European study on the feasibility to develop standardized rules for the design and construction of Generation IV nuclear reactors

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afnor NORMALISATION

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Foreword

This document has been prepared by task group from CEN/WS 64 "Design and Construction Code for mechanical equipment of innovative nuclear installations", the secretariat of which is held by AFNOR.

Introduction

In February 2011, several members of the SNETP (Sustainable Nuclear Energy Technology Platform) taskforce for ESNII set up a CEN Workshop on “Design and construction code for mechanical equipment of innovative nuclear installations” (CEN/WS 64). This Workshop, open to all the organizations among nuclear development stakeholders that agree with the SNETP objectives, intended to contribute to share a common European approach on structural integrity for innovative nuclear installations components by:

- rationalizing pre-normative R&D activities in Europe and capitalizing European R&D results into an European Framework,
- capitalizing European and international feedback of experience gained in the design and construction of innovative nuclear systems (ITER, PFBR (India), etc….)
- meeting the WENRA objectives to develop a common European approach for innovative nuclear prototypes in the field of structural integrity,
- reinforcing the links between European mechanical engineering standards and the nuclear industry.

CEN Workshops concept offers a flexible mechanism and approach to standardization in which companies can bring their standardization and specification requirements and are given the opportunity to rapidly elaborate consensus documents in an international environment. As they are conducted under the CEN umbrella, Workshops have to respect the CEN’s values of openness, transparency and agreement through consensus. The result of a Workshop is normally a CEN Workshop Agreement (CWA) that can constitute technical specifications, guidance material, best practice, information, etc. CWAs are listed in the CEN Members catalogues and, although their use remains purely voluntary, they can serve as a basis for the development of an EN or ISO Standard.

According to the ESNII Task Force recommendation, the Workshop developments were carried out on the RCC-MRx basis in consideration of the choice already made in France and in Belgium to build the mechanical components for ASTRID and MYRRHA. This position is reinforced by the adoption of this code in other ongoing projects, such as the CEA’s RJH experimental reactor or the ITER’s tokomak vacuum vessel or the European Spallation Source (ESS). It is also expected to be used in the future ESNII projects ALFRED and ALLEGRO.

As the RCC-MRx is the property of AFCEN, the latter was the proposer of the Workshop and proposed to chair it. This was agreed at the kick-off meeting that took place in Brussels on February, 3rd 2001. It was also agreed among the participants to the Workshop and with the CEN that both CEN and AFCEN will have the copyright on the result of the work and that this work will be carried out applying similar processes as those in force in AFCEN for the evolution of its codes. In this framework, the CEN Workshop 64 Agreement was supposed to be a collection of modification files of RCC-MRx code that AFCEN took the commitment to include in the 2012 edition of the code.

The European Commission (EC) supports this approach in the perspective of the implementation of Generation IV reactors in Europe and in the world. The EC points out the advantage of enforcing a unique European code for components design and manufacturing both as regards the reduction of costs, delays in implementation, difficulties in follow-up, etc. and as regards the competitiveness of European industry as provider of these components.

In this context, the EC expressed a wish to further investigate the way to promote an existing code as the European code, if possible recognized internationally by a large group of stakeholders, for the design and construction of mechanical equipments of Generation IV reactors. To this aim, the EC ordered a study on the feasibility of this to AFNOR, which held the CEN/WS 64 secretariat, making use in particular of the lessons learnt from this Workshop.

The European Commission in conjunction with AFNOR set up a Task Group on a European study on the *feasibility to develop standardized rules for the design and construction of Generation IV nuclear reactors*. This Group will deliver by end 2012 a report containing recommendations to the European Commission and ESNII members in which conditions in which Generation IV reactors should be designed and build in the Community with standardized rules supported by the industry. This study should investigate how a shared industrial experience in components design and manufacturing can lead to dedicated European Codes recognized internationally by a larger group of stakeholders.

1 Scope and requirements of the feasibility study

The objective of this study is to analyse the need for a European design code and standardized rules for Gen IV reactors supported by the industry and its feasibility.

The requirements for this study were:

- Feedback from the Workshop 64 experience and recommendation for further steps
- Performance of a SWOT analysis of candidate codes for a possible evolution towards an endorsement as the European code for Generation IV future demonstrators and facilities by a European standardization body
- Make a survey on standardization needs on the field on design codes. This survey had to be expand outside the CEN/WS 64 members to include stakeholders of demonstrators, Engineering manufacturing firms, National regulators, WENRA, standardization member bodies, others technical committee in nuclear fields and other identified partners
- Identify topics on need for pre-normative and long-term research for an European code

The resulting document shall be communicated among the European stakeholders.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
SNETP
Sustainable Nuclear Energy Technology Platform

Technology platforms bring together a broad spectrum of stakeholders to formulate and implement common research agendas in strategic areas which could have significant impact on Europe's competitiveness and sustainability objectives.

The Sustainable Nuclear Energy Technology Platform (SNETP) is the European Technology Platform aimed at promoting the research, development and demonstration of European nuclear fission technologies, covering current and future nuclear systems, including safety research, fuel cycle, appropriate R&D infrastructure and human resources.

SNETP was launched on September 21, 2007 in Brussels. The Vision Report, endorsed by 35 major nuclear research-orientated organizations and nuclear industry stakeholders, was distributed at this event. Following the launch, the Governing Board set up three Working Groups to establish the first edition of the Strategic Research Agenda (SRA), the Deployment Strategy (DS) and an action plan on Education, Training & Knowledge Management.

2.2
ESNII
European Sustainable Nuclear Industrial Initiative (ESNII)

Europe, through SNETP, has defined its strategy and technological pathway for developing the fast neutron reactors:

- the Sodium Fast Reactor (SFR) as a first track aligned with Europe’s prior experience, and,
- two alternative fast neutron reactor technologies to be explored on a longer timescale: the Lead cooled Fast Reactor (LFR) and the Gas cooled Fast Reactor (GFR).

ESNII is Europe’s demonstration program for Fast Neutron Reactor technologies with closed fuel cycle.

2.3
ISO
International Organization for Standardization

ISO is the world’s largest developer of voluntary International Standards. International Standards, developed through global consensus, give state of the art specifications for products, services and good practice, helping to make industry more efficient and effective.

2.4
CEN
CEN (Comité Européen de Normalisation/ European Committee for Standardization) is a business facilitator in Europe, removing trade barriers for European industry and consumers. Its mission is to foster the European economy in global trading, the welfare of European citizens and the environment. Through its services it provides a platform for the development of European Standards and other technical specifications.

CEN is a major provider of European Standards and technical specifications. It is the only recognized European organization according to Directive 98/34/EC for the planning, drafting and adoption of European Standards in all areas of economic activity with the exception of electro-technology (CENELEC) and telecommunication (ETSI).

CEN produces European Standards (EN), Technical Specifications (CEN/TS) and Technical Reports (CEN TR) in Technical Committees with national delegations of its members. It also hosts Workshops to define technical specifications, guidance material, best practice, information, etc. with interested parties in CEN Workshop Agreements (CWA).

2.5
AFNOR
Association Française de NORmalisation

AFNOR is the Fench body that ensures standardization and its promotion, directly or through the bodies appointed by AFNOR and approved by the minister responsible for industry as Sector-based Standardization Bureaus. Standards are drafted by the Sector-based Standardization Bureaus (BNS) appointed by AFNOR, or by AFNOR itself in areas common to a large number of sectors or in sectors for which there is no approved BNS. As the central coordinator of standardization in France, AFNOR conducts a census of standard requirements and mobilizes the interested parties. It permanently ensures that the published standards remain pertinent.

2.6
AFCEN
Association Française pour les règles de conception, de construction et de surveillance en exploitation des matériels des Chaudières Electro-Nucléaires

AFCEN is the French society for the rules governing the design, construction and operating supervision of the equipment items for electro nuclear boilers, registered as a non-profit organization under French law. AFCEN elaborates these rules and publishes them in specific collections, named “codes”, under its own copyright.

2.7
ASTRID
It's Advanced Sodium Technological Reactor for Industrial Demonstration.

It is a prototype of a Sodium Fast Reactor (SFR) with a design power corresponding to an electrical production of a few hundred MW. Its main objective is to demonstrate, at an industrial scale, improvements of the current technology by qualifying innovative technical options in selected areas in which some progress is expected (in particular safety and operability) and to be a test bed for the implementation of advanced techniques of in-service inspection and repair. It will also have the capacity to perform radioactive waste transmutation in order to demonstrate its feasibility, at an industrial scale, and its ability to reduce the amount and dangerousness of these wastes. Furthermore, ASTRID will have to offer the possibility to perform experimental irradiations in a fast neutron spectrum.

ASTRID should be in operation at the beginning of the 2020's. In this aim, a first phase of preliminary draft takes place from mid-2010 to the end of 2012. At this date, the first technical and financial elements will enable to decide whether the project is to be carried on. During this first phase, the safety orientations will be discussed with the Safety Authority. If the decision to carry on is taken, a further two-year phase of studies will be launched, notably to establish the Safety Options File of the installation. Then, in 2014, the design and construction phases will be started.

2.8
MYRRHA
Multipurpose hYbrid Research Reactor for High tech Application

MYRRHA is a flexible fast spectrum research reactor (50-100 MWth) conceived as an accelerator driven system (ADS), able to operate in sub-critical and critical modes. It contains a proton accelerator of 600 MeV, a spallation target and a multiplying core with MOX fuel, cooled by liquid lead-bismuth (Pb-Bi).

The first objective of MYRRHA is to be operated as a high-flux and flexible fast spectrum irradiation facility. Such a facility will therefore be able to host several experimental devices and loops in support of material and fuel research for different innovative reactor systems and fusion material research and for the production of radio-isotopes for medical purposes. To respond to this objective, attractive irradiation conditions for the experimental devices and rigs need to be assured.

Secondly, MYRRHA needs to demonstrate the ADS technology and demonstrate efficient transmutation in such a facility and in this way be able to serve as test-bed for transmutation. Thirdly, MYRRHA, as it will be designed also to be able to operate in a critical mode; will contribute to the demonstration of the Lead Fast Reactor technology. Lead-bismuth eutectic was selected due to its low melting temperature (124.5 °C), allowing the primary systems to function at rather low temperatures. These low working temperatures are an evident mitigating approach to limit the corrosion problems due to Heavy Liquid Metal (HLM). To take advantage of the thermal inertia provided by a large coolant volume, a pool-type system in which the components of the primary loop (pumps, heat exchangers, fuel handling tools, experimental rigs, etc.) are inserted from the top in penetrations in the cover was chosen. The loading of fuel assemblies is foreseen to be from underneath, which is not the classical approach of the sodium fast reactors. However, the employed technology is the same. The reasons behind the approach are firstly to keep a large flexibility for the experimental devices loading from the top and secondly, from the safety point of view, the fact that all structures including the spallation module are in place before starting the core loading. The pool vessel, which contains the core of the MYRRHA machine and the whole series of internals, is located in an air-deficient containment environment.

Furthermore, several factors lead to the decision to design both operation and maintenance (O&M) and In-Service Inspection & Repair (ISI&R) of MYRRHA with fully-remote handling systems.

2.9
ALLEGRO
Experimental facility for the development and demonstration of Gas-cooled Fast neutron Reactor (GFR) technologies

Allegro is to be a gas-cooled fast reactor (GFR) with thermal capacity in the range 50-80 MW. It has funding support as a demonstration project of the Generation IV International Forum, in which France, Japan, Switzerland and the EU are partners on the GFR concept.

2.10
WENRA
Western European Nuclear Regulator's Association

WENRA is a network of Chief Regulators of EU countries with nuclear power plants and Switzerland as well as of other interested European countries which have been granted observer status.

Its main objectives are to develop a common approach to nuclear safety, to provide an independent capability to examine nuclear safety in applicant countries and to be a network of chief nuclear safety regulators in Europe exchanging experience and discussing significant safety issues.

2.11
ITER
International Thermonuclear Experimental Reactor) is an international nuclear fusion research and engineering project, which is currently building the world's largest and most advanced experimental TOKAMAK nuclear fusion reactor at the Cadarache facility in the south of France. The ITER project aims to make the long-awaited transition from experimental studies of plasma physics to full-scale electricity-producing fusion power plants. The project is funded and run by seven member entities — the European Union (EU), India, Japan, China, Russia, South Korea and the United States. The EU, as host party for the ITER complex, is contributing 45% of the cost, with the other six parties contributing 9% each.

The ITER fusion reactor itself has been designed to produce 500 megawatts of output power for 50 megawatts of input power, or ten times the amount of energy put in. The machine is expected to demonstrate the principle of producing more energy from the fusion process than is used to initiate it, something that has not yet been achieved with previous fusion reactors. Construction of the facility began in 2007, and the first plasma is expected to be produced in 2019.

2.12
PFBR[1]
A breeder reactor is a nuclear reactor capable of generating more fissile material than it consumes because its neutron economy is high enough to breed fissile from fertile material like uranium-238 or thorium-232. Breeders were at first considered superior because of their superior fuel economy compared to light water reactors.

2.13
RJH
Réacteur Jules Horowitz

RJH is a 100 MW research reactor, dedicated to irradiation experiments on materials and fuel for present and future generations of nuclear power reactors. It is under construction in CADARACHE, France, to be operated from 2016 on by the Commissariat à l'Energie Atomique et aux energies alternatives (CEA), the French agency in charge of the R&D in the nuclear area. RJH is financed and will be operated in the framework of an international consortium gathering ten participants, from both public agencies and industry.

2.14
ALFRED
Advanced Lead Fast Reactor European Demonstrator.

The LFR demonstrator ALFRED is planned for a power of about 100 MWe and to be connected to the grid. The realisation of the LFR Demonstrator ALFRED will include several phases (2010-2025): conceptual design, decision point (2013), detailed engineering, construction of components and civil engineering, on site assembly and commissioning. Romania has offered to host ALFRED

2.15
GIF
Generation IV International Forum

The Generation IV International Forum (GIF), was chartered in July 2001 to lead the collaborative efforts of the world's leading nuclear technology nations to develop next generation nuclear energy systems to meet the world's future energy needs.

2.16
GEN IV
Generation IV nuclear energy systems are future, next-generation technologies that will compete in all markets with the most cost-effective technologies expected to be available over the next three decades.

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[1] From Wikipedia, the free Encyclopaedia

Comparative advantages include reduced capital cost, enhanced nuclear safety, minimal generation of nuclear waste, and further reduction of the risk of weapons materials proliferation. Generation IV systems are intended to be responsive to the needs of a broad range of nations and users.

The Generation IV systems selected by the GIF for further study are:

- Gas-cooled fast reactor (GFR) which features a fast-neutron-spectrum, helium-cooled reactor and closed fuel cycle;
- Very-high-temperature reactor (VHTR) which is a graphite-moderated, helium-cooled reactor with a once-through uranium fuel cycle;
- Supercritical-water-cooled reactor (SCWR) which is a high-temperature, high-pressure, water-cooled reactor that operates above the thermodynamic critical point of water;
- Sodium-cooled fast reactor (SFR) which features a fast-spectrum, sodium-cooled reactor and closed fuel cycle for efficient management of actinides and conversion of fertile uranium;
- Lead-cooled fast reactor (LFR) which features a fast-spectrum, lead/bismuth eutectic liquid-metal-cooled reactor and a closed fuel cycle for efficient conversion of fertile uranium and management of actinides;
- Molten salt reactor (MSR) which produces fission power in a circulating molten salt fuel mixture with an epithermal-spectrum reactor and a full actinide recycling fuel cycle.

These systems offer significant advances in sustainability, safety and reliability, economics, proliferation resistance and physical protection.

2.17
Code
Document that gathers rules for the design, the supply of components, the construction process…, of specific equipment

2.18
SWOT
Strengths, Weaknesses/Limitations, Opportunities, and Threats analysis

SWOT analysis (alternately SLOT analysis) is a strategic planning method used to evaluate the Strengths, Weaknesses/Limitations, Opportunities, and Threats involved in a project venture. It involves specifying the objective of the project and identifying the internal and external factors that are favourable and unfavourable.

To perform the analysis, strengths must be understood as characteristics of the project that give it an advantage over others, weaknesses (or limitations) as characteristics that place the project at a disadvantage relative to others, opportunities as external chances to improve performance (e.g. make greater profits) in the environment and threats as external elements in the environment that could cause trouble for the project

3 Process set to perform the study

This study takes the opportunity of the work done by CEN/WS 64 on AFCEN's RCC-MRx code to analyze how an existing code for the design, construction of mechanical equipments of nuclear reactors can be modified, focusing on the needs of ESNII (Generation IV), and how this code may become an European code (on long perspectives) convenient for any type of Generation IV reactors. The Workshop activities also give information resulting from a practical experience of code elaboration as a common work between European stakeholders.

Proactive participation of the technical expertise centres and the manufacturing industry at large (pipes, welding, forging, vessels manufactures, high temperature operating industry) was also searched through the industry and standardization networks.

Furthermore, a broad internet consultation was organized in the beginning of the study on the current use of existing codes and the expectations for a unified codification process at an international level, at least European.

The duration of the study was fixed to 12 months starting from the date of signature of the contract with the European Commission.

The study was planned to be carried out in 5 steps:

- Step 1: Establishment of a Task group with members of the CEN/WS 64
- Step 2: Research of information and data collection for the first status on existing codes used in Europe for the design and construction of fast neutron reactors and their components and for the SWOT analysis
- Step 3: Feed-back of the CEN WS 64 as an « Europeanization exercise » as regards the rule-making process as well as the identification process of the needs for pre-normative R&D studies.
- Step 4: Research of information and survey for the feasibility of developing adoption of a European work on “Design and construction Code for Nuclear industry”
- Step 5: Communication on the results of the feasibility study

The Kick-off meeting of the study took place on January 17th, 2012 in Brussels. A task group "feasibility study" was set during the meeting. The members participating to this study were:

- LOUMETO Jocelyn - AFNOR
- NILSSON Karl-Fredrik - JRC
- LELIÈVRE Didier - AFCEN
- LAMBERTS Damien - SCK-CEN
- BLAGOEVA Darina - NRG
- COUPLET Damien - GDF-Suez
- SABBAGH Pascal - ESS
- WEYN - VINCOTTE
- SWINDELLS Norman - FERRODAY
- BUCKTHORPE Derek – AMEC

A first conference-call meeting was scheduled on February 10th, 2012 to:

- organize the future work and define practical aspects of the process,
- discuss and validate the questionnaire for the internet survey to gather information on the present use of the existing codes and on the expectations regarding the development and adoption of a European Code under the umbrella of CEN,
- discuss and validate the first framework of the documents,
- elaborate the list of existing codes to consider in the study,
- discuss the codes of this list on which the SWOT analysis had to be performed,
- discuss the type of input needed to define pre-normative or long-term R&D items to advocate.

On March, 14th, 2012 a meeting was held to:

- discuss the proposals derived from WS 64 for pre-normative and long-term R&D items,
- discuss and comment the on-going draft,
- discuss the SWOT analysis.

By June, 20th, 2012, a meeting was set to finalize the interim report, on the basis of:

- the definitive list of the task group members,
- the final SWOT analysis,
- a compendium of medium and long-term modification requests from CEN/WS 64 selected by the task group members.

On September 10th 2012 a meeting in conjunction with a WS 64 plenary was held to:

- discuss the results of the survey and its outcome,
- validate the recommendation concerning a next step to the work-shop 64,
- propose an business plan for a standardization structure if needed,
- discuss and validated the draft to be published,
- launch a 1 month approval ballot on the final draft and final proof-reading.

On October 2012, the comments received on the final draft were treated and the draft updated.

The final document was handed-over to European commission by the end of November 2012.

STEPS	M+1	M+2	M+3	M+4	M+5	M+6	M+7	M+8	M+9	M+10	M+11	M+12
Step 1: Establishment of a Task Force with the members of the CEN WS 64												
Step 2: data collection and SWOT analysis												
Step 3: Feed-back of the « Europeanization exercise »												
Step 4: information and data collection for the development and adoption of a European Code under the umbrella of CEN												
Step 5 : Communication on the results of the feasibility study												

4 List of existing codes

Design and Construction Codes provide a set of essential engineering tools for the design assessment and construction of systems components. They define the common reference between prime contractors, operators, designers, engineers, manufacturers, suppliers, inspectors and safety authorities. They take into account the quality level of equipment necessary to meet nuclear standards. Whenever new materials are used or loading and environmental conditions change, the design codes need to be modified and extended accordingly.

In the nuclear area, they define the quality level of equipment necessary to meet nuclear standards. Whenever new materials are used or loading and environmental conditions change, the design codes need to be modified and extended accordingly. Pre-normative research is required to advance existing codes and standards. The following sections list some of the Nuclear Design Codes used for current and new proposed reactors systems.

4.1 RCC-MRx (France)

The design and construction rules applicable to mechanical components of pressurized water reactors (PWR) nuclear islands (RCC-M) and of nuclear installations (RCC-MRx - applicable for high temperature structures and ITER vacuum vessel) are parts of the collection of design and construction codes for nuclear power plants edited by AFCEN. The scope of the RCC-M and RCC-MRx Codes is limited to mechanical components:

- considered to be important in terms of nuclear safety and operability,
- playing a role in ensuring safe containment, partitioning, guiding, securing and supporting,
- containing fluids,

such as vessels, pumps, valves, pipes, bellows, box structures, heat exchangers and their supports.

RCC-MRx was developed especially for Sodium Fast Reactors (SFR), Research Reactors (RR) and Fusion Reactors (FR-ITER); it can also be used for components of other types of nuclear facilities.

These codes gather the rules applicable to the design and manufacture of mechanical equipments submitted to high pressure, high temperature, corrosion by coolant, irradiation, etc.

The AFCEN code dedicated to PWRs (RCC-M) was formally accepted by the safety authority as references in the design and construction process for the French reactors. As regards the other types of nuclear installations, including reactors, no such acceptance was formalized. Although the RCC-MRx is favourably considered by the Authority, the latter insists in some cases on developing a specific safety demonstration for each equipment involved in the global safety of the installation, even if the rules of the code were applied for its design and construction.

While AFCEN Codes do not have the status of standards, they are based on existing standards and on nuclear industry practice, and provide additional information or clarification options for use in the civil nuclear industry. The benefit of feedback on nuclear design, construction and operational issues from its broad range of international membership, gained over the last 30 years, has helped establish AFCEN codes as the basis of construction and operating rules for nuclear power plants.

4.2 ASME III (USA)

At the beginning of the XXst century, after several steam boiler explosions in the United States (notably in the "Grover Shoe Factory" 58 deaths), the American Society of Mechanical Engineers (ASME) appointed a committee ?to formulate a standard specification for the construction of steam boilers and other pressure vessels and for the care of same in service?.

With time, these rules evolved into the Boiler and Pressure Vessel Code (BPVC) including section III dedicated to nuclear vessels (rules for construction of nuclear power plant components). The first edition (1915) was 114 pages long and the 2001 edition is about 16000 pages long, giving an idea of large amount of work and experimentation it contains. Here is brief history of its evolution.

1915: first publishing of "Rules for the construction of stationary Boiler and For Allowable Working pressures", design factor =5 (allowable stress = specified tensile /design factor). Section I for fired vessel, Section VIII pressure vessels (mainly for the petrochemical industry) 1942-45 World War II due to steel shortages the design factor is reduce to 4. This was justified (a posteriori) by the use of better material and improved non-destructive examination method.

1955: review aiming to reduce fabrication costs (design factor 3 or 3.5) mainly for the chemical industry (Section VIII). The safety was maintained by (what appears to be now the cornerstones of the code):

- Material selection ·
- Fracture toughness ·
- Rules for fatigue ·
- Extensive non-destructive ·

1963: Section III dedicated to the Nuclear industry is published with the Pressurized Water Reactor and Boiling water reactor in mind (T<800°F<430°C). It is basically a simplified version of Section VIII (only steam and water).

1976: issue of Criteria for the Design of Elevated temperature Class 1 components (effect of thermal creep) which will become subsections NH. Oak Ridge N.L. was developing breeder reactor at the time and was supporting this development.

1983: ASME Code is published in both metric units and US customary units (inch, psi) as previously.

ASME III was accepted by the Atomic Energy Commission (in 1963). It is now legally incorporated by reference by the United States Nuclear Regulatory Commission see: Title 10, Code of Federal Regulations § 50.55a Codes and standards*:" Systems and components of boiling and pressurized water cooled nuclear power reactors must meet the requirements of the following standards referenced in paragraphs of this section: The ASME Boiler and Pressure Vessel Code, Section III, Division 1 (excluding Non-mandatory Appendices),[1]".* Alternatives are accepted.

The last version was released in 2010+2011 addendum.

4.3 JSME (Japan)

Detailed Design and Construction Rules in Japan have historically been provided by the Japanese Government as part of a regulation system. In 1994 this changed and it was decided that the codes and standards produced by the Standards Development Organisations should be applied. A Committee was established within the Japan Society of Mechanical Engineers (JSME) in 1997 to provide technically sound Codes and Standards to protect people's safety from industrial hazards and to promote industrial development and a agreement was reached between the regulator and industry that the regulator should endorse and apply SDO codes and standards as part of their regulation of power plants in Japan. Since its foundation in 1997 the committee within the JSME has issued a number of JSME Standards covering Design and Construction of LWR's and FBR's, rules on pipe rupture, Wall thinning management, materials for nuclear facilities, welding, Spent fuel reprocessing facilities, nuclear storage, etc. which have been published as JSME Nuclear Codes. Some of these are counterparts to the ASME Codes and Standards such as JSME S NCI-2008 which are counterparts to the ASME Div III, Section 1 Rules.

JSME Nuclear Code editions are published every three to five years with addenda issued generally on a yearly basis. The JSME Nuclear Codes are subject to technical evaluation by the Japan Nuclear Energy Organisation (JNES) and endorsed by the Nuclear and Industry Safety Agency (NISA). The JSME Code organisation covers Mechanical and non-destructive testing, vessels, piping, pumps, valves, pressure testing, core support structures, surveillance testing. For the section on vessels, it covers class 1 and class 2 vessels, whereas other Codes such as ASME will have separate sections covering all components under each Classification. The designation for Class1 vessels in the JSME Codes is PVB-3000 compared with NB-3000 for Class 1 Design in ASME. With regard to rules on materials, design, fabrication, etc. the basic technical requirements are similar to ASME. When comparing allowable stresses the JSME and ASME have similar limitations. With regard NDE the JSME is slightly more restrictive in some areas and for examinations they are almost identical. Overall however the JSME Codes provide the same level of requirements as those of Western Codes such ASME particularly for Class 1 Components.

JSME committee has now established design codes for different technology:

- Codes for structural integrates and operational functions of equipment related to mechanical engineering
- Codes for Nuclear Power Generation Facilities
- Codes for Construction of Spent Nuclear Fuel Storage Facilities
- Codes for Other Nuclear Facilities

None of these codes are especially dedicated to GEN IV reactors and there are mainly in Japanese although some of them are available in English (e.g. "*Rules on Thermal Power Generation Facilities*",)

4.4 KTA (Germany)

In Germany, the Nuclear Safety Standards Commission (KTA) has the task to issue nuclear safety standards for topics in the area of nuclear technology. The KTA standards are issued where a consensus between experts of the manufacturers, the operators of nuclear power plants, authorized experts and state officials is apparent and supports their application. The KTA standards are published by the German authorities, are therefore required by federal regulation and thereby made into law. The standards are published online, too (www.kta-gs.de).

KTA design standards are generally compatible with the ASME Code but are restricted to specific systems of light water reactors. For example, KTA 3211.2 is restricted to design rules for pressure and activity retaining components and piping outside the primary loop for light water reactors. Here, activity retaining components are e. g. piping-systems or vessels, which contain radioactive fluids or steam.

KTA standards apply for specific systems of power plants and contain rules and regulations for specific subjects like materials or in-service inspection. A typical division of subjects is presented with the standards for Pressure and Activity Retaining Components of Systems outside the Primary Circuit.

Here, KTA 3211.1 details materials, KTA 3211.2 outlines design and analysis, KTA 3211.3 contains rules for manufacturing and KTA 3211.4 covers in-service inspection and operational monitoring.

However, not all KTA standards are divided in this manner.

4.5 PNAE (Russia)

Nuclear Reactors in operation in the Russian Federation and elsewhere in Eastern Europe are designed and constructed according to the Soviet (Russian) Codes PNAE with some changes used in a few countries (i.e. Czech Republic) where National Standards (i.e. N.T.D. in Czech Republic) are additionally introduced.

In the Russian Federation the nuclear power plant safety regulation system has a three level hierarchy structure, the first level relates to general principles and criteria, the second refers to Norms and Rules which are required to fulfil those principles and the third non-mandatory guidance. The Russian Norms PNAE are from the second level.

The Russian Regulations are contained in two regulatory documents concerning strength analysis, the Russian Norm PNAE G-7-002-86 "Regulations for Strength Analysis of NPP Equipment and Pipelines" and "Rules for Arrangement and Safe Operation of the Nuclear Power Plant Equipment and Pipelines" PNAE G-7-008-89. The main Norms for strength assessment are given in PNAE G-7 -002-86.

The rules relate to equipment and pipelines and are subdivided into safety classes (OPB-88/97). The Safety Classes are essential for determining other classifications (seismic, design, quality, etc.). The correlation of Safety Class to Design Standards, equipment qualification, quality assurance and In-service Inspection is done on a case by case basis during the design stage. However Safety Class 1 usually corresponds to quality and design group A. Safety Class 2 may belong to either group B or Group C dependent on other classification factors.

4.6 Codes used to other part of World: China, India, Korea...

ASME III and RCC-MRx are used in Korea, India and China (except for fast reactors).

India uses both RCC-MRx and RCC-M.

5 SWOT analysis

5.1 General

RCC-MRX and ASME III are the two main codes selected for future high safety classified mechanical components of nuclear installations and it was confirmed by the results of the survey.

- The French RCCM-Rx
  this code has been specially developed to suit with Sodium Fast reactors and RJH. Tests on material to found data have been specifically elaborate to insure the consistency of the code and its cover a wide range of safety equipment.

- The US ASME III
  it has the advantage of longer use and gathers important practical use's data. Its development involves a large number of experts worldwide and the code is very well-known by the users.

Both codes are available in English and have been selected by experts to be analysed through the SWOT procedure.

Moreover the other codes are mostly PWR oriented, often with a limited short-medium-term possibility of evolution (JSME, KTA), in particular in consideration of the public acceptance of nuclear activities in their original country, and also because they are oriented towards domestic application, sometimes not translated in any European language

2 brainstorming meetings have been necessary (on March 14th and June 20th 2012) to found consensus on main characteristics of each code as shown into the table below and experts finalised their analysis into the final report by focusing on:

- Complementary details on each code's characteristics

- Making a general assessment to both codes in order to be able to make a comparison

5.2 ASME III

	STRENGTHS	WEAKNESSES
Technical aspects (scope, requirements, technicity, etc…)	ASME is a worldwide engineering society focused on technical educational and research issues.	Irradiation effects are not taken into account. Not all corrosion effects are taken into account.
	Developed in conjunction with many experts from all parts of the nuclear and non-nuclear industry (utilities, designers, manufacturers, service companies, Engineering, Research Associations, Safety authorities, etc…)	Standards used are not in line with European Approach and EN but from the US.
	References an extensive list of US standards	The process has a legal basis in the USA and this could delay the introduction of some changes in the code
	Has a continuous and well organised procedure for updating and incorporating improvements	Developed for ASME materials. Not as prescriptive as RCC-M or RCC-MRx with regard to material or welding/filler material information. Differences of approach with RCC-MRx for high temperature application (ASME creep damage through the section; RCC-MRx creep damage at a point).
	Most of the background data is publically referenced	Originally developed for low temperature systems. Additions for high temperature added later as code case (for infrequent high temperature excursions) and then as separate section.
	Incorporates information feedback from users and from field experience	The ASME is less specific with respect to component design than RCC-M / RCC-MRx and leaves more responsibility to the owner (designer and/or manufacturer).
	Well established and proven methodology. Pioneered the Codes & Standards approach for Generation II and III nuclear systems	
Applicability (widespread use, handling, etc…)	Internationally known and accepted by worldwide users and manufacturers	Not currently developed for all Generation IV systems. Specific ASME Divisions are currently being developed for US preferred GIF reactors
	The ASME approach is of broad scope (developed from pressure vessel technology)	
	Not specific to one design. Covers a range of different Nuclear systems and types	
	No national regulation in conflict with the code in Europe	

	OPPORTUNITIES	THREATS
Environnement (Political, Incidents, etc…)	Scope for worldwide harmonisation with regard to methodology and materials information (openness to any worldwide experts)	Its systematic use may not be as easily supported at a European political level.
	Opportunities for European experts to participate in and enhance the development of the ASME Code in a direction more applicable to European application. Will also gain information to support development of a corresponding European Code applicable to European	Disadvantage for European industry as ASME requirements are centred on US based involvement. Effort put into ASME developments may only serve to enhance US based Industries.
Strategical aspects	large human, technical and research resources and facilities available in the US for European and harmonised developments	Developments are focussed towards US industry priorities and needs. European Industry priorities will take second place
	ASME Developments linked to GIF Research activities which is worldwide.	European Code developments not accepted by US or other partners where the demonstrator construction is not in Europe (e.g. European HTR vs NGNP) The choice of ASME III as European code may lead to dependence on US political decision

5.3 RCC-MRx 2010

	STRENGTHS	WEAKNESSES
Technical aspects (scope, requirements, technicity, etc...)	Developed by experts on design for nuclear components	Specific for some designs
	Feedback from the experience of French and Indian sodium fast reactors, (Phenix, Super Phenix, PFBR) and experimental installations (Rapsodie, OSIRIS, RJH…)	Developed by a limited number of parties
	Specifically developed for fast and experimental reactors, in particular as regards high temperatures.	Access to the raw data is difficult, lack of related publications
	Covers a wide range of safety related equipments and not only the pressure boundaries	Lack of reference to the details of the basic design rules
	Only code dealing with material irradiation and, for some materials, with creep and irradiation	Irradiation effects are not taken into account. Not all corrosion effects are taken into account.
	Provides rules related to buckling.	Mostly based on French technologies feedbacks
	Continuous and well organized procedure for updating and incorporating improvements, including the evolution of referenced standards.	
	Some material data come from specific test for the development of the code	
	All material data have formula allowing a programed computational assessment and enabling accurate calculation, use of spread sheet, etc…	
	References ISO and EN standards.	
	Developed for European materials.	
	All the material data are found in the same document	
	Provides guidance for non-elastic assessment with supporting material properties for cyclic analysis	
	Self-supported code requiring limited complementary specifications.	
Applicability (widespread use, handling...)	RCCM-R and RCC-Mx (basis of RCC-MRX) is already applied in some European countries and in India	
	Selected code for all ESNII reactors, RJH, ESS, ITER and the Indian PFBR program	
	Possibility to widen the scope of the code to new equipments through probationary phase rules.	

	OPPORTUNITIES	THREATS
Environnement (Political, Incidents, etc...)	Wish from EC to develop European standards	Acceptance out of France
	Unique code for industry that could be the basis of an European code	Not validated by safety authorities
	No national regulation in conflict with the code in Europe, possibility to take specific regulations into account in dedicated appendices	Driven by some commercial interest (lack of presence of various stakeholders)
	Possibility to take long time factors (e.g. development of knowledge) into account	Relies on AFCEN policy
Strategical aspects	AFCEN support to make it used by a larger number of stakeholders beyond Europe	Relatively few organizations involved in the development of the code
	ESNII support to have common rules for industry	European Code developments not accepted by US or other partners where the demonstrator construction is not in Europe (e.g. European HTR vs NGNP)
	EC support to make it European code	Possibility to widen the scope of the code to new equipments through probationary phase rules but may cause potential safety issue
	R&D support available in French CEA (one of the leading research centres in the world in nuclear energy area)	
	Benefits from European research programs and from GIF Research activities	

5.4 Analysis

The 2 SWOT analyses brought valuable information on both design codes that confirmed that clear advantages of using RCC-MRx as document on which the "*Europeanization* exercise" will have to be performed:

- The main reason, RCC-MRx is a code specific to GEN IV and research reactors
- It is the most used by research centre and is the most adapted to handle future reactors needs
- Important European nuclear projects feedbacks were the basis of its development
- For now it is development by a fewer number of parties than for ASME III but collaborations are already set by AFCEN with different countries worldwide (India in particular) and the Europeanization process will get involved more European parties
- It is not dependent on non-EU countries

The identified weaknesses can be reduced by this Europeanization through:

- Increase the number of involved organizations and countries into the development of the code
- Expand the code to other reactor types
- Opportunity to improve the traceability of data

6 Focus on RCCM-Rx 2010 – Europeanization process

6.1 General

6.1.1 Identification of stakeholders

The proposers of this Workshop are:

— AFCEN and AFCEN members,

— Stakeholders of SNETP task force for ESNII,

The identification of the stakeholders of the feasibility study was based on the members list of the **CEN WORKSHOP 64** on "***Design and Construction Code for mechanical equipment of innovative nuclear installations (European Sustainable Nuclear Industrial Initiative)***", from the CEN-CENELEC focus group on Nuclear Energy. It was completed by contacting industries involved in the nuclear industry as providers (e.g.; Vallourec or Nucleopolis), technical supports (Institut de soudure) or regulators (ASN). Only some organizations already involved into the Workshop 64 accepted to participate to the task-group.

Furthermore, the CEN-CENELEC focus group on Nuclear Energy launched from early February to mid-April both to its members (see annex 2) and CEN-CENELEC member bodies an enquiry on standardization needs for Nuclear Energy and a specific question was dedicated to the feasibility study (see annex 1).

Structure	Status	Involvement		
		CEN/ WS64	Feasibility Task-force	Survey[2]
AFCEN	Technical Committee	X	X	X
AFNOR	National committee, National Standards Body, Technical Committee	X	X	X
AMEC	Vendor or manufacturer	X	X	X
ANDRA	Vendor or manufacturer			X
ANSALDO NUCLEARE SPA	Research organization or University	X		X
AREVA NP & TA	Nuclear Power Industry, Utility	X		X
ASN	Regulator			X
BNEN	National committee, National Standards Body, Technical Committee			X
CEA SACLAY	Research organization or University	X	X	X
CEA DAM	Research organization or University			X
DGCCRF	Regulator			X
DIRECTION GENERALE DES	Regulator			X

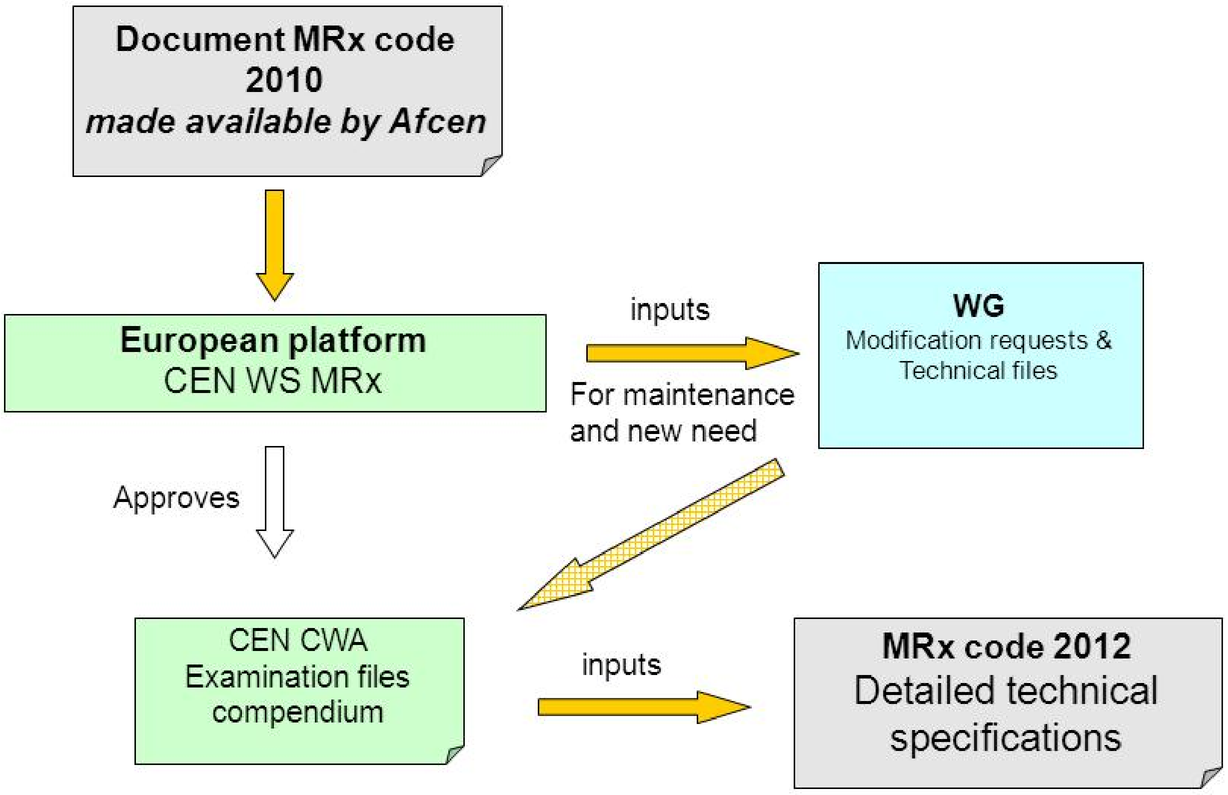
[2] Organizations that have received the questionnaire.

Structure	Status	Involvement		
		CEN/ WS64	Feasibility Task-force	Survey[2]
DOUANES ET DROITS INDIRECTS				
EDF SEPTEN	Nuclear Power Industry, Utility	X		X
EICHROM INDUSTRIES	Vendor or manufacturer			X
ENEA	Research organization or University	X		X
EUROPEAN COMMISSION/JRC	Research organization or University	X	X	X
EUROPEAN SPALLATION SOURCE ESS AB	Research organization or University	X	X	X
FERRODAY LIMITED	Vendor or manufacturer	X	X	X
GDF SUEZ	Nuclear Power Industry, Utility	X	X	X
GIIN	Nuclear Power Industry, Utility			X
INSTITUT DE LA SOUDURE	Technical support			X
IRSN	Technical support for the regulator			X
ITER ORGANISATION	Research organization or University	X		X
KIT - KARLSRUHER INSTITUT FUR TECHNOLOGIE	Research organization or University	X		X
LCIE LANDAUER SAS	Vendor or manufacturer			X
MIRION TECHNOLOGIES	Vendor or manufacturer			X
NRG - NUCLEAR RESEARCH & CONSULTANCY GROUP	Research organization or University	X	X	X
NUCLEOPOLIS	Representing providers for the Nuclear industry			X
RESEARCH CENTRE REZ	Research organization or University			X
SAPHYMO				X
SCK / CEN	Research organization or University	X	X	X
SERVICE COMMUN DES LABORATOIRES, SCL VILLENEUVE D'ASCQ	Technical support for the regulator			X
SIS	National committee, National Standards Body, Technical	X		X

Structure	Status	Involvement		
		CEN/ WS64	Feasibility Task-force	Survey[2]
	Committee			
SMITHS HEIMANN SAS	Vendor or manufacturer			X
UNM	National committee, National Standards Body, Technical Committee			X
UTE	National committee, National Standards Body, Technical Committee			X
VALLOUREC	Vendor or manufacturer			X
VINCOTTE	Vendor or manufacturer	X		X

6.1.2 Workshop process

The process to produce the CEN Workshop Agreement schematized in the following diagram:



6.2 Outputs of the Europeanization process

The workshop 64 focused on drafting a technical document that gather Modification Request Files received from the users of the AFCEN RC-MRx code.

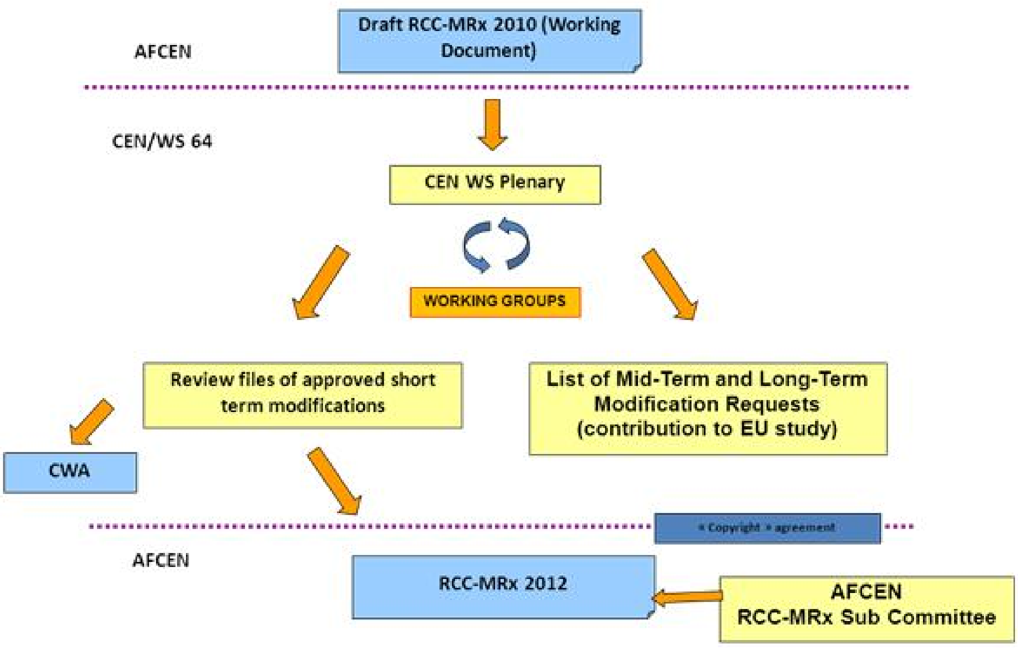
34 requests for modification to be made to the RCC-MRx were received by the Workshop 64 members. They have been discussed and sorted by the working group into 4 categories:

- 20 short-term modification requests to be implemented into the 2012 version of code,
- 7 medium-term modification requests that will need further pre-normative research that would be either on data or on tests and experiments
- 1 request was considered as long-term issue to be considered for deeper R&D projects
- 5 requests were rejected for different reasons

In parallel, a task- was created in order to draft a document that will be a feedback of the shared experience from the Europeanization exercise that constitutes the Workshop 64.

The feasibility study draft report have been made available on Internet to promote collaborative work between task-group member who could bring their input directly on the document, at any time: http://ws64nuclearcode.afnor.org

6.2.1 Implementation into the RCC-MRx 2012



As stated into the Workshop 64 business plan, all the Requests for Modification that are validated by the Workshop's participants have to be endorsed by the AFCEN sub-committee in order to be included into the published RCC-MRx 2012 version.

6.2.2 Workshop Agreement Contents

The final draft CEN Workshop Agreement (CWA) contains the complete set of Modification Review Files of the validated request for modifications to be included into the RCC-MRx 2012 section 2 and RCC-MRx 2012 section 3.

6.3 Feedbacks and experience learned from CEN/WS 64

The process proposed in the Business Plan was applied as much as the tight project scheduling allowed it.

Initially, 4 specific Working Groups, respectively on “Design rules”, “Materials specifications”, “Tests and non-destructive examinations”, “Welding and Fabrication (Manufacturing)”, were proposed in the Business Plan. Eventually, only one Working Group was actually constituted as most modification proposals dealt with design rules and/or materials specifications.

The proposed documents to be reviewed were transmitted by the requesters before each meeting and thorough technical reviews of these documents were performed by experts, and for the most obvious ones, the working group' convenor dealt with before acceptance by the working group. AFCEN through the convenor was responsible to perform full technical review of the proposals before inclusion into the code RCC-MRx.

The workshop gathered 14 registered members, among which industry and research bodies were roughly equally represented. The members came from 5 European countries and 3 international organizations. Although France was the most represented country in the Workshop, the modification proposals it reviewed arose from almost all represented countries.

10 meetings were organized, among which 5 were technical meetings of the Working Group. The attendance was always significant and the technical discussions and exchanges were kept at a good level.

34 modifications of the RCC-MRx were proposed by the Workshop 64 members, which can be considered as indicative of a strong implication.

Multiple reviews of the proposed Modification Requests during each meeting served as one main quality control indicator and the work took advantage of the careful proof-reading of an English participant.

Among the proposals, 5 were rejected, either because they lacked technical justification or because they dealt with topics that appeared out of the scope of the code. 7 proposals were sorted as possible medium-term modifications as they require further pre-normative research either on data collection or on tests and experiments, 1 proposal was sorted as possible long-term modification as deeper R&D program is necessary to support it as a modification request.

Finally, 20 modification requests were reviewed and approved by the Workshop as suitable for integration into the 2012 edition of the code. Their review files constitute the workshop agreement (CWA).

Nevertheless, some drawbacks of the process were identified, mostly resulting from the limited manpower available in AFCEN in the first place, and very likely in the other member companies. Main improvable points were the raised:

— as the modifications approved by the Workshop have to be integrated in the AFCEN code, a formal endorsement by the AFCEN subcommittee was required. This partly involves a duplication of the work carried out in the Workshop,

— Decrease of the attendance during meeting: the fact is that many workshop members did not have formal Request for Modifications for immediate discussion,

— the possibility to convene frequent meetings with all the Workshop participants is limited, the formal consensus on numerous proposals seems difficult to achieve rapidly.

— very few participants had on-going projects. The modification proposals are therefore abstract or theoretical, with no (or not enough) experimental data to support them. This appears clearly in the ratio of modification proposals that were not sorted as “short-term, suitable for integration in the RCC-MRx” by the Workshop. This is even clearer if one considers that, among the approved modification requests, a great part deals with corrections of already existing rules.

General appreciations were received from participants to the Workshop 64 who considered that participation in the CEN 64 Workshop and in the Feasibility Study has been a very positive and rewarding experience. There was willingness on the part of AFCEN to listen to advice from the European membership of the workshop and to accept contributions for additions and changes to the MRx Code. This experience should be the basis of further developments of the Code to reflect the wider knowledge to which this collaboration would then have access.

If the AFCEN Code is to be accepted – in near future – as the reference European Code then a European and even an International participation and contributions to its further development will have to be managed on a continuous basis.

7 Identified itemrs for pre-normative and R&D investigation

7.1 General

A major difference between the design of nuclear and non-nuclear mechanical components is that their design life is much longer and that they are submitted to additional requirements.

As the design and construction of nuclear reactors constitute a very large part of the cost of nuclear energy, there is a trend to increase the design life of future nuclear reactors to at least 60 years.

Moreover nuclear components are exposed to severe conditions that may induce specific long-term degradation mechanisms, in particular irradiation damage but also corrosion of the structural materials by the coolants. Compared to present reactors, the future fast neutron reactors structural materials will suffer significantly higher irradiation damages, higher temperatures and will possibly be on contact with coolants for which the degradation mechanisms are not well understood.

A major challenge is therefore how to take into account these conditions for which there is no direct experimental data to anticipate slow degradation mechanisms and predict the end-of-life material behavior when exposed to harsh conditions.

The main degradation mechanisms are the following:

— ductility and fracture toughness reduction resulting from irradiation damage;

— creep and creep-fatigue but also long term microstructural changes (thermal ageing) due to high temperature;

— stress corrosion and liquid metal corrosion induced by the interaction between coolant and the structural materials.

These degradation mechanisms interact so that the key material properties, i.e. fracture toughness…, are affected in long-term processes that strongly depend on the materials detailed composition, in particular alloying elements, but also on their manufacturing processes (heat treatment).

Targeted research that integrates experiments and modeling to predict the long-term material properties in order to transfer this information into the design codes is therefore the prime challenge.

This will require accelerated test, access to facilities where such tests can be performed and understanding of the basic mechanisms to extrapolate the results of accelerated tests to the operational conditions. For instance creep mechanism at high temperature or stress is often resulting of glide and climb of dislocations whereas at lower temperature and stress levels it would be diffusion-governed. In this case, an extrapolation of accelerated tests data based on a specific mechanism would be non-conservative. Thus targeted research to model the relevant processes at the appropriate size and time scale by physics-based models is necessary in combination with methods to link the different scales, often referred to as multi-scale modeling. Accelerated test techniques and physics-based models to extrapolate date to operational conditions is necessary for long-term performance of existing materials already qualified for nuclear applications but would be even more important for assessing new materials and new generations of existing materials.

As design rules need to be robust and simple to use, they are primarily based on elastic calculations and defect free components. Various factors and safety margins are then used to account for inelastic features.

Research to account for inelastic effects and defects, in a way that make it possible to include such effects in the design codes to optimize design without sacrificing safety is also a major issue. As an alternative to deterministic assessment and safety margins, it is also possible to adopt a probabilistic approach. This can provide a better understanding and quantification of safety margins and lead to more optimized design.

Most of the GEN IV reactor concepts use other coolant fluids than water. In the objective of a safe long-timelife operation of these reactors, **the issue of the corrosion of structural components by these fluids has to be addressed in terms of R&D**. This is particularly crucial for liquid metal cooled reactors

7.2 Effect of environment

7.2.1 Corrosion by coolant

Most construction codes consider corrosion as uniform in the component lifetime and specify a corrosion allowance, i.e. an additional thickness of material that is sacrificed during the lifetime of the component, to be foreseen by the design engineer. Some more guidance is available concerning inter-granular corrosion prevention: material selection and post-weld heat treatment, etc. However the available information concerning corrosion is limited. For example ASME III (ed. 2004) div1 the "non-mandatory appendix W: Environmental effect on Components" is only 27 pages long (out of many thousands of pages for the entire document). The appendix is mainly descriptive and gives guidelines. The lack of information is striking given that corrosion is an important issue for ageing nuclear installations [19]. Indeed corrosion damage prevention is much a broader issue not only involving construction rules but also operating condition (mainly coolant chemistry) and In-Service Inspection (ISI) programs.

Implicit hypotheses with regards to the structural integrity are made when using these construction codes:

1) the structural material, on contact with the coolant, has the same behaviour as in air except the depletion of the corrosion allowance,

2) any flaw, local corrosion, local thinning, will be detected by ISI before defects become critical (limited corrosion speed),

3) the chemical composition of coolant stays within the requested range all over the system (at least the safety related part),

4) defaults in the coolant chemistry control system that could cause high speed corrosion are detected soon enough to take corrective action (even just before ISI).

For usual coolants like water (even borated water) these assumptions are correct, even if some faster than expected degradation may still occur [20], [21], [22]. They must be confirmed for other coolants planned to be used in GEN IV systems.

7.2.2 Liquid metal

The Uniform Liquid Metal Corrosion (LMC) is concerned by three main mechanisms: oxidation, dissolution, and erosion. Oxidation is the operating LMC mechanism. These phenomena might be worsened by local effect crevice, stress concentration, fretting. And interaction with other damage mechanism like fatigue, creep, and plastification.

7.2.3 Sodium

In EBR II no corrosion was found after 35 years of service. It seems that as long as you are using stainless steel and as long as chemistry control is stringent (Oxygen, Carbon) together with good cleanliness (RCC requirement) corrosion is barely evident. The chemistry control is "relatively simple (compared to other types)" is just a cold trap where sodium oxide is precipitated as oxygen has to be kept low (see: FBR primary sodium chemistry control) control approach and experience [23]

The implicit hypotheses are then fulfilled. Furthermore the cleaning of sodium wetted components is feasible. Visual inspection can be carried out with usual means including direct visual inspection with the naked eye. The corrosion prevention philosophy is to reduce the oxygen content in order prevent oxidation. Then, there is no oxide layer development on the wall material. When the proper materials are used, their dissolution is very slow (even negligible) if the bare metal is in contact with the coolant. One drawback is that when two bare metal surfaces come into contact, it causes seizure galling sticking if their material is the same (or even alike).

In 1987, a significant corrosion problem occurred in Super Phenix fuel storage tank. The analysis of this event showed that the tank material carbon steel was not adapted for this use. Furthermore, as it happened shortly after the beginning of operation, an improper cleaning was strongly suspected as caustic corrosion due to NaOH after insufficient cleaning before reuse of heat exchangers was reported on other sodium cooled reactors (Phenix, FPR, BN 350).

7.2.4 Lead bismuth eutectic (LBE)

At the moment (2012); there is no licensed nuclear reactor using LBE (licensed to present understanding of a safety authority).

The soviet nuclear submarines that used LBE were developed as "cold war fighter interceptor" to dash out and kill the imperialist nuclear ship (before he was able to launch a nuclear strike on your fatherland).

The pioneering spirit of period could be even felt in [24]: *"The operation experience also accompanied by the number of accidents which are inevitable for any new technology mastering (the history of technique has demonstrated it) and revealed the difficulties of servicing these RIs(Reactor Installations) at their base places and refueling has received inconclusive assessment by the expert, who have been familiarized with it more or less "*.

This was especially true for first submarine K27 (Commissioned in 1963) of this type with improper chemistry control (air ingress) In 1968: the core was plugged by the oxides and products of steam/water interaction causing core partial meltdown. The lessons learned from K27?s troublesome history were used in the design of the 705 submarine (known in the west as Alfa sub.).These were more successful in terms of reliability: 7 submarines were built "only" 2 suffered accident (in less than 20 year): In 1971: damage to the primary circuit pipelines due to corrosion at their outer side resulting in radioactive coolant leakage. In 1982: global corrosion damage of the steam generator (SG) tube bundle caused by poor quality of feed water; ~ 150 L of radioactive coolant leaked into the compartment due to personnel errors. These 2 accidents seemed to be caused by the corrosion but on external side due to water (1971) and on the secondary water side (1982).

According to the Russian experience the basic factors ensuring high corrosion-erosion resistance of structural materials in heavy liquid metal coolant (Pb, Pb-Bi) are as follows:

- use of silicon alloyed steels;
- passivation by oxygen using special regime of coolant;
- using additional corrosion barriers such as oxide films formed on working surfaces of circuit components under reactor start-up conditions.

Nevertheless it is difficult to judge the Russian experience as they carried out very few inspections and part of this experience is still a military secret.

Regarding corrosion prevention philosophy, the LBE contains sufficient amounts of oxygen that result in the formation of an oxide scale on the steel surface. Ideally, this oxide scale should be protective and 'self-healing', thus hindering the further attack of the steel during its long-term use. On the contrary, if the steel service conditions do not allow the formation of a stable oxide scale on the steel surface, for example at high temperatures and/or low liquid metal oxygen concentrations, dissolution becomes the prevalent LMC mechanism. Dissolution occurs due to the high solubility of certain alloying elements (i.e., Ni, Cr, Fe) into the liquid LBE and it is followed by liquid metal penetration and ferritization of the dissolution-affected zone in austenitic 316L stainless steels. Erosion is the mechanical ablation of the steel during its exposure to the flowing liquid metal: it may become severe at high flow velocities, in cases of two-phase flow (e.g., when solid phases, such as PbO particles, are present in the liquid metal), and/or at sites of flow instability. High flow velocities lead to fast oxide scale removal, establishing a very aggressive erosion-corrosion type of HLMC. Local corrosion problem are also likely to occur. The main goal of the coolant chemistry control system is to maintain oxygen levels sufficient to keep good oxide layer passivation and, in the meantime, low enough to avoid the formation of slags (lead oxide). Its secondary function is to capture low freezing intermetallic or oxide compounds (cold trap).

Phenomena like Liquid metal embrittlement could change the mechanical properties of ferritic martensitic steel (According to " Handbook on Lead-bismuth Eutectic Alloy and Lead Properties, Materials Compatibility, Thermal-hydraulics and Technologies" [2]), meaning that hypothesis 1 is invalid. In this case we have 2 options:

1) The code should restrict material choice to materials not affected by change in proprieties due to LBE interactions or that could be safely protected against these detrimental effects.

2) The code is completed with the modified material prop (of course when mat prop are acceptable for the use in nuclear component (e.g. Ductility is still satisfactory.)). But this addition needs a lot of testing (in different conditions) so that it could have the required quality to be implemented in the code.

Proper In service inspection methods are still to be adapted and our invented for LBE. The cleaning of LBE wetted component is not yet developed to sufficient scale (at moment tensile sample) new types of damage, like fertilization are to be detected by non-destructive inspection (at the moment micrograph is used but this requires cutting through the component) the validation of hypothesis 2 needs some R&D.

As diffusion speed of oxygen in LBE is very slow, area where flow is stagnant should be avoided.

Under abnormal condition, such as a fault in oxygen control, LBE corrosion could be rather fast. This type of safety problem is still to be investigated in depth before drawing any conclusion.

7.3 Design rules

7.3.1 General

The aim of this item is to state on the Inclusion of long-term material properties and degradation mechanisms for which there is no direct experimental data. This could be in form of material curves form accelerated data extrapolated to the operational conditions, but it could also be in form of Design rules for how extrapolation for how a specific materials property and a given class of materials could be done.

This is both medium and long-term research. Medium research includes how to address cyclic softening for ferritic-martensitic steels for ratcheting, creep and creep-fatigue. To assist extrapolation for high temperature applications it would be worthwhile to explore the possibility to construct deformation and fracture maps that maps the different mechanisms to with respect to stress and temperature.

7.3.2 Inclusion of environmental effects in the Design Code.

This refers both to material curves and design factors. This is an urgent need for lead and lead-bismuth reactors and the first steps should be a medium term programme.

7.3.3 Development and inclusion of higher-level design rules that allow for in-elastic design and defect assessment.

Models exist already and methodologies developed in the R5 and R6 assessment codes could be used as the basis for a medium term objective.

7.3.4 Extension of the actual design rule to proton damages (Request from CEN/WS 64 – MR 25)

RCC-MRx is based on neutron irradiation only. However, spallation sources and accelerator are subject to proton irradiation that shows harder embrittlement than pure neutron irradiation. In order to use this design standard in this kind of environment, it would be useful to add special rules for this kind of irradiation.

7.3.5 Titanium Ti6Al4V Material data (Request from CEN/WS 64)

Titanium is a material that is more and more used in a nuclear environment. Besides its good mechanical properties in term of strength, it is lighter, less sensitive to heating by particles... than steel for example.

In order to take advantage of this material, basic material properties as well as irradiated material properties has to be investigated.

7.3.6 Missing 18AS irradiated material data – T91 (18AS) Stainless steel (Request from CEN/WS 64 – MR 06)

To consider this request into RCC-MRx a deep investigation is still to be carried on.

T91 is the preferred steel choice when being in contact with liquid metal like lead-bismuth. This material has for example been used for the MEGAPIE project. T91 is present in the RCC-MRx design code (18AS), but only for not irradiated state. However, as this material is often used to be a structural shroud, irradiated material data are needed.

7.3.7 Cryogenic aluminium alloy material properties and Design rules (Request from CEN/WS 64 – MR 07)

There is a lack of data on material properties and design rules related to cryogenic applications:

- For temperatures higher than 20°C, characteristics are given in RCC-MRx, appendix X3.1A
- For temperature lower than 20°C, no data in the code
- For tensile and yield properties (Rm, Rp), which are increasing when temperature decreases, the value at 20°C is kept,

Other characteristics have to be defined:

- Young modulus E,
- Thermal expansion,
- coefficients of linear expansion,
- Fracture toughness.

Some data are available (tests from Air Liquid, Thermophysical Properties of Matter de Y. S. Touloukian, etc…) but work has to be done to collect and to validate them to introduce them in the code.

7.3.8 Define criteria for tests: procedure, preparation, examination and acceptance (Request from CEN/WS 64 – MR 23)

Chapters RB 1213, RD 1213 are referring to RB 5000 for hydrostatic test specification, for which there is note: to be defined later. This is very important chapter and it shall be developed and included in RCC-MRx. similar chapter exists in RCC-M B 5000, in ASME Sec III Division 1 and 2, ASME Sec VIII Division 2. User of RCC-MRx shall prepare test specification based on general knowledge or existing codes which is not good. Test pressure is defined in REC 3257.4, but test procedure, preparation for testing, test examination and acceptance criteria are not defined in current version of RCC-MRx.

7.3.9 Data for neutron irradiation effect on mechanical properties are needed for A3.10S stainless steel – A3.10S Stainless steel (Request from CEN/WS 64 – MR 26)

X6NiCrTiMoVB25-15-2 structural hardening austenitic stainless steel property group A3.10S, product form forging and bar for bolting.

The following data are needed:

a) Irradiation conditions:

- Maximum dose – up to 1 (3) dpa
- Irradiation temperature – 100 – 350 C

b) Needed data:

- Negligible irradiation damages Dirneg dpa
- Irradiation creep – stress relaxation
- Properties for analysis – irradiation
  - conventional yield strength at 0.2 % offset rp0.2 (after irradiation)
  - tensile strength rm (after irradiation)
  - values of sem and set (after irradiation)
  - ductility characteristics (before and after irradiation)

7.4 Materials specifications

7.4.1 Research on how material compositions and microstructure affect the materials properties and degradation.

This will assist in development of new materials and modifications of existing materials. This could also be used to define the specifications and margins of materials. Probabilistic methodologies could also be used to provide guidance of material specifications.

7.4.2 Charpy Impact test after ageing (Request from CEN/WS 64)

This request aims to improve requirements on the use of KU specimens instead of KV to determine Charpy impact test after ageing.

Concerning the requirements for KV impact tests after accelerated ageing for austenitic stainless steel base metal (Tome 2 - RPS for X2CrNiMo 17-12-2 with nitrogen controlled) and austeno-ferritic stainless steel filler metal (Tome 4- RS 2700), they have been set in RCC-MR 2007 from KU requirements previously in the code (2002 edition and before); the conversion was established with a ratio surface factor. Today, in the frame of R&D Astrid Program, Charpy tests with both KU a KV notches are launched to validate and not the conversion factor used and the necessity or not to go back to KU impact tests after ageing (the AFCEN data base is filled with KU values). The Modification request is postponed (medium term) results will be obtained in 2013.

7.5 Tests and non-destructive examinations

7.5.1 Definition of criteria for tests: procedure, preparation, examination and acceptance (MR 23)

Chapters RB 1213, RD 1213 are referring to RB 5000 for hydrostatic test specification, for which there is note: to be defined later. This is very important chapter and it shall be developed and included in RCC-MRx. Similar chapter exists in RCC-M B 5000, in ASME Sec III Division 1 and 2, ASME Sec VIII Division 2. User of RCC-MRx shall prepare test specification based on general knowledge or existing codes which is not good. Test pressure is defined in REC 3257.4, but test procedure, preparation for testing, test examination and acceptance criteria are not defined in current version of RCC-MRx.

7.5.2 Development of accelerated tests and recommendations for how such tests should be used in order to predict long-term material properties and influence of extreme environments for which no explicit data exist (i.e. very high irradiation levels).

Such extrapolation requires that there is no a major shift in degradation mechanisms and that degradation mechanisms are understood. In the future it may be possible to monitor the degradation by non-destructive examinations and surveillance programmes. Such monitoring can be used as an additional measure to ensure that degradation does not progress faster than assumed by the Design Rules.

8 Field of interest for future standardization – result of survey

8.1 General – Survey on "Standardization Needs feasibility to develop standardized rules for the design and construction of Generation IV nuclear plants and equipment"

The main aim of this survey is the collection of needs on standardization and the view on existing codes from all stakeholders.

The questionnaire for the survey was discussed and validated by the task-group on February 10th 2012 (see annex C). An Internet address was widely circulated to nuclear field' stakeholders for this web-survey. 5 main fields of interest were to be covered:

— Utilization of existing design and/or assessment codes

— Needs for standardization in the field of design and construction

— Needs for better consistency amongst existing codes or needs for more generic documents

— Interaction with broader context

A specific section on the parallel "Survey on standardization needs for nuclear energy in Europe" launched by the CEN-CENELEC focus group (see annex 1) dedicated to the feasibility study bring also numbers of respondents from who 4 showed their interest for the results of the survey and 12 asked to be informed about the outcome of the whole study.

8.2 Description and method used for the survey

This feasibility study should investigate through a survey how a shared industrial experience in components design and manufacturing can lead to dedicated European Codes recognized internationally by a larger group of stakeholders.

A questionnaire was set by the task-group on "feasibility study" (see annex C) on February 2012 and AFNOR uploaded an Internet-based survey to ease replies from stakeholders and the collection of feedback data. The Web-link to the survey was widely distributed to CEN Workshop 64' members, ESNII members and all AFNOR's partners on nuclear field energy.

A first set of rough result was discussed on June 20th 2012 and it was decided to extend the survey for 2 months to have more feed-backs.

8.3 Summary of the responses on the Questionnaire on Standardization needs" in the field of Design code

Twenty replies have been received. For SCK-CEN, NRG, ASN and AFCEN there were two replies. Hence 16 organizations replied. The assessment is, however, based on the 20 replies. The respondents represent different types of organizations, but they only represent a small number of all relevant organizations. Thus one should be careful in drawing definite conclusions. Nevertheless, it is still possible to get some clear ideas.

The questions were organized under five topics, each with two or three sub-questions. The answers to specific questions were: ‘Yes’, ‘No’, ‘Not relevant (NR)’. In many cases there was ‘No answer’. For each question it was possible to provide a short justification for the answer.

Below is a very short summary of the answers.

8.3.1 Questions regarding your utilization of existing design and/or assessment codes and in service inspection codes in the field of Nuclear energy – (documents coming from IEC, ISO, ASTM, organisations, etc.)

a) Do you use design and/or assessment codes and in service inspection codes produced by national nuclear standards organizations of countries different from yours?

The answers – **12 "Yes", 1 "No" and 7 "Not Applicable**" – show that ASME and RCC-M/MRx were clearly the most used codes.

b) Are you aware of potential conflicts between national design and/or assessment codes and in service inspection codes in nuclear sector that are used in the nuclear energy sector in various European countries ?

The equally split answers – **7 "Yes", 6 "No" and 7 "Not Applicable**" – show half of the respondents claimed conflict. The stated conflicts were of both technical (e.g. inconsistencies between curve) as well as between code and regulation.

c) Do you have difficulties to use/comprehend existing design and/or assessment codes and in service inspection codes documents that would require interpretation and/or clarification?

There does not seem to be a serious problem with interpreting different codes as the results show – **4 "Yes", 7 "No", 2 "No response" and 7 "Not Applicable**". Some comments to 'Yes' were actually not related to the question. For instance that a certain code has limited elastic-plastic analyses or do not address the new possibilities from FE calculations.

8.3.2 Questions addressing the need for standards in the field of design and construction for nuclear equipment and components in Europe Pre-normative research (PNR) in a generic sense relates to activities which produce entry data as input for the standardisation process; PNR can relate to specific needs for research that would assist the standards making process or overcome problems that are preventing completion of their work.

a) Are there any needs for specific pre-normative research in support of standardization of an European standard for design and/or assessment codes and in service inspection codes?

With **9 "Yes", 2 "No", 2 "No response" and 7 "Non Applicable"**, there seem to be a strong support for pre-normative R&D, in particular with respect to long-term effects such as irradiation and environmental effects.

b) Do you think that the existence of a specific committee under the umbrella of CEN to deal with standards/documents for design and/or assessment codes and in service inspection codes will improve the efficiency of your project/work?

We cannot draw any clear conclusion based on the replies. With **5 "Yes", 5 "No" and 5 "Non Applicable",** the specific answers did not give any clear answers.

8.3.3 Questions addressing the need for a better consistency among existing codes as well as the need for applying "generic" codes to the nuclear sector

a) Have you identified existing codes (e.g.: RCC-MRx, ASME III, etc…) that can be used for design and construction that are mutually inconsistent or conflicting?

Those that answered **Yes – 5** – had opted for ASME. The most important conclusion is that it is relevant to have one code but most organizations had not yet made a final decision. 6 responded "No" and 9 "Not applicable".

b) From your experience, what is the main issue that could restraint to standardization of an European code on design and construction (difference in existing methods, difference in acceptable criteria …)?

Obviously many organizations see obstacles but they can be of quite different nature (cost for a European code, lack of harmonization between national regulatory requirements, political and commercial interests, and difference in specific technical criteria). The restraints are negative which can be interpreted as a support to a European code.

c) How does the lack of a unique European code impact your activities in foreign countries?

Incoherence in codes is a problem but the solution is not necessarily a European code as the responders stated (**6 "Yes, 7 "No responses" and 8 "Not Applicable)**

8.3.4 Questions related to the interaction with the broader context

a) What are your national regulations which can interact with the existing design and/or assessment codes and in service inspection codes?

No clear conclusion can be drawn from theses replies. First of all not many answers (10) and for **Yes (7)** it is not clear if the interaction is positive or negative and **3 did not answer and 11 stated the questions being "Not Applicable"**.

b) What are the main European regulations in force or under development which can interact with the existing design and/or assessment codes and in service inspection codes?

4 responders stated "Yes" but there seem to be no major regulation from Europe. Pressure Equipment Directive was mentioned. 13 "No Applicable" and 3 "Non responses" confirmed this conclusion.

c) What are the multinational agreements (e.g. non-proliferation treaties, agreements between the European co-operation for Accreditation (EA) and international accreditation bodies, use of ISO/IEC/EN 17000 series) in force or under development which can interact with the existing design and/or assessment codes and in service inspection codes?

Multinational agreements do not seem to interact too much – **3 "Yes" for 4 "Non responses" and 14 "Not Applicable"** –. At least it seems not to have a negative effect. ASME and OECD’s MDEP were mentioned.

8.3.5 Other Questions

a) Are you currently participating in nuclear energy code development?

Most organizations (**8 out of 20 responses**) are involved in code development in general (AFCEN, CEN WS, RCC-M, ASME etc). This possibly also applies to most that did not provide and answer.

b) Do you think that participation in standardization is important for your company or organization because of its impact on and benefits for your business?

It is clear that for most organization standardization is a major issue (**9 "Yes" out of 20 replies**) and, more important is that no organization replied "No". There is a clear need for standardization.

8.4 Analysis of the results (rough data Annex C)

8.4.1 General and caution

The Survey respondent's data are summarized henceforth. In total 20 responses were collected from 16 organizations as a result of the study.

From the organizations participated in the study, the major input of 37.5 % (6 responses) was contributed by Research Organizations or Universities, followed by National committee/ National Standards body/ technical committee, providing 25 % (4 responses) of the feedback received. Regulators were represented by 18.8 % (3 responses), vendors/manufactures - by 12.5 % (2 responses). The representation of Nuclear Power utilities and certification and accreditation bodies was equal to 6.2 % (1 response). 12.5 % (or 2 responses) of the input was given by other organizations. No feedback has been obtained from technical supports for regulators, transport providers and insurance companies.

Five groups of questions regarding the utilization of the existing design and/or assessment codes and in-service inspection codes in the field of Nuclear energy were asked and the feedback for each of them is evaluated hereafter.

8.4.2 Questions regarding your utilization of existing design and/or assessment codes and in service inspection codes in the field of Nuclear energy – (documents coming from IEC, ISO, ASTM, organisations, etc.)

a) Do you use design and/or assessment codes and in service inspection codes produced by national nuclear standards organizations of countries different from yours?

62.5 % (10 responses) of the respondents claim that they use codes, produced by national nuclear standards organization of countries different than the respondent's one. 6.2 % do not use such codes and 5 % of the respondents did not provide any input. The majority of the questioned organizations is using ASME III (2004, 2010) design code and the French RCC-M, RCC-MR, RCC-MRx, RCC-Mx codes. The German KTA design standard was also mentioned by some of the responders. The R6 procedure - Revision 4 including amendment 8, 2010 (Assessment of the integrity of structures containing defects) was quoted once.

The major part of the questioned organizations is using different in-service / inspection codes, as: RSE-M (Rules for In-service Inspection of Nuclear Power Plant Components), ENSI Guideline B07 (Swiss Federal Nuclear Safety Inspectorate: Equipment qualification), KTA 3201.4 2010-2011 (Components of The Reactor Coolant Pressure Boundary of Light Water Reactors - Part 4: In-Service Inspections And Operational Monitoring), ASME XI (Rules for In-service Inspection of Nuclear Power Plants Components), ASME Section V-ENIQ (European Network for Inspection and Qualification) Methodology, NF EN 13445-5:2009 and NF EN 13480-5:2002 (Inspection And Testing standards).

b) Are you aware of potential conflicts between national design and/or assessment codes and in service inspection codes in nuclear sector that are used in the nuclear energy sector in various European countries ?

As regards to a potential conflict between national design and/or assessment codes and in-service inspection codes, used in various European countries, 37.5% of the respondents answered positively. A smaller fraction of the respondents (31.2%) is not aware of eventual conflicts and the same fraction (31.2%) considered the question as not-relevant. In particular, differences and conflicts are noticed in the sections dealing with piping systems; piping sizes, piping joints - flange designs; lack of some analysis considered mandatory by the respondents (e.g. ladle or chemical analysis, representative of a heat of steel as reported by the producer) was also mentioned. Another divergence between ASME and KTA codes pointed out in the survey is the different fatigue design curves for austenitic steels.

Detailed comparison between ASME, Section III and KTA codes variations is done in [17]. For instance, KTA has higher requirements for the stress intensities of Class 2 and 3 components, while the equations to determine stress intensities for Class 1 components are nearly identical in both codes and standards. The stress intensification factors differ also for piping analysis although the equations for piping in both codes are almost identical.

In [15] ASME Section III and the RCC-M are compared. Although the codes are similar (but not identical) and provide equivalent safety in operation, they have different approaches in ensuring compliance with technical requirements. The technical differences, as material limits, design approaches, welding qualification procedure and examination etc. are revealed in detail in [2].

Negligible creep is also treated differently in ASME and RCC-MR codes [17]. Differences in criteria levels, classifications of stresses, usage factors, rules for preventing P-type and S-type damage are also revealed in [16].

Differences in hydro-test qualification and testing, considering RCC-M code, ASME code, KTA code, Etc. are presented in [160].

The ASME versus RCC-M aspects in the new EPR builds on different locations (Olkiluoto 3, Flamanville 3, Taishan) is discussed in [16].

Conflicts are observed not only between codes themselves but also between codes and regulations. An example is given with France: "*no code is supposed to meet all regulatory requirements*".

Additionally, organization having its own codes is revealed in the survey, namely NIKIET (one of Russia's largest centres for nuclear engineering and technology). 11 RBMK reactors are built so far, using NIKIET code. The current R&D NIKIET programs include fast reactor concept with a heavy metal coolant (BREST), simplified vessel-type boiling water reactor with natural coolant circulation (VK-300), and advanced pressure tube reactor with inherent safety features (MKER).

c) Do you have difficulties to use/comprehend existing design and/or assessment codes and in service inspection codes documents that would require interpretation and/or clarification?

37.5% of the questioned responders do not have difficulties in interpretation and use of the codes; 31.2 % did not provide feedback and only 6.2% considered the question as not relevant. Still 25% of the responders encounter difficulties in the use and interpretation of the existing codes and claim that further clarification of the codes' documents would be required.

Terminology is one of the encountered problems, e.g. understanding of what 'radius of curvature' is in different languages might be different in Italian, French, English, German and Dutch codes. The suggestion for improvement is to illustrate additionally by sketches when doubts of misinterpretation exist.

Another problem faced by organization, operating different facilities is that the existing codes do not fully cover the running facilities: e.g. example is given with the physical parameters.

Limited support in performing plastic analysis, according to the ASME code is pointed out as another difficulty. Additional codes drawback, indicated in the survey is that the present codes are focused on using formulas rather than taking advantage of the Finite Element Methods (FEM) as an evaluation tool. FEM are used increasingly as a design and assessment tool and the up-to-date codes need to take FEM into consideration.

8.4.3 Questions addressing the need for standards in the field of design and construction for nuclear equipment and components in Europe Pre-normative research (PNR) in a generic sense relates to activities which produce entry data as input for the standardisation process; PNR can relate to specific needs for research that would assist the standards making process or overcome problems that are preventing completion of their work.

a) Are there any needs for specific pre-normative research in support of standardization of an European standard for design and/or assessment codes and in service inspection codes?

As regards the PNR, 43.8% of the respondents consider PNR is needed; 12.5% (2 feedbacks) think that there is no PNR need; 31.2% did not provide feedback and 12.5% consider the question as not relevant.

The respondents provided positive answer; claim a great need of PNR in support of a European standard. A PNR may be necessary as well to define or clarify rules to be inserted in an AFCEN code.

The Multinational Design Evaluation Programme (MDEP) initiated by the Nuclear Energy Agency (NEA) with the participation of 10 countries (Canada, China, Finland, France, Japan, Republic of Korea, Russian Federation, South Africa, United Kingdom, and the United States) is given as an example for PNR. It is a multinational initiative to develop innovative approaches to leverage the resources and knowledge of the national regulatory authorities who will be undertaking the review of new reactor power plant designs. The overall MDEP goals are increased cooperation and enhanced convergence of requirements and practices. MDEP accomplishments include: coordinated performance of vendor inspections, establishment of the MDEP library, development of common positions in the area of digital instrumentation and controls, and development of a comparison table which will identify the similarities and differences between the Korean, Japanese, and French codes for class I pressure vessels as they compare to the ASME code. EPR and AP1000 reactor designs are addressed in the program. Progress towards harmonized regulatory practices and requirements for Generation IV reactor design is foreseen as a natural outgrowth of the programme, as the participating regulatory authorities find that multinational cooperation and convergence of regulatory practices become routine elements of their planning and execution of new design evaluations.

It is noteworthy that 6 of the 7 countries actively participating in the Generation IV International Forum (GIF) are also MDEP participants. However, the respondent was not sure whether Gen IV concepts are included.

The lack of well characterized advanced materials for nuclear usage, as well as fabrication of heavy-section components out of these materials is identified as an important issue: mechanical properties as strength, creep, fatigue and other performance properties at higher temperatures, as well as thermal properties as capacity, emissivity, conductance will influence material choice in the new fast neutron systems to be built.

Long term thermal and radiation impact on material properties and other material aging effects need further research in case of GEN IV nuclear systems. Lack of materials test data under higher doses neutron irradiation, as well as environmental degradation impact on the material properties and component performance, also in synergism with the neutron embrittlement processes, is identified as a serious knowledge gap. For instance very few is known about the effect of corrosion-erosion in LBE or lead under intense neutron irradiation. How to address environmental fatigue, applied to European materials, and progressive deformation in a correct but not too conservative way are other examples of the scarcity of the present codes.

b) Do you think that the existence of a specific committee under the umbrella of CEN to deal with standards/documents for design and/or assessment codes and in service inspection codes will improve the efficiency of your project/work?

5 respondents out of 20 consider the existence of specific committee under the umbrella of CEN as necessary. It is believed that this would increase the efficiency and reliability of the ongoing projects, especially design projects involving collaboration between several European partners. In case of a European call for tender, the existence of an unified European design code would facilitate significantly the process.

AFCEN also supports European initiatives, like the WS64 currently in progress under the aegis of CEN, since this contributes to improve the AFCEN codes in a European framework. The specific committee can give a standardization of the European standards, solving interpretation problems with or lack of specific information. Additionally, an existence of a permanent committee is seen as helpful in continuous improvement of the standards, taken into account arising needs of designers and manufacturers.

8.4.4 Questions addressing the need for a better consistency among existing codes as well as the need for applying "generic" codes to the nuclear sector

a) Have you identified existing codes (e.g.: RCC-MRx, ASME III, etc…) that can be used for design and construction that are mutually inconsistent or conflicting?

A higher proportion from the respondents (9 replies) does not have an opinion; 6 respondents do not see any conflicts, but 5 recognizes mutual inconsistency or conflicts between the existing codes. In particular, inconsistencies and conflicts are found between ASME III and RCC-MRx, ASME III and NIKIET, ASME and KTA (fatigue curves in particular).

b) From your experience, what is the main issue that could restraint to standardization of an European code on design and construction (difference in existing methods, difference in acceptable criteria …)?

One of the main restraints pointed out by the respondents (9 out of 20 respondents) is the specificity and the lack of harmonization of regulatory national requirements. For instance AFCEN codes are used in different countries and this often leads to be compliant with various regulations. Consequently, AFCEN decided to include specific appendix in AFCEN codes to meet the national regulatory requirements. Another restraint may come from the standardization procedures that do not comply with the time management usually taken into account in code developments. As a matter of fact the latter are generally made in support of on-going projects that cannot afford to wait for large periods that a decision concerning technical rules is taken. Furthermore, AFCEN codes are used in several projects that are not solely located in Europe. Therefore, a European consensus could be of no interest if these projects are carried out in non-European countries.

Another restraint is financial: a multiyear EU-financed project with experts from a number of active countries, could resolve this problem. The acceptance of proven data and methodology is also a restraint: proven can be understood as accepted or could be accepted by the National safety authority, based on well referenced criteria.

As restraint, how to address the newly implemented code changes to the running existing installation is also given.

The acceptance criteria, material data, fabrication requirements, non-destructive examination requirements are given as an example of issues that could restraint to standardization of an European code on design and construction. A large part of the common code according to the survey participants could be shared and only "specific section dedicated to nuclear system types (e.g. pressurized or not, water or liquid metal etc.) can be developed.

c) How does the lack of a unique European code impact your activities in foreign countries?

Around one quarter of the respondents (5 replies out of 20) claim that the lack of a unique European code impacts their activities in foreign countries. In particular, significant problems were encountered when working and collaborating with countries implementing Russian codes (WWER), instead of RCC-M or ASME codes.

Big international projects as ITER and RJH and European projects like ALFRED, are given as examples where participants are required to use codes, different than the national ones, which also means additional costs.

The communication with the licensing authorities and providers (materials designation etc.) is not coherent according to the survey participants due to the lack of an unique European code.

Qualifications of inspection Techniques are also NOT always accepted due to differences in National Regulations, which can be avoided with the introducing of an unique European code.

8.4.5 Questions related to the interaction with the broader context

a) What are your national regulations which can interact with the existing design and/or assessment codes and in service inspection codes?

Only 4 of the respondents indicate an interaction between the national regulations and the existing design and/or assessment codes and in-service inspection codes. The Swedish Radiation Safety Authority (SSM) FS-regulations and relevant rules in Sweden and the NVRs (Nuclear Safety regulations) of Netherlands are given as an example. In Belgium, the ASME III is officially used for nuclear installations at the moment and it is usually accepted by The Federal Agency for Nuclear Control (FANC).

As a general rule the AFCEN codes are elaborated to comply with most of the existing safety regulations. Nevertheless, if a specific national regulation strongly interacts with the main part of a code, a related national appendix is provided in order to meet its requirements.

b) What are the main European regulations in force or under development which can interact with the existing design and/or assessment codes and in service inspection codes?

The EC - PED (pressure equipment directive - 97/23CE), ENIQ and ENSI B07 are indicated by the survey participants as regulations in use interacting with the existing design and/or assessment codes and in service inspection codes.

c) What are the multinational agreements (e.g. non-proliferation treaties, agreements between the European co-operation for Accreditation (EA) and international accreditation bodies, use of ISO/IEC/EN 17000 series) in force or under development which can interact with the existing design and/or assessment codes and in service inspection codes?

Less than 20% of the participants provided a response. However, it is indicated that AFCEN codes are permanently upgraded to take into account the evolution of such agreements, when necessary, in particular as regards technical standards. The Multinational Design Evaluation Programme (MEDP), initiated by French NEA is an example for a multinational initiative taken by national safety authorities to develop innovative approaches to leverage the resources and knowledge of the national regulatory authorities who are currently or will be tasked with the review of new reactor power plant designs.

8.4.6 Other Questions

a) Are you currently participating in nuclear energy code development?

8 participants (out of 20) gave a positive answer. Involvement in the RCC-M, RCC-MRx, RSE-M, RCC-E, RCC-C, ETC-C and ETC-F, ASME BPV (Section III), as well as participation in the R6 development panel is reported by the survey respondents.

b) Do you think that participation in standardization is important for your company or organization because of its impact on and benefits for your business?

9 of the respondents (out of 20) find involvement in standardization important for their companies or organizations. It is certainly acknowledged that having a unique European code fitting to the current and future needs will facilitate significantly the future European projects dealing with the new generation nuclear installations. The organizations and companies dealing with currently running projects (MYRRHA lead fast reactor, ECC etc.) are forced to use the existing codes, often at the edge of domain of use. The design of the future commercial fast reactors also depends on a reliable and proven code.

It is expected that a uniform code for Europe could boost European industrial developments, spin-offs, which we will be profitable also for the code developers.

8.5 General conclusion for the survey

Despite the few amount of responses registered (20 usable) and some inconsistencies into these responses that make difficult more rigorous and complete analysis, valuable information can be taken out this survey and may help to give final recommendation to the whole study:

- In spite the presence of ASME III, RCC-MRx is clearly the design code that European stakeholders should focus on to have a standardized tools for future Gen IV reactors,
- There is a shared wishes from stakeholders on the field of design to be part of standardization work and so, the development of a to-be European design code,
- Pre-normative researches are pointed out as one of the major issue that will need strong support. Many challenges are to be undertaken:
  - to fix existing conflicts either between code but with different regulation also,
  - to extend the use of the code to other technical aspects (such as irradiation and environmental effects),
  - to solve the issues related to funding,
- etc…

9 Recommendation for further actions

9.1 Future of the CEN/Workshop 64 initiative

The participants to the Workshop 64 were invited to express their views on this initiative. This project was due to last 2 years and with the CWA published at the end of 2012, Workshop 64 will have to be disbanded. The issue for the participants was to consider whether or not the exercise was a valuable experience and if it worth to be maintained.

Two options were to be considered:

a) To disband the workshop 64 after a last plenary meeting

For this option, the representative of Tractebel (GDF-SUEZ Belgium) thought that the quality control process in the workshop was not sufficient and therefore that it must be stopped. From his point of view, the work should remain inside the AFCEN structure.

AFCEN does not deny the quality of the work done by the Workshop 64. Nevertheless, in consideration of efficiency (limited available manpower) and reactivity (ongoing projects to satisfy) requirements, AFCEN does not wish to renew the Workshop 64 initiative in its present form.

b) To renew the workshop on design code for <u>at least</u> 3 years (2013-2015)

This is to cope with the annual publication on amendments as scheduled by AFCEN and the next revision of the RCC-MRx code in 2015. With this option, the workload will be re-considered fewer plenary meetings each year to validate the inputs from European partners that will be sent to AFCEN working groups for discussion, approval and implantation into the RCC-Mrx.

Participants in favour:

- Pascal SABBAGH (ESS)
- Karl-Frederik NILSSON (JRC)
- Jens NIETVELT (SCK-CEN)
- Derek BUCKTHORPE (AMEC)
- Vladmir BARABASH (ITER)

The participants considered that future updating of the RCC-MRx shall be considered with the same wide participation of European and International, stakeholders even outside of the CEN Workshop system. An example of how AFCEN could achieve this could be learned from the experience of ISO TC184/SC4 in the development of the product data technology standards based on ISO 10303 ‘Product data representation and exchange’ whose development has required collaboration between all of the world’s main manufacturing nations and has used the expertise of hundreds of engineers from some of the largest companies over a period of thirty years. The success of this collaboration was only possible as a result of strong central management and the development of agreed procedures for quality control and quality assurance.

During the meeting held in Luxembourg on 2012-12-06, participant requested a permanent European structure allowing European and international stakeholders to stay involved in the development of medium and long term evolution of the code in conjunction with R&D projects. Accordingly, a proposed new CEN workshop will take into account the need of long-term structure. Examples

AFCEN proposal for possible future actions

AFCEN drew from this 2 years' experience learned the necessity to continue the process of involving more users to the development of design codes in general. AFCEN considers that a continuation of this initiative is worthwhile and shall be done in better condition as one of the major restraint which appears clearly during the Workshop 64 initiative was the real lack of resources problem and the feeling that Workshop 64' participants were duplicated the work already undertaken by the AFCEN sub-committee and its working groups.

That main concern brought AFCEN to propose future steps to pursue the Europeanization process of the RCC-MRx:

- Integration of the voluntary partners as AFCEN members in the AFCEN RCC-MRx sub-committee
  - Mainly oriented towards project teams already constituted: ITER, ESS, MYRRHA…
  - Benefits from the settled down process of the sub-committee
  - Availability of a broader expertise than in the WS 64
- Creation of an international “prospective” advisory group of the RCC-MRx subcommittee that could be a new CEN Workshop that features will be defined in close cooperation with ESNII partners and Workshop' participants. This structure could be:
  - Mainly oriented towards future projects: ALFRED, ALLEGRO…
  - Focused on identifying of the needed pre-normative researches and possible operators to perform them,
  - Bringing advice on in-depth code modification to address “new” topics such as:
    - Corrosion by liquid metal coolants
    - Management of engineering data

9.2 Recommendations of the CEN CENELEC Focus group Nuclear Energy

The CEN-CENELEC focus group on Nuclear Energy has a mandate from CEN and CENELEC technical boards to make a report on standardization needs for Europe covering the entire nuclear energy production. For that purpose an enquiry on standardization needs for Nuclear Energy was launched from early February to mid-April both to its members and CEN-CENELEC member bodies. The answers were analysed and the draft report for approval by the CEN and CENELEC technical boards was approved on November 14th (document CEN-CENELEC FG Nuclear Energy N22R3)

This report raised the question of the harmonsation needs in Europe and pre-normative research with 2 recommendations supporting initiatives such as CEN WS 64 for innovative nuclear installations (recommendation 5) and the follow up of the example of the Europeanization initiative of AFCEN code RCC-MRx for generation IV done in CEN WS 64 via a new CEN workshop (recommendation 6) Furthermore, this Europeanization process could be enlarged to other AFCEN codes using CEN workshops with the aim to answer the needs of the nuclear industry for generation III reactors.

9.4 Recommendations of the final meeting on 2012-12-06 in Luxembourg

The study report was approved with the addition of :

— a proposal for a "permanent structure to be defined" in the recommendations

In clause

— the summary of the discussions on knowledge management of the nuclear expertise.

The outputs of the discussion on capitalization and promotion of the European expertise in nuclear energy was: to promote openness towards other stakeholders outside the nuclear sector and also inside to link with the SNETP activities. With the objective to identify cross cutting technologies

Details are given in clause 10 and Annex F

10 Final meeting on 2012-12-06 in Luxembourg

The attendance list of the meeting, the agenda and the presentation are available in annex F

Feedback of the CEN WS 64

The CEN workshop had less than 2 years before the publication of AFCEN RCCMRx code 2012 and it has a very short time to really develop a long term strategy and prospective views. The expertise was focused on ongoing projects and the change requests impacting the new edition of the code. The need to have a permanent structure allowing prospective views and working in good and close cooperation with the AFCEN subcommittee RCCMRx was identified. Both the strategic point to update RCCMRx to the European needs, important to build Europe in the future and the organizational point to allow a continuous development of the code through the feedback of the users with a permanent structure were pointed out.

The follow up of the CEN WS 64 will be proposed in 2013, it could be enlarged to Generation III codes as AFCEN supports it. A new step of Europeanization is the approval of the RCC AFCEN codes by the UK regulator to be used in the new EPR projects. One main point will be to improve the organization and methodology used between the workshop and the AFCEN subcommittees.

Knowledge management

One main discussion of the meeting was on knowledge management. There is in Europe a lot of knowledge concerning nuclear energy and one main concern is how to capitalize it. Can a standardization, codification or a CEN workshop work be a tool of knowledge codification and then its diffusion and promotion ?

At the moment, there are mainly national well established groups, mainly learned society working through colloquies and seminars like AFIAP or l'Institut de Soudure in France or the UK technical advisory group on material integrity in NPP….Their collaboration at the European level was discussed as the issue is now European. Training was identified as the main tool to promote expertise.

CEN workshop 64 was also identified as a positive initiative to capitalize and promote nuclear knowledge. It was reminded that each member of the CEN workshop 64 received the draft RCCMRx code when he registered to the workshop. Through the change requests and their process, the knowledge of the community increased and was capitalized. The idea that the workshop has to grow up and interact with other stakeholders inside and outside the nuclear sector was also discussed even if it was reminded by AFCEN that codes rules making are really dedicated to nuclear developments and RCCMRx is especially dedicated to ongoing projects like ASTRID and RJH…...Two other constraints were identified: the high level of confidentiality in all the projects and contracts and the lack of new big project except ITER in the nuclear sector.

Two types of knowledge have to be considered: the academic and R&D one that was said more easily to manage and the operational one that is a lot more difficult to identify and capitalize as it comes from the operation knowledge of people.

The capitalization and promotion of knowledge in the nuclear sector is a European issue as a lot of knowledge was lost in the past 20-30 years. Both the work done in AFCEN in establishing rules and codes and the Europeanization process done in CEN workshop 64 give an opportunity to promote the existing knowledge and capitalize and promote the future one. It was also reminded that CEN workshop where established for the promotion of results of prenormative research. Thus the coordination with prenormative research and/or long term research and promotion of the results when needed will be proposed to be included in the mandate of the new workshop

The management of knowledge was identified as a key issue in the development of new products and new technologies. The increase of complexity led to the evolution of the different stakeholders and the examples of other industries like aeronautics could be fruitful to the nuclear sector. European framework programme through projects but mostly through platforms, give a tool for the promotion of new products and technologies and cross cutting technologies. As a conclusion, promotion of the openness towards other stakeholders outside the nuclear sector and also inside to link with the SNETP activities with the objective to identify cross cutting technologies was recommended.

11 Compliance with the call for tender

Reference to AFNOR reply to the call for tender on the feasibility study (document *TenderENER-D2--2011-197*), the compliance with the European Commission demands was set:

- Step 1: Establishment of a Task Force with the members of the CEN WS 64

  Refers to clause 3 and 7

- Step 2: Research of information and data collection for the first output on existing codes used in Europe for the design and construction of fast neutron reactors and their components – Swot analysis

  Refers to clause 6 and 9

- Step 3: Feedback of the « Europeanization exercise » developed in CEN WS 64

  Refers to clause 7 and 7.3 in particular

- Step 4: Research of information and survey for the feasibility of developing adoption of a European work on “Design and construction Code for Nuclear industry” following CEN WS 64

  Refers to clause 9 and, especially, to clause 9.6. Refers also to annex C

- Step 5: Communication on the results of the feasibility study

  Refers to:

    - the whole study report
    - the conference organized in Luxembourg on 2012-12-06 clause 10

- Expected outcomes from the feasibility study
  - Final report,
    - analysis to select existing code and perform a “Europeanization exercise” (clause 4 and 6),
    - feedback of this exercise (**clause 7 and annex C**) with the compendium of medium and long term requests (annexes A and B of this report) for modification that will allow the identification of the need for pre-normative R&D studies.
    - the successful factors to be considered in the further standardization process of this sector of Generation IV components design and manufacturing code (**clause 7.3 of this report**)
  - A strategic view of the standardization needs for the development of Generation IV reactors (**clause 8, 9 and annex D of this report**)

Annex A
(informative)

List of Short-term modification requests to RCC-MRx version 2010 proposed by the participating members of CEN/WS 64

N°	Proposer	Paragraph	Subject of the potential request
01	AFCEN	RS 2900 and 2700	Temperature limit for Reference Data Sheets of filler materials
02	AFCEN	RDG 4000 & REC 2200 et 2300	Limit of class 3 component in the negligible creep domain and in the negligible irradiation domain. In this aim, give in the REC chapter the way to determine the negligible creep/irradiation domain
04	ESS AB	RDG 2320	Precise the type of irradiation (neutron) in the scope of the code
09	ESS AB		Review of applicability of inelastic design
10	FERRODAY	notations table	Add alias for each notation identifier to enable them to be computer processable
11	FERRODAY	All	Edit to remove errors and to amend terminology to British usage where necessary to avoid ambiguity.
12	FERRODAY	A16.3200	Agree or develop the methods for specifying the orientation of the plane of defects of complex orientation
12	FERRODAY	A16.3200	Agree or develop the methods for specifying the location of defects
16	SCK•CEN	RB 3251.112	Definition of Radius of curvature (ambiguous) distance from axisymmetric axis ≠ math. Curvature : a sketch would be nice
17	SCK•CEN	RM 243-2 (A318AS)	18AS plates between 15 and 250 (instead of 150) mm thick, classes N1Rx et N2Rx
20	JRC	A.16.8424.3	Concern 1: It seems that the parameter "t" is in fact the parameter "h"-the thickness of the tube. Concern 2: Decimal comma should be replaced with decimal point to ensure consistency.
21	JRC	A.16.8424.3	Concern 1: Parameter rr needs to be defined. Concern 2: Decimal comma should be replaced with decimal point to ensure consistency.
22	ITER	RM 332-1.51	Clarification about Charpy impact tests: Current version is following: The Charpy impact tests specified for Solution Heat Treatment and for Solution Heat Treated and Aged condition shall be performed only for parts with an operational temperature equal to or above 450°C, or when low ferrite content is expected. More logical if temperature equal or above 450°C without reference to ferrite content, because ferrite content is already defined as very low (less that 1%). For other similar austenitic steels there is no such requirement.
28	JRC	A16	Several mistakes in the text: wrongly used coma or point for decimal into formula and were discussed and approved
29	JRC	A16	Idem
30	JRC	A16	Idem
31	JRC	A16	Idem
32	JRC	A16 97/210	Several mistakes in the text: Missing coefficients

N°	Proposer	Paragraph	Subject of the potential request
33	JRC	A16 94/210	Change "part" by "longitudinal throughout defect…"
34	ESS AB	RB3261.2	Clarification of rules for type S damages in non-significant creep and significant irradiation

Annex B
(informative)
List of medium term, long term and other type of modification requests from CEN/WS 64

Req N	Proposer	Chap	Paragraph	Subject of the potential request (Medium terms)	WG	Comments
03	AFCEN	Tome 2	RM 332-1, RM 332-3, RM 332-4, RM 333-1	Charpy Impact test after ageing : use of KU specimens instead of KV for this determination	WG2	Was a short term request postponed for lack of information
05	ESS AB	A3		Titanium Ti6Al4V Material data (to be included into the code)	WG1	AFCEN and ESS will start working on the collection data
06	ESS AB	A3		Fill in missing 18AS irradiated material data	WG1	Results are not "mature" enough and work still need to be done on it. Request Postponed
07	ESS AB	A3/RB		Cryogenic aluminium alloy material properties and Design rules	WG1	There are very few known applications. This item is considered as Medium term MR because collect of data on possible application or data on this material are needed.
23	ITER	RB, RD	RB 1213, RD 1213	Chapters RB 1213, RD 1213 are referring to RB 5000 for hydrostatic test specification, for which there is note: to be defined later. This is very important chapter and it shall be developed and included in RCC-MRx. Similar chapter exists in RCC-M B 5000, in ASME Sec III Div 1,2, ASME Sec VIII Div 2. User of RCC-MRx shall prepare test specification based on general knowledge or existing codes which is not good. Test pressure is defined in REC 3257.4, but test procedure, preparation for testing, test examination and acceptance criteria are not defined in current version of RCC-MRx.	WG1	It was rejected as "short term modification request" because some tests proposed are not accurate enough
25	ESS AB	All		Extension of the actual design rule to proton damages: usual dpa and usual dpa + helium deposition	WG1	Request 04 was split into 2 requests. Possibility to add it into RCC-MRx 2012 with a Code Case. Work will be done on 316LN (A3.1S) Material.
26	ITER	A3.10S	Section III	Data for neutron irradiation effect on mechanical properties are needed for this	WG1	There are needs for new data on specific irradiation

Req N	Proposer	Chap	Paragraph	Subject of the potential request (Medium terms)	WG	Comments
			–Tome 1– S Z	material.		conditions

N°	Proposer	Chap	Paragraph	Subject of the potential request (others)	WG	Comments
08	ESS AB	A3		Fill in missing Steel 3S irradiated material data (data for irradiated 3S by spallation source)	WG1	Withdrawn by proposer
13	NRG	RMC	RMC 1211 and 1212	small (diameter 4 mm) tensile specimen size requirements for irradiated materials		The request was not precise enough. It is not in the scope of RCC-MRx to define the size and shape for the tensile test of specimen. These information are to be find into other standards adopted by RCC-MRx (EN ISO 6892-2, EN ISO 6892-1)
14	NRG	RM	RM 243-2x	Reference and irradiated tensile properties for Eurofer 97 (9% Cr) steel	WG1	Not enough data available to consider the request.
15	SCK•CEN	A3GEN	A3.GEN.42	When applied to 3S gives suprisingly high SemA at low Dpa(<5)	WG1	Short term – Rejected as it is not a Modification Request but a request for clarification
24	ITER	RB	Table 3615.1	This Table 3615.1 includes list of dimensioned standards. For carbon steel pipes standards and sizes are defined in NF EN 10216-1 NF, EN 10216-2. For Stainles steel pipes ASME/ANSI B36.19M is recommended. However, in EN standard for stainless steel EN 10216-5 in Chapter 8.8.1 Outside diameter and wall thickness: Tubes shall be ordered by outside diameter D and wall thickness T. Preferred outside diameters D and wall thicknesses T are given in EN ISO 1127. Consider to use of EN ISO 1127 for stainless steel as dimensional standard. Note: see misprint in title of Table RB3615.1	WG1	Could not be included into the CWA the request was reviewed during the last meeting but the requester was not present to argument this point
27	FERRODAY			New appendix A.21: “Guide to the standardized representation of engineering data for digital recording, reporting and archiving”.		Information is valuable but is out of the scope of CWA

Annex C
(informative)

Questionnaire of the Survey of "Needs for standardization in nuclear codes design fields"

Standardization Needs
feasibility to develop standardized rules for the design and construction of Generation IV nuclear plants and equipment

4°ˇ¹Ⱡ11°ⱧSˇ#

Background

The European Commission in conjunction with AFNOR set up a Task Group on an European study on the feasibility to develop standardized rules for the design and construction of Generation IV nuclear reactors. This Group will deliver by end 2012 a report containing recommendations to the European Commission and ESNII members in which conditions in which Generation IV reactors should be designed and build in the Community with standardized rules supported by the industry. This study should investigate how a shared industrial experience in components design and manufacturing can lead to dedicated European Codes recognized internationally by a larger group of stakeholders.

The first step towards the production of the above report is the collection of needs from all European stakeholders.

To this effect, we kindly ask you to complete the questionnaire-below

The report with the public results following the information collected through this questionnaire will not disclose the name of the respondent or his/her company, unless agreed otherwise by the respondent

The range of standards in use by the Nuclear Energy sector in Europe is very broad. *For the purpose of this questionnaire, we are considering mainly in our scope the domains of standardization in Europe for design codes.*

Respondent's Data

Please provide below your name, contact details and also on whose behalf you are providing the answers. As it is possible or even likely that you will receive this questionnaire through multiple channels, we ask to only send in one response. But where you are responding on behalf of more than one entity (for example answering on behalf of a company and on behalf of an association), then you can submit multiple answers.

Name of the respondent/coordinator of the answer: (start typing here) ....

Company, Organization or Committee whose input is represented:

(start typing here) ....

Contact Email address: (start typing here)...

Telephone number: (start typing here) ....

Your organization/yourself is representing (Please add "X" in the relevant box below)

☐ a National committee, a National Standards Body or a Technical Committee

☐ Regulator

☐ Technical support for the regulator

☐ Nuclear Power Industry, Utility

☐ Vendor or manufacturer

☐ Research organization or University

☐ Transport provider

☐ Certification and accreditation

☐ Insurance

☐ Other, specify hereafter:

---

1 – Questions regarding your utilization of existing **design and/or assessment codes and in service inspection codes** in the field of Nuclear energy – (*documents coming from IEC, ISO, ASTM, organisations, etc.)*

1-A. Do you use design and/or assessment codes and in service inspection codes produced by national nuclear standards organizations of countries different from yours?

Type "YES , "NO", or "not relevant": ....

If YES, please provide the full reference and publication date

(start typing here)..

1-B. Are you aware of potential conflicts between national design and/or assessment codes and in service inspection codes in nuclear sector that are used in the nuclear energy sector in various European countries ?

Type YES , NO or not relevant: ....

If yes, please specify below the standard and the scope of the document (systems, structure or component) and the conflicting issue.

(start typing here) ....

1-C. Do you have difficulties to use/comprehend existing design and/or assessment codes and in service inspection codes documents that would require interpretation and/or clarification**?**

Type YES , NO or not relevant: ....

If yes, please specify below

(start typing here) ....

---

2 – Questions addressing the need for standards in the field of design and construction for nuclear equipment and components in Europe

2-A. Pre-normative research (PNR) in a generic sense relates to activities which produce entry data as input for the standardisation process; PNR can relate to specific needs for research that would assist the standards making process or overcome problems that are preventing completion of their work.
Are there any needs for specific pre-normative research in support of standardization of an European standard for design and/or assessment codes and in service inspection codes?

Type YES or NO: ....

Please specify below.

(start typing here)...

2-B. Do you think that the existence of a specific committee under the umbrella of CEN to deal with standards/documents for design and/or assessment codes and in service inspection codes will improve the efficiency of your project/work?

Type YES or NO: ....

If yes, please specify below

(start typing here) ....

---

3 – Questions addressing the need for a better consistency among existing codes as well as the need for applying "generic" codes to the nuclear sector

3-A. Have you identified existing codes (e.g.: RCC-MRx, ASME III, etc…) that can be used for design and construction that are mutually inconsistent or conflicting?

Type YES or NO: ....

If yes, please specify below

(start typing here) ....

3-B. From your experience, what is the main issue that could restraint to standardization of an European code on design and construction (*difference in existing methods, difference in acceptable criteria …*)?

(start typing here) ....

3-C. How does the lack of a unique European code impact your activities in foreign countries?

Please elaborate below

If applicable,

(start typing here) ....

---

4 – Questions related to the interaction with the broader context

4-A. What are your national regulations which can interact with the existing design and/or assessment codes and in service inspection codes?

(start typing here) ....

4-B. What are the main European regulations in force or under development which can interact with the existing design and/or assessment codes and in service inspection codes?

(start typing here) ....

4-C. What are the multinational agreements (*eg non-proliferation treaties, agreements between the European co-operation for Accreditation (EA) and international accreditation bodies, use of ISO/IEC/EN 17000 series*) in force or under development which can interact with the existing design and/or assessment codes and in service inspection codes?

(start typing here) ....

---

5 – **Other Questions**

5-A. Are you currently participating in nuclear energy code development?

Type YES or NO: ....

If yes, please specify below to which code and which level

(start typing here) ....

5-B. Do you think that participation in standardization is important for your company or organization because of its impact on and benefits for your business?

Type YES, NO or "not applicable": ....

If yes, please specify below

(start typing here) ....

Annex D
(informative)

Rough Data of the Survey

Standardization Needs for design & construction codes

Authors	Jocelyn LOUMETO
Date of report generation	10/08/2012 17:44:00

D.1 Description of the Survey

The European Commission in conjunction with AFNOR set up a Task Group on an European study on the feasibility to develop standardized rules for the design and construction of Generation IV nuclear reactors. This Group will deliver by end 2012 a report containing recommendations to the European Commission and ESNII members in which conditions in which Generation IV reactors should be designed and build in the Community with standardized rules supported by the industry. This study should investigate how a shared industrial experience in components design and manufacturing can lead to dedicated European Codes recognized internationally by a larger group of stakeholders.

The first step towards the production of the above report is the collection of needs from all European stakeholders.

The report with the public results following the information collected through this questionnaire will not disclose the name of the respondent or his/her company, unless agreed otherwise by the respondent

The range of standards in use by the Nuclear Energy sector in Europe is very broad. For the purpose of this questionnaire, we are considering mainly in our scope the domains of standardization in Europe for design codes.

D.2 Questions & response' data

D.2.1 General questions

D.2.1.1 Respondent's Data

Data

Response options	Number of responses	Percentages
No answers	0	0 %
Answer	20	100 %

Details

Answer
Institut de Sudure Industrie
European Spallation Source ESS
SCK•CEN
AFCEN : AFCEN is a French Association for the rules governing the Design, Construction and Operating Supervision of the Equipment Items for Electro Nuclear plants. At now, AFCEN has about 40 members (companies) from different countries (France, England, China, and Belgium). AFCEN codes are currently used at least in France, China, India, England and Finland… AFCEN published 7 codes: RCCM (design and construction of mechanical components for PWRs), RSEM (mechanical components for PWRs in operation), RCC-MRx (design and mechanical components for Fast breeder reactors and research reactors), RCCE (I and C and electric system components for PWRs), RCCC (fuel for PWRs), ETCC (civil works for EPR plants) and ETCF (Fire for EPR plants).
NRG
NRG, in-service inspections
AREVA NP Uddcomb AB
AFCEN*
x*
ASN
Asn*
pp*
SCK•CEN
SCK•CEN*
ANSALDO Nucleare S.p.A.
ENEA
ESS AB
AFNOR
EICHROM Europe
GDF-SUEZ

*Double inputs and evident mistakes represent **4** responses

D.2.1.2 Represented organization

Data

Response options	Number of responses	Percentages
No answers	0	0 %
a National committee, a National Standards Body or a Technical Committee	4	25 %
Regulator	3	18.8 %
Technical support for the regulator	0	0 %
Nuclear Power Industry, Utility	1	6.2 %
Vendor or manufacturer	2	12.5 %
Research organization or University	6	37.5 %
Transport provider	0	0 %
Certification and accreditation	1	6.2 %
Insurance	0	0 %
Other, specify hereafter:	2	12.5 %

Details

Response options	Number of responses per categories																	
No answers	1			1			1	1									1	1	
a National committee, a National Standards Body or a Technical Committee									1	1	1								
Regulator																			
Technical support for the regulator															1				
Nuclear Power Industry, Utility							1								1				
Vendor or manufacturer		1	1										1	1	1	1		1	
Research organization or University																			
Transport provider												1							
Certification and accreditation																			
Insurance																			
Other, specify hereafter:					Nuclear research and consultancy organization	Nuclear research and consultancy organization: in-service inspection department											1		Engineer office

D.2.2 Questions regarding your utilization of existing design and/or assessment codes and in service inspection codes in the field of Nuclear energy – (documents coming from IEC, ISO, ASTM, organisations, etc.)

D.2.2.1 Do you use design and/or assessment codes and in service inspection codes produced by national nuclear standards organizations of countries different from yours?

Data

Response options	Number of responses	Percentages
No answers	7	35 %
Yes	12	60 %
No	0	0 %
Yes with comments	1	5 %
	20	

Details

Yes	No	Yes with comments
1		ASME BPV (2010), EN-standard (2009/2010), ECC-M (2007, little)
1		RCC- MRx
1		ASME III 2004 (design) ASME XI (inspection)
	1	
1		ASME 2010, KTA (not recent as on the web site), R6 Revision 4 including amendment 8, 2010
1		ASME Section XI and ASME Section V - ENIQ Methodology; KTA 3201.4 2010-2011; ENSI B07
1		ASME III, different edition depending on project.
1		RSE-M, RCC-M, NF EN 13445-5:2009, NF EN 13480-5:2002
1		Draft 2010 AFCEN RCC-MRx
1		ASME Boiler and Pressure Vessel Code
1		RCC-MR (2007), RCC-Mx (2008)
1		to be defined
1		ASME, RCCM, RSEM, KTA, R6
12	**1**	**12**

D.2.2.2 Are you aware of potential conflicts between national design and/or assessment codes and in service inspection codes in nuclear sector that are used in the nuclear energy sector in various European countries ?

Data

Response options	Number of responses	Percentages
No answers	7	35 %
Yes	7	35%
No/not relevant	6	30%
Yes with comments	7	35%
	20	

Details

Yes	No/not relevant	Yes with comments
1		There are many difference/conflicts, piping in particular.
	1	
1		Flange design and piping size, mandatory ladle analysis
1		NIKIET (organization that made its own design code) , ASME III
1		For example new austenitic fatigue curve in ASME is different from KTA
1		Different scopes; Regulations
	1	
1		Conflicts are not only between codes themselves but also between codes and regulations. In France, no code is supposed to meet all regulatory requirements.
	1	
	1	
	1	
1		on-going work to avoid that situation
	1	

D.2.2.3 Do you have difficulties to use/comprehend existing design and/or assessment codes and in service inspection codes documents that would require interpretation and/or clarification?

Data

Response options	Number of responses	Percentages
No answers	7	35 %
Yes	4	20 %
No	7	35 %
Not relevant	2	10 %
Yes with comments	4	20 %

Details

Yes	No	Not relevant	Yes with comments
1			We have written a number of papers addressing the current design rules and requirements, in particular, those given in ASME BPV, Section III, and EN-13480.
1			code does not apply directly to our facility (physical parameters not fully covered)
1			We are working in international la environment (Italian French English Belgian) and the understanding of term like radius of curvature is not exacts the same. It is some time better to add sketches.
	1		
	1		
	1		
1			Among others the support in doing plastic analysis according to the ASME code is limited. Many codes are also focused on formulas whereas todal we use FEM more and more so the code should be more focused on evaluation with this tool.
	1		
	1		
	1		
		1	
		1	
	1		
4	**7**	**2**	**4**

D.2.3 Questions addressing the need for standards in the field of design and construction for nuclear equipment and components in Europe

D.2.3.1 Pre-normative research (PNR) in a generic sense relates to activities which produce entry data as input for the standardisation process; PNR can relate to specific needs for research that would assist the standards making process or overcome problems that are preventing completion of their work.
Are there any needs for specific pre-normative research in support of standardization of an European standard for design and/or assessment codes and in service inspection codes?

Data

Response options	Number of responses	Percentages
No answers	7	35 %
Yes	9	45 %
No	2	10 %
Not relevant	2	10 %
Yes with comments	11	55 %

Details

Yes	No	Not relevant	Yes with comments
1			Great needs. The current attempt, MDEP, imitated by NEA and organized by other 7 countries, is a great example. We are not sure if G-IV included.
1			irradiated materials properties, advanced materials for nuclear usage
1			irradiation effect assessment, effect of corrosion
	1		Research may be necessary to define or clarify rules to be inserted in an AFCEN code. On the other hand, no PNR seems required in support of a European standard
1			How to address environmental fatigue applied to European materials.
	1		We use codes as presented.
1			One issue is how to address progressive deformation in a correct but not to conservative way.
		1	
1			Material behaviour under irradiation AND in LBEor lead
		1	
1			There are many, for instance irradiation effects, environmental effect, degradation effects on material properties
1			proton damages
1			treatment and long term storage of radioactive waste and spent fuel from nuclear installation; material long term ageing; human and administrative errors
9	2	2	11

D.2.3.2 Do you think that the existence of a specific committee under the umbrella of CEN to deal with standards/documents for design and/or assessment codes and in service inspection codes will improve the efficiency of your project/work?

Data

Response options	Number of responses	Percentages
No answers	8	40 %
Yes	5	25 %
No	5	25 %
Not relevant	3	15 %
Yes with comments	6	30 %

Details

Yes	No	Not relevant	Yes with comments
1			It can affect our on-going project/work in many aspects, e.g. efficiency, reliability, and so forth.
		1	
1			As we are working with other European partner for the design. And in the future we will have made European call for tender. So a unified code would be easier
			AFCEN does not intend to make European standards from its codes. Nevertheless, AFCEN could support European initiatives, for instance like the workshop (WS 64) currently in progress under the aegis of CEN, that would contribute to improve these codes in a European framework.
	1		Don't know what will be dealt with.
	1		
1		1	
	1		
1		1	The specific committee can give a standardization of the European standards solving any interpretations or lacks of information
1			An open permanent committee could help in continuously improve the standards taken into account arising needs of designers and manufacturers
	1		
	1		
5	5	3	6

D.2.4 Questions addressing the need for a better consistency among existing codes as well as the need for applying "generic" codes to the nuclear sector

D.2.4.1 Have you identified existing codes (e.g.: RCC-MRx, ASME III, etc…) that can be used for design and construction that are mutually inconsistent or conflicting?

Data

Response options	Number of responses	Percentages
No answers	9	45 %
Yes	5	25 %
No	6	30 %
Not relevant	0	0 %
Yes with comments	5	25 %
	20	

Details

Yes	No	Not relevant	Yes with comments
1			We refer to our papers given in ICONE16-20.
	1		
1			ASME III and RCC-MRx
1			ASME III and NIKIET at least
1			Fatigue curves in ASME and KTA.
	1		
	1		
1			RCC-MRx, ASME III
	1		
	1		
	1		
5	6		5

D.2.4.2 From your experience, what is the main issue that could restraint to standardization of an European code on design and construction (difference in existing methods, difference in acceptable criteria …)?

Data

Response options	Number of responses	Percentages
No answers	8	40 %
Not relevant	3	15 %
Yes with comments	9	45 %

Details

Not relevant	Yes with comments
	Economy should be the biggest obstacle. A call for a particular EU-financed project (3-5 years), with experts from a number of active countries, should resolve this problem.
	A large part of the common code could be shared and "specific section dedicated to nuclear system types (e.g. pressurized or not, water or liquid metal etc...)
	The acceptance off proven data and methodology. Here proven as be understood as accepted (or Could be accepted) by our National safety authority (e.g. FANC for Belgium), based on well referenced criteria.
	The main restraint is the specificity and the lack of harmonization of regulatory national requirements. From our experience, AFCEN codes are used in different countries and this often leads to be compliant with various regulations. Consequently, AFCEN decided to include specific appendix in AFCEN codes to meet the national regulatory requirements. Another restraint may come from the standardization procedures that do not comply, in terms of reactivity, with the time management usually taken into account in code developments. As a matter of fact the latter are generally made in support of on-going projects that cannot afford to wait for large periods that a decision concerning technical rules is taken. Furthermore, AFCEN codes are used in several projects that are not solely located in Europe. Therefore, a European consensus could be of no interest if these projects are carried out in non-European countries.
	Change of code in existing installations.
	National differences
1	
	acceptable criteria, material data, fabrication requirements, non-destructive examination requirements
1	
	acceptable criteria, methods and material data for design rules
1	
	political and commercial interests; European bureaucracy
3	

D.2.4.3 How does the lack of a unique European code impact your activities in foreign countries?

Data

Response options	Number of responses	Percentages
No answers	8	40 %
Not relevant	7	35 %
Yes with comments	6	30 %

Details

Not relevant	Yes with comments
	A great problem. For example, it ihas been a "headache" problem working with those countries where reactors are built on VVR, rather than ECC-M or ASME.
	talking to licensing authorities and providers is not coherent (materials designation etc)
1	SCK•CEN at moment few activity outside Belgium but nevertheless with our shares in ITER and RJH and other European project (like ALFRED)we gone have to use the additional code (additional cost) if no European code is accepted
	AFCEN codes are used out of Europe, for instance in India. The lack of a unique European code has no impact in this case.
1	
	Qualifications of inspection Techniques are NOT always accepted due to differences in National Regulations
1	
1	
1	
1	
	Difficulty to impose a standard when they have local national standards
1	
7	**6**

D.2.5 related to the interaction with the broader context

D.2.5.1 What are your national regulations which can interact with the existing design and/or assessment codes and in service inspection codes?

Data

Response options	Number of responses	Percentages
No answers	11	55 %
Not relevant	3	15 %
Yes with comments	7	35 %
	20	

Details

Not relevant	Yes with comments
	Sweden: SSM FS-regulations and relevant rules.
	At the moment only ASME III is officially used for nuclear installation in Belgium (usually accepted by FANC)
	As a general rule the AFCEN codes are elaborated to comply with most of the existing safety regulations. Nevertheless, if a specific national regulation strongly interacts with the main part of a code, a related national appendix is provided for to meet its requirements.
	NVRs (Nuclear Safety regulations) of Dutch government.
	None
1	
1	ISPRA
1	
	Royal and ministerial decrees deinfing rules for nuclear installations
3	**7**

D.2.5.2 What are the main European regulations in force or under development which can interact with the existing design and/or assessment codes and in service inspection codes?

Data

Response options	Number of responses	Percentages
No answers	13	65 %
Not relevant	3	15 %
Yes with comments	4	20 %
	20	

Details

Not relevant	Yes with comments
	We really have no idea, but general environmental and energy preservation regulations.
	EC - PED (pressure equipment directive - 97/23CE) which is at the root of nuclear pressure equipment regulation in France.
	ENIQ / ASME / KTA / ENSI B07
1	
	ASN (Nuclear Safety Authority)
1	
1	
3	**4**

D.2.5.3 What are the multinational agreements (e.g. non-proliferation treaties, agreements between the European co-operation for Accreditation (EA) and international accreditation bodies, use of ISO/IEC/EN 17000 series) in force or under development which can interact with the existing design and/or assessment codes and in service inspection codes?

Data

Response options	Number of responses	Percentages
No answers	13	65 %
Not relevant	4	20 %
Yes with comments	3	15 %

Details

Not relevant	Yes with comments
	We know nothing but MEDP (Multinational Design Evaluation Programme), initiated by French NEA. The NEA has been invited to perform the Technical Secretariat functions for the Multinational Design Evaluation Programme (MDEP). MDEP is a multinational initiative taken by national safety authorities to develop innovative approaches to leverage the resources and knowledge of the national regulatory authorities who are currently or will be tasked with the review of new reactor power plant designs.
	AFCEN codes are permanently upgraded to take into account the evolution of these agreements, when necessary, in particular as regards technical standards.
	ASME Sections Xi / V ; ISO / IEC 17025: 2005
1	
1	
1	
1	
4	**3**

D.2.6 Other Questions

D.2.6.1 Are you currently participating in nuclear energy code development?

Data

Response options	Number of responses	Percentages
No answers	10	50 %
Yes	8	40 %
No	2	10 %
Not applicable	0	0 %
Yes with comments	8	40 %

Details

Yes	No	N.A*	Yes with comments
1			ASME BPV code, Section III. We try to influence the revision and development.
1			CEN WS 64
1			indirectly to RCC MRx by participating CEN WS MRx (64) end matter European project
1			Editor of AFCEN codes : RCC-M, RCC-MRx, RSE-M, RCC-E, RCC-C, ETC-C and ETC-F
1			R6 - participation in R6 development panel
	1		
1			RCC-MRx
	1		
1			CEN WS64
1			ASME, RCCMRx, ENIQ
8	**2**		**8**

* Not applicable

D.2.6.2 Do you think that participation in standardization is important for your company or organization because of its impact on and benefits for your business?

Data

Response options	Number of responses	Percentages
No answers	10	50 %
Yes	9	45 %
No	0	0 %
Not applicable	0	0 %
Yes with comments	10	50 %

Details

Yes	No	N.A*	Yes with comments
1			It will greatly ease our work, in particular, dealing with future projects in the whole Europe.
1			we need to have a standard fitting to our characteristics
1			As we are developing new reactor type or building experimental ring we are often at edge of domain of use. So it is interesting of us to know if the edge is ignorance uncertainty or return of experiment. Father more we have world-class irradiated material testing facility that could help to develop irradiated data base. SCK•CEN Is also use to work in an European framework with multicultural engineers that could highlight some ambiguity potential misunderstandings.
1			Standardization is the aim of AFCEN
1			We expect that we can assist in the development and qualification of the European code pursued, and that a uniform code for Europe could boost European industrial developments, spin-off of which we will profit from as well.
			Yes, it is important, although time consuming.
1			Design of future reactor depends on it
1			Our company is involved in the design and construction of Generation IV NPP
1			possibility to add/clarify chapters for our needs
1			sharing experience with other industrial organisation for more efficient safety
9			**10**

Annex E
(informative)

Recommendations from the CEN/CENELEC Focus group on Nuclear energy that concern the Workshop 64

E.1 Recommendation 5: Pre-normative research in nuclear energy

CEN-CENELEC Focus Group on nuclear energy,

- Considering research and development activities at European level supported by DG Research and Innovation in JRC, in NUGENIA (Generations II and III), in SNETP-ESNII (Generation IV) as well as in other industrial initiatives,
- Considering national research and development programmes,
- Considering that research is essential in ensuring and continuously improving nuclear safety,
    - Confirms that itechnology development and safety needs should be the main drivers for these research and development activities,
    - Encourages the inputs from these research and development activities into international standardization, and
    - Supports initiatives such as CEN WS64 for innovative nuclear installations.

E.2 Recommendation 6: Follow up of CEN WS 64 initiative

CEN-CENELEC Focus Group on nuclear energy,

- considering CEN WS 64 initiative and results on "Design and construction code for mechanical equipments of innovative nuclear installations",
- considering nuclear new power plants or research facilities projects in Europe,
- considering AFCEN’s role as international industrial platform on which a European approach of codification can be built,
    - supports the follow up of the example of the Europeanization initiative of AFCEN code RCC MRx for GENIV done in CEN WS 64 via a new CEN Workshop,
    - supports in particular the initiative to enlarge this Europeanization process to other AFCEN codes using CEN workshops with the aim to answer the needs of the nuclear industry for generation III reactors

Annex F

Nuclear energy
What harmonization for Generation IV code in Europe ?

European study - Feasibility of the development of standardization rules for design and construction of Generation IV nuclear reactors

The meeting will take place on 2012-12-06 from 10:30 to 15:30 in Luxembourg:
Euroforum building - 10 rue Robert Stumper, Luxembourg

For registration: francoise.bronet@afnor.org before 2012-12-03

The European Commission in conjunction with AFNOR set up a Task Group on a European study on the feasibility to develop standardized rules for the design and construction of Generation IV nuclear reactors. The results of this study will be delivered during this meeting on: 6th December 2012 in Luxembourg

In February 2011, several members of the SNETP (Sustainable Nuclear Energy Technology Platform) taskforce for ESNII and AFCEN set up a CEN Workshop on "Design and construction code for mechanical equipment of innovative nuclear installations" (CEN/WS 64). This Workshop, intended to contribute to share a common European approach on structural integrity for innovative nuclear installations components by:

- rationalizing and capitalizing pre-normative R&D activities into an European Framework,
- capitalizing European and international knowledge and feedback of experience gained in innovative nuclear systems (ITER, PFBR (India), etc.…),
- meeting the WENRA objectives to develop a common European approach
- reinforcing the links between European mechanical engineering standards and the nuclear industry

The Workshop developments were carried out on the RCC-MRx basis in consideration of the choice already made in France and in Belgium to build the mechanical components for ASTRID and MYRRHA. This position is reinforced by the adoption of this code in other ongoing projects, such as the CEA's RJH experimental reactor or the ITER's tokomak vacuum vessel or the European Spallation Source (ESS). It is also expected to be used in the future ESNII projects ALFRED and ALLEGRO.

.

This approach was evaluated in the study that will be presented as an advantage of enforcing a unique European code for components design and manufacturing

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AGENDA

The meeting will take place on 2012-12-06 from 10:30 to 15:30 in Luxembourg: Euroforum building - 10 rue Robert Stumper, Luxembourg

1. ***Welcome and introduction***

2. ***Presentation and aim of the European study on the feasibility of the development of standardization rules for design and construction of Generation IV nuclear reactors***

3. ***Presentation of CEN WS 64 on "Design and construction code for mechanical equipment of innovative nuclear installations", feedback and first conclusions on this experiment***

4. ***AFCEN views and proposals for possible future actions***

5. ***Discussions and perspectives***

To go farther: How to capitalize and promote the European expertise in nuclear energy?

6. **Conclusions of the meeting**

COMMUNICATION GROUPE AFNOR • SCP

Registration: send your details to francoise.bronet@afnor.org before 2012-12-03

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LISTE DE PRESENCE

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European study - Feasibility of the development of standardization rules for design and construction of Generation IV nuclear reactors

2012-12-06 from 10:30 to 15:30 in Luxembourg:
Euroforum building - 10 rue Robert Stumper, Luxembourg

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LISTE DE PRESENCE

European study - Feasibility of the development of standardization rules for design and construction of Generation IV nuclear reactors

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European feasibility study

Development of standardization rules for design and construction of Generation IV nuclear reactors

Luxembourg, 2012-12-06

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AGENDA

1. Welcome and introduction
2. Presentation and aim of the European study on the feasibility of the development of standardization rules for design and construction of Generation IV nuclear reactors
3. Presentation of CEN WS 64 on “Design and construction code for mechanical equipment of innovative nuclear installations”, feedback and first conclusions on this experiment
4. AFCEN views and proposals for possible future actions
5. Discussions and perspectives
6. To go farther: How to capitalize and promote the European expertise in nuclear energy?
7. Conclusions of the meeting

2 2012-12-06 afnor NORMALISATION

2. Presentation and aim of the European study

- **Objective: to analyse the need for a European design code and standardized rules for Gen IV reactors supported by the industry**
- **Requirements:**
  - Feedback from the CEN Workshop 64 experience and recommendation for further steps
  - SWOT analysis of candidate codes for a possible evolution towards an endorsement as the European code for Generation IV
  - Survey on standardization needs on the field on design codes.
    - + outside the CEN/WS 64 members to include stakeholders of demonstrators, Engineering manufacturing firms, National regulators, WENRA, standardization member bodies, others technical committee in nuclear fields and other identified partners
  - Identification of topics on need for pre-normative and long-term research for an European code
- **The resulting document shall be communicated among the European stakeholders and presented during this meeting**

Process of the study

- **The study was planned to be carried out in 5 steps in 12 months:**
  - **Step 1: Establishment of a Task group with members of the CEN/WS 64**
    - Kick-off meeting on January 17th, 2012 in Brussels.
      - Task group "feasibility study" : *JRC, AFCEN, SCK-CEN, NRG, GDF-Suez, ESS, VINCOTTE, FERRODAY, AMEC*
  - **Step 2: Research of information and data collection on existing codes used in Europe and SWOT analysis**
    - first conference-call meeting on February 10th, 2012
      - process, questionnaire for the internet survey, framework of the study, list of existing codes & choice for Swot analysis, input needed to define pre-normative or long-term R&D items
    - March, 14th, 2012 meeting and June, 20th, 2012:
      - Swot analysis on AFCEN RCCMRx and ASME III

Process of the study

- **Step 3: Feed-back of the CEN WS 64 as an « Europeanization exercise » - Rule-making process & identification process of the needs for pre-normative R&D studies.**
  - March, 14th, 2012 meeting and June, 20th, 2012:
    - Proposals derived from WS 64 for pre-normative and long-term R&D items - Compendium of medium and long-term modification requests from CEN/WS 64 selected by the task group members.
- **Step 4: Research of information and survey for the feasibility of developing adoption of a European work on "Design and construction Code for Nuclear industry"**
  - February 10th, 2012 , May/June and June/July 2012 and September 10th 2012
    - Questionnaire, survey, results and outcomes, recommendation for next step of CEN WS 64

Process of the study

- **Step 5: Communication on the results of the feasibility study<**
    - interim report - compendium of medium and long-term modification requests from CEN/WS 64 selected by the task group members. (June, 20th, 2012)
    - draft study - 1 month approval ballot (September 10th 2012) & resolution of comments received (October 2012).
    - Presentation during 2012-12-06 meeting

Timetable

STEPS	M+1	M+2	M+3	M+4	M+5	M+6	M+7	M+8	M+9	M+10	M+11	M+12
Step 1: Establishment of a Task Force with the members of the CEN WS 64												
Step 2: data collection and SWOT analysis												
Step 3: Feed-back of the « Europeanization exercise »												
Step 4: information and data collection for the development and adoption of a European Code under the umbrella of CEN												
Step 5 : Communication on the results of the feasibility study												

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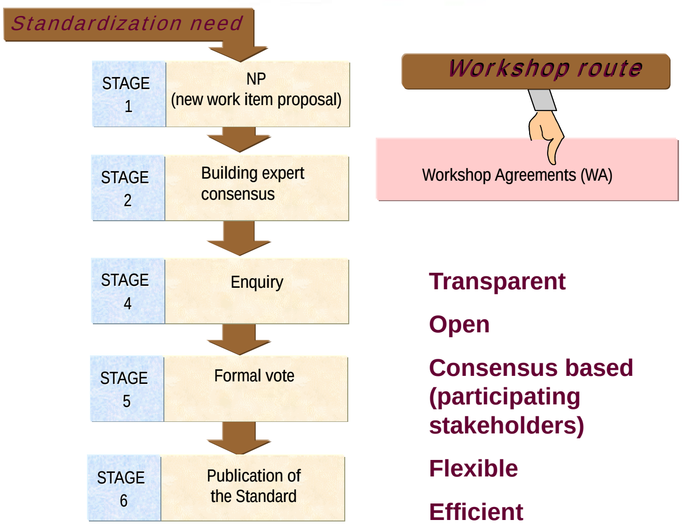
CEN Workshop



Transparent

Open

Consensus based (participating stakeholders)

Flexible

Efficient

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CEN Workshops : The way to rapid consensus

Fast

Flexible

Open

Efficient

- WHAT IS A CEN WORKSHOP?
  - **A meeting place for market stakeholders** to discuss critical standards issues and agree how to resolve them.
  - **Involving any interested party** with the minimum bureaucratic formalities, low participation costs and no geographical restrictions.
  - **A fl exible working platform** for rapid elaboration of consensus documents at European level.
- WHAT IS A CEN WORKSHOP AGREEMENT (CWA)?
  - **A consensus document** providing technical specifications,guidance material, best practice and information etc...
  - **A CEN publication widely available** from the 30 CEN member bodies, and sometimes online for downloading.
  - **Follow-up possibilities** Maintained as a CWA for three years and renewed, or transformed into more formal European or International standard

3. Presentation of CEN WS 64 on “Design and construction code for mechanical equipment of innovative nuclear installations”, feedback and first conclusions on this experiment

4. AFCEN views and proposals for possible future actions

WS 64 – Assessment – Proposals for a continuation

D. LELIEVRE, AFCEN, Chairman of WS 64

Presentation of the study performed by AFNOR
on behalf of the European Commission to
evaluate the possibility of setting up a permanent structure to
develop an European code for the design and construction of
mechanical equipments of GEN IV nuclear systems,
Luxembourg, December 6th, 2012

Groundings of WS 64

- ✓ Gather stakeholders of GEN IV nuclear systems to
  - Propose design and construction rules for mechanical equipments of these systems
  - Identify the possible R&D programmes necessary to consolidate these rules
  - Integrate consolidated rules, if any, in an existing code, in this case the AFCEN RCC-MRx code, according to its editor’s procedure
- ✓ … in a structure recognized at the European level providing
  - A suitable framework to organize the review of the proposed rules
  - A guarantee of transparency for the results of the works
  - Light enough procedures to be rapidly implemented and capable to take decisions
  - Compliant with AFCEN’s interests, especially as regards copyrights
- ✓ A CEN Workshop appeared as a good way to meet these objectives

2

Working arrangements of WS 64

- ✓ Rules are created as modifications of the current version of the code (that was dealt to the WS members at the beginning)
  - On the basis of argued proposals (modification request files)
  - Discussed and amended in experts working groups (WG) gathering, if possible, scientists, suppliers (manufacturers) and final users (licensees)
  - Formally endorsed by the plenary meeting of the WS members
  - Proposed to AFCEN for integration in the 2012 edition of the code
- ✓ Proposals that are not sufficiently well-argued are evaluated
  - Listed as medium-term modifications if they only require a few complementary arguments
  - Listed as long-term modifications if the require significant complementary arguments or R&D programmes to support them
  - Rejected if they are out of the scope of the code
- ✓ Workshop agreement (CWA) is the collection of rules that can immediately be integrated ("short-term" rules)

3

Workshop assessment
Positive aspects

- ✓ 14 registered members
  - Industry and R&D equally represented
  - Participants from 6 countries + 3 international organizations
  - France is the most represented country, but far from majority
- ✓ 10 meetings
  - 5 plenary meetings,
  - 5 technical meetings
- ✓ 33 modification proposals
  - 20 proposals converted into modification files and integrated in MRx
  - 8 proposals considered as suitable for a medium- or long-term integration in the code

4

Workshop assessment
Unsatisfactory aspects

- Some defections
  - 16 participants at the kick-off meeting, 14 registered participants
  - No participation from ALLEGRO project team
  - Attendance to the meetings decreased during the workshop
- Business plan process not strictly respected
  - All modification files not thoroughly discussed and validated in plenary meeting
  - Complementary review in AFCEN for endorsement
  - Only one Working Group whereas 4 were proposed
- A minority of short-term technical modifications
  - Most short-term proposals are editorial
  - Most technical proposals are not sufficiently supported for immediate integration in the code

5

Workshop assessment
Experience feedback

- Significant expectations related to the code
  - Number of registered participants
  - Number of pertinent modification proposals (only 5 rejected)
  - Wish to continue the "experiment" from most of the participants
- Only on-going projects are in position to make short-term technical modification proposals
  - Modifications generally require pre-normative R&D that is not yet founded for other projects
  - Project teams are not always familiar with the code evolution process
- AFCEN has to improve its process to anticipate medium- or long-term evolution of its codes

6

Possible continuation

- ✓ **Integration of the voluntary partners as AFCEN members in the RCC-MRx sub-committee**
  - ➢ **Mainly oriented towards project teams already constituted: ITER, ESS, MYRRHA…**
  - ➢ **Benefits from the settled down process of the sub-committee**
  - ➢ **Availability of a broader expertise than in the WS 64**
- ✓ **Creation of an international "prospective" advisory group**
  - ➢ **Mainly oriented towards future projects: ALFRED, ALLEGRO…**
  - ➢ **Identification of the needed pre-normative research and possible operators to perform it**
  - ➢ **Advice on in-depth code modification to address "new" topics:**
    - **Corrosion by liquid metal coolants**
    - **Management of engineering data**
  - ➢ **Could be a new CEN Workshop : features to define**

7

4. Discussions and perspectives

- Main results of the study : Long and Medium term modifications, feed back from the task force, results of the survey
- European perspectives

5. To go farther: How to capitalize and promote the European expertise in nuclear energy?

Results of the study: Main identified needs

- **Primary need: increasing the design life of reactors (> 60 years)**
- **How to handle harsh environemental conditions on nuclear components:**
  - Irradiation & temperature damages
  - Corrosion of materials by coolant
- **Needs for data on materials behaviour mainly to anticipate the they slow degradation mechanisme such as:**
  - ductility and fracture toughness reduction
  - Creep, creep-fatigue and thermal ageing
  - stress corrosion and liquid metal corrosion

Stakeholders wishes: "Targeted research that integrates experiments and modeling to predict the long-term material properties in order to transfer this information into the design codes is therefore the prime challenge."

Results of the study: Main identified R&D issues

- **Effects of environment:**
  - Corrosion by coolant is often considered as being uniform in the component during its life-time
  - The Uniform Liquid Metal Corrosion (LMC) with three main mechanisms: oxidation, dissolution, and erosion
  - With Sodium, no corrosion is evident. When using stainless steel and as long as chemistry control is stringent (Oxygen, Carbon) together with good cleanliness (RCC requirement) corrosion is barely evident
  - Lead bismuth eutectic (LBE) is still not used by in service of R&D reactors and many issues are still to be investigate
- **Design rules: R&D will help to state on the Inclusion of long-term material properties and degradation mechanisms for which there is no direct experimental data.**
- **Material specification: to assist in development of new materials and modifications of existing materials**
- **Tests and non-destructive examinations: needs to develop new methodologies and test requirements**

Feedbacks from the survey

20 responses registered giving valuable qualitative information:

- **RCC-MRx is clearly the design code that European stakeholders should focus on to have a standardized tools for future Gen IV reactors,**
- **There is a shared wishes from stakeholders on the field of design to be part of standardization work and so, the development of a to-be European design code,**
- **Pre-normative researches are pointed out as one of the major issue that will need strong support. Many challenges are to be undertaken:**
  - to fix existing conflicts either between codes but with different regulation also,
  - to extend the use of the code to other technical aspects (such as irradiation and environmental effects),
  - to solve the issues related to funding,

Future actions

- **CEN/Workshop 64 initiative**
  - 2 years
  - CWA 16519:2012 published in November 2012
- **Two options considered:**
  - ◆ To disband the WS 64 without follow up

    Request of Tractebel (GDF-SUEZ Belgium) that the work should remain inside the AFCEN structure..
  - ◆ To renew the WS64 for 3 years (2013-2015)

    To cope with the annual publication on amendments. Next revision of the RCC-MRx code in 2015

    The participants considered that future updating of the RCC-MRx shall be considered with the same wide participation of European and International, stakeholders even outside of the CEN Workshop system

    Participants in favour: ESS, JRC, SCK-CEN, AMEC, ITER

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Future actions

AFCEN does not deny the quality of the work done by the Workshop 64. Nevertheless, AFCEN does not wish to renew the Workshop 64 initiative in its present form - manpower and reactivity concerns

AFCEN proposal for possible future actions

- ◆ To continue the process of involving more users to the dvpt of design codes in general.
- ◆ To continue the initiative of Europeanization of RCCMRx
  Improvement of the organization of the work to be done in the CEN WS and the AFCEN sub-committee

AFCEN proposes :

- ◆ Integration of the voluntary partners as AFCEN members : ITER, ESS, MYRRHA…
- ◆ Creation of an international “prospective” advisory group of the RCC-MRx subcommittee - could be a new CEN Workshop defined in close cooperation with ESNII partners and Workshop' participants - future projects: ALFRED, ALLEGRO…
  - Identification of the needed pre-normative researches and possible operators
  - Advice on in-depth code modification to address “new” topics such as corrosion by liquid metal coolants and management of engineering data

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Support of CEN/CENELEC Focus group on Nuclear Energy

Recommendations of the CEN CENELEC Focus group Nuclear Energy (*Report to be approved by CEN and CENELEC BTs)*

- The CEN-CENELEC focus group on Nuclear Energy has a mandate from CEN and CENELEC technical boards to make a report on standardization needs for Europe covering the entire nuclear energy production. For that purpose an enquiry on standardization needs for Nuclear Energy was launched from early February to mid-April both to its members and CEN-CENELEC member bodies. The answers were analysed and the draft report for approval by the CEN and CENELEC technical boards was approved on November 14th (document CEN-CENELEC FG Nuclear Energy N22R3)
- **This report raised the question of the harmonisation needs in Europe and pre-normative research with 2 recommendations supporting initiatives such as CEN WS 64 for innovative nuclear installations (recommendation 5) and the follow up of the example of the Europeanization initiative of AFCEN code RCC-MRx for generation IV done in CEN WS 64 via a new CEN workshop (recommendation 6) Furthermore, this Europeanization process could be enlarged to other AFCEN codes using CEN workshops with the aim to answer the needs of the nuclear industry for generation III reactors.**

Recommendations of CEN CENELEC FG Nuclear energy

Recommendation 5: Pre-normative research in nuclear energy

CEN-CENELEC Focus Group

Considering research and development activities at European level supported by DG Research and Innovation in JRC, in NUGENIA (Generations II and III), in SNETP-ESNII (Generation IV) as well as in other industrial initiatives,

Considering national research and development programmes on nuclear energy,

,Considering that research is essential in ensuring and continuously improving nuclear safety,

- Confirms that technology development and safety needs should be the main drivers for these research and development activities,
- Encourages the inputs from these research and development activities into international standardization, and
- Supports initiatives such as CEN WS64 for innovative nuclear installations.

Recommendations of CEN CENELEC FG Nuclear energy

Recommendation 6: Follow up of CEN WS 64 initiative

CEN-CENELEC Focus Group on nuclear energy,

considering CEN WS 64 initiative and results on "Design and construction code for mechanical equipments of innovative nuclear installations",

considering nuclear new power plants or research facilities projects in Europe,

considering AFCEN's role as international industrial platform on which a European approach of codification can be built,

- supports the follow up of the example of the Europeanization initiative of AFCEN code RCC MRx for GENIV done in CEN WS 64 via a new CEN Workshop,
- supports in particular the initiative to enlarge this Europeanization process to other AFCEN codes using CEN workshops with the aim to answer the needs of the nuclear industry for generation III reactors

5. To go farther: How to capitalize and promote the European expertise in nuclear energy?

Examples of involvment of nuclear energy stakeholders in standardization: CEN and ISO chaimanship

- CEN/TC 121/SC 5 Non destructive testing
  - Secr AFNOR chair AREVA NP
- ISO/TC 135/SC 4 Non destructive testing Eddy current methods
  - Secr AFNOR chair Intercontrole (AREVA)
- ISO/TC 44/SC 5 Testing and inspection of welds
  - Secr AFNOR chair AREVA NP
- ISO/TC 156/WG 9 Corrosion testing of materials for power generation convener CEA

6. Conclusions of the meeting

- Approval of the report – Identification of amendments if needed and review of the recommendations

Addition of proposal for a "permanent structure to be defined"

Add a summary on knowledge management

- Results of the discussion on capitalization and promotion of the European expertise in nuclear energy

To promote openness towards other stakeholders outside the nuclear sector and also inside to link with the SNETP activities. With the objective to identify cross cutting technologies

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