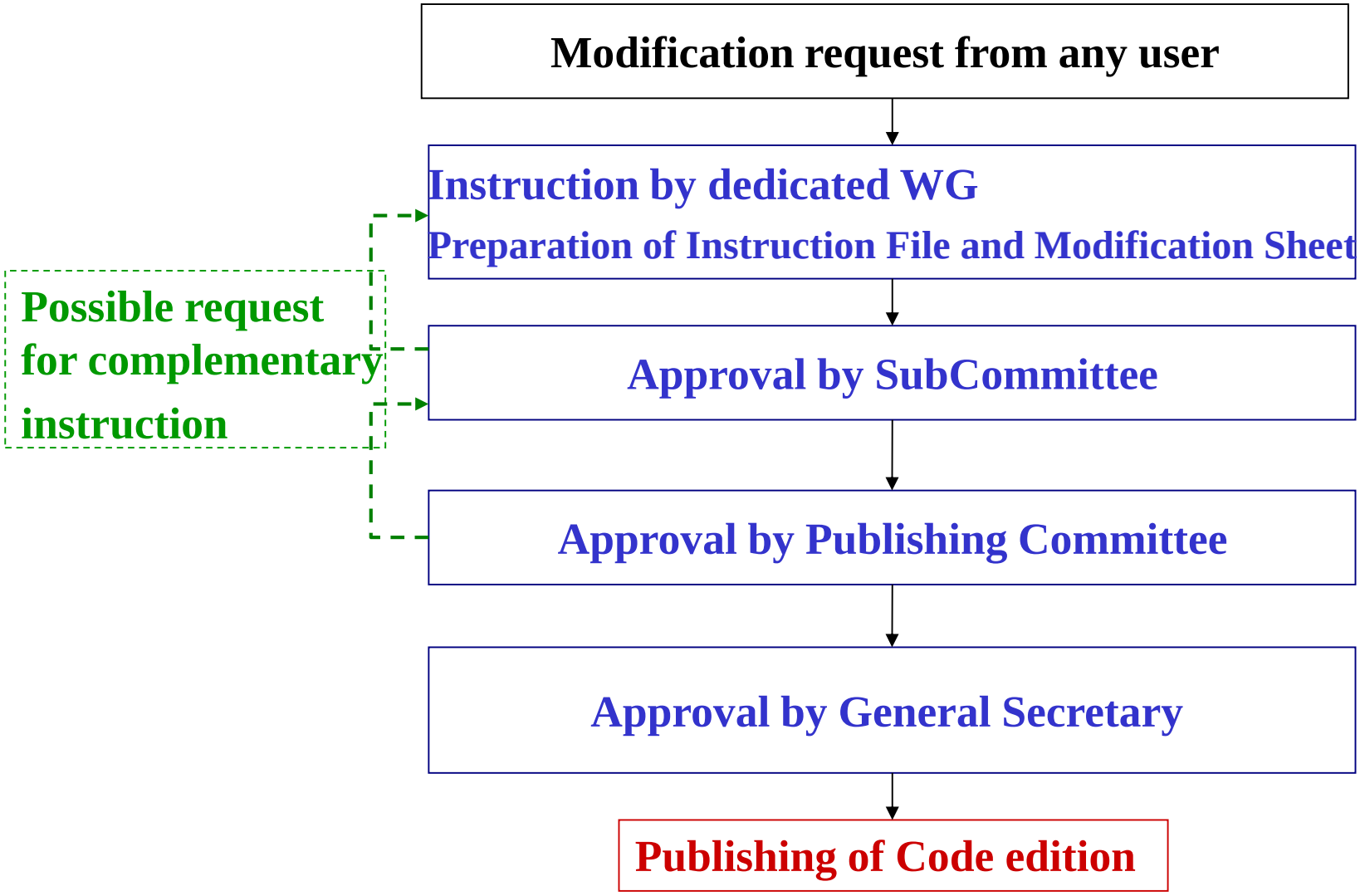
RCC-MRx Subcommittee
(Design and construction SFR, ITER, RR,…)
C. Petesch CEA

- WG1 Design
- WG2-3 Materials Examination
- WG4-5 Welding Fabrication

RSE-M Subcommittee
(In Service Inspection PWR)
L. Lobgeois EdF

1. Test
2. Examination
3. Flaw analysis
4. Repair
5. ISI

Procedure for code updating



Code management

Afcen Working Groups

MRx-WG1 (Tome 1)
and MRx-WG2-5 (Tomes 2,3,4,5)

Objectives :

Investigation on Modification Requests (Instruction files = justifications + modified text).

Updating and Preparation of justification documents (Criteria), new editions.

GTT-Rx : Pre-Normative Task Groups for the RCC-MRx Code

Objectives :

Preparation of Modifications with their justification reports and modified text.

CEN Workshop CWS64

Objectives :

Recommandations
R&D propositions

Afcen RCC-MRx Sub-Committee (MRx-SC)

Afcen members and invited experts

Objectives :

Organisation and dispatching the MRx-WG work according Afcen procedures, examination and approbation of WG work :
Instruction files, justification documents (Critria) , new editions.
Find the ressources for the MRx-SC and MRx-WG activities.

Participation in CEN MRx Workshop – instruction of CW Agreements

Pre-Normative r&D

Objectives :

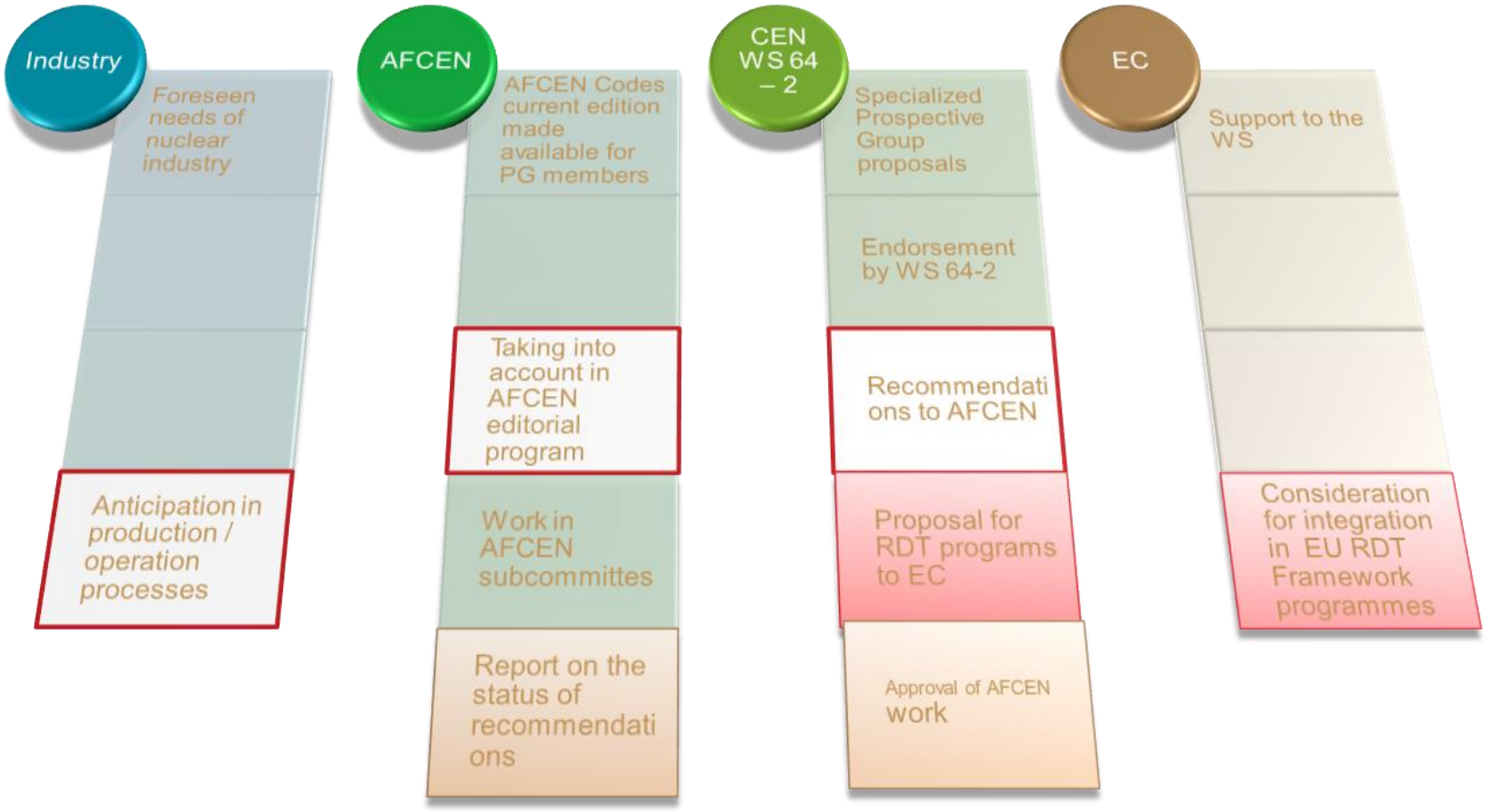
Modifications of RCC-MRx Code with their justification reports and modified texts.

Afcen Editorial Committee for publication (MRx editions every 3 years)

Users of RCC-MR, RCC-MX, RCC-MRx

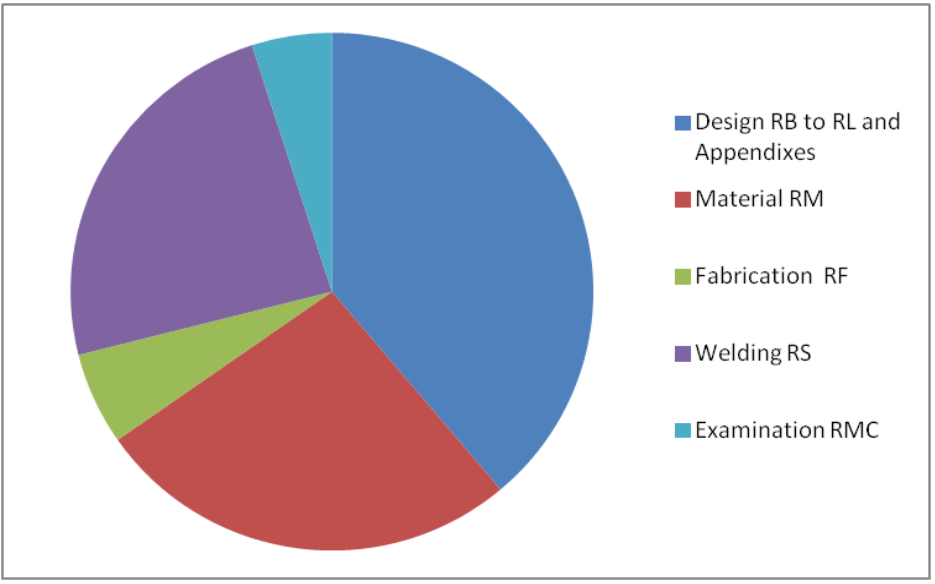
Modification Requests

CEN WS 64

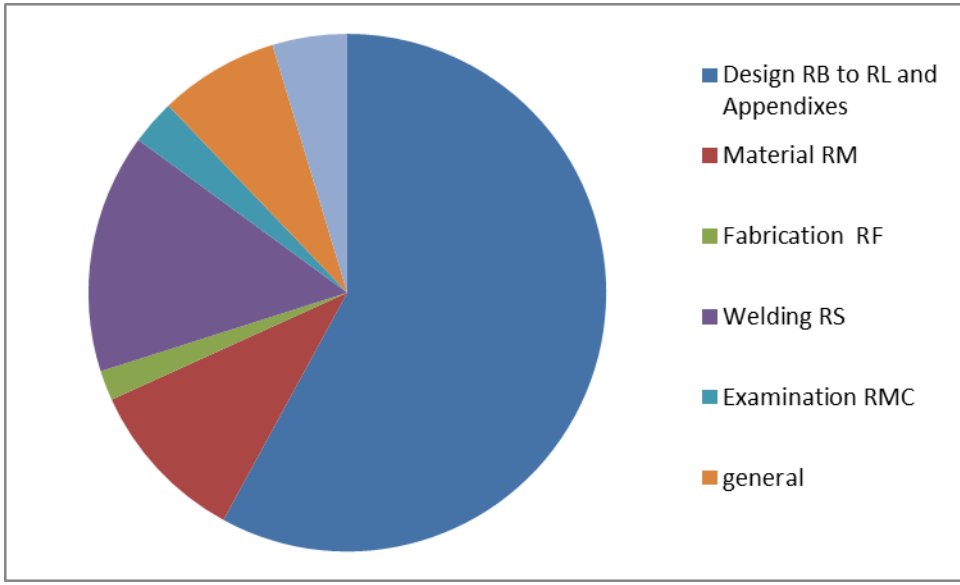


Modification requests overview

OVERVIEW OF THE MODIFICATION REQUESTS DISTRIBUTION



2012 Edition



2015 Edition

On-going developpments

- ✓ **Mid and long term needs for materials:**
  - Material characteristics at high temperatures
    - 316LN, 800 Alloys, …
  - Lifetime and irradiation issues
    - 60 Years Lifetime thermal ageing , creep/fatigue approach to re-assess, database to extent (base metal but also welds),
    - Irradiation issues
  - Adaptation of the ratcheting and creep-fatigue rules for 9%Cr and other non-stainless steel materials
  - Joining processes
    - hot isostatic pressing
  - Welding
    - new filler materials, especially for automatic welding,
    - ageing&creep issues
  - Hard rolling
  - Hard facing materials (stellite replacement)
- ✓ **Mid and long term needs for components design**
  - Sodium and high temperature bellows rules
  - Compact heat exchanger (for gas power conversion)
  - Sodium Nuclear valves design rules
- ✓ **Best compliance with regulation evolution (eg : pressure equipments regulation)**
- ✓ **Possible impact of future safety assessments**

Conclusions

- ✓ To answer to GEN IV projects needs, some topics are still not codified, dealing with complex technical issues, requiring research and development or needed to collect participation of different experts.
- ✓ There is also a need for an opening to new processes, new materials, new design rules:
  - Development of probationary phase rules,
  - Work on a guideline defining how to get and evaluate the material data for their introduction in the RCC-MRx code,
  - Participation to the Cen Workshop 64.
- ✓ This opening shall be done in parallel to a work on the development of Criteria (background) of the code
  - Stainless Steel Material Report,
  - Design rules (Creep design rules, Bolt design rules, Ratcheting rules, Irradiation rules,…).
- ✓ Edition of design criteria is planed in 2017, a next edition of the code in 2018

Thanks for your attention

afcen

Shaping the Rul

www.afcen.com