Strål
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Swedish Radiation Safety Authority

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Research

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Participation in the European Committee for Standardization´s workshop regarding civil structures

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SSM perspective

Background

During the period 2014-2018, a CEN[1] workshop (Phase 2 Prospective Group 3 civil works) have been carried out. The aim of the workshop is to provide a base founded on the French standard in order to be able to establish a possible future European standard for the design of civil structures at nuclear power plants. The workshop has identified which additional investigations, research activities and changes that must be made on the existing French standard. CEN is the organization that issues the Eurocodes, which in Sweden is applied for the design of conventional civil structures as well as nuclear reactors and other nuclear facilities. Representatives from France, Germany, England, Poland, Finland and Sweden, among others have been part of the workshop.

Results

This report present the proposals identified by the Prospective Group 3 civil works. There are 12 identified proposals and they are all French code evolution proposals. None are research development proposals. Some of the identified proposals are to:

- Develop the management and quality assurance guidelines related to latest development in codes and standards.
- Add an appendix for defence in depth design of civil works for containment building of Nuclear Power Plant.
- Add an appendix for defence in depth / safety concept of civil works for pools in nuclear facilities.
- Editing the damping ratios for different structural materials.
- Editing some load combinations.
- Update the guidelines regarding the protection against aircraft crash, as a design extension hazard.
- Update the guidelines with the most important cases of special concrete.
- RCC-CW's consistency to EN[2] -206 (Concrete – Part 1: Specification, performance, production and conformity)

The results from the workshop is important in order to be able to establish a possible future European standard for the design of civil structures at nuclear power plants.

Objective

The results are valuable when it comes to future radiation safety assessments of civil structures in nuclear facilities and for future development

1 The European Committee for Standardization
2 Eurocode

of the SSM report "Design Guide for Nuclear Civil Structures (DNB)" (2017:07). DNB has been developed from Eurocodes and is aimed to be used for the design of civil structures at nuclear power plants in Sweden. It is important that SSM follows the work within this area, in order to develop a European code that is applicable for the design of civil structures at nuclear power plants.

Project information
Contact person SSM: Sofia Lillhök
Reference: SSM 2017-959 / 7030157-00

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Abstract

In this report is reported from the participation in the European Committee for Standardization (CEN) workshop 064 phase 2 (WS64 phase 2) “Design and Construction Codes for Gen II to IV nuclear facilities (pilot case for process for evolution of AFCEN Codes)”.

Herein is summarized the work so far carried out within the Prospective Group 3 (PG3) “civil works”, from the start of the workshop during the third quarter 2014 to mid-December 2017. The workshop finalization has been planned for the third quarter 2017, hence a workshop duration of 3 years. However, the workshop has been prolonged by 1 year.

The objectives are summarized as follows:

- A mechanism for a broad set of partners involved with design and construction of nuclear facilities in Europe.
- Allow partners not yet using AFCEN codes to learn about these codes.
- To give the opportunity to all participants to express their specific requirements for the long-term modifications of the Codes including identification of pre-normative research where necessary.
- During the process, other solutions in existing codes shall be considered. In ideal case, the result should be a combination of solutions from others codes, sometimes also allowing alternate approaches.
- Enable members to:
    - recommend medium-long term orientations of evolution of those codes,
    - identify the R&D needs associated to these recommendations,
    - look for explicit or implicit references to national standards in the codes and propose their substitution by international standards,
    - interact with the Multinational Design Evaluation Programme (MDEP) in view of:
        - on the one hand, promoting convergence actions in particular via MDEP SDO Board and asserting European practices at the international level,
        - on the other hand, converting MDEP recommendations in codes evolution proposals.

In this report is presented the proposals identified by the Prospective Group 3 civil works.

Sammanfattning

I denna rapport redovisas deltagandet i CEN:s arbetsgrupp ”Workshop 064 phase 2 (WS64 phase 2) Design and Construction Codes for Gen II to IV nuclear facilities (pilot case for process for evolution of AFCEN Codes)”.

Arbetet som har genomförts inom ramen för grupp 3 behandlande byggnadskonstruktioner (”Prospective Group 3 (PG3) civil works”) från starten av projektet under tredje kvartalet 2014 fram till och med december 2017 sammanfattas. Projektet planerades ursprungligen att avslutas det tredje kvartalet 2017, men har förlängts med 1 år.

Målsättningen med arbetet är att:

- Skapa möjligheten för ett brett deltagande av intressenter involverade i dimensionering och uppförande av kärntekniska anläggningar i Europa.
- Möjliggöra för deltagare som ej tidigare har använt standarder upprättade av AFCEN att få möjligheten att lära sig mer om dessa standarder.
- Ge möjligheten för alla deltagare att uttrycka och framföra synpunkter vad gäller framtida förändringar av standarder på lång sikt. Detta inkluderar även identifieringen av nödvändig forskning att utgöra underlag för framtida uppdateringar.
- Nyttja redan existerande standarder i arbetet med att identifiera framtida nödvändiga uppdateringar.
- Ge deltagarna möjligheten att:
    - Rekommendera hur standarderna bör utvecklas och förbättras på medellång och lång sikt,
    - identifiera nödvändig forskning som kopplar till givna rekommendationer,
    - ersätta nationella standarder som refereras till med internationella standarder, och
    - interagera med “Multinational Design Evaluation Programme (MDEP)”.

I föreliggande rapport redovisas de rekommendationer som har framtagits inom grupp 3 byggnadskonstruktioner.

1. Introduction

1.1 General

In this report, it is reported from the participation in the European Committee for Standardization (CEN) workshop 064 phase 2 (WS64 phase 2) “Design and Construction Codes for Gen II to IV nuclear facilities (pilot case for process for evolution of AFCEN Codes)”.

Herein is summarized the work so far carried out within the Prospective Group 3 (PG3) “civil works”, from the start of the workshop during the third quarter 2014 to mid-December 2017. The workshop finalization has been planned for the third quarter 2017, hence a workshop duration of 3 years. However, the workshop has been prolonged by 1 year.

1.2 Objectives

Amongst other things, the WS64 phase 2 objectives are described in the so called Business Plan (see Appendix 5).

The objectives are summarized as follows:

- A mechanism for a broad set of partners involved with design and construction of nuclear facilities in Europe.
- Allow partners not yet using AFCEN codes to learn about these codes.
- To give the opportunity to all participants to express their specific requirements for the long term modifications of the Codes including identification of pre-normative research where necessary.
- During the process, other solutions in existing codes shall be considered. In ideal case, the result should be a combination of solutions from other codes, sometimes also allowing alternate approaches.
- Enable members to:
  - recommend medium-long term orientations of evolution of those codes,
  - identify the R&D needs associated to these recommendations,
  - look for explicit or implicit references to national standards in the codes and propose their substitution by international standards,
  - interact with the Multinational Design Evaluation Programme (MDEP) in view of:
    - on the one hand, promoting convergence actions in particular via MDEP SDO Board and asserting European practices at the international level,
    - on the other hand, converting MDEP recommendations in codes evolution proposals.

1.3 Organization

The workshop consists of 3 prospective groups, covering the following subjects:

- Mechanics generation II-III
- Mechanics generation IV
- Civil works

The prospective groups work is coordinated by a Workshop Coordination Committee and the practicalities handled by a Secretariat. The workshop organization is shown in Figure 1.1.

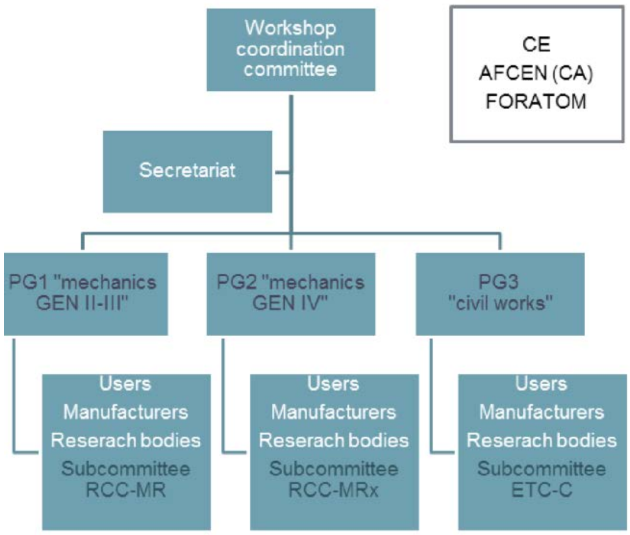

Figure 1.1 – CEN workshop 064 phase 2 organization (from the CEN WS 064 phase 2 business plan).

The work is organized in such a manner that the main part of the work is carried out by the PG3 members. The members meet typically 3 times a year. During each of these meetings, normally a specific part of the AFCEN code (RCC-CW [11]) is presented by an AFCEN representative and specialist. The topics presented are discussed by the members, and investigations and actions are initialized.

Based on the actions and investigations performed by the PG members, the prospective group then agree upon recommendations (proposals) to be forwarded to AFCEN. The recommendations are one of the following:

- To recommend medium-long term orientations concerning the evolutions of the codes
- To identify the related R&D actions
- To see to the "denationalization" of references

The proposals are prepared by a sub-set of experts within the prospective group, and then presented and discussed within the PG. After adjustments, the final proposal is issued for balloting within the PG as well as the workshop. If approved, the proposal become a part of workshop agreement. The proposal is also handed over to AFCEN.

At the end of the workshop, the approved proposals will become the main body of the final CEN Workshop Agreement (CWA). The CWA constitute the formal outcome of the workshop, and will be published by CEN as an open report.

The planning valid before the recently prolongation of the workshop by one year is presented in Figure 1.2. For more details on the different parts, see Appendix 5. Due to the prolongation of the workshop, the CWA is planned for publication during the autumn 2018.

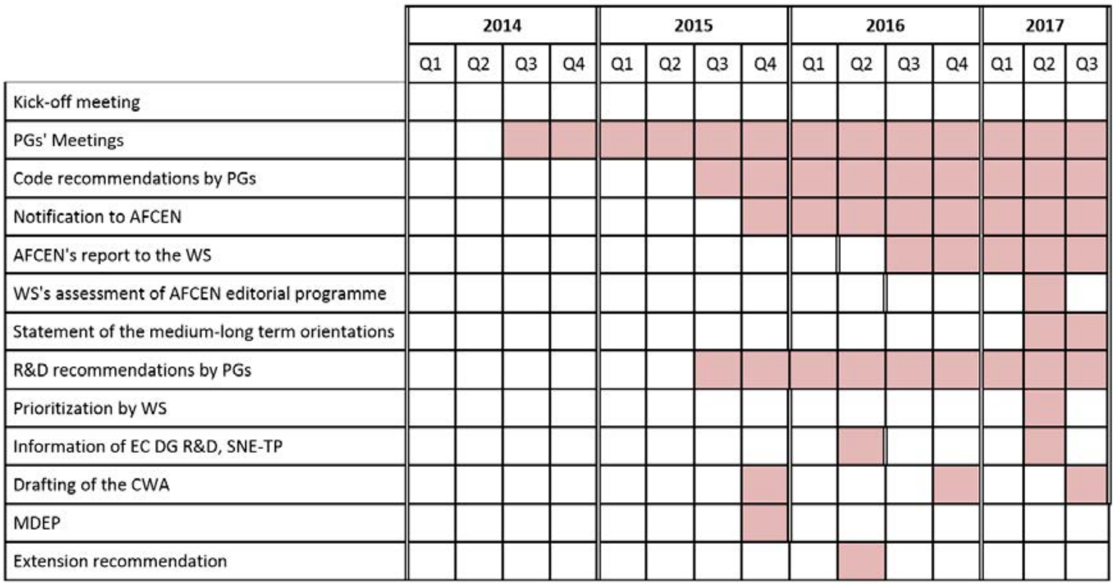

Figure 1.2 – CEN workshop 064 phase 2 planning valid before the recent prolongation of the project by one year (from the CEN WS 064 phase 2 business plan).

1.4 Participants

The Workshop has ~50 participating members, coming from 10 different European countries (Belgium, Finland, France, Germany, Italy, Netherlands, Poland, Sweden, United Kingdom and Ukraine).

Participants in the Prospective Group 3 on civil works are listed in Table 1.1. Included in the table is also stated code evolution (CE) proposal lead.

Table 1.1 – WS 064 Phase 2 PG3 list of participants.

Country	Organization	Name	CE proposal lead
Belgium	Tractabel Engineering	Nicolas de Deken	CE-04
	SCK CEN	Jeroen Engelen	
Finland	STUK	Pekka Välikangas	CE-01; CE-02
France	EDF	Etienne Gallitre	…
	IRSN	Gilbert Gulhiem	
	CEA	Jean-Claude Magni	
	AFNOR	Sylvie Picherit	…
	IRSN	Corine Piedagnel	CE-05
	IRSN	Francois Tarallo	CE-06; CE-10
Germany	VGB Power Tect Service	Stephan Kranz	CE-03
	RWE Power AG	Martin Widera	
Poland	Warsaw University of Techn.	Tomasz Piotrowski	CE-08; CE-09; CE-12
Sweden	Vattenfall AB	Anders Bergqvist	
	Scanscot Technology AB	Ola Jovall	CE-07; CE-11
United Kingdom	Amec Foster Wheeler	Tim Viney	

2. WS 064 phase 2 PG3 proposals

2.1 General

During the workshop, several proposals has been prepared. A summary of the proposals, together with their present status, is given in Table 2.1.

In the following sections are the proposals summarized. Proposals marked with yellow has been changed since the 2016 workshop reporting

Table 2.1 – PG3 code evolution (CE) proposals and issues.

ID	Title	Lead	Status
PG3/CE-01	Management and quality assurance guidelines	Pekka Välikangas	Approved
	The proposal is related mainly to ISO 9001:2008 [19], IAEA GS-R-3 [15] and NSQ-100 [20] (A new nuclear standard dedicated to quality of the supply chain). It is possible that the proposal is relevant also to other than the civil works (CW) codes, but current proposal is concentrating on RCC-CW [11].		
PG3/CE-02	Post tensioned reinforced containment.	Pekka Välikangas	Draft
	DiD is chaining from geotechnical structures, base slab, reinforced concrete structures, liner structures, post tensioning systems and monitoring systems. Depending on design criteria there are tolerances and specific testing and quality control need for execution. Finally monitoring and maintenance are ensuring the safe use of the building. Also, PSA point of view will be added to the proposal. To be discussed in 10^{th} PG3 meeting in line with post Fukushima actions in different countries. Proposal will be updated following discussion with Stephan Kranz.		
PG3/CE-03	Leak-tight pools.	Stephan Kranz	Draft
	DiD is chaining from geotechnical, reinforced concrete and liner structures as well as monitoring and leakage collection systems. Also, specific execution and quality control requirements to civil works are ensuring the safe use of the pool. Also PSA point of view will be added to the proposal. To be discussed in 10^{th} PG3 meeting in line with post Fukushima actions in different countries. Proposal will be updated following discussion with Stephan Kranz.		
PG3/CE-04	Damping ratios a) without spectra b) with spectra	Stephan de Deken	Draft
	Structural damping factors to be applied during structural analyses for earthquake events is not presented unambiguously in the present code.		

	Code is not stating that it is focusing there on the dimensioning of building frameworks. Damping phenomena in equipment qualification is different issue, which should be stated clearly. Part a) is kept as a code evolution proposal while part b) has been changed to a research development proposal (RD-02)		
PG3/CE-05	Combinations of actions	Corine Piedagnel	Approved
	The system of load combination table requires more explanation concerning both design basis condition and design extension condition. More clearance is needed on how principal loads are indicated by higher load factors in corresponding load combination. Designers needs to be supported more on defining partly known equipment loads as permanent / live loads.		
PG3/CE-06	DEH aircraft crash	Francois Tarallo	Approved
	Guidelines for protection against wide-body airliner crash as a design extension hazard (DEH).		
PG3/CE-07	BWR design	Ola Jovall	Approved
	The RCC-CW [11] contains rules for the design, construction and testing of the NPP civil engineering structures in PWR reactors. The purpose is to initiate a systematic identification and evaluation of typical as well as truly unique BWR features of importance for the design of civil works. This investigation to identify and implement into the RCC-CW [11] design part necessary amendments and modifications to in addition to PWR´s also cover the design of BWR units.		
PG3/CE-08	Special concrete	Tomasz Piotrowski	Approved
	Potential list of authorized concrete to be included in the code in order to specify most important applications with corresponding safety functions and main parametrization.		
PG3/CE-09	Universalisation	Tomasz Piotrowski	Approved
	One of the reason for developing RCC-CW [11] from ETC-C by a Sub-Committee was the necessity for new NPP Projects to comply with requirements from international regulations and practices. For this purpose the UNIVERSALISATION of RCC-CW [11] code is an obvious challenge. An important part has been already done but still there are parts and chapters that contain specific national requirements that are not commonly used in other countries (in Europe and in the World). They are mostly requirements in CCONC chapter.		
PG3/CE-10	Maintenance and monitoring	François Tarallo	Draft
	The aim is to alert Afcen and to provide main principles. Good texts about this topic already exist (WENRA, OECD). Furthermore, it is also specified that maintenance is not always a question of LTO. Ageing management starts from design and construction phases continuing to inspections and maintenance.		

	This proposal was commented in PG3 meeting and some references were added. Pekka Välikangas will have a last review before sending it to Mr. Tarallo.		
PG3/CE-11	Steel containments	Ola Jovall	Approved
	The current version of the RCC-CW [11] Code covers the design of PWR pre-stressed reactor containments. It is preferable that the RCC-CW [11] Code cover a broad variety of different plant types. At present time, no guidance is given in the Code regarding the design of steel (metal) reactor containments. It is proposed the integration of design requirements for steel (metal) reactor containments.		
PG3-CE12	Consistency with EN-206	Tomasz Piotrowski	Draft
	The proposal will be drafted by Tomasz Piotrowski and Pekka Välikangas. After December meeting, updated draft will be sent to PG3 members for email discussion and comments.		
CE = code evolution proposal RD = research development proposal			

2.2 PG3/CE-01 Management and quality assurance

2.2.1 Title

MaQuA: Development of management and quality assurance guidelines in RCC-CW [11] codes related to latest development on management and quality assurance codes and standards.

2.2.2 Code reference

Management and quality assurance requirements and guidelines are addressed in RCC-CW [11] part A. In GGENP GENERAL PROVISIONS subsections are stated references to corresponding requirements so that both industry standard ISO 9001:2008 [19] and regulative guide IAEA GS-R-3 [15] are acknowledged. Referred codes and papers in this proposal are:

- RCC-CW [11], 2015 edition, part A - GGENP GENERAL PROVISIONS
- ISO 9001:2008 [19], Quality management systems – Requirements
- IAEA GS-R-3 [15], Safety of Nuclear Power Plants: Design
- IAEA SRS 69 [14], Management system standards: comparison between IAEA GS-R-3 [15] and ISO 9001:2008 [19]
- NSQ-100 [20], A new nuclear standard dedicated to quality of the supply chain
- WENRA [27] reference level 03, Issue C, Management System
- European Utility Requirements (EUR) [9]

2.2.3 Brief outline

Management and quality assurance requirements of RCC-CW [11] code are based on ISO 9001:2008 [19] and IAEA GS-R-3 [15]. This gives a good industrial standard and nuclear safety regulation based guidelines for management and quality assurance. Since the RCC-CW [11] is under development it is good and important possibility to take a look at neighboring development of management and quality specific standards and codes which shall be important references in future.

- IAEA is currently updating IAEA GS-R-3 [15] and following corresponding development in ISO and Nuclear Quality Standard Association (NQSA).
- NQSA is developing NSQ-100 [20] for supporting quality control of supply chains in nuclear industry. NSQ-100 [20] will be important reference since it is based on IAEA GS-R-3 [15], ASME NQA-1-2008 [4] and on the latest experience from NPP construction projects.

2.2.4 State of the art knowledge

The Fukushima accident and on-going NPP construction projects have prompted increased international efforts to develop guidelines for nuclear safety specific features also for management and quality assurance. Regulatory requirements on such issues have been developed in IAEA. Also national regulators like Finnish Radiation and nuclear safety authority (STUK) has been developing corresponding guidelines.

Since NPP projects are huge efforts, lot of subcontracting is needed starting from design phase. Therefore, NQSA's effort for guide lining the management and quality assurance in supply chain is also important. The RCC-CW [11] is already considering both industrial (ISO) and regulatory safety requirements. This gives a good basis for successful code evolution in order to ensure that latest development on this topic is considered and referred in the RCC-CW [11] code.

2.2.5 Suggested objectives to the code evolution

This CE –proposal suggest following issues to be studied and executed based on further reasoning:

1. Addressing specific reference codes and standards concerning management and quality assurance guidelines.
2. Acknowledging possible new methodology and guidelines, especially concerning management and quality control in supply chains of design and execution.
3. Revising and possibly extending the RCC-CW [11] code under development.
4. If needed, developing new approach for the management and quality assessment requirements.

2.3 PG3/CE-02 Post tensioned reinforced containment

2.3.1 Title

Defense in depth design of civil works for containment building of Nuclear Power Plant.

2.3.2 Code reference

RCC-CW [11] code give principles for analyzing, designing and maintaining nuclear power plant structures. These guides are generic for civil structures and concentrated on pressurized water reactor plants. Code starts from geotechnical design aspect and ends to monitoring and maintenance guidelines. Both deterministic and probabilistic methods are described in detail. Referred codes and papers in this proposal are:

- RCC-CW [11], 2015 edition, part 1 design, part 2 construction, part 3 maintenance and monitoring
- IAEA SSR 2/1 [18], NPP Design specific safety requirements
- IAEA SSG-30 [16], Safety classification of structures, systems and components in NPP

- IAEA NS-G-1.10 [13], Design of reactor containment systems for nuclear power plants

2.3.3 Brief outline

RCC-CW [11] code is describing good practices for the design, execution, monitoring and maintenance of NPP civil structures. Also NPP specific civil construction materials, structures and technology are described. Together with this information and IAEA guidelines and national regulatory guidelines it is possible to accomplish comprehensive defense in depth (DiD) design for dimensioning, execution, monitoring and maintenance for NPP containment building civil works. In IAEA SSG-30 [16] are outlined principles on how requirements for safety functions and design criteria for design provisions should be set. Moreover, IAEA NS-G-1.10 [13] is outlining containment specific safety goals, anticipated physical phenomena and corresponding identified design criteria. Also, examples of containment designs have been illustrated in a specific annex.

The total point of view between safety principles and design provisions are managed by competent experienced specialists and design managers especially when project specifications are made. RCC-CW [11] code is then an important tool supporting the continuation of this specialized design area. One difficulty is that there seems to be quite long time gaps between construction projects at the same time when specialists are retiring or moving to other industrial area. Therefore, it is suggested that in RCC-CW [11] code could include similar way as IAEA NS-G-1.10 [13] is supporting the containment designs an annex on how to ensure defense in depth design for certain NPP specific buildings and structures and how the DiD is contributing together with good conventional design practices commonly accepted safety goals. Beyond that the support from probabilistic risk and safety assessments (PRA/PSA) would also be beneficial to be illustrated in the corresponding design process.

Post tensioned reinforced leak-tight containment include certain kind of geotechnical structures, base slab, reinforced concrete structures, liner structures, post tensioning systems and monitoring systems forming the DiD of the civil works part of containment. Depending on design criteria there are tolerances and specific testing and quality control needs for execution. Finally monitoring and maintenance are ensuring the safe use of the building.

Extra annex in RCC-CW [11] could combine corresponding safety and design goals with conventional good design practices described in technical standards and codes. Also how the safety cases could be measured and ensured by PRA/PSA could be referenced in the annex.

Above mentioned annex could refer to relevant parts in RCC-CW [11] code and outline how different design solutions, quality control and monitoring and maintenance form a chain of means for final safety. This can also support the discussion on how different safety functions can cover each other and ensure the balance between optimization and safety.

2.3.4 State of the art knowledge

Efficient development of project specification is based on reference plants and before used codes and standards. RCC-CW [11] is renewed from ETC-C [10] code. Also regulatory requirements on such issues have been developed recently. This kind of development is a continuous procedure in order to react if new findings and relevant information are received. The proposed annex supports the code development from the focus of specific important NPP structure.

2.3.5 Objectives of the code evolution programme

This CE –proposal suggest following issues to be studied and executed based on further reasoning:

1. Addressing specific reference codes and standards concerning containment design guidelines.

2. Acknowledging possible new methodology and guidelines, especially concerning total point of view by DiD study of the design and execution considerations of NPP containment.
3. Revising and possibly extending the RCC code under development.
4. If needed, developing new approach for supporting the implementation of RCC-CW [11] code in project specifications.

2.4 PG3/CE-03 Leak tight pools

2.4.1 Title

Defense in depth / safety concept of civil works for pools in nuclear facilities.

2.4.2 Code reference

RCC-CW [11] code gives principles for analyzing, designing and maintaining nuclear power plant structures. These guides are generic for civil structures and concentrated mostly on pressurized water reactor plants. Code starts from geotechnical design aspect and ends to monitoring and maintenance guidelines. Both deterministic and probabilistic methods are described in detail in principle, but no reference to pool structures are given. Especially safety point of view for different kind of pools in nuclear facility is missing. Referred codes and papers in this proposal are:

- RCC-CW [11], 2015 edition, part 1 design, part 2 construction, part 3 maintenance and monitoring
- IAEA SSR 2/1 [18], NPP Design specific safety requirements
- IAEA SSG-30 [16], Safety classification of structures, systems and components in NPP
- IAEA SSG-15 [17], Storage of spent nuclear fuel
- WENRA report, Safety of new NPP designs [27], March 2013

2.4.3 Brief outline

RCC-CW [11] code is missing conceptual safety concept guidance in order to acknowledge defense in depth (DiD) thinking for ensuring leak-tightness and other important functions of water containing pools in nuclear facility. WENRA report, 2013 [27] gives guidance on how DiD levels should be identified in order to be independent from each other. And finally how these independent DiD levels should be strengthened separately.

RCC-CW [11] code should identify these different kind of pools, like spent fuel pools as well as service water and severe accident management related water storages, which are important against big radiation release and/or for protection of nuclear facility. Related type of structures to be tested and specially considered in detail design, like continuous welds, anchorage and static systems holding boiling water inside should be identified.

RCC-CW [11] is describing good practices for the design, execution, monitoring and maintenance of NPP civil structures. Also, NPP specific civil construction materials, structures and technology are described. Together with this information and IAEA guidelines, WENRA and national regulatory guidelines it is possible to accomplish comprehensive defense in depth (DiD) design for functional design (load combinations), dimensioning, execution of civil works as well as monitoring and maintenance different pools. In IAEA SSG-30 [11] it is outlined principles on how requirements for safety functions and design criteria for design provisions should be set in general level. Moreover, IAEA SSG-15 [17] is outlining specific safety goals for storage of spent nuclear fuel, anticipated physical phenomena and corresponding identified design criteria. Also, examples of corresponding storage designs have been illustrated in a specific annex.

The total point of view between safety principles and design provisions are managed by competent experienced design specialists and design managers especially when project specifications are mature enough. RCC-CW [11] code should be developed to be also a useful tool supporting the continuation of this specialized design area. One difficulty is that there seems to be quite long time gaps between construction projects at the same time when specialists are retiring or moving to other industrial area. Therefore, it is suggested that RCC-CW [11] code should include an annex supporting the pool design on how to ensure DiD design for pool geometry, different type of structures and how the DiD is contributing together with good conventional design practices commonly accepted safety goals. Beyond that the support from probabilistic risk and safety assessments (PRA/PSA) would also be important to be illustrated in the corresponding design process.

Depending on the amount of including radioactive materials, pool require certain kind of geotechnical, reinforced concrete and liner structures as well as monitoring and leakage collection systems. Also, specific execution and quality control requirements are needed to be described for civil works in order to ensure corresponding part the safe use of the pool. Depending on design criteria there are tolerances and specific testing, mock-ups and quality control needs for execution. Finally monitoring and maintenance are ensuring the safe use of the storage. Extra annex in RCC-CW [11] could combine corresponding safety and design goals with conventional good design practices described in technical standards and codes.

The proposed annex could refer to relevant parts in RCC-CW [11] code and outline how different design solutions, quality control and monitoring and maintenance form a chain of DiD levels for final safety. This can also support the discussion on how different safety functions can cover each other and ensure the balance between optimization and safety.

2.4.4 Suggestion for outlining the Appendix

Efficient development of project specification is based on reference plants and before used codes and standards. RCC-CW [11] is renewed from ETC-C code. Also, regulatory requirements on such issues have been developed recently. This kind of development is continuous procedure in order to react if new findings and relevant information are received to be taken into account in basic design. The proposed annex supports the code development from the focus of specific important NPP structures. Following parts can be seen forming the DiD system for safety concept of fuel and spent fuel pools which can be basically measured with PRA/PSA, depending on the events to be analyzed.

A. RCC-CW [11] code should support as simple as possible thinking on safety and design for different kind of pools, when the concept of common geometry, boundary conditions and anchorage solutions for steel liner of pools are set.
B. Stress-strain behavior of steel liner as a primary barrier ensuring leak-tightness should be based on well controlled system of supportive backing for welds, anchorage system and reinforced concrete structures of the pool. Clear anchorage system and boundary conditions should smooth blistering in order to get stable strain control of liner itself and ensuring localized system of leakage monitoring system for efficient leakage identification.
C. The leakage monitoring system must ensure clear identification of possible leakage areas or zones and finding efficiently possible structural faults for correction.
D. Surrounding reinforced concrete structures of the pool must be robust in order to support reasonable design margin for leakage barrier function of steel liner part. Reasonable crack control and displacements in reinforced concrete structures ensure that strains in steel liner are in reasonable area and that the concrete part of the pool is also functioning

as a secondary barrier against leakage in order to have reasonable time to find and correct possible faults in steel liner pointed out by leakage monitoring system.

E. Other possible secondary barriers, like geotechnical barriers and/or leakage collection structures should be acknowledged too.

The above mentioned DiD levels are forming together DiD system against leakages and other design criteria with corresponding parametrization for pools in nuclear facility. Corresponding design should be based on tested design criteria in accordance with RCC-CW [11] code and if need be reviewed/measured by PRA/PSA methods for safety assessment. It is acknowledged that for this more data and benchmarking is needed, which might conclude that the issue is more on RD proposal than CE proposal. One possibility to make the safety assessment of leakages and/or other design criteria is to chain the above-mentioned A – E DiD levels. Analysis of the concept could be best practice study with statistical design and material parameters in order to acknowledge critical parts in the design and monitoring of the pool. Probabilistic assessment could be formulated for example to follow the functionality of leak-tightness barriers in accordance with safety goals from utility (level 1 PSA) and environment point of view (level 2 PSA). Possible events to be analyzed by PRA/PSA are (exemplarily):

- Increase of pool temperature due to loss of spent fuel pool cooling remark: boiling temperature of the water may increase up to 120 °C due to overpressure in the containment
- Integrity and leak-tightness of the pool due to external events like earthquake, aircraft crash or external explosion even beyond the design loads due to acceleration
- Leak at the pool or at connected systems
- Drop of fuel rods or heavy loads
- Corresponding primary design of barriers and basic parameters are (exemplarily):
  1. Steel liner vs. deformation capacity including blistering and discontinuation in welds
  2. Leakage monitoring and collection system vs. inspectability and information management
  3. Cracking controlled reinforced concrete structures vs. reinforcement ratio and anticipated leakage development
  4. Geotechnical barriers including drainage system inside the building in case of flood between the pool and the soil vs. isolation and pumping capacity.

2.5 PG3/CE-04a Damping ratios (without spectra)

2.5.1 Title

Damping ratios without floor response spectra.

2.5.2 Description of the proposal

2.5.2.1 Technical content

The RCC-CW [11] code as it is in its current status doesn't make any difference between the so-called "OBE" (Operating Basis Earthquake) and "SSE" (Safe Shutdown Earthquake) when it gives the damping ratios to be taken into account for the structural analysis.

Remark: OBE and SSE are abbreviations coming from the US regulation. This could be translated in the RCC-CW [11] terminology by "DBSE" and "DBE", respectively.

It is important to note that in this Code Evolution Proposal, we consider that the RCC-CW [11] deals only with the purposes of design and structural analysis. Meaning that the following topics are not covered by the code:

- Floor response spectrum generation
- Leak tightness
- Structural displacements calculations (closure of the joints between buildings for example)

2.5.2.2 Concerns / improvements

This lack of damping ratio for some specific situations could lead to mistakes in the way of determining the seismic accelerations acting on a structure and therefore, could lead to a wrong design of this structure.

We propose to make a review of the literature and the standards about these damping ratios, and especially the American regulation. Then, based on this review, we propose to provide a new table presenting the damping ratios including the missing situations described above.

This evolution of the code is not specific to a particular type of reactor. It can be applied as a generic feature. Therefore, this code evolution should be discussed and applied by the other working groups (PG1, PG2) as far as they deal also with damping ratios aspects. There is a need to keep coherence between all the codes managed by the different working groups.

2.5.2.3 Supporting data and scientific references

There are already existing and available standards and norms applying the differentiation between OBE and SSE earthquakes.

We can provide these references to codified solutions and helpful literature:

- ASCE 4-98 [2]: Seismic analysis of Safety –related nuclear structures
- US NRC – RG. 1.61 [26]: Damping values for seismic design of nuclear power plants
- ASME: ASME III- division 2 [3] - Appendix N (version 1992 et suivantes) – N1230 Damping
- RCC-G [12]: RCC-G Tome-I Conception: règles de conception et de construction du génie civil des Ilots nucléaires REP

2.5.2.4 Required additional data / research

An effort could be done to find more references and literature dealing with these aspects.

But there is no real need to launch a supporting R&D program on this topic.

2.5.3 Integration in the code

2.5.3.1 Type of modification / evolution

This new proposal has a very small impact on the existing code. The only change would be to edit the table (Table DA 4210-1: Relative Damping Values) giving the damping ratios and to replace it by an upgraded one.

2.5.3.2 Proposed structure of the revised code

A simple way to improve this table could be to adapt with the values coming from the US NRC – RG. 1.61 [26].

It is proposed to give these damping values for Design Basis Service Earthquake (DBSE) (i.e. OBE in US terminology):

DBSE damping values	
Structural Material	Damping (% of critical damping)
Reinforced Concrete	4%
Prestressed Concrete	3%
Reinforced Masonry	4%
Welded Steel	3%
Bolted Steel	5%
Tanks impulsive modes	2%
Tanks sloshing modes	0.5%

It is proposed to give these damping values for Design Basis Earthquake (DBE) (i.e. SSE in US terminology):

DBE damping values	
Structural Material	Damping (% of critical damping)
Reinforced Concrete	7%
Prestressed Concrete	5%
Reinforced Masonry	7%
Welded Steel	4%
Bolted Steel	7%
Tanks impulsive modes	3%
Tanks sloshing modes	0.5%

It is also proposed to add a comment explaining that "If the DBSE ground acceleration is selected to be less than or equal to one-third of the DBE ground acceleration, then a separate DBSE analysis is not required."

2.5.3.3 Group opinion of the proposal

This code evolution proposal has already been discussed by the members of the PG3 group and this new revision includes the last comments received. However, this new revision has still to be discussed during the next PG3 meeting for approval

2.6 PG3/CE-04b Damping ratios (with spectra)

2.6.1 Project title

Research of damping phenomena during seismic loads from structural serviceability and equipment qualification point of view in order to support the RCC-CW code evolution.

CODE reference (in particular AFCEN codes):

PG3-CE-04b proposal and corresponding AFCEN/AFNOR discussion related to RCC-CW [11], 2015 edition, part D Design, DA Seismic Analysis, DA4210 Damping.

2.6.2 Brief outline

In PG3-CE-04b has been discussed that in RCC-CW [11] damping phenomena should be stated more clearly for equipment qualification, when the level of the used capacity of structures is low and corresponding and therefore damping is also lower than stated in RCC-CW [11]. In the discussion from AFCEN point of view it was presented that concerning floor response spectra it will require long time to clarify the requirements. Even thought that improvement is needed the agreement will be difficult to reach since there are not enough technical data.

Therefore, it is practical to make corresponding research and development proposal.

Damping phenomena is challenging especially when the serviceability of civil structures must be studied both from forces/stresses and displacements/deformations amplitudes point of view. Also, floor response spectra for functional qualification of ex. mechanical equipment require more attention when corresponding building frameworks are dimensioned against higher loadings than the loads for equipment qualification.

2.6.3 Objectives of the research programme

Study the background of corresponding North American standards and guidelines (cf PG3 CE 04b).

Study measured vibration testing data and actual data from earthquakes.

Study the possibility to implement above mentioned information to RCC-CW [11].

Research report for concluding the studies and assessment of applicability in RCC-CW [11].

2.6.4 State of the art knowledge

The state of the art knowledge is divided in different engineering domains, like civil, mechanical and electrical engineering, but the most relevant part concerning this proposal is in civil engineering in machine foundation design. Differences between random vibrations vs. harmonic vibration phenomena should be acknowledged.

For commenting this proposal, it is good to acknowledge recent research of vibration phenomena like IRIS 3.

2.6.5 Project description

The work plan for developing this proposal and corresponding research of RCC codes could consist of the following steps

1. This draft is based on earlier studies on PG3-CE-04b and is presented in PG3 meeting on 12th December 2017.
2. Proposal will be sent by email after the meeting to PG3 group and comments will be asked until two weeks from the email.
3. Final proposal will be edited latest during the last PG3 meeting on 22nd – 23rd January 2018. If possible AFCEN specialist will take part to the discussion.
4. Election in the last PG3 meeting.

2.6.6 Estimated duration

Proposal will be completed during last PG3 meeting and elected, if not in the meeting, until the end of January 2018.

2.6.7 Deliverables

Research proposal to EC.

EC review of the topic.

WS064 closure.

2.7 PG3/CE-05 Combinations of actions

2.7.1 First proposal: General comment for variable thermal load

2.7.1.1 Description of the proposal

Technical content

Variable thermal actions are defined according to chapter DGENR 3323. When thermal effects are calculated with a linear elastic analysis, the induced thermal loads may be reduced by factors which take into account the cracking of concrete under the effect of the heat. Those factors are defined in chapter DCONC 4223, provided that required conditions concerning bending reinforcement ratio and concrete f_{ck} are met. The elementary action so obtained is the variable action Q_{kT}.

Concerns / improvements

In order to prevent any confusion between those factors and concomitance factors issued from Eurocodes, it would be preferable to distinguish each notion:

- In DCONC 4223, description of a simplified method which can be used for structure design in order to define elementary thermal loads Q_{kT},
- In DGENR 3400 definition of the combinations of actions.
- should be added when calculating the contribution of thermal loads"

Supporting data and scientific references

Good design practice.

Required additional data/research

No additional data or new methods needed to support the proposed evolution.

2.7.1.2 Integration in the code

Type of modification / evolution

The proposed evolution requires minor editing of the existing code.

Proposed structure of revised code

In DCONC 4223:

- suppress the following text: "The previous value of the factor reduction are not accounted for in Table DGENR 3400-1 and Table DGENR 3400-2 and should be included when calculating the contribution of thermal loads"
- add at the end of the second paragraph concerning the determination of thermal effects: "The elementary action so obtained is the variable thermal action Q_{kT}"

In DGENR 3400 nota (d):

- suppress the following text "Coefficients defined in DCONC (concerning the reduction of thermal loads in linear elastic analysis) are not accounted for in Table DGENR 3400-1 and should be added when calculating the contribution of thermal loads"

Group opinion of the proposal

Shortly describe the opinion of the concerned prospective group(s) on the proposal. Report if the opinion is unanimous or if there are any opposing opinions. In the latter case also report the opposing opinion.

Mention the AFCEN representative(s) view point and, when necessary, that of R&D members.

2.7.1.3 Interaction with AFCEN

WS 064 proposal submission to AFCEN

Indicate the date of submission of the proposal to AFCEN.

AFCEN feedback

Indicate the status of the request to AFCEN: in progress or answered (in this case, indicate the date of answer and the nature of the answer: fully accepted, accepted with provisions, rejected).

WS 064 actions

Give the group evaluation of the response and proposed action(s) from AFCEN.

Indicate if a revision of the proposal is needed.

2.7.2 Second proposal : General comment for operating loads

2.7.2.1 Description of the proposal:

Technical content

Operating loads (Q_{kl}) are defined according to chapter DGENR 3322. It's written that "In order to better characterize each load, it shall be stated in design whether its intensity is either known, estimated or factored in globally".

It's necessary to well identify the different kinds of operating loads:

- Mobile part of heavy equipment which can be moved and stored for a long time during maintenance operation;
- Mobile operating loads related to handling or maintenance, which are really live loads on floors. For the first one, the concomitance factors assigned to those loads in DBD and DED combinations must be equal to 1.00.

For the second one, the concomitance factors can be equal to those recommended by Eurocodes (Ψ_0 = 0,7; Ψ_1 = 0,5; Ψ_2 = 0,3).

Concerns / improvements

See integration in the code below

Supporting data and scientific references

Good design practice.

Required additional data/research

No additional data or new methods needed to support the proposed evolution.

2.7.2.2 Integration in the code

Type of modification / evolution

The proposed evolution requires minor editing of the existing code.

Proposed structure of revised code

In DGENR 3222:

- Give a realistic definition of live loads: "mobile operating loads related to handling or maintenance"
- Add a comment about "action due to heavy equipment stored during maintenance situations" as it has been done for the lift operating.
- Point that "all fixed equipment self-weight must be considered as permanent loads"

In DGENR 3400:

- Suppress nota (1)
- Include in nota (c), the notion included in the third paragraph of nota (1): "For global analysis Ψ_2 = 0,3 can be reduced to 0,2 to represent the non-simultaneity of all operating loads in the whole structure. In all cases, the minimum value of Ψ_2 Q_{kl} is 1kN/m2."

- The Ψ factors are recommended values for power plants. They can be modified by the project with appropriate justification.
- Add a new nota or a new paragraph in nota (c) concerning mobile part of heavy equipment which can be moved and stored for a long time during maintenance operation: “For mobile part of heavy equipment which can be moved and stored for a long time during maintenance operation, the concomitance factors assigned to those loads in DBD and DED combinations must be equal to 1.00. If there is no precise evaluation of such loads and if their values are included in a global elementary case, the load factor applied to this case must be equal to 1.”

Group opinion of the proposal

Shortly describe the opinion of the concerned prospective group(s) on the proposal. Report if the opinion is unanimous or if there are any opposing opinions. In the latter case also report the opposing opinion.

Mention the AFCEN representative(s) view point and, when necessary, that of R&D members.

2.7.2.3 Interaction with AFCEN

WS 064 proposal submission to AFCEN

Indicate the date of submission of the proposal to AFCEN.

AFCEN feedback

Indicate the status of the request to AFCEN: in progress or answered (in this case, indicate the date of answer and the nature of the answer: fully accepted, accepted with provisions, rejected).

WS 064 actions

Give the group evaluation of the response and proposed action(s) from AFCEN.

Indicate if a revision of the proposal is needed.

2.7.3 Third proposal : Specific comments on some load combinations

2.7.3.1 Description of the proposal:

Technical content

Modification of some load combinations

Concerns / improvements

See integration in the code below

Supporting data and scientific references

Good design practice.

Required additional data/research

No additional data or new methods needed to support the proposed evolution.

2.7.3.2 Integration in the code

Type of modification / evolution

The proposed evolution requires minor editing of the existing code.

Proposed structure of revised code

COMBINATIONS	COMMENT	PROPOSAL

1bw, 1bs, 1bwl,3a, 3c, 3e	Factor 0.9 for Q_{kt}	Put in coherence the table for all combinations in construction situations
All DBD and DED combinations	Factor 1.0 for P (or 0.0 in some construction situations)	Put in coherence the table
2ft, 2gt, 2h: Pool combinations	Those combinations are not coherent: 2ft, 2gt: Q_{kw}, Q_{ks} 2ft: $Q_{kwl,EF}$ instead of $Q_{kwl,\phi EF}$ with a factor equal to 1.2 2 gt: $Q_{kwl,EF}$ instead of $Q_{kwl,\phi EF}$ with a factor equal to 1.0	Review pool combinations
3c, 3d		Note (5) should be mentioned under the limit state
5 to 10	Are not concerned by nota (d) (factor 0,5 applied to Q_{kT}) because the temperature effect is included in the action.	Improve redaction of nota (d)
16		It should be reasonable to take into account a wind effect in case of exceptional snow

<u>Group opinion of the proposal</u>

Shortly describe the opinion of the concerned prospective group(s) on the proposal. Report if the opinion is unanimous or if there are any opposing opinions. In the latter case also report the opposing opinion.

Mention the AFCEN representative(s) view point and, when necessary, that of R&D members.

2.7.3.3 Interaction with AFCEN

<u>WS 064 proposal submission to AFCEN</u>

Indicate the date of submission of the proposal to AFCEN.

<u>AFCEN feedback</u>

Indicate the status of the request to AFCEN: in progress or answered (in this case, indicate the date of answer and the nature of the answer: fully accepted, accepted with provisions, rejected).

<u>WS 064 actions</u>

Give the group evaluation of the response and proposed action(s) from AFCEN.

Indicate if a revision of the proposal is needed.

2.8 PG3/CE-06 DEH aircraft crash

2.8.1 Title

Guidelines regarding the protection against aircraft crash, as a design extension hazard (DEH)

2.8.2 Code reference

Design basis are addressed in RCC-CW [11] 2015 edition, part 1 design.

2.8.3 Brief outline

Since the RCC-CW [11] is under development it is a good opportunity to update the text related to DEH aircraft crash as follows:

- a modification of DGENR 3335
- a modification of DCONC 10000
- a new appendix dedicated to DEH aircraft crash

2.8.4 Objectives of the code evolution

This CE –proposal suggests a safety approach and some guidelines regarding the protection against a commercial aircraft crash, considered as a DEH scenario. This proposal is consistent with the current state of the art, in particular the recent WENRA recommendations.

2.8.4.1 Modification of DGENR 3335 Accidental Aircraft crash: Adb,apc and Ade,apc

Design extension values and analysis

The Project defines the design extension actions Ade,apc associated to aircraft crash. For DED aircraft, the design study shall be carried out, in accordance with the method described in APPENDIX DC. If that method is not applicable (for example when the impact area is non-circular), the guidelines of appendix DEH Aircraft Crash will be followed. Other method shall be subject to the Project approval. The justifications concern:

- the structural stability study,
- the strength of the exposed walls.

The induced vibrations have to be analysed with a method consistent with seismic analysis methods described in APPENDIX DA. (this appendix have to be discussed later)

2.8.4.2 Modification of DCONC 10000 ADDITIONAL RULES FOR THE DESIGN OF THE AIRPLANE RESISTANT SHELL

a. As far as DEH aircraft crash is concerned, the Appendix DC is not always applicable (see above modification of DGENR 3335). It should be mentioned in the text.
b. The reference to “document [1]” is not clear: must be clarified.

2.8.4.3 Introduction of a new appendix: APPENDIX xxx. DEH Protection against aircraft crash

References

WENRA RHWG Report [27]. “Safety of new NPP designs”. March 2013

YVL Guide A.11 [24]. “Security of a nuclear facility”. 15 November 2013

Riera J.D., “On the stress analysis of structures subjected to aircraft impact forces”, Nuclear Engineering and Design, 8 (1968) 415-426 [25].

Reports of IRIS (Improving Robustness Assessment Methodologies for Structures Impacted by Missiles) benchmarks:

IRIS_2010 [21] Final Report OECD/NEA/CSNI/R(2011)8, 19 January 2012

IRIS_2012 [22] Final Report OECD/NEA/CSNI/R(2014)5, 30 June 2014

Report OECD/NEA/CSNI/R(2015)5 [23]. “Bonded or Unbonded Technologies for Nuclear Reactor Prestressed Concrete Containments”. June 2015

A. Safety related requirements concerning DEH aircraft crash

General requirements and possible protective features

Civil works components required to bring the facility to a safe state shall be designed taking into account the direct and indirect consequences of an airplane crash including the mechanical effects on structures, the induced vibrations and the airplane fuel induced fires and explosions.

Buildings containing nuclear fuel and building housing key safety functions shall be designed to prevent airplane fuel from entering them. Fires caused by airplane fuel shall be assessed as different kinds of fire ball and pool fire combinations. Other consequential fires due to the airplane crash shall be addressed.

Regarding the protection against DEH aircraft crash, the following features can be incorporated in the design of the plant: geographical separation of redundant safety systems, bunkerization of the external walls and roofs of the concerned buildings, airplane shell, steel lining of some internal faces as a response to leak-tightness requirement or scabbing products confinement.

Safety related requirements related to the civil structures

Depending on the safety assessment of the aircraft crash external hazard, the possible requirements assigned to civil structures are:

- overall stability, no collapse; this aspect is necessary for the protection of the relevant systems and components inside the building. The overall stability covers the global tilting, or sliding, of the building on its foundation. The collapse means either the ruin of some frameworks of the building (for instance stability frames made of columns and beams, either metallic or concrete ones), or the ruin of the front wall that receives the impact and develops flexural plastic hinges
- local stability and supporting of equipment
- limitation of structural displacements, in order to prevent one or several of the following consequences:
    - the interaction between two buildings
    - the contact of an airplane shell onto the protected building, thus exerting unexpected loading on the corresponding structures
    - the degradation of equipment (pipes…) or special features (seals…)
- containment of radioactive material, or leak tightness. The leak tightness of a structure is usually ensured by a steel liner when the concrete alone is not sufficiently leak tight.
- prevention of perforation of structural elements, in particular when hard missile is concerned. Though not perforated, a concrete plate might be damaged by cone cracking (leading to a loss of leak tightness if the liner is damaged), spalling or scabbing.
- prevention or limitation of scabbing (scabbing means ejection of concrete debris and possible damage of equipment present behind the wall)
- structural and functional resistance against impact-induced vibrations. The operability of relevant equipment might be jeopardized
- structural resistance and protection against impact-induced fire and explosion.

Acceptance criteria related to the mechanical behavior of the civil structures

When analyzing the mechanical behavior of civil structures with respect of the above listed requirements, acceptance criteria must be defined. Some examples of acceptance criteria are given here after:

- overall stability, no collapse:
  - tilting: limitation of the uplift area of the base (for instance 30 % in case of no representation of the uplift); limitation of the compressive stresses in the foundation soil
  - sliding: limitation of the global shear force under the building to a fraction of the shear resistance of the soil
- local stability and supporting of equipment: limitation of rebar strains
- limitation of structural displacements: absence of unacceptable contact between adjacent structures
- containment of radioactive material, or leak tightness: limitations of the liner's strains, in order to prevent its tearing
- prevention of perforation of structural elements: the acceptance criteria depend on the method used:
  - empirical formulae such as the one of appendix DD in case of hard missile
  - analytical method such as the one of appendix DC in case of deformable missile. Acceptance criteria: $\sigma_c < 1.2\ f_{ck}$, $\varepsilon_s < 5\ \%$ (class B), provided the rebars have no overlapping in the scabbed area
  - finite element method (FEM), applicable whether the missile is hard or deformable. Absence of perforation if the velocity of the missile comes to zero before the end of the calculation
- prevention or limitation of scabbing: empirical formulae such as the one of appendix DD;
- structural and functional resistance against impact-induced vibrations. FEM may be used, to check that the dynamic loading of the relevant equipment stays within their qualification domain
- structural resistance and protection against impact-induced fire and explosion.

B. Definition of the mechanical loadings

Projectiles or missiles causing mechanical impacts are generally classified into two categories, based on the missile's deformability with respect to the deformability of the impacted structure: hard missile and soft (or deformable) missile. The corresponding impact is then called hard or soft.

<u>Definition of the projectiles</u>

As a general rule, aircrafts entering in the DEH scenario are large commercial aircrafts. The order of magnitude of their masses and dimensions are significantly greater than those of the DBD aircrafts[1]: masses from 100 tons to 500 tons, length and wing span from 40 m to 80 m. Their impact velocities range from 100 m/s to more than 200 m/s. When reaching a target near the ground level (altitudes 40 m to 80 m), their trajectory may form, with a horizontal plane, an angle that depends on the capacity of the aircraft and of the cause of the crash, accidental or not.

Those aircrafts might carry an important mass of fuel, reaching a third of the total weight. The tanks are located in the wings, the central tank being located in the fuselage. In terms of rigidity in the axial direction, the rather "soft" fuselage is supported by the stiffer wing boxes. Anyway, the plane as a whole is rather deformable, except the central parts of the engines and of the landing gears.

<u>Definition of the loadings</u>

[1] DBD aircrafts are usually small Cessna or Lear Jet crafts, less than 6 tons, and military air fighters such as a 20 tons Phantom.

There are two main differences between the loadings of a commercial aircraft and those of DBD aircrafts: the magnitude (both the maximum applied force and the momentum), and the loading area, that is both circular (fuselage) and rectangular (wings).

The commercial aircraft crash loadings may be either defined as load/time curves derived from an analytical method, or computed with the help of a finite element model of the airplane:

- the analytical method is based on a simplified spatial model of the aircraft, described by J.D. Riera in 1968 [25]. According to this method, the masses and crushing strengths are distributed along the fuselage axis. The crushing strength induces instantaneous and homogeneous deceleration in the remaining uncrushed part of the aircraft. The impact is supposed perfectly soft: the target is rigid, the projectile is deformable and there is no rebound. Then, the application of Newton's second law leads to the impact force. This approach cannot represent the loadings due to the harder parts (engines…) of the aircraft. Those loadings can be computed using FEM method (see next bullet). Alternatively, dedicated empirical formulae such as the one of appendix DD can be used.
- the aircraft may be explicitly modeled with the help of a FEM fast dynamic code. In this case, the corresponding loadings should nevertheless be checked for consistency with the Riera [25] approach.

The structure of those aircrafts being rather deformable, the crash loading is essentially due to the mass spatial distribution of the aircraft. The part due to the crushing strength is secondary.

Whatever the approach, it is recommended to check that the momentum and the kinetic energy associated to a loading do correspond to the characteristics and the impact velocity of the aircrafts chosen in the hazard scenario.

For the purpose of the structural analysis, the crash loading is applied on a realistic surface, corresponding to the shape and dimensions of the different parts of the aircraft that contribute to the loading.

C. Analysis guidelines: recommended approach

In analyzing a large commercial airplane crash on a civil structure, realistic (or best estimate) analysis methods and initial assumptions may be used. A sensitivity analysis shall be applied to assess cliff edge phenomena.

Due to the severity of such hazards, the analysis is highly non-linear and highly sensitive to the input data and model choices, such as the constitutive law of concrete. Therefore, the following 5-step methodology is recommended.

<u>Step 1: Building the Team of Analysts</u>

When studying an Impact Engineering problem, the first and maybe most important choice is the one of the team of analysts. That team should have a strong background in the type of problem concerned. Only calculation codes and tools familiar to the team should be used.

<u>Step 2: The Preliminary Analysis</u>

Before any "complex" simulation, the finite element method (FEM) being the most common, it is mandatory to carry out a preliminary analysis of the problem. Engineer tools shall be used: simplified methods, empirical formulae, analogy with previous problems and with existing tests. The basic information shall be gathered and discussed:

- the range of the problem: impulsive, dynamic or quasi-static
- the order of magnitude of the main parameters: duration of the impact, energy, momentum, probable strains and displacements
- the probable behavior of the projectile –deformability- and of the target –bending and/or punching. The differences between the mechanical behaviors have an influence on the modeling strategy: it is necessary to "feel" in advance the dominant rupture mode, flexural or/and punching mode

- design criteria: acceptable damage and deflections to the target, performance of the target after the impact, for example a requirement of leak-tightness.

Step 3: Choice of Tools and Validation of input Data

The calculation codes and tools should include appropriate physics and calculation methods. Before simulation, the analyst shall identify the issues to be focused on and then he shall apply a consistent set of assumptions, namely concerning the limiting conditions and the concrete behavior law.

The models, including the constitutive law of concrete, should be calibrated using representative experimental results, when available for example IRIS_2010 [21] and IRIS_2012 [22]. However, due to the numerous numerical ways for matching the tests results, it must be checked that the selected one does not cover either a computational "crime" or a physical law violation.

Step 4: The Numerical Simulations

Several different numerical simulations shall be performed, organized in sensitivity studies. The case shall be presented as simply as possible, with a focus on the main physical phenomena.

Projectile modeling: see above, paragraph B. Definition of the loadings.

Target modeling (reinforced concrete plates): in the case of bending behavior of the plate, surface elements (such as shell element) can be considered; in the case of punching behavior, volume elements appear as mandatory (at least in the area of the expected punching cone); the boundary conditions shall be carefully modeled; a partial model of the civil structure, using the existing symmetry, may be considered, with a special attention to the boundary conditions possibly causing numerical errors.

In case of FEM analysis, it is recommended to carry out sensitivity studies to define an adapted element size and time step; the results should not change when the mesh is refined, or when the time step is reduced. The validity of the selected concrete constitutive law should be checked by modeling and performing comparisons with some real experimental cases[2]. If not, compression and splitting tests on samples may be used as minimum references.

If the concrete can be significantly damaged (punching behavior of a concrete structural element):

- care must be given to erosion technics, that are not based on physics. Their safe use requires a special skill
- though FEM is the most common way to simulate the problem, other methods are well suited to concrete fragmentation (SPH[3], lattice discrete particle method, discrete element method…). They can be used, if appropriate.

Material properties: in the impact analyses, the material properties should be best estimate and may take benefit of the strain rate effect (for steel and concrete) and of the confinement (for concrete), according to the state of the art in that field.

A simplified analysis, with engineering attitude, has to be systematically adopted in parallel to the necessarily sophisticated FEM simulations: it allows quick sensitivity studies and improving of engineer's judgment.

Empirical formulae: when using an empirical formula, namely for hard impact analysis, the joint use of several formulae is advisable. Each formula should be used inside its validity range.

Step 5: Handling of Results

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[2] For instance, the information on Sandia, Meppen and IRIS Impact testing campaigns can be found in the literature

[3] Smoothed Particle Hydrodynamic

The analysis of the results needs a careful approach, comprising the minimum following provisions.

The calculation results must go through a critical analysis, a “sanity check”, to confirm the consistency of the simulation. For example, in a “soft” impact the projectile momentum should be more or less transmitted into impulse in the target. The results should be presented with usual structural engineering quantities.

Both random and epistemic uncertainties shall be assessed and quantified, as far as possible. An appropriate margin shall be incorporated in order to take those uncertainties into account.

D. Aircraft crash and pre-stressing system

This text deals with the pre-stressing system that takes an important part in the confinement function of some reactor’s containments.

In the event of an aircraft impact, a concrete containment can be subjected to loads and damage, possibly reaching the ultimate capacity of the structure. There are four types of consequences on that structure: axial and bending deformations of the wall, shear deformations of the wall, local damage (spalling, penetration and scabbing) of the wall, and induced vibrations. Each part of the structure (the concrete itself, reinforcing steel, pre-stressing steel, liner, etc.) takes part in the resistance and in the leak tightness of the wall.

The robustness of a pre-stressed structure impacted by an energetic projectile depends on whether the tendons are bonded to their ducts (with a cement grout) or unbonded. In the latter case the ducts may be filled with grease or wax, and some sliding of the tendons in their ducts may occur.

A containment wall whose tendons are protected by grouting, thus bonded to the structure, appears as more robust to impact loads than a containment whose tendons are greased or waxed, thus unbonded to the structure. The main reasons are the ability of bonded tendons to remain anchored to the concrete even if they are locally ruptured, and the contribution of bonded tendons, as passive steel, to the capacity of the reinforced concrete sections in the zone of the impact.

In addition, in the case of heavy damage to the containment wall induced by an aircraft crash, the leak tightness of that wall depends on its crack network. Important and numerous cracks mean not only a poor leak tightness of the concrete itself, but also significant strains imposed to the steel liner, increasing the probability of its tearing. In that situation, the possibly pressurized air and steam fluids present in the reactor building will seek their way out through the wall, even more easily if they find some voids or possible paths that interconnect the cracks. If not completely sealed, the pre-stressing ducts could offer such paths. In that respect, the bonded ducts technology appears as safer.

2.9 PG3/CE-07 BWR design

2.9.1 Title

BCD (BWR Civil Design): Increasing the types of units to be covered by the design section of the RCC-CW Code – BWR.

2.9.2 Code reference

The RCC-CW [11] contains rules for the design, construction and testing of the NPP civil engineering structures in PWR reactors. It describes the principles and requirements for the safety, serviceability and durability conditions, based on Eurocode design principles (European standards for the structural design of construction works) combined with specific measures for safety-classified structures.

The design of NPP shall ensure that safety-classified structures have the appropriate characteristics to ensure that safety functions can be performed with the necessary reliability, can be safely operated within the operational limits and conditions for the full duration of their design life and can be safely decommissioned.

In this purpose, the RCC-CW [11] combines design rules and requirements for both Design Basis and Design Extension Domains with dedicated approaches.

The safety analysis and consequently the design of NPP structures are based on the safety functions (containment, leak-tightness, support, etc.). Depending on these safety functions, the RCC-CW [11] gives different criteria for structure material (concrete, reinforcement, liners, anchorages, etc.) and for design situation.

Referred codes and papers in this proposal are:

- RCC-CW [11], 2015 edition – Part 1 Design
- Eurocodes

2.9.3 Brief outline

The safety objectives for nuclear reactors are the same independently of the type of unit at hand, however the events and circumstances to be considered, the safety functions to be ensured, and the corresponding criteria and design situations may differ to some extent.

Depending on the safety functions, the RCC-CW [11] specify criteria for applicable design situations covering the design of PWR units, with a pre-stressed reactor containment.

Included in the design part of the RCC-CW [11] (and the Eurocodes) are the following areas,

- requirements,
- actions and combinations of actions,
- materials,
- durability,
- structural analysis,
- ULS and SLS design, and
- detailing and specific measures for different type of construction.

The purpose of this Code Evolution is to initiate a systematic identification and evaluation of typical as well as truly unique BWR features of importance for the design of civil works. This investigation to identify and implement into the RCC-CW [11] design part necessary amendments and modifications to in addition to PWR´s also cover the design of BWR units. The investigation shall consider all of the areas listed above.

For each of the identified BWR features, the outcome of the investigation could be classified as follows,

- The existing design provisions in the RCC-CW [11] cover the situation, no adjustments needed
- The existing design provisions have to be adjusted
- New design provisions have to be added

For the last two outcomes above, adjusted/new design provisions should be developed, and added to the RCC-CW [11]. For the first one, the present wording of the RCC-CW [11] may have to be adjusted to ensure the understanding that the present design provisions also are applicable for BWR´s.

Code development work for typical, hence not truly unique, BWR features is recommended to be coordinated with other code evolution and code development projects, if such projects exist.

This could preferably end up in a situation where the adjusted/new design provisions are applicable for BWR´s as well as PWR´s.

For truly unique BWR features, specific design provisions should be added to the RCC-CW [11] and marked accordingly.

During the code evolution and development process, it may be identified that research programmes have to be launched to support the development of the new design provisions.

2.9.4 State of the art knowledge

Design provisions for BWR units exist in other Codes & Standards, and are discussed in industry documentation such as the EUR:

http://www.europeanutilityrequirements.org/Documentation/EURdocument.aspx

Also, on the market today are BWR units for which at least their basic design are in accordance with USNRC requirements, or is evaluated at the moment:

http://www.nrc.gov/reactors/new-reactors/design-cert.html

Additional research may be needed in key areas (to be identified during this code evolution project), and to comply with the latest European safety objectives, especially when they differ from US requirements. Ongoing evaluation in the UK:

http://www.onr.org.uk/new-reactors/assessment.htm

2.9.5 Objectives of the code evolution programme

This CE –proposal suggest following issues to be studied and executed based on further reasoning:

1. Identification of typical as well as truly unique BWR features (events and circumstances; safety functions; type of construction; etc.).
2. Implications on the design provisions (requirements; actions and combinations of actions; materials, durability; structural analysis; ULS and SLS design; detailing and specific measures for different type of construction; etc.).
3. Classification of the BWR features (already covered by the RCC-CW [11]; existing provisions have to be adjusted; new design provisions have to be established).
4. Specification of necessary code development work and research needs. When found appropriate, coordination of code development work and research with corresponding needs for PWR´s.
5. Code development and research work finalization.
6. Implementation into the RCC-CW [11] the necessary adjustments and modifications for BWR design, including needed design provisions that are common with PWR´s, following the formal AFCEN procedures.

The implementation of adjusted/new design features could be carried out in steps, implementing first the most urgent new RCC-CW [11] sections. If so, it should be clearly specified in the RCC-CW [11] the actual status of what is and what is not covered regarding the design of BWR´s.

2.10 PG3/CE-08 Special concrete

2.10.1 Description of the evolution

2.10.1.1 Technical content

The term special concrete means the concrete that has some special properties that are different than in so called – ordinary concrete. Due to this fact they usually play a very specific and very important role in construction. Special concretes are both those with extraordinary properties and those produced by unusual techniques. Both cases lead to special requirement for such concrete. Types of special concrete form a very wide list. According to Portland Cement Association (US) publication "Design and Control of Concrete Mixtures" following ACI CT-13 [1] "ACI Concrete Terminology, they are presented in a table below.

Special types of concrete made with portland cement		
Architectural concrete	High-early-strength concrete	Roller-compacted concrete
Autoclaved cellular concrete	High-performance concrete	Sawdust concrete
Centrifugally cast concrete	High-strength concrete	Self-compacting concrete
Colloidal concrete	Insulating concrete	Shielding concrete
Colored concrete	Latex-modified concrete	Shotcrete
Controlled-density fill	Low-density concrete	Shrinkage-compensating concrete
Cyclopean (rubble) concrete	Mass concrete	Silica-fume concrete
Dry-packed concrete	Moderate-strength lightweight concrete	Soil-cement
Epoxy-modified concrete	Nailable concrete	Stamped concrete
Exposed-aggregate concrete	No-slump concrete	Structural lightweight concrete
Ferrocement	Pervious (porous) concrete	Superplasticized concrete
Fiber concrete	Photocatalytic Concrete	Terrazzo
Fill concrete	Polymer-modified concrete	Tremie concrete
Flowable fill	Pozzolan concrete	Ultra High Performance Concrete
Flowing concrete	Precast concrete	Vacuum-treated concrete
Fly-ash concrete	Prepacked concrete	Vermiculite concrete
Gap-graded concrete	Preplaced aggregate concrete	White concrete
Geopolymer concrete	Reactive-powder concrete	Zero-slump concrete
Heavyweight concrete	Recycled concrete	
Special types of concrete not using portland cement		
Acrylic concrete	Gypsum concrete	Polymer concrete
Aluminum phosphate concrete	Latex concrete	Potassium silicate concrete
Calcium aluminate concrete	Magnesium phosphate concrete	Sodium silicate concrete
Epoxy concrete	Methyl methacrylate (MMA) concrete	Sulfur concrete
Furan concrete	Polyester concrete	

Of course, it is not possible to introduce all the requirements for special concrete into the RCC-CW [11], so the code should be focused on the most important cases.

In the RCC-CW [11] only the following information is presented: "Special concrete are defined as:

- self-compacting concrete SCC,
- fibre concrete FC,
- heavy and neutron-absorbing concrete HWC,
- light concrete LWC,
- high temperature resistant concrete,
- underwater concrete,
- various concrete placed at the interface of soil and structure (blinding concrete, etc.).

The properties of special concrete shall be justified on the basis of tests validating their suitability to meet their requirements. The tests, production, transport and placement of special concrete shall be adapted to the characteristics of the material. These requirements shall be defined by the Project."

This for sure is not sufficient to assure the proper quality and performance for such a major and and important material in NPP construction. The guideline or method for design and construction using special concretes widely used in NPP should be presented.

It is worth adding that since 2014 a new standard EN 206:2013 [5] was published. It supersedes EN 206-9 [7] and EN 206-1 [6]. This should be the entry point for all the modifications. It is stated that the concrete under EN 206 [5] is:

- normal-weight, heavy-weight and light-weight;
- mixed on site, ready-mixed or produced in a plant for precast concrete products;
- compacted or self-compacting to retain no appreciable amount of entrapped air other than entrained air.

Additional or different requirements may be given for specific applications in other European Standards, for example: special technologies (e.g. sprayed concrete according to EN 14487 [8]). Therefore, special concrete depending on the specific application can have additional requirements that should be specified (if needed).

Moreover, supplementary requirements or different testing procedures may be specified for specific types of concrete and applications, for example:

- concrete for massive structures (e.g. dams);
- dry mixed concrete;
- concrete with a I>max of 4 mm or less (mortar);
- self-compacting concretes (SCC) containing lightweight or heavy-weight aggregates or fibre;
- concrete with open structure (e. g. pervious concrete for drainage).

Ultimately it should be taken into account that EN 206 [5] does not apply to:

- aerated concrete;
- foamed concrete;
- concrete with density less than 800 kg/m3;
- refractory concrete.

This code evolution is related to all reactor types (BWR, PWR or LWR).

The potential list of authorized concretes should be updated in the code in order to specify most important applications with corresponding safety functions and main parameters.

First it should be specified where the special concretes could and are allowed to be applied in NPP. The proper list of possible applications based on experience in NPP construction should be added to the code first.

Following AFCEN representative information given at 17-03-2016 PG3 meeting it is proposed to change CCONC 2400 chapter for:

CCONC 2400 SPECIAL CONCRETE

Special concrete could be defined in two ways:

- - special concrete due to special technology of production and application e.g. sprayed concrete according to EN 14487 [8], underwater concrete etc. Following EN 206:2013 [5] special concrete due to specific application can have additional requirements that should be specified (if needed).
- - special concrete due to special performance. The most common special concrete it this group used in NPP are:
    - **SCC (self-compacting concrete)** is widely used in area of very dense reinforcement. The new version of EN 206:2013 [5] already includes EN 206-9 [7] "Additional rules for self-compacting concrete (SCC)" and there is an informative

annex G – guidelines for self-compacting concrete in the fresh state that implements the rules from EN 206-9 [7].

- **fibre concrete FC** also Ultra High Performance Fibre Reinforced Concrete (UHPFC).

  Both steel fibres for (SFRC) and Polymer fibres are used (PFRC) in Reinforcing Concrete (RC). Polypropylene fibres are widely used to improve the thermal performance of concrete in fire – particularly for vehicle tunnels. Their application is decided on an empirical basis with full-scale fire testing to verify the performance of the exact concrete mix design. The fire tests are particular to each project and there is no standard test. Although the performance and specification of the fibre concrete mix used in the EPRTM core catcher has undoubtedly been verified, by Areva/EDF testing, this information remains commercially confidential. It probably uses polypropylene fibres.

  There are some French standards under development (NFP 18-451, NFP 18-470 and NFP 18-710). The French Association Française de Génie Civil (AFGC) published Bétons Fibrés à Ultra Hautes Performances: Recommandations provisoires (Ultra High Performance Fibre-Reinforced Concretes: Interim Guidance) in English and French. There is very little straightforward advice in this document on determination of flexural resistance from standard tests. Shear values are similarly difficult to calculate and refer to the BPEL code from 1999.

  In EN 206:2013 [5] there are application rules for fibre concrete added. The other standards in this field are: EN 14721 [28] – for Measuring the fibre content in fresh and hardened concrete. It just defines the method and not the frequency or the testing regime. Conformity testing will need to be prescribed in the project specification, perhaps using the DAfStb [43] document mentioned below; EN 14889-1 [29], EN 14889-2 [30] - these give the specification for fibres themselves and should be referenced in any project but are not very relevant to design or construction.

  There is also extensive literature (including standards such as EN14487 [8] and EN14488 [31]) on the use of sprayed concrete in tunnels, repair and slope stabilization (e.g. EN 14488-7 [32] - Testing sprayed concrete - Fibre content of fibre reinforced concrete).

  In 2012 Guidance to fibre concrete - Properties, Specification and Practice in Europe was also published by European Ready Mixed Concrete Organization (ERMCO).

  Fibre reinforced concrete is also treated in fib Model Code 2010 [44] where constitutive rules are laid out to provide guidance on sectional resistance (shear and flexure) and crack control (in combination with bar reinforcement).

  Design Guidance is also provided in DAfStb Richtielinie Stahlfaserbeton 2012-11 [43].

  The UK Concrete Society produced Technical Report 63 TR 63 [46] Guidance for the design of steel fibre-reinforced concrete (includes amendment No. 1 Oct 2007) in 2007 but the design guidance has been superseded by more recent documents such as the fib Model Code [44].

  In the USA the standards used are: ASTM C1116/C1116M-06 [38] Standard Specification for Fibre-Reinforced Concrete; ASTM A820 / A820M – 11 [39] Standard Specification for Steel Fibres for Fibre-Reinforced Concrete. There are also standards for testing such concrete like: ASTM C1018-97 [40] Standard

Test Method for Flexural Toughness and First-Crack Strength of Fibre Reinforced Concrete (Using Beam With Third-Point Loading)

Finally, there are recent, publically available, research papers on impact performance of fibre concretes which may be directly applicable to Aircraft Impact Protection: Hrynyk [48] and Jeon [49].

The problem in fibre concrete is testing the influence of fibres on concrete. The fib and DAfStb documents require the design strength of materials to be determined using beam tests to EN14651 [33]. This standard requires the use of a displacement controlled beam testing machine:

Testing machine meeting the machine class 1 requirements in EN 12390-4 [34], capable of operating in a controlled manner i.e. producing a constant rate of displacement (CMOD or deflection), and with sufficient stiffness to avoid unstable zones in the load-CMOD curve or load-deflection curve.

In practice there are very few independent facilities that have testing machines capable of measuring this parameter correctly. Beam testing machines are normally load controlled and frequently are not stiff enough to overcome the shock loading at the transition between the elastic behavior of plain uncracked concrete and the plastic behavior post cracking. One national testing facility is at the Belgian CSTC, south of Brussels, there are none in the UK outside universities. The other difficulty with EN14651 [33]is the acknowledged variability in test results, and lack of repeatability. For this reason it may be worth considering the use of statically indeterminate plate testing methods, such as the French Railways (SNCF) test or EN 14488-5 [50] Testing sprayed concrete Part 5: Determination of energy absorption capacity of fibre reinforced slab specimens, if only for production control. There is also the new EFNARC plate test.

- **heavy and neutron-absorbing concrete HWC –** is not used in NPP – the shielding is provided by a sufficient thickness of ordinary concrete. It is possible that due to lack of space and employing the ALARA (As Low As Reasonably Allowable) principle that HWC will be used in the future. If the specific shielding efficiency against gamma or neutron radiation is needed a justification based on computer simulations (e.g. Monte Carlo method) or experimental test (mock-up) is obligatory. The example procedures for shielding evaluation are in: DIN 6847-2:2014-03 [37] (Germany) Medical electron accelerators - Part 2: Rules for construction of structural radiation protection; PN – 86/J-80001 (Poland) used for calculation of solid shielding against X and gamma radiation used. It is an archive standard that was not updated; NCRP Report No. 147 [45] Structural Shielding Design for Medical X-Ray Imaging Facilities, which presents recommendations and technical information related to the design and installation of structural shielding for facilities that use X rays for medical imaging.

  It includes a discussion of the various factors to be considered in the selection of appropriate shielding materials and in the calculation of barrier thicknesses. The standards in this field are: ACI 304.3R-96 [41]: High Density Concrete: Measuring, Mixing, Transporting, and Placing; ACI 211.1-91 [42]: Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete (Reapproved 2009); DIN 25413-1 [35] Classification of shielding concretes by proportion of elements; neutron shielding; DIN 25413-2 [36] Classification of shielding concretes by proportion of elements; gamma shielding
- **sacrificial concrete** - it is applicable to EPR technology – there are some different types of this kind of concrete like iron concrete and siliceous concrete. If such concrete is supposed to be used the specific requirement should be given.

One summary on these concretes is given in Molten Core - Concrete Interactions in Nuclear Accidents, Theory and Design of an Experimental Facility published in 2005 by VVT in Research notes 2311 [47]. There are also some patents on this material: Patent CN102176332, Patent CN102176331.

The other special concretes like light-weight concrete LWC, could be used in NPP but should be limited to auxiliary buildings..

The other special concretes like light-weight concrete LWC, could be used in NPP but should be limited to auxiliary buildings.

Second step of this code evolution is to find and analyze the standards and guidelines for the special concrete that are important (especially for nuclear safety reasons). Finally, the additional or different requirements should be derived for the RCC-CW [11].

2.10.1.2 Scope of the application

The proposed evolution of the code could be used to solve special problem during design and construction and may lead to structural optimization and radiation protection. Future projects and possible future applications (especially Gen IV reactors) are likely to make use the proposed evolution.

Indicate whether it is proposed in the framework of a specific application or if it has a generic nature

2.10.1.3 Associated deadlines

As soon as possible – the moment CCONC 2400 SPECIAL CONCRETE does not bring anything new and is potentially dangerous for safety and quality reasons. For example, a projects could define a so called ‘special concrete’ by declaration of high temperature resistant concrete and there would be no specified requirements

2.10.2 Required R&D to support the evolution

Currently desk studies and a literature search is likely to provide a first stage evolution. If more specified research fields will be discovered, then R&D should support them to further define the requirements

2.10.3 Integration in the Code(s)

2.10.3.1 Type of evolution

The evolution is limited to one modification – change in chapter 2400 Special concrete. A cross reference to other standards and codes can be used.

2.10.3.2 Feasibility appreciation

Provide a feasibility appreciation from the work group, taking opinions of all groups of interest in consideration. This should include the opinion of the AFCEN representative.

For Section 2 this should include the opinion of R&D organization representatives

2.10.4 AFCEN taking into account

2.10.4.1 Submission

Indicate the expected/actual date of submission

2.10.4.2 Opinion of AFCEN taking into account

Indicate the date of answer and the answer made by AFCEN to the submitted proposal.

Give the group's opinion on this answer.

2.11 PG3/CE-09 Universalisation

Specific part(s) (if identified):

In general:

Part C Construction CCONC - Concrete

Particularly related to Freeze/Thaw resistance:

CCONC 1300 AGGREGATES FOR HYDRAULIC CONCRETE AND MORTARS

CCONC 1370 AGGREGATES REQUIREMENTS FOR CONCRETE SUBJECT TO SEVERE FREEZETHAW ATTACK

CCONC 2900 ADDITIONAL REQUIREMENTS FOR CONCRETE SUBJECT TO SEVERE FREEZE-THAW ATTACK

CCONC 21000 QUALIFICATION TEST

CCONC 21080 ADDITIONAL REQUIREMENTS FOR CONCRETE SUBJECT TO SEVERE FREEZETHAW ATTACK

CCONC 3000 MANUFACTURE

CCONC 3320 ADDITIONAL REQUIREMENTS FOR CONCRETE SUBJECT TO SEVERE FREEZETHAW ATTACK

CCONC 5000 PLACING OF CONCRETE

CCONC 5900 CONFORMITY CONTROL TEST

CCONC 5960 ADDITIONAL REQUIREMENTS FOR CONCRETE SUBJECT TO SEVERE FREEZE-THAW ATTACK

Possible other concerned codes: -

2.11.1 Brief outline

The RCC-CW [11] was initially developed by EDF on the basis of the last version of the RCC-G series which contain civil engineering design and construction rules for French NPPs. An initial edition of the Code was issued as ETC-C by EDF in April 2006 and serves as a reference document for Flamanville 3 Project. Since 2009, the development has continued under the frame of AFCEN leading to the publication of the AFCEN ETC-C 2010 Edition and the AFCEN ETC-C 2012 Edition. ETC-C 2010, first edition published by AFCEN has been used for the Generic Design Assessment of EPR in UK. ETC-C 2012 integrates the feedback of Flamanville 3 and of the Generic Design Assessment. This history results in embedding many national (French, German, and UK) requirements. One of the reason for developing RCC-CW [11] from ETC-C by a Sub-Committee was the necessity for new NPP Projects to comply with requirements from international regulations and practices. For this purpose the UNIVERSALISATION of RCC-CW [11] code is an obvious challenge.

An important part has been already done but still there are parts and chapters that contain specific national requirements that are not commonly used in other countries (in Europe and in the World). They are mostly requirements in CCONC chapter (list of NF standards are presented in GRFD 2120, see Figure 1 and Figure 2 below), NF marking (no other national marking is presented in GREFD 3200) and accreditation (only COFRAC – French accrediting body is presented in GREFD 3300: in Uk it is UKAS, in Germany it is DAkkS, in Belgium - BELAC, Finland - FINAS, Poland – PCA – they all signed ILAC MRA - International Laboratory Accreditation Cooperation Mutual Recognition Arrangement).

GREFD 2120 Standards referred to in chapter CCONC

Table GREFD 2120-1 Standards referred to in chapter CCONC

STANDARD	DATE	TITLE
NF EN 206-1/CN	12/2012	Concrete - Part 1 : specification, performance, production and conformity - National addition to NF EN 206-1
NF P 15-317	09/2006	Hydraulic binders - Sea-water resisting cements
NF P 15-319	01/2014	Hydraulic binders – Cements for works using waters with high sulfate content
NF P 18-363	12/2014	Admixtures for concrete, mortar and grout – Tusschenbroeck test
NF P 18-370	07/2013	Admixtures - Curing products for concrete and mortar - Definition, specifications and marking
NF P 18-424	05/2008	Concrete - Freeze test on hardened concrete - Freeze in water - Thaw in water
NF P 18-425	05/2008	Concrete - Freeze test on hardened concrete - Freeze in water-Thaw in water
NF P 18-459[2]	03/2010	Concrete - Testing hardened concrete – Testing porosity and density
NF P 18-454[4]	12/2004	Concrete - Reactivity of a concrete formula with regard to the alkali-aggregate reaction - Performance test
NF P 18-507[3]	11/1992	Additions for concrete - Water retention - Method for measurement of fluidity by flowing with the "cone de Marsh"
NF P 18-508	01/2012	Additions for concrete - Limestone additions - Specifications and conformity criteria
NF P 18-509	09/2012	Additions for concrete - Silicious additions - Specifications and conformity criteria.
NF P 18-545	09/2011	Aggregates – Defining elements, conformity and coding
NF P 18-576[1]	02/2013	Aggregates - Measurement of the friability coefficient for fine aggregate
XP P 18-420	05/2012	Concrete - Scaling test for hardened concrete surfaces exposed to frost in the presence of a salt solution
XP P 18-594	02/2004	Aggregates – test methods on reactivity to alkalies

Figure 1. A group of NF standards referred to in chapter CCONC in RCC-CW

GREFD 3200 MARK NF

NF002 – Liants hydrauliques (hydraulic binders) - 07/2013 – see APPENDIX CD

NF085 – Adjuvants pour bétons, mortiers et coulis, produits de cure (Admixtures for concrete, mortar and grout and curing compounds) – 12/2013 – see APPENDIX CD

NF033 – Béton prêt à l'emploi (ready-mixed concrete) – 01/2015

NF030 – Produits spéciaux destinés aux constructions en béton hydraulique (special products for construction with hydraulic concrete) – 01/2011 – see APPENDIX CD

NF139 – Aciers pour béton armé (steels for reinforced concrete) – 12/2013

NF254 – Armatures (reinforcement) – 11/2012

GREFD 3300 ACCREDITATION

COFRAC (French accrediting body)

Figure 2. NF mark and accreditation presented in RCC-CW

If the RCC-CW [11] code aspires to be an Universal International Code these parts should to be changed. Off course they are resulting from a long experience of French Nuclear Energy sector so the removal is not a good solution.

Independently the requirements according to EN 206-1 [6] standard should be changed to these according EN 206 [5].

2.11.2 Suggestion for outlining the mother code and appendix/-es

As there is a need for developing the RCC-CW [11] code towards a more international code, a review of European and National standards and procedures, especially in in the field of concrete technology should be the goal. In a result the national (mostly French) specific descriptions should be organized differently. The suggestion is to threat RCC-CW [11] code a Mother Code and to create a National Appendix or a group of National Appendices that would contain the national requirement resulting from national experience. In such structure the use of RCC-CW [11] code in each country would be easier and requirement would be clearer. If some requirement in the implementing country would not exist it will be possible to use other country's Appendix as a model one. It is recommended that these National Annexes would be created in cooperation with the specific country representatives. An example of such action is the CB Appendix in the latest RCC-CW 2016 edition, entitled Concrete properties according to exposure classes as an extract NF EN 206-1/CN:12/2012 – Table NAF.1 (in this case I recommend change its name to be more close to that from EN 206 - "Recommended limiting values for composition and properties of concrete in relation to exposure classes").

2.11.3 Description of the specific code evolution related to Freeze/Thaw resistance

2.11.3.1 Freeze/Thaw degradation mechanism

In ACI 349.3R-02 [51] Evaluation of Existing Nuclear Safety-Related Concrete Structures in a chapter related to Degradation mechanisms due to Freezing and thawing it is written:

"The effects of freezing and thawing in concrete can be quite damaging at a critical saturation level. For nuclear plants located in weathering regions (as defined in ASTM C 33 [52]), cycles of freezing and thawing can be of some concern for externally exposed structures. The key factors involved include concrete properties, such as water-cementitious materials ratio (w/cm), entrained-air void size and distribution, aggregate type and strength, and environmental factors such as number and severity of freezing cycles and supply of critical moisture levels. Very little damage has been reported in safety-related structures as a direct result of cycles of freezing and thawing. This performance record is likely the result of prudent materials selection, concrete testing, quality control, and structural design. Degradation from freezing-and-thawing cycles initiates as scaling and cracking in the cover concrete. Propagation results in steel reinforcement exposure, loss of structural concrete section, and loss of bond between the concrete and the reinforcement. Wedging effects from freezing of condensation in surface irregularities, such as popouts, joints, and anchor bolt sleeves, are also a local possibility. The visual survey should quantify the degree of scaling and cracking, including the affected surface area and depth of damage. Any contributing factors, such as surface geometry supporting ponding of moisture or lack of air entrainment, should also be documented." In IAEA-TECDOC-1025 [53] Assessment and management of ageing of major nuclear power plant components important to safety: Concrete containment buildings table 6.2 it is presented that 20 of 244 (8,2%) occurrences and manifestations of degradation of concrete materials were reported as a result of freeze/thaw factor. It is the third factor after shrinkage (56 events) and construction defects (54 events). Although the Freeze-Thaw attack is not the main safety problem of NPP there are countries in Europe where it is the main corrosion process of civil structures. This progressive phenomenon is increasing with the number of frost cycles so it is of big importance in the countries where climate is humid continental type (Dfb according to Koppen-Geiger climate type). RCC-CW [11] is now based mainly on French experience and French standards. In France the problem is located mainly in mountains where none of NPPs is located. In other European countries, especially in these with humid continental, other approaches and procedures are used to assure freeze-thaw durability of concrete structures.

2.11.3.2 Technical content of a proposal

The proposal is to draw universal requirements against freeze-thaw attack in RCC-CW [11] (e.g. based on EN 206:2014 [5] only) and move the national requirements to a special National Annex.

2.11.3.3 Scope of application

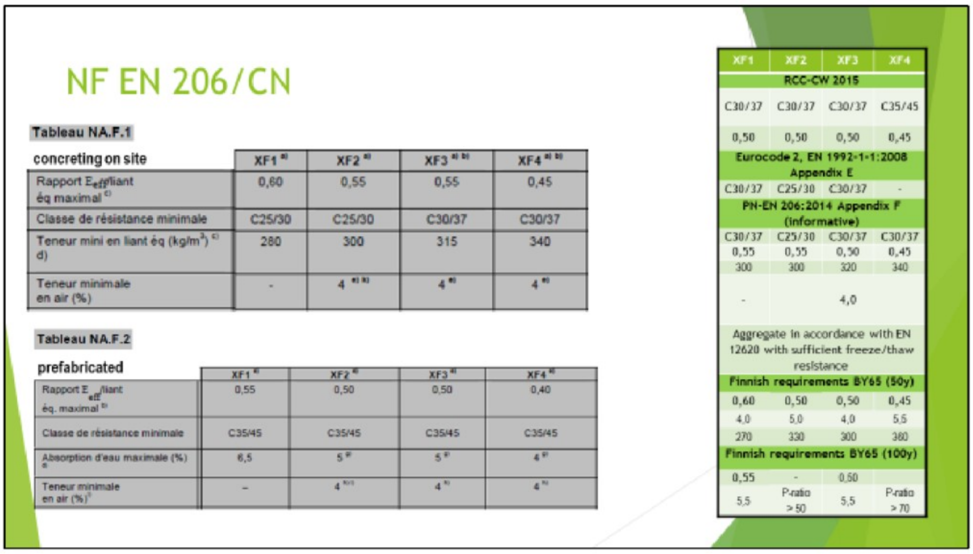
The scope of application for these special Freeze/Thaw requirements should is identified for concrete classified in XF exposure classes. Concrete structures in NPP that are protected from freezing/thawing by using a thermal insulation on the external surface and are not subjected for this kind of physical corrosion are not classified in this exposure classes.

2.11.3.4 Background information for Freeze/Thaw resistance

Freeze/Thaw topic in RCC-CW [11] is presented in the Attached Paper: Special requirements for freeze thaw resistance of concrete in PWR nuclear civil works.

<u>Present requirements in RCC-CW on the background of Eurocode 2, Poland and Finland case</u>

In RCC-CW [11] the basic requirements for concrete resulting from XF exposure classes that are expressed in limiting values for composition and properties of concrete are increased in relation to Eurocode 2 and EN 206 [5].



NF EN 206/CN

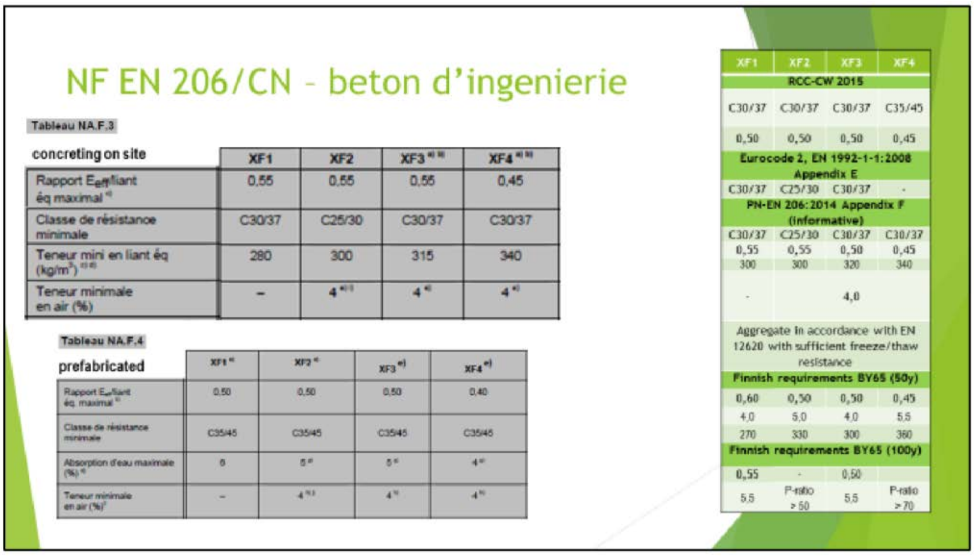
Tableau NA.F.1

concreting on site	XF1 [a)]	XF2 [a)]	XF3 [a) b)]	XF4 [a) b)]
Rapport E_{eff}/liant éq maximal [c)]	0,60	0,55	0,55	0,45
Classe de résistance minimale	C25/30	C25/30	C30/37	C30/37
Teneur mini en liant éq (kg/m^3) [c) d)]	280	300	315	340
Teneur minimale en air (%)	-	4 [e) b)]	4 [e)]	4 [e)]

Tableau NA.F.2

prefabricated	XF1 [a)]	XF2 [a)]	XF3 [a)]	XF4 [a)]
Rapport E_{eff}/liant éq. maximal [b)]	0,55	0,50	0,50	0,40
Classe de résistance minimale	C35/45	C35/45	C35/45	C35/45
Absorption d'eau maximale (%) [e)]	6,5	5 [f)]	5 [f)]	4 [f)]
Teneur minimale en air (%) [f)]	–	4 [h) i)]	4 [h)]	4 [h)]

XF1	XF2	XF3	XF4
RCC-CW 2015			
C30/37	C30/37	C30/37	C35/45
0,50	0,50	0,50	0,45
Eurocode 2, EN 1992-1-1:2008 Appendix E			
C30/37	C25/30	C30/37	-
PN-EN 206:2014 Appendix F (informative)			
C30/37	C25/30	C30/37	C30/37
0,55	0,55	0,50	0,45
300	300	320	340
-	4,0		
Aggregate in accordance with EN 12620 with sufficient freeze/thaw resistance			
Finnish requirements BY65 (50y)			
0,60	0,50	0,50	0,45
4,0	5,0	4,0	5,5
270	330	300	380
Finnish requirements BY65 (100y)			
0,55	-	0,50	
5,5	P-ratio > 50	5,5	P-ratio > 70



NF EN 206/CN - beton d'ingenierie

Tableau NA.F.3

concreting on site	XF1	XF2	XF3	XF4
Rapport Eeff/liant éq maximal	0,55	0,55	0,55	0,45
Classe de résistance minimale	C30/37	C25/30	C30/37	C30/37
Teneur mini en liant éq (kg/m³)	280	300	315	340
Teneur minimale en air (%)	-	4	4	4

Tableau NA.F.4

prefabricated	XF1	XF2	XF3	XF4
Rapport Eeff/liant éq. maximal	0,50	0,50	0,50	0,40
Classe de résistance minimale	C35/45	C35/45	C35/45	C35/45
Absorption d'eau maximale (%)	6	5	5	4
Teneur minimale en air (%)	-	4	4	4

XF1	XF2	XF3	XF4
RCC-CW 2015			
C30/37	C30/37	C30/37	C35/45
0,50	0,50	0,50	0,45
Eurocode 2, EN 1992-1-1:2008 Appendix E			
C30/37	C25/30	C30/37	-
PN-EN 206:2014 Appendix F (informative)			
C30/37	C25/30	C30/37	C30/37
0,55	0,55	0,50	0,45
300	300	320	340
-		4,0	
Aggregate in accordance with EN 12620 with sufficient freeze/thaw resistance			
Finnish requirements BY65 (50y)			
0,60	0,50	0,50	0,45
4,0	5,0	4,0	5,5
270	330	300	360
Finnish requirements BY65 (100y)			
0,55	-	0,50	
5,5	P-ratio > 50	5,5	P-ratio > 70

Figure 3. NF EN 206/CN vs Eurocode 2 and Poland and Finland case

Also, some additional requirements related to freeze-thaw attack are formulated both for aggregates as a component and concrete as a final product. Detailed formations are given in chapters describing: qualification test for nominal concrete mix, suitability test for manufactured concrete and conformity control test during concreting.

Aggregates for concrete subject to exposure classes XF3 and XF4 should not be liable to frost damage according to NF P 18-545 and EN 12620+A1:2010 [54]. In addition, the water absorption of both fine and coarse aggregates shall comply with the requirements of code A aggregated described in NF P 18545:2004 – it means that WA24≤2,5% measured according to EN 1097-6:2013 [55]. These requirements where erased for XF1 and XF2. In qualification stage of aggregate freeze/thaw susceptibility can be measured according to EN 1367-1:2007 [56] (F) or EN 1367-2:2010 [67] (MS) or EN 1097-2:2010 [57] (LA), or EN 1097-6:2013 [55] (WA24). In suitability test and conformity control these tests are not required.

The use of fly ash, either as an addition or as a constituent of the cement, is acceptable on condition that the loss on ignition of the fly ash respects Category A of EN 450-1:2012 [58] (loss of ignition, L ≤ 5% measured according to EN 196-2:2013 [59]).

In RCC-CW [11] qualification stage for nominal concrete mix it is repeated after EN 206:2014 [5] that concrete subject to exposure classes XF2, XF3 or XF4 shall have a minimum air content of 4% measured according to EN 12350-7:2011 [60]. In addition, for concrete subject to exposure classes XF3 or XF4 and formulated with an air-entraining admixture, the qualification test shall include (for one mix of the nominal concrete mix) a measurement of the spacing factor L according to EN 480-11:2008 [61]. The criteria for L values are:

- L ≤ 250 μm for concrete subject to exposure class XF3,
- L ≤ 200 μm for concrete subject to exposure class XF4.

This requirement could be replaced by the performance tests based on French experience using freezing map and de-icing map of France (Figure 4). They present freezing zones divided onto:

- mild freezing conditions – less than 3 days with temperature < -5°C,
- moderate freezing conditions – other cases,
- severe freezing conditions – more than 10 days with temperature < -10°C,

and de-icing zones based on number of days with de-icing:

- not frequent: n < 10,

- frequent: 10≤n<30,
- very frequent: n≥30.

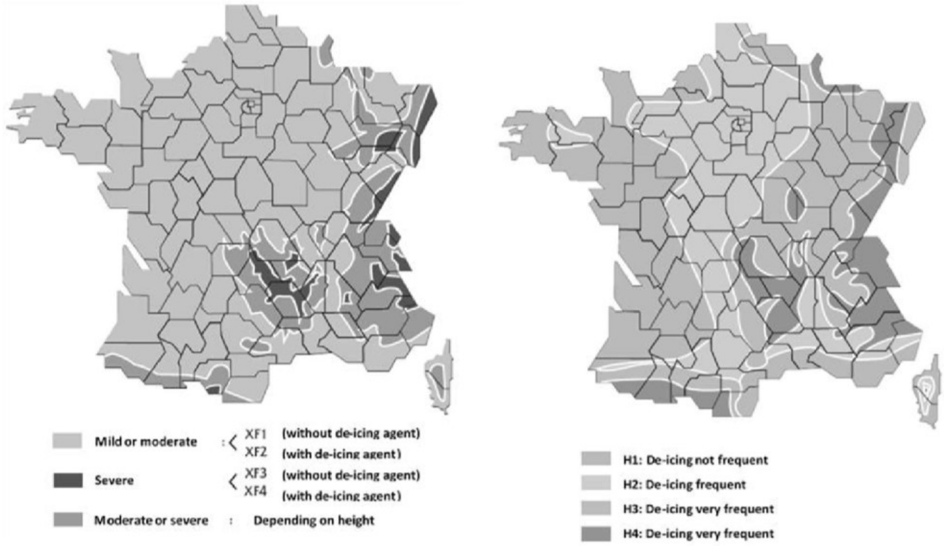


Figure 4. Freezing map and de-icing map of France according to NF EN 206/CN

Following RCC-CW [11] for concrete in XF3 and XF3 in place of the measurement of the factor L or in case the specified maximum value of L is not respected, the concrete shall be subject to a performance test as follows:

- NF P 18-424 (freezing in water and thawing in water), for concrete subject to severe freeze-thaw attacks with a high degree of water saturation defined by EN 206:2014 [5] – it means XF3 and XF4 – the limit value is Δl/l < 400μm/m;
- NF P 18-425 (freezing in air and thawing in water) with the limit value of (Fn2/Fo2)x100 ≥ 75 is for:
    - o concrete subject to moderate freeze-thaw attacks, irrespective of the degree of water saturation of the concrete (in NF EN 206/CN moderate freeze-thaw attack means XF1 and XF2 so case is not possible), or
    - o concrete subject to severe freeze-thaw conditions with a moderate degree of water saturation defined by EN 206:2014 [5] (in EN 206:2014 moderate degree of water saturation means XF1 or XF2 so such case is not possible as well)

Table 1. Exposure class description and performance test selection for specific conditions in France

	EN 206:2014		NF EN 206/CN		Performance test according to RCC-CW
Exposure class	Saturation	De-icing	Freezing zone	De-icing zone	
XF1	**Moderate**	No	Mild / Moderate	No-deicing / Not frequent	-
XF2	**Moderate**	Yes	Mild / **Moderate**	Frequent / Very frequent	NF P 18-425*
XF3	**High**	No	**Severe**	No-deicing / Not frequent	**NF P 18-424**
XF4	**High**	Yes	**Severe**	Frequent / Very frequent	**NF P 18-424**

* only for HPC

In RCC-CW [11] it is written that: "Concrete subject to exposure classes XF2, XF3 or XF4 according to EN 206-1 [6] supplemented with a frost zone map usually included in EN 206-1 [6], National Annexes, shall have a minimum air content of 4% in accordance with EN 206-1 [6]." – it is not usual to include frost zone map in other countries' National Annex.

The present statements of RCC-CW [11] allow only for French procedure that is additionally modified and contain mistakes – e.g.

PART C CONSTRUCTION RCC-CW 2015
CCONC CONCRETE

CCONC 2880 Additional requirements for concrete subject to severe freeze-thaw attack

1- For concrete subject to exposure classes XF2, XF3 or XF4 according to EN 206-1, supplemented by a frost zone map usually included in EN 206-1 National Annexes, all the test results on the air content of the fresh concrete shall meet the minimum content specified in EN 206-1 (4%).

2- For concrete subject to exposure classes XF3 or XF4 and formulated with an air-entraining admixture, the qualification test shall include (for one mix of the nominal concrete mix) a measurement of the spacing factor $\overline{L}$ according to EN 480-11.

In place of the measurement of the factor $\overline{L}$ or in case the specified maximum value of $\overline{L}$ is not respected, the concrete shall be subject to a performance test as follows:

- A performance test in accordance with NF P 18-424 (freezing in water and thawing in water), for concrete subject to severe freeze-thaw attacks with a high degree of water saturation as defined by EN 206-1,
- A performance test in accordance with NF P 18-425 (freezing in air and thawing in water), for concrete subject to moderate freeze-thaw attacks, irrespective of the degree of water saturation of the concrete, or for concrete subject to severe freeze-thaw conditions with a moderate degree of water saturation as defined by EN 206-1.

See table NA.1 from NF EN 206/CN

Tableau NA.1 — Classes d'expositions en fonction de l'intensité du gel et de la fréquence de salage

Gel \ Salage	Aucun	Peu fréquent	Fréquent	Très fréquent
Faible ou modéré	XF1	XF1	XF2	XF2 [a]
Sévère	XF3	XF3	XF4	XF4

[a] A l'exception des chaussées en béton et des éléments d'ouvrages d'art très exposés qui seront classés en XF4.

For high performance concrete subject to exposure classes XF2, XF3 or XF4, which are formulated with little or no air entraining admixture and do not contain the minimum air content the measurement of L is not relevant, so the qualification test shall include a performance test as well. High performance concrete (HPC) is differentiated from ordinary concrete by a compressive strength class of a high strength concrete (HSC – concrete with a higher strength than C50/60) and by one or more desired properties such as a higher level of compactness (for example for porosity or permeability requirements).

It is also acceptable to waive the requirement for the minimum air content for concrete exposed to frequent or very frequent attack from deicing agents (XF2 or XF4) – in such case the scaling test according to XP P 18-420 that is the same as "slab test" in CEN/TS 12390-9:2007 [62] should be performed. This procedure is also similar to the one expressed in EN 1388:2005 except for number of cycles (increase from 28 to 56). The requirement is the mass of the scaling particles after 56 freeze/thaw cycles is $m_{56} \leq 600$ g/m^2. This value is different than the conformity criteria for concretes according to Borås method in Swedish Standard SS 13 72 44 [63] that are based on mass of scaling at 28 days (m_{28}), 56 days (m_{56}) and at 112 days (m_{112}) and are expressed as:

Very good: m_{56} average < 100 g/m^2

Good: m_{56} average < 200 g/m^2 or
m_{56} average < 500 g/m^2 and $m_{56}/m_{28} < 2$ or
m_{112} average < 500 g/m^2

Acceptable: m_{56} average < 1000 g/m^2 and $m_{56}/m_{28} < 2$ or
m_{112} average < 1000 g/m^2

Unacceptable: the above not complied with.

Although in references of EN 206:2014 [5] the procedure from CEN/TR 15177:2006 [64] is mentioned, up to now there is no uniform European standards for internal testing frost resistance of concrete. This procedure describes three methods of testing internal frost resistance of concrete, i.e. Test beam, slab test and CIF, and does not replace national standards in the manner of its examination and evaluation related to the frost resistance of concrete.

Great Britain case

In BS 8500-1 2006 [65] there is Table A.8 that gives concrete properties and limiting values to resist the XF exposure classes. These recommended concrete qualities are suitable for an intended working life of both “at least 50 years” and “at least 100 years”. There are other limits minimum cement content for lower and higher strength concrete in specific exposure classes and they depends on aggregate size. Requirement for minimum air content is also applicable to lower strength concrete is specific exposure classes (Table 3).

Table 3. Limiting values for composition and properties of concrete to resist freezing and thawing according to BS-EN 8500-1:2006

Exposure class	Min. strength class	Max w/c ratio	min. air content and min. cement or combination content (kg/m3) for max. aggregate size			
			32/40 mm	20 mm	14 mm	10 mm
XF1	C20/25	0,60	3.0 260	3.5 280	4.5 300	5.5 320
	C28/35	0.60	- 260	- 280	- 300	- 320
XF2	C25/30	0.60	3.0 260	3.5 280	4.5 300	5.5 320
	C32/40	0.55	- 280	- 300	- 320	- 340
XF3	C25/30	0.60	3.0 260	3.5 280	4.5 300	5.5 320
	C40/50	0.45	- 320	- 340	- 360	- 360
XF4	C28/35	0.55	3.0 280	3.5 300	4.5 320	5.5 340
	C40/50	0.45	- 320	- 340	- 360	- 360

German and Poland case

Similar concept is in German DIN 1045-2:2008 [66] but due to more severe climate the requirements are more restricted as the limit value of air content depending on the aggregate size is: up to 8 mm ≥ 5,5 %; up to 16 mm ≥ 4,5 %; up to 32 mm ≥ 4,0 %; up to 64 mm ≥ 3,5 %. Probably in the nearest future the same idea will be implemented in Poland in new version of PN-B-06265:2004.

Lithuania case

In Lithuania that is near to Poland and have similar climate conditions and where Visaginas Nuclear Power Plant is a planned to be constructed, there is another sense of freeze/thaw resistance presented in LST 1974:2012. It is defined as a limit value for:

$\Delta f_{c} = (f_{c28} - f_{c\,Ncycle})/f_{c28}$,

where: $f_{cNcycle}$ – compressive strength after N cycles of freezing/thawing (for XF4 it is recommended Ncycle = 300), f_{c28} – 28 days compressive strength

2.11.3.5 Associated deadlines

In the next RCC-CW [11] evolution

2.11.4 Description of the specific code evolution related to ASR

ASR topic is partially presented in the Attached Paper: Determining the reactivity of concrete aggregates for Nuclear Power Plant concrete structures.

2.11.5 Required R&D to support the evolution (if any)

a. Expected results

b. Schedule and costs

2.11.6 Integration in the code(s)

a. Type of evolution The evolution is related to several modifications in the rules in the current RCC-CW [11], and it may require a deep change in the code structure. A cross reference to another code (e. g., BS, DIN etc.) can be used.

b. Feasibility appreciation

2.11.7 AFCEN taking into account

a. Submission

b. Opinion on AFCEN taking into account

2.12 PG3/CE-10 Maintenance and monitoring

2.12.1 Description of the proposal

2.12.1.1 Technical content

There is a need to incorporate in RCC-CW [11] some guidance concerning inspection and maintenance principles of the civil works of nuclear facilities, encompassing concrete and steel structures, earth works and secondary elements such as water stop seals and membranes.

Ageing starts from design and construction. Further on ageing management is insured with inspection and maintenance program. Civil structures are passive systems and therefore they have a special way of thinking compared to mechanical components (brainstorming).

As a general rule, effective maintenance, surveillance and in-service inspection are essential for the safe operation of a nuclear power plant. Those activities help maintaining the functions required of Structures, Systems and Components (SSC), by detecting and mitigating their degradation.

It is important to recall that inspection and maintenance are necessary throughout the life of the facility, and not only when long term operation is intended, as a safety principle. And this principle should be applied to every parts of the code (geotechnical, concrete, liner…) where corresponding ageing mechanisms are also described.

Concerning the civil works structures and accessories, which are passive components, their inspection and maintenance are simpler and more straightforward than those of mechanical and electrical equipment. They generally do not require any functional test, apart from the reactor containment, which is not addressed in the present text.

The inspection and maintenance programs derive from an analysis of the functions required of civil components. Those functions can be stability, support of equipment, leak-tightness, respect of the geometry (i.e. limitation of the deformations and of the displacements). They may be adversely affected by the evolution of civil works physical characteristics.

The possible physical evolution of the civil works during their lifetime, beginning with the construction phase, is due to normal phenomena such as concrete drying and shrinkage, concrete carbonation, soil settlement, ageing of elastomeric components, but also pathologies such as steel corrosion and concrete degradations, namely alkali-silica reaction and delayed ettringite formation.

The surveillance of civil works is based mainly on periodic visual inspections and topographic surveys. Non destructive examination methods can also be used when applicable. The inspections may point out deviations when the observed state of the civil elements is outside pre-defined acceptance criteria. The deviations detected during the inspections are analyzed to decide whether corrective maintenance is necessary, in view of maintaining the functions required of civil components.

The periodicity of inspections must be consistent with the kinetics of the possible physical evolution or degradation of the civil works. For example, the concrete structures may be inspected every several years, whereas earth structures such as dikes require more frequent visits because their potential degradation phenomena such as internal erosion can develop in a few weeks.

The experience shows that periodic inspections reveal degradation phenomena of civil elements, but also non conformances associated to the construction phase of the facility.

Programmed in-service inspection of civil elements is really efficient only if their current maintenance is conscientiously carried out. In particular the buildings and rooms must continuously be kept clean of any dust, mud or debris, even in places not frequently visited such as the roofs of buildings. If not, corrosion of rebars, attack of leaktight membranes by vegetation or other degradation phenomena may develop much faster than usually expected.

Besides, the inspectability of civil structures and components is a key concern during the design phase of a project. Poor inspection feasibility could shorten the service life of a building, or at least increase the cost of inspection and maintenance. One typical example is the seismic isolation elastomeric pads, that require sufficient access and practical arrangement for their inspection and, if necessary, for their change.

2.12.1.2 Concerns / improvements

RCC-CW [11] addresses design and construction of civil works, but gives no guidance concerning their maintenance, apart from the monitoring and testing of the reactor containment. However some maintenance and inspection principles of the civil works as a whole must be taken into account in the design of nuclear reactors. As a consequence, there is a need to incorporate such principles in the code.

The proposed evolution is of a generic nature.

2.12.1.3 Supporting data and scientific references

An important documentation, both national and international, exists on that topic. A few references are given here after:

- IAEA Safety Guide NS-G-2.12 [68]"Ageing management for nuclear power plants"
- Any containment specific? IAEA TEC DOC 1025 [53]
- IAEA Safety Guide NS-G-2.6 [69] "Maintenance, Surveillance and In-service Inspection in NPPs"
- IAEA Technical Report NP-T-3.5 [70] "Ageing management of concrete structures in NPPs"
- IAEA IGALL [71] report
- YVL A.8 [72]
- WENRA reports
- WENRA issues I and K
- OECD reports
- ACI 349.3R [51]
- NUREG

2.12.1.4 Required additional data/research

No additional data nor new methods needed to support the proposed evolution.

2.12.2 Integration in the code

2.12.2.1 Type of modification / evolution

The proposed evolution requires minor editing of the existing code.

2.12.2.2 Proposed structure of revised code

It is proposed to add, in part M –MAINTENANCE AND MONITORING-, and after the section MCONT, a new section : MINSMA -INSPECTION AND MAINTENANCE DURING OPERATION-. Concerns also other parts of RCC-CW [11].

A first draft of that new section is given in 1.a.

In addition, the first paragraph of part M should be modified as follows:

"This part of the code provides the requirements, guidance and recommendations for the initial integrity testing and for the leakage testing of the concrete containment to be performed for the "Acceptance" or "Pre-Operational" tests. It also provides some recommendations for In-Service Inspection (ISI) of that containment.

More generally, this part of the code provides the requirements, guidance and recommendations for the inspection and the maintenance of the civil works of a nuclear facility."

2.12.2.3 Group opinion of the proposal

Shortly describe the opinion of the concerned prospective group(s) on the proposal. Report if the opinion is unanimous or if there are any opposing opinions. In the latter case also report the opposing opinion.

Mention the AFCEN representative(s) view point and, when necessary, that of R&D members.

2.12.3 Interaction with AFCEN

2.12.3.1 WS 064 proposal submission to AFCEN

Indicate the date of submission of the proposal to AFCEN.

2.12.3.2 AFCEN feedback

Indicate the status of the request to AFCEN: in progress or answered (in this case, indicate the date of answer and the nature of the answer: fully accepted, accepted with provisions, rejected).

2.12.3.3 WS 064 actions

Give the group evaluation of the response and proposed action(s) from AFCEN.

Indicate if a revision of the proposal is needed.

2.13 PG3/CE-11 Steel containments

2.13.1 Description of the proposal

2.13.1.1 Technical content

It is proposed the integration of design requirements for steel (metal) reactor containments.

2.13.1.2 Concerns / improvements

The current version of the RCC-CW [11] Code covers the design of PWR pre-stressed reactor containments.

It is preferable that the RCC-CW [11] Code cover a broad variety of different plant types. At present time, no guidance is given in the Code regarding the design of steel (metal) reactor containments

This improvement proposal is generic in nature, proposing a complete set of design rules to be added into the Code.

2.13.1.3 Supporting data and scientific references[4]

The use of steel reactor containments has a long history, and hence supporting data and scientific references are abundant. Below is summarized information and codes & standards for the vessel design in the US and Germany. At the end is also included a comparison between the US and German design codes.

However, first we look at the point at which the steel containment is embedded into the concrete base mat and the common foundation. Since this is one of the most challenging details, it need proper consideration in the steel and the concrete design parts of the Code.

Connection between the vessel and the supporting concrete structure

Going back to the earliest steel containment vessels in the US, the transition from fully embedded steel to free standing steel incorporated a sand pocket transition. The concept was based on providing some resistance to the pressure generated growth of the vessel just above the point of embedment. This was achieved by use of “springs” constituted by the sand resisting the growth of the vessel, and therein reducing the resulting stresses. The compacted sand provided the initial growth restraint and it was assumed that it could restore itself with time related resettlement. The stresses thereby calculated met the stress limits applicable to local general primary membrane and bending allowable as specified in ASME III. While the detail was productive, two nuclear power plants experienced some corrosion in this inaccessible sand pocket area. It is noteworthy that present designs could eliminate the sand pocket detail and the thicknesses and geometry used in that area, along with detailed finite element analysis results in stresses that meet the ASME III Code allowable stress criteria.

For present designs, the bottom head could be embedded directly into the concrete. The containment vessel is then assumed as an independent, free-standing structure above the embedment in the concrete. Vertical and lateral loads on the containment vessel and internal structures are transferred to the base mat below the vessel by shear studs, friction, and bearing. Seals are provided at the top of the concrete on the inside and outside of the vessel to prevent moisture between the vessel and concrete.

Vessel design - USA

The historical records of a major construction of steel containment vessels identifies a total of about 60 steel containment vessels having been completed during the time frame starting in 1953 and ending in about 1976. Most of the steel containment vessels constructed in the 1950’s and

[4] The main part of the information herein presented has been extracted from the Scanscot Technology report “O. Jovall et al, Canadian Nuclear Safety Commission: CNSC 397.1, Recommendations on Assessing Civil Structures for New Nuclear Power Plants, 608 pages (08410/FR-01)”. Some information has also been collected from “R. Meisvinkel et al, Design and Construction of Nuclear Power Plants, 150 pages (Wiley 2013)”. Steel containment code (KTA, ASME, USNRC etc.) changes after the issuing of the above reports has not been incorporated into this proposal.

early 1960's where built in accordance with the Section VIII of the American Society of Mechanical Engineers (ASME) Code, along with ASME VIII Code Cases 1270N, 1271N, 1272N, and 1273N. These Code Cases established the allowable stress criteria. With the introduction in 1963 of ASME III Code, Subsection NE governing the design, fabrication and erection of steel containment vessels for nuclear service, containments built from about 1965 and after were built in accordance with ASME III Subsection NE and the N-MC Code Stamp.

The design governed by ASME III Subsection NE is based on allowable stress design, similarly to what is explained for the KTA Code in the next section regarding vessel design in Germany.

The design, fabrication and erection techniques were well established during this time frame. Design at discontinuities such as embedment and change of shapes used state of the art structural mechanics techniques. In addition, the art of cold forming steel shells to a prescribed shape was refined so as to fabricate shells to meet the configuration tolerances.

Materials used during the late 1950's and early 1960's were SA-201B FBX and SA-212B FBX, both to A-300. The yield and ultimate stresses were 32000 psi (221 MPa) and 60000 psi (414 MPa) for SA-201B and 38000 psi (262 MPa) and 70000 psi (483 MPa), for SA-212B, respectively. The most popular steel used during the late 1960's was SA-516 Gr 70, with yield strength of 38000 psi (262 MPa) and ultimate of 70000 psi (483 MPa) wherein the SA-516 Gr 70 being an updated version for SA-212B FBX. A counterpart material was SA-516 Gr 60 with a 32000 psi (221 MPa) yield and a 60000 psi (414 MPa) ultimate wherein the SA-516 Gr 60 being an updated version of SA-201B FBX.

Today's most often used material is SA-738 Gr. B with yield strength of 60000 psi (414 MPa) and an ultimate of 85000 psi (586 MPa). Prior to the development of the higher ultimate, the material used was SA-537 Class 2, with the same yield strength but an ultimate of 80000 psi (552 MPa). It is apparent that the quality of the steel has improved substantially during the time frame. It is noteworthy to contrast the allowable stress used in the 1950's of about 15000 psi (103 MPa) to today's allowable of 26700 psi (184 MPa).

For a design pressure of ~4 bar overpressure at a design temperature of approximately 150 °C, and a design external pressure of ~200 mbar partial vacuum, a typical vessel is cylindrical with a diameter of ~40 m and a height of approximately 60 to 70 m. The wall thickness in most of the cylinder is then ~40 to 50 mm. The wall thickness of the lowest course of the cylindrical shell is normally increased to provide margin in the event of corrosion in the embedment transition region.

List of US codes & standards:

- United States Nuclear Regulatory Commission (USNRC) Standard Review Plan NUREG 0800, Section 3.8.2 [73].
- USNRC Regulatory Guide 1.57 [74].
- ASME II, Materials Parts A, B, C, and D [75].
- ASME III, Subsection NCA General Requirements for Division 1 and 2 [76].
- ASME Code, Section III, Subsection NE, Metal Containment, 2001 Edition, including the 2002 Addenda [77].
- ASME Code, Case N-284-1, Metal Containment Shell Buckling Design Methods, Class MC, Section III, Division 1.
- ASME III, Subsection NC for Class 2 components [78].
- ASME Code, Section III, Subsection NF Component Supports [79].
- ASME V, Nondestructive Examination [80].
- ASME Code, Section IX, Welding and Brazing Qualifications [81].
- ASME Code, Section XI, Rules for In-service Inspection [82].

- AISI/ANSI N690 American National Standard for the Design, Fabrication, and Erection of Steel Safety Related Structures for Nuclear Facilities [83].

Vessel design - Germany

Except for two of the eight operating blocks (December 2017), all reactor containments in Germany are made of steel (commercial operation from 1985 to 1989). The containments of the more recent German PWR plants (Convoy and pre-Convoy plants) consist of a steel sphere 56 m in diameter with walls 30 – 40 mm thick. These dimensions are based on a design pressure of in the range of 4 – 5 bar overpressure at a design temperature of 150 °C.

Steel containments are designed in accordance with KTA. KTA 3401 covers materials, design conditions, design, production and testing. The material that 3401.1 requires is 15 MnNi 63 steel, whose mechanical characteristics, with a yield point of 330 – 370 MPa and a tensile strength of 490 – 630 MPa are comparable of those of construction steel S355.

Design is governed by KTA 3401.2, and is based on permitted stresses (allowable stress design), departing from the partial factor safety concept. Permitted stresses are defined for four stress levels and the various stress categories allowing for how steel characteristics change with high temperatures. A loss of coolant accident as the dominant verification demand of the containment is put in the operating stress level and hence not regarded as a failure case.

Stability studies are also required to cover the possibility of a partial vacuum arising in the containment. The pressure test here assumes a partial vacuum of 45 mbar and a partial vacuum of 5 – 30 mbar in normal operation.

List of German codes & standards:

- Safety Standards of the Nuclear Safety Standards Commission (KTA) KTA 3401.1 Steel Containment Vessels, Part 1, Materials [84].
- Safety Standards of the Nuclear Safety Standards Commission (KTA) KTA 3401.2 Steel Containment Vessels, Part 2, Analysis and Design [85].
- Safety Standards of the Nuclear Safety Standards Commission (KTA) KTA 3401.3 Steel Containment Vessels, Part 3, Manufacture [86].
- Safety Standards of the Nuclear Safety Standards Commission (KTA) KTA 3401.4 Steel Containment Vessels, Part 4, Inservice Inspections [87].
- Safety Standards of the Nuclear Safety Standards Commission (KTA) KTA 3205.1 Component Support Structures with non-integral Connections Part 1, Component Support Structures with the Non-Integral Connections for Components of the Reactor Coolant Pressure Boundary (Class 1 Components) [88].
- Safety Standards of the Nuclear Safety Standards Commission (KTA) KTA 3205.2 Component Support Structures with non-integral Connections Part 2, Component Support Structures with the Non-Integral Connections for Pressure and Activity-Retaining Components in Systems Outside the Primary Circuit [89].
- Safety Standards of the Nuclear Safety Standards Commission (KTA) KTA 3205.3 Component Support Structures with non-integral Connections, Part 3, Series-Production Standard Supports [90].
- DIN 18800 Part 1, Steel Structures: Design [91].

KTA and ASME comparison

Load combinations

The table below shows the specified load combinations valid for the ASME III Code. The table compares favorably with the German Code KTA 3401. It is especially important to note that the seismic loads are a part of Service levels 2 and 3 of the German code. These service levels are comparable to ASME III Service Levels C and D.

LOAD COMBINATIONS AND SERVICE LIMITS FOR CONTAINMENT VESSEL

Load Combination and Service Limit											
Load Description	**Con**	**Test**	**Des.1**	**Des.2**	**A1**	**A2**	**A3**	**C1**	**D 1**	**C2**	**D2**
Dead D	x	x	x	x	x	x	x	x	x	x	x
Live L	x	x	x	x	x	x	x	x	x	x	x
Wind W	x				x						
Safe shutdown earthquake Es								x	x		x
Tornado Wt										x	
Test pressure Pt		x									
Test temperature Tt		x									
Operating pressure Po					x					x	
Design pressure Pd			x			x		x			x
External pressure (2.9 psid) Pe				x			x		x		
Normal reaction Ro				x	x		x		x	x	
Normal thermal To				x	x		x		x	x	
Accident thermal											

Allowable stresses

A comparison of allowable stresses of the KTA 3401 vs. the ASME III Code is shown below. The baseline design condition, where the applicable temperature is 150 °C, is presented here. The material is SA 738 Gr. B and there is a KTA code limitation of 320 MPa at 150 °C for the yield point stress.

Note that all stresses are stress intensities = stress 1 – stress 2.

Service Level	Pm(ksi) Pl(ksi)	Pm+Pb(ksi)	Pm+Pb+Q(ksi)	Pm+Pb+Q+F.(ksi)
0 (design)	31.1	34.8	--	--
1 (A & B)	31.1	34.8	77.5	fatigue
2 (C)	34.8	39	85.4	fatigue
3 (D)	39	43.6	--	--

Allowable Stresses based on Table 5.2-1 of KTA 3401.2

Service Level	Pm(ksi) Pl(ksi)	Pm+Pb(ksi)	Pm+Pb+Q(ksi)	Pm+Pb+Q+F.(ksi)
0 (design)	26.7	40.1	--	--
1 (A & B)	26.7	40.0	84.9	fatigue analysis
2 (C)	32.0	48.0	88.5	fatigue analysis
3 (D)	32.0	48.0	--	--

Allowable Stresses based on Table NE-3221-1of ASME III

In the tables shown above, it is obvious that the allowable for the primary membrane stresses in the KTA Code are greater than those of the ASME, in all other stress categories, the ASME allowable are greater than those of KTA. The allowable buckling stresses that are not shown here are greater for Code Case N-284 than those in accordance with DASt 013 [93] and DIN 18800. Below is included a comparison of the Codes based on typical steel materials for each of the Codes (instead of as in the table above the use of the same steel material for both of the Codes).

General primary membrane stress (P_m) allowable:
KTA 3401.2 -> $P_m \leq 0.67*S_y \leq 46.4$ ksi (320 MPa) at the design temperature of 300 °F (150 °C) -> $t = p*R/P_m$ -> assume R of 130 feet and a yield point of at least 320 MPa, the minimum required wall thickness is t = 1.48, or about 1.5 inches (38 mm).

ASME III, NE -> $P_m \leq 26.7$ ksi (184 MPa), when using SA 738 Gr. B (yield stress of 60 ksi (414 MPa), ultimate stress of 85 ksi (586 MPa)) -> $t = p*R/(S*E-.6*p) = 1.726$ inches, or about 1.75 inches (44 mm).

Local primary membrane stress (P_l):
KTA 3401.2 -> $P_l \leq 0.75\ S_y = 34.8$ ksi (240 MPa).

ASME III -> $P_l \leq 1.5*S_m$, where $S_m = S_u*1.1\ /3.5 = 26.7$ ksi. $1.5\ *S_m = 40.05$ ksi (276 MPa).

It is noteworthy that while the local primary membrane stress can go to the elevated allowable, the ASME III code restricts the region over which it exceeds $1.1*S_m = 29.37$ ksi (202 MPa) cannot exceed 1.0*sqrt(R*t), thus making sure that the stress is truly a local primary membrane stress. The German KTA 3401.2 code does not make that distinction.

External pressure load:
While the internal pressure analysis above indicates that the cylindrical shell thickness may be reduced using the KTA Code instead of the ASME Code, if so the external pressure load (partial vacuum) case may result in the addition of additional circumferential stiffeners.

Surface stresses:
KTA -> $P_l+P_b+Q \leq 1.67*S_y = 1.67*46.4 = 77.5$ ksi (535 MPa)

ASME -> $P_l+P_b+Q \leq 3.0*S_m = 3.0*26.7 = 80.1$ ksi (552 MPa)

Stability criteria:
An important difference between the Codes lies in the stability criteria as specified. The buckling criteria as listed in the KTA Code is in accordance with DASt 013 [93] and DIN 18800. This buckling criteria tends to give an allowable axial compressive stress that is considerably lower than that obtained in using the ASME III Code Case N-284-1 criteria. A reference table taken from the preparation of back up data of the Code Case shows that buckling allowable determined by use of DIN 18800 tend to be anywhere from 15% to 30% lower than those determined by Code Case N-284. Hence, the use of the DIN 18800 allowable will require more cylindrical shell thickness.

2.13.1.4 Required additional data/research

It is foreseen that present codes & standards, together with available Regulatory Body documents, guidelines etc., could be used as the basis for establishing new design rules in the RCC-CW [11] for the design of steel reactor containments. However, since the major codes & standards available (KTA and ASME) are allowable stress design codes, research activities are needed to correctly transfer the design from the allowable stress design space to the partial factor safety concept used in the Eurocodes / RCC-CW [11].

Since neither the KTA Code nor the ASME Code consider design extension conditions (DEC), due to internal events, or design extension external events (DEEE), research is needed to properly in the RCC-CW [11] Code address DEC and DEEE.

2.13.2 Integration in the code(s)

2.13.2.1 Type of modification / evolution

This is a major revision of the existing RCC-CW [11] Code. A complete new section on steel reactor containment design has to be added. In addition, a design section for the design of the load transfer from steel-to-concrete in the steel containment embedment zone into the concrete base mat and common foundation has to be developed.

2.13.2.2 Proposed structure of revised code

It is preferred that also the steel reactor containment design rules to be added into the RCC-CW [11] Code are in accordance with the Eurocodes[5] / RCC-CW [11] design concept, hence the partial factor safety concept. As explained in section 1d, this implies new design rules to be implemented (as compared to reference any of the existing codes & standards).

However, it could also be the case that the steel containment design is incorporated into RCC-CW [11] following the allowable stress design concept, the implementation then facilitated as being in line with the design philosophy of the major reference design codes (see section 1c). The RCC-M code [92] and the corresponding AFCEN group of experts could then be employed in the code evolution work.

2.13.2.3 Group opinion of the proposal

Shortly describe the opinion of the concerned prospective group(s) on the proposal. Report if the opinion is unanimous or if there are any opposing opinions. In the latter case also report the opposing opinion.

Mention the AFCEN representative(s) view point and, when necessary, that of R&D members.

2.13.3 Interaction with AFCEN

2.13.3.1 WS 064 proposal submission to AFCEN

Indicate the date of submission of the proposal to AFCEN.

2.13.3.2 AFCEN feedback

Indicate the status of the request to AFCEN: in progress or answered (in this case, indicate the date of answer and the nature of the answer: fully accepted, accepted with provisions, rejected).

2.13.3.3 WS 064 actions

Give the group evaluation of the response and proposed action(s) from AFCEN.

Indicate if a revision of the proposal is needed.

2.14 PG3/CE-12 Consistency with EN-206

This CE requires further discussion and corresponding web meeting will be arranged. Following topics should be discussed:

- At the top, there is RCC-CW [11] and for conventional parts, there are EN standards and further on national annexes.

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[5] EN-1993 Design of steel structures will then be included in the set of codes being the part of the scientific references (section 1c).

- RCC-CW [11] should concentrate on nuclear facility specific concrete technology requirements which are beyond EN standards.
- Reinsuring that RCC-CW [11] is referring carefully to EN standards.
- If separate appendix to RCC-CW [11] is needed for listing specific terminology between RCC-CW [11] and EN 206 [5]
- The target is not to delete the reference to the French standards but to identify national level requirements and nuclear specific which have to be in the main text.

2.14.1 Brief outline

The RCC-CW [11] was initially developed by EDF on the basis of the last version of the RCC-G series which contain civil engineering design and construction rules for French NPPs. An initial edition of the Code was issued as ETC-C by EDF in April 2006 and serves as a reference document for Flamanville 3 Project. Since 2009, the development has continued under the frame of AFCEN leading to the publication of the AFCEN ETC-C 2010 Edition and the AFCEN ETC-C 2012 Edition. ETC-C 2010, first edition published by AFCEN has been used for the Generic Design Assessment of EPR in UK. ETC-C 2012 integrates the feedback of Flamanville 3 and of the Generic Design Assessment. This history results in embedding many national (French, German, and UK) requirements. One of the reason for developing RCC-CW [11] from ETC-C by a Sub-Committee was the necessity for new NPP Projects to comply with requirements from international regulations and practices. For this purpose, the CONSISTENCY OF TERMINOLOGY of RCC-CW [11] code with other Standards (especially EN 206 [5]) is an obvious challenge. An important part has been already done but still there are parts and chapters that contain terms and definitions that are not commonly used in other in Europe and in the World. They are present mainly in CCONC chapter.

The following examples in this issue could be described.

<u>Type of concrete</u>

In RCC-CW [11] there is:

The type of concrete (strength class, target consistence, D_{max}, grading, water content, type and content of cement) shall be adapted to the structure taking account of exposure classes of EN 206-1.

The composition of each type of concrete shall be defined by a nominal concrete mix which indicates, for one cubic metre of placed concrete:

- The concrete denomination,
- The type and the mass (dry materials) of the various categories of aggregates,
- The type and the mass of the cement,
- The type and the mass of the additions,
- The type and percentage of dry material content and the mass of any admixtures and additives,
- The total water volume: volume of mixing water plus volume of water provided by the different concrete constituents:
  - Aggregates,
  - Additions,
  - Admixtures and additives.
- The effective water/equivalent binder ratio (calculated in accordance with NF EN 206-1/CN for a determined equivalent binder content and effective water content).

In EN 206 [5] the definition of type of concrete (distinguished by its density) is in compressive strength class description

3.1.5.5
compressive strength class
fr: classe de résistance à la compression
de: Druckfestigkeitsklasse
classification comprising the type of concrete (normal-weight and heavy-weight or lightweight), the minimum characteristic cylinder strength (150 mm diameter by 300 mm length) and the minimum characteristic cube strength (150 mm edge length)

And additionally by the specific types of concrete in chapter 1:

(6) Supplementing requirements or different testing procedures may be specified for specific types of concrete and applications, for example:

— concrete for massive structures (e.g. dams);

— dry mixed concrete;

— concrete with a D_{max} of 4 mm or less (mortar);

— self-compacting concretes (SCC) containing lightweight or heavy-weight aggregates or fibres;

— concrete with open structure (e. g. pervious concrete for drainage).

<u>Nominal concrete mix vs. Specification of concrete</u>

In RCC-CW [11] type of concrete is defined by the nominal concrete mix – presented above.

In EN 206 [5] concrete is described by Specification of Concrete

3.1.1.17
specification of concrete
fr: spécification du béton
de: Festlegung
final compilation of documented technical requirements given to the producer in terms of performance or composition

And in chapter 6.1 of EN 206 [5] it is stated that

(3) Concrete shall be specified either as designed concrete referring in general to classification or target values given in Clause 4 and requirements given in 5.3 to 5.5 (see 6.2) or as prescribed concrete by prescribing the composition (see 6.3). The basis for designing or prescribing a concrete composition shall be results from initial tests (see Annex A) or information obtained from long-term experience with comparable concrete, taking into account the basic requirements for constituents (see 5.1) and concrete composition (see 5.2 and 5.3.2).

A set of required data for designed (Chapter 6.2) and prescribed (Chapter 6.3) concrete acc. to EN 206 [5] are very different from these required for nominal concrete mix in RCC-CW [11].

Additionally, to the above Concrete family is defined in EN 206 [5]. In Annex K a procedure for assessment of membership and conformity of concrete family is also given.

3.1.1.2
concrete family
fr: famille de béton
de: Betonfamilie
group of concrete compositions for which a reliable relationship between relevant properties is established and documented

Annex K
(informative)

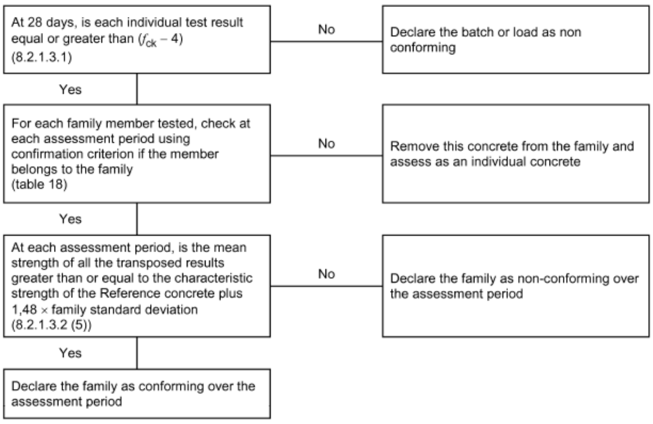
Concrete families

K.1 General

(1) This annex provides details on the use of concrete families as permitted in 8.2.1.1.

NOTE For further guidance, see CR 13901 and CEN/TR 16369.

K.3 Flow chart for the assessment of membership and conformity of a concrete family



<u>QUALIFICATION TEST/SENSITIVE STUDY/INFORMATION TEST/ SUITABILITY TEST/ CONFORMITY CONTROL TEST</u>
<u>vs.</u>
<u>CONFORMITY CONTROL/PRODUCTION CONTROL and EVALUATION OF CONFORMITY</u>

In RCC-CW [11] there is required a Qualification test:

CCONC 2800 QUALIFICATION TEST

The study of the concrete composition shall comprise the determination of the nominal concrete mix and a qualification test.

During qualification test next to Study of the validity of the nominal concrete mix a Sensitivity study of the nominal concrete mix is performed

CCONC 2820 Sensitivity study of the nominal concrete mix

The aim of the sensitivity study is to assess the sensitivity of the nominal concrete mix to changes in the constituent proportions, when the variations go beyond the tolerances defined in CCONC 3100.

Than an Information test is made:

CCONC 2900 INFORMATION TEST

The information test shall have two main objectives:

- To determine the compressive strength of the concrete at an early age in order to check that it is compatible with the methods of construction and in particular with the minimum strength necessary for the formwork removal,
- To determine the evolution of the concrete strength after 28 days.

Before concreting a Suitability test is required:

CCONC 3300 SUITABILITY TEST

CCONC 3310 General requirements

No load of any concrete mix shall be placed without undergoing an initial suitability test.

The concrete mix subject to the suitability test shall be the validated nominal concrete mix.

No modifications to the nominal concrete mix shall be made, with the exception of the admixture dosage.

The water content of aggregates shall be determined during the suitability test before production of each batch.

During the suitability test shall be defined:

- The method of introduction of the admixtures,
- The mixing time of the concrete,
- The working time of the concrete.

Finally, a Conformity Control Test is described in RCC-CW [11]:

CCONC 5900 CONFORMITY CONTROL TEST

Conformity control test shall be performed to verify that the concrete complies with the requirements.

In EN 206 [5] the quality of concrete is assured by the proper specification of concrete and Conformity control and Production Control

8 Conformity control and conformity criteria

8.1 General

(1) Conformity control comprises the combination of actions and decisions to be taken in accordance with conformity rules adopted in advance to check the conformity of the concrete with the specification of concrete. Conformity control is an integral part of production control (see Clause 9).

9 Production control

9.1 General

(1) All concrete shall be subject to production control under the responsibility of the producer.

Evaluation of conformity is described in Chapter 10 of EN 206 [5]:

10 Evaluation of conformity

10.1 General

(1) The producer is responsible for the evaluation of conformity for specified requirements of the concrete. For this purpose, the producer shall carry out the following tasks:

a) initial tests, when required (see 9.5 and Annex A);

b) production control (see Clause 9), including conformity control (see Clause 8).

Additionally, in EN 206 [5] normative Annexes the Initial test (Annex A) and Identity test (Annex B)

3.1.5.8
identity test
fr: essai d'identification
de: Identitätsprüfung
test to determine whether selected batches or loads come from a conforming population

3.1.5.9
initial test
fr: essai initial
de: Erstprüfung
test or tests to check before the production starts how a new concrete or concrete family shall be composed in order to meet all the specified requirements in the fresh and hardened states

Quality control of Concrete is a very important issue so the quality assurance procedures described in RCC-CW [11] should be consistent with these given in EN 206 [5]. If the RCC-CW [11] code aspires to be an Universal International Code this part should to be revised.

An example of a simple consistency action is the CB Appendix in the latest RCC-CW 2016 edition, entitled Concrete properties according to exposure classes as an extract NF EN 206-1/CN:12/2012 – Table NAF.1 In this case I recommend to change its name to be more close to that from EN 206 - “Recommended limiting values for composition and properties of concrete in relation to exposure classes”.

Independently the references to EN 206-1 [6] standard should be changed to EN 206 [5].

2.14.2 Suggestion for outlining the mother code and appendices

As there is a need for developing the RCC-CW [11] code towards a more international code, a review of consistency with European Standards (especially EN 206 [5]) should be the goal. In a result the full consistency with EN standards should be obtained except in the case that you need a specific term for nuclear facility civil works which is not in the EN 206 [5].

2.14.2.1 Associated deadlines

In the next RCC-CW [11] evolution

2.14.3 Required R&D to support the evolution (if any)

2.14.3.1 Expected results

2.14.3.2 Schedule and costs

2.14.4 Integration in the code(s)

2.14.4.1 Type of evolution

The evolution is related to several modifications in the rules in the current RCC-CW [11], and it may require a deep change in the code structure. (requires further discussion).

2.14.4.2 Feasibility appreciation

2.14.5 AFCEN taking into account

2.14.5.1 Submission

2.14.5.2 Opinion on AFCEN taking into account

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Appendix 1: List of figures

Appendix 2: List of tables

Appendix 3: Abbrevations

ACI	American Concrete Institute
AFCEN	French Association for Design, Construction, and In-Service Inspection Rules for Nuclear Island Components
ALARA	As low as reasonable allowable
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
BWR	Boiling water reactor
CE	Code evolution (outcome of WS64 phase 2)
CEN	European Committee for Standardization
CSA	Canadian Standardization Association
CWA	CEN workshop agreement (outcome of WS64 phase 2)
DBD	Design basis design
DBE	Design basis earthquake
DBSE	Design basis shutdown earthquake
DEC	Design extension condition
DED	Design extension domain
DEH	Design extension hazard
DiD	Defense in depth
EN	CEN European standard
EUR	European Utility Requirements
FC	Fibre concrete
FEM	Finite element method
HWC	Heavy and neutron-absorbing concrete
I/O	Inspection organization
IAEA	International Atomic Energy Agency
ISO	International Organization for Standardization
LWC	Light concrete
LWR	Light water reactor
MDEP	Multinational Design Evaluation Programme
NEA	Nuclear Energy Agency (OECD)
NPP	Nuclear power plant
NQSA	Nuclear Quality Standard Association

OBE	Operational basis earthquake
OECD	Organisation for Economic Co-operation and Development
PFRC	Polymer fibres reinforced concrete
PG	WS 064 phase 2 prospective group
PRA	Probabilistic safety assessments
PSA	Probabilistic risk assessments
PWR	Pressurized water reactor
R&D	Research and development
RC	Reinforced concrete
SCC	Self-compacting concrete
SFRC	Steel fibres reinforced concrete
SLS	Servicability limit state
SPH	Smooth particle hydrodynamics
SSE	Safe shutdown earthquake
STUK	Radiation and Nuclear Safety Authority in Finland
UHPFC	Ultra high performance fibre reinforced concrete
UK	United Kingdom
ULS	Ultimate limit state
US	United States
USNRC	United States Nuclear Regulatory Commission
WENRA	Western European Nuclear Regulators Association
WS	Workshop (CEN workshop 064 phase 2)

Appendix 4: Symbols

σ_c	Compressive stress in the concrete
ε_s	Tension strain in the reinforcement
f_{ck}	Characteristic compressive cylinder strength of concrete at 28 days

Appendix 5: Business plan

CEN Workshop 064 phase 2 revised business plan June 2015 – Final version

10 pages

Design and Construction Codes for Gen II to IV nuclear facilities (pilot case for process for evolution of AFCEN codes)	**CEN/WS 64 phase 2**
Date : **2015-10-19**	**N26** **(replaces N 25)**
Assistant: *Elisabeth DERCHE* *Direct phone : + 33 (0) 1 41 62 81 45* *Elisabeth.derche@afnor.org*	*Your contact:* *Sylvie PICHERIT* *Direct phone : + 33 (0)1 41 62 82 66* *Sylvie.picherit@afnor.org*

Revised Business Plan June 2015
Final version

Comments	Please find here after the Workshop 064 phase 2 Business Plan, as revised during the first Plenary meeting of the 8 th of June 2015 and approved following consultation of the workshop members (September 2015).
Follows up	For information

Business Plan proposal for a CEN Workshop

CEN/WS 64 – Phase 2
Design and Construction Codes for Gen II to IV nuclear facilities
(pilot case for process for evolution of AFCEN codes)

(as revised at the first plenary meeting of the 08 th of July 2015)

CONTENTS

EUROPEAN COMMITTEE FOR STANDARDIZATION

Status of this Business Plan

1. Background to the CEN Workshop

1.1 The Market environment

In the nuclear industry, specific design and construction Codes provide a set of essential engineering tools for the design, construction, and integration of nuclear high safety class components and systems. These Codes are the common reference between all actors involved in the design and construction of power plants and other nuclear facilities, starting from the main supplier of the technology, the architect engineer, the operator, manufacturers and suppliers of components, contractors, but also inspectors and safety authorities. These Codes are a reliable basis to ensure the quality level of components and systems, necessary to meet high nuclear safety levels.

Codes permanently integrate the lessons learnt from industrial practice of the different stakeholders (both in terms of failures and in terms of best practices) and the safety requirement evolutions. They are mostly based on scientific results or, failing that, on experience-proof postulates.
Codes are contractual bases for the projects, in the first place between contracting authorities and their providers of specific key equipment. In addition, they can be used as a basis in the arguments between licensees and safety authorities, in particular at the time of reactors licensing or periodical safety assessment.

1.2 Motivation for the creation of "CEN/WS 64 phase 2"

In the EU, for historical reasons and depending on the country, the nuclear reactors in operation today were designed and built using either the US ASME Code, equivalent "European national" codes (AFCEN for France, KTA for Germany), or Russian codes (NIKIET), or even a mixture of codes adapted at national level. This led to a European nuclear reactors fleet that has been built within a "patchwork" of reference codes, leading in some cases to over costs, delays in the implementation and a more complex follow-up of activities. The need for harmonization has been recognized at diverse occasion and some initiatives are already trying to improve the situation, for example, as Multinational Design Evaluation Programme (MDEP), the CORDELL group of the WNA, NUGENIA.

These codes are one of the major contributors for driving cost for new nuclear power plants. Harmonization of these codes is a way of reducing their impact. Another way is a simplification of the codes.

In the perspective of the implementation of Generation IV systems, an experiment was carried out in the European area to federate stakeholders in a common code elaboration process derived from the current AFCEN[1] process.

- Tentative Europeanization process to an AFCEN code relating to Generation IV systems

  This initiative was the set up in 2011 of the CEN Workshop on "Design and construction codes for mechanical equipment of innovative nuclear installations" (CEN/WS 64) proposed by the European Sustainable Nuclear Industrial Initiative (ESNII) and AFCEN.

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[1] **Afcen**: *Association Française pour les règles de Conception, de construction et de surveillance en exploitation des matériels des Chaudières Electro Nucléaires*
French Association for the rules governing the Design, Construction and Operating Supervision of the Equipment Items for Electro Nuclear Boilers.

This Workshop, financially supported by the European Commission (DG ENER) and in which participated a wide range of organizations among nuclear development stakeholders, aimed at investigating the Europeanization potential of an existing code (AFCEN RCCM-Rx: design and construction rules for mechanical equipments of research and fast neutron reactors) for innovative nuclear facilities (mainly Generation IV systems).

As a main result of the CEN/WS 64, it appeared that the modifications of the Code required by partners involved in short term concrete design and/or construction projects (referred to as short term modifications in the CEN/WS 64) should preferably take place in the existing dedicated AFCEN subcommittees. But for stakeholders with potential medium or long term projects or desiring to learn more about the Codes and their evolution process, in order to introduce appropriately their requirements into the Codes and to identify the associated pre-normative research needs, the Workshop experience should be the base for a veritable European process for future developments of the AFCEN Codes.

In parallel, the CEN-CENELEC investigated the situation of nuclear standards in Europe and the potential need to create a European technical structure dedicated to this area under its umbrella.

- Investigation on European needs related to nuclear energy standards by a Focus Group

In 2011 CEN-CENELEC created a dedicated Focus Group on nuclear energy. In 2012, this Focus Group issued a report with an overview on suitable standards already publicly available (from ISO, IEC, CEN and CENELEC or other sources) or in preparation, to meet specific needs for products and services in the nuclear sector. A set of recommendations was proposed to both the CEN and CENELEC Technical Boards and endorsed by these Boards (CEN BT C145/2012, CENELEC BT D144/C002-C005). One of the recommendations encourages the follow up of the CEN/WS 64 to enlarge the Europeanization process to other AFCEN Codes using CEN Workshops.

Based on the results of the CEN Workshop 64 and the recommendations of the CEN-CENELEC Focus Group, in April 2013, the European Commission in the framework of ENEF (European Nuclear Energy Forum) decided to support a CEN/WS 64 phase 2 with the target to enlarge the scope to the codes for mechanical equipment and civil engineering of GEN II to GEN IV nuclear installations. Indeed, seeing the perspective of the Long Term Operation for GEN II NPPs and the potential new NPPs of GEN III, the aim would be to offer an opportunity to a wide range of stakeholders to gain a deep understanding of the AFCEN codes and their evolution process, to allow them to define their long term requirements for the codes modification and the adaptation to their needs. It would also lead to the definition of pre-normative research priorities. At the end this would help initiating the harmonization process of codes at EU level.

1.3 Existing standards and standard related activities and documents

According to another recommendation of the Focus Group, CEN/TC 430 was set up in September 2013 in view of implementing ISO/TC 85 & SCs' existing and forthcoming standards at the CEN level.
Civil engineering, fuel technology, electrical equipments and mechanical standards for nuclear facilities are not addressed in ISO/TC 85. ISO/TC 85 has currently 3 subcommittees respectively dedicated to radiation protection (SC 2), nuclear fuel cycle (SC 5) and reactor technology (SC 6).
None of them is dealing with topics covered by AFCEN codes.
Electrical equipment standards for the nuclear sector are addressed in IEC/TC45 (Nuclear instrumentation), IEC/SC45A (Instrumentation, control and electrical systems for nuclear facilities) at international level and in CLC/TC45AX (Instrumentation, control and electrical systems for nuclear facilities) and CLC/TC45B (Radiation protection instrumentation) at European level. Some of the

standards developed at international level or endorsed as EN at European level by those Committees are dealing with topics covered by AFCEN code RCC-E.

2. Workshop Proposers and Workshop Participants

The present CEN Workshop is proposed by Afcen and Afcen members.

In addition, ENEF[2], SNETP[3] (and in particular NUGENIA) and Foratom called for participation at the kick-off meeting.

3. Workshop objectives

The proposal consists into a voluntary mechanism for a broad set of partners involved with design and construction of nuclear facilities in Europe. It will allow partners not yet using AFCEN codes to learn about these codes. It will also give the opportunity to all participants to express their specific requirements for the long term modifications of the Codes including identification of pre-normative research where necessary."

During this process, other solutions in existing codes shall be considered. In ideal case, the result should be a combination of solutions from others codes, sometimes also allowing alternate approaches.

The prospective work to be done would be applicable to GEN III and IV NPPs and long-term operation/lifetime extension for GEN II NPPs.

The proposed CEN WS 64 phase 2 will enable members to:

a) recommend medium-long term orientations of evolution of those codes ;
Some rules presently considered cannot directly be included in the codes either because of an insufficient robustness of their demonstration or because there is no suitable way to deal with them in the current status of the code. When the integration of new rules of comparable nature or related to the same field seems feasible in a medium-long term period, an evolution of the code structure could be recommended to allow this integration

b) identify the R&D needs associated to these recommendations ;
Inventory of the R&D needs for the codification shall be established with a corresponding list of priority actions.
Some R&D needs for setting design rules for some equipments or, more frequently, to dispose of basic data for some materials and in particular for irradiated materials were already identified (e.g. materials not currently used in the nuclear industry , proton irradiation effects on materials).

c) look for explicit or implicit references to national standards in the codes and propose their substitution by international standards or, failing that, to advocate the elaboration of such standards ;

d) interact with the Multinational Design Evaluation Programme (MDEP) in view of:

[2] European Nuclear Energy Forum
[3] Sustainable Nuclear Energy Technology Platform

- on the one hand, promoting convergence actions in particular via MDEP SDO Board and asserting European practices at the international level,
- on the other hand, converting MDEP recommendations in codes evolution proposals.

4. Workshop programme

WS 64 – phase 2 will take place for a 3-year period, ending by 2017.

In order to meet its objectives, “WS 64 – phase 2” plans to prepare the following deliverables:

➢ **Yearly statements of the proposed evolutions**

These statements will consist in a formal activity report of the prospective groups and will contain a list of proposed evolutions for one or several codes, including possible substitution of standards taken as reference. For each evolution, depending on the stage of discussions' progress in the prospective groups, the following information will be given:

- the description of the evolution, i.e. its technical content, its scope of application and the associated deadlines;
- the required R&D to support the evolution, i.e. its technical content and expected results, the resources needed and their availability, its specificity to a project or for the community, and in this case, recommendations regarding to its funding and the associated intellectual property;
- the procedure to integrate the evolution in the code(s), i.e. the description of the modifications to perform, the expected deadline for implementation as well as the position of the code editor for the proposed modification.

➢ **A triennial statement of the medium-long term orientations stated in the CWA**

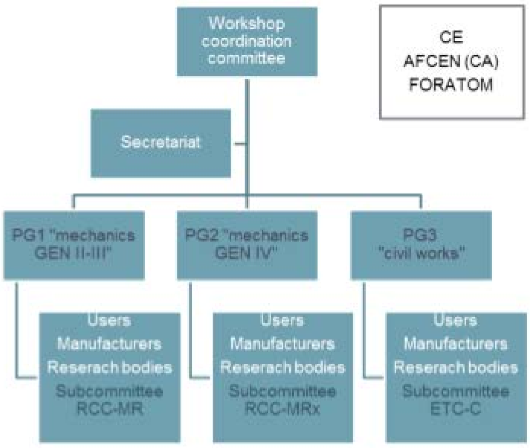
This statement would allow the stakeholders to evaluate the workshop and its working group's efficiency for the code “Europeanization” process. It will also allow the AFCEN (and other possible code editing bodies) to take advantage of the associated European evolution of its codes and the rules included in them. This triennial statement will be documented in the version of the CWA at the end of Workshop 64 phase 2.

In addition to the above statements, the workshop will regularly report on the evolution of the work and results achieved by the prospective groups to the EC/ENEF working groups dealing with nuclear installation safety and competitiveness and MDEP if possibility is given to.

	2014				2015				2016				2017		
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Kick-off meeting															
PGs' Meetings															
Code recommendations by PGs															
Notification to AFCEN															
AFCEN's report to the WS															
WS's assessment of AFCEN editorial programme															
Statement of the medium-long term orientations															
R&D recommendations by PGs															
Prioritization by WS															
Information of EC DG R&D, SNE-TP															
Drafting of the CWA															
MDEP															
Extension recommendation															

5. Workshop structure

5.1 General organisation



- **Workshop plenary meetings**

In order to enable an ongoing notification of the recommendations to Afcen, it was decided at the first plenary meeting in June 2015 that the proposals will be submitted to a webconsultation of the all workshop 064 phase2 members. Only the proposals for which no consensus could be achieved will be rediscussed during the plenay meeting.

The Workshop endorses the recommendations from the prospective groups dealing with the proposed code evolution, with R&D, and with references to international standards. The Workshop notifies to the codes editors the recommendations dealing with the code contents.. Additionally, it will assess how the recommendations are taken into account by the codes editors and give its feedback to them.

It may intervene in case of serious trouble in the workshop functioning or if some decision concerning its work has to be taken.

- **Prospective groups**

There is no a priori limitation for the number of groups or for the topics to be considered. On the practical point of view, it is proposed in a first phase to create prospective groups corresponding to the codes dealing with mechanical equipments for GEN II-III reactors, with mechanical equipments for GEN IV installations and with the civil work for reactors.

  - To recommend medium-long term orientations concerning the evolutions of the codes
  - To identify the related R&D actions
  - To see to the « denationalisation » of references

To this end AFCEN will provide, free of charge, participant organizations with one copy of the relevant AFCEN Code(s) for the prospective groups.
To support the identification of R&D needs and the recommendation of medium-long term orientations, it may be useful to get access to some research and background information that constitutes the basis for what is in the AFCEN Codes of today. When needed, the Prospective Groups will ask AFCEN for such information. AFCEN will supply it to the Prospective Groups to such an extent possible due to proprietary aspects.

- **Conveners – Chairman, Vice-Chairman's meeting (call) for cross-cutting items; one week before PG meetings – optional**

5.2 Workshop Chairman and Vice-Chairman

The responsibilities of the Workshop Chairman are:
- to chair WS plenary meetings;
- to ensure that the WS delivers in line with its BP;
- to manage the consensus building process;
- to interface with the CCMC regarding strategic directions, problems arising, external relationships;
- to work with the Workshop secretariat and prospective groups convenors on general management issues.

Vice-chairperson

The responsibilities of the Vice-chairperson are to assist the chairperson in its function and to replace him in case of absence/unavailability.

5.3 The Workshop Secretariat

The Workshop Secretariat is in charge of:

- organizing Workshop meetings (Coordination Committee and Prospective Groups), both as physical and electronic meetings;
- assembling the CWA and yearly statements;
- producing and distributing Workshop meeting reports and action lists;
- constituting the administrative contact point for the Workshop;
- managing Workshop membership lists;
- managing Workshop document registers;
- ensuring the follow-up of action lists;
- assisting the chairman in monitoring and follow-up of electronic discussions.

5.4 Prospective Groups Convenors

The Prospective Group Conveners were appointed during the Workshop kick-off meeting by the participants.

They are in charge of:

- planning the Prospective Group meetings so that it delivers in line with the Workshop Business Plan,
- convening the Prospective Group meetings and chairing them,
- managing the consensus building process,
- interfacing with the Workshop Chairperson regarding strategic directions, problems arising, external relationships, etc.

Prospective Group experts shall comprise representatives of the Workshop registered participants. However, experts coming from other organizations may be invited to join a Prospective Group meeting on invitation of the Convenor, and with the agreement of the Prospective Group experts.

6. Resource requirements

The registration and participation at this CEN Workshop is free of charge for every member of the Workshop, but each participant will bear his/her own costs for travel and subsistence.
The administrative costs of the Workshop Secretariat and other logistical support, for instance the online conference tool, will be shared between the CEN Workshop members.

7. Distribution of CWA

The copyright of the final agreement will be with CEN, though all proposers will get a free copy of the CEN Workshop Agreement for their own use.

8. Related activities, liaisons, etc.

The proposed CEN/WS 64 phase 2 will cooperate with:

- AFCEN

- MDEP
- CSNI - WGIAGE
- if necessary, CEN/TC 430 "Nuclear energy, nuclear technologies, and radiological protection", ISO/TC 85 "Nuclear energy, nuclear technologies, and radiological protection", CLC/TC 45AX "Instrumentation and control of nuclear facilities", CLC/TC 45B "Radiation protection instrumentation", IEC/TC 45 "Nuclear instrumentation".

- **Coordination with AFCEN**

In order to promote their recommendations, CEN/WS 64 – phase 2 should have strong and continuous relationships with the AFCEN in order to allow code evolution but as well to make sure that the recommendations elaborated by the prospective groups are relevant in a rule-making process. To achieve this, senior representative of each involved AFCEN subcommittee should make the link with the corresponding prospective group and participate in its work.

Furthermore, the President of AFCEN Editing Committee will report yearly to the workshop on the taking into account of its recommendations in the editorial programme.

- **Coordination with MDEP**

Topics in relation with the codes are dealt with in MDEP through its Mechanical Codes and Standards working group in which participate the main Standard Development Organisations (SDO) in the area (ASME, AFCEN, CSA, JSME, KEA and NIKIET).

The coordination will take place with the AFCEN representatives as AFCEN is the only European SDO involved in the programme and, as it is a proposer, will participate to the workshop.

9. Contact points

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2019:23

The Swedish Radiation Safety Authority has a comprehensive responsibility to ensure that society is safe from the effects of radiation. The Authority works to achieve radiation safety in a number of areas: nuclear power, medical care as well as commercial products and services. The Authority also works to achieve protection from natural radiation and to increase the level of radiation safety internationally.

The Swedish Radiation Safety Authority works proactively and preventively to protect people and the environment from the harmful effects of radiation, now and in the future. The Authority issues regulations and supervises compliance, while also supporting research, providing training and information, and issuing advice. Often, activities involving radiation require licences issued by the Authority. The Swedish Radiation Safety Authority maintains emergency preparedness around the clock with the aim of limiting the aftermath of radiation accidents and the unintentional spreading of radioactive substances. The Authority participates in international co-operation in order to promote radiation safety and finances projects aiming to raise the level of radiation safety in certain Eastern European countries.

The Authority reports to the Ministry of the Environment and has around 300 employees with competencies in the fields of engineering, natural and behavioural sciences, law, economics and communications. We have received quality, environmental and working environment certification.

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