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ADAPTATION OF RCC-M DESIGN AND CONSTRUCTION RULES TO THE EVOLUTION OF PROJECTS NEEDS, REGULATORY EVOLUTIONS AND INTERNATIONAL EXCHANGES

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ABSTRACT

The design and construction rules for mechanical components of LWR nuclear islands (RCC-M) constantly evolve to reflect the needs of the industry with the objective to fulfill the regulatory demands. Each year, an addendum is thus prepared by Afcen.

The December 2008 addendum includes in particular new grades for products procurement, evolutions on destructive and non destructive examination provisions, consideration of new editions of standards, improvements of text for an easier application.

For a better consistency with regulatory demands, technical code requirements have been updated (pressure test, overpressure protection, examination requirements or material properties), and in certain cases, provisions have been shifted in non-mandatory appendices established for various regulatory contexts for a better adaptation to applications abroad.

In parallel, the conditions for consistency with the European Pressure Equipment Directive (PED) and the French Nuclear Pressure Equipment regulation (ESPN Order dated December 12, 2005) have been deepened and a comparison work was done in the context of the MDEP (Multinational Design Evaluation Procedure initiative of OECD) with equivalent ASME code provisions.

The paper will present the content of the 2008 addendum of RCC-M, and the present status of these two studies on regulatory conformance and international comparisons, as well as some orientations for further evolutions.

INTRODUCTION

As explained in [1], the 2007 edition of the RCC-M had the objective of providing tools for LWR nuclear island construction with a special objective: providing consistency with the new European and French regulations.

Since that edition, return of experience dictated updating of some provisions related to regulatory concerns, in view of providing more flexibility for application in different regulatory contexts.

In addition, the 2008 addendum of the RCC-M integrates modification sheets resulting from requests from code users depending on projects and applications.

This paper intends to present code updating as well as the present status of works conducted in parallel on code consistency with applicable regulations and on international comparisons of codes and standards conducted in the context of the MDEP working group of OECD.

NOMENCLATURE

A: Elongation at fracture.
AFCEN: French Association for design, construction and in-service inspection rules for nuclear island components.
ASME: American Society of Mechanical Engineers.
ASN: French Nuclear Safety Authority.
CE: European Community.
CEN: European Committee for Standardization.
EN: European Standard.
EPR: Evolutionary Power Reactor.
ESPN: Nuclear Pressure Equipment.
FBR: Fast Breeder Reactors.
ISO: International Standards Organization.
KTA: German Kerntechnischer Ausschuss.

KV: Material toughness.

LWR: Light Water Reactors.

MDEP: Multinational Design Evaluation Procedure.

MPS: Main Primary System.

MSS: Main Secondary System.

OECD: Organization for Economic Co-operation and Development.

Pd: Design pressure.

PED: European Pressure Equipment Directive.

RCC-M: French Design and Construction rules for Mechanical components of PWR nuclear islands.

Rm: Ultimate tensile strength.

Z: Reduction of area at fracture.

THE RCC-M CODE

The RCC-M [2] is part of AFCEN codes on construction and in-service surveillance of equipment: Table 1. It is devoted to mechanical equipment of LWR applications and its scope is indicated in Figure 1, which also gives the correspondence with equivalent ASME provisions. It is established in French and issued in French and English editions. In case of doubt, the French text shall consequently be taken as reference.

Code	Scope
RCC-C	Nuclear Fuel
RCC-E	Electrical Equipment
RCC-M	Mechanical components of LWR reactors
RCC-MR	Mechanical components of FBR reactors
RCC-G	Civil Works (edited by Afcen)
RSE-M	In-service surveillance of mechanical components

Table 1: List of AFCEN codes

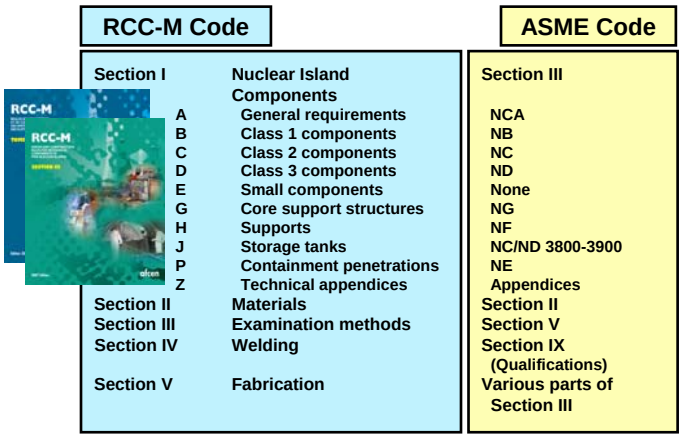

Figure 1: General structure of RCC-M and correspondence with ASME Code

Codes are updated following a process starting with a modification request established by any code user or by Afcen working groups. The instruction of these requests is conducted according to the Afcen quality manual and lead in case of agreement to issuing modification requests, which are collected every year to constitute addenda.

THE 2008 ADDENDUM

The 2008 addendum to the RCC-M 2007 edition is dated December 2008 and includes every modification sheet approved by RCC committees from June 2007 to December 2008. It thus includes modification sheets numbered 1059 to 1095, discussed hereafter.

General

There are few evolutions on RCC-M structure, except one concerning appendices, where it did appear desirable, in order to prepare the possibility of issuing appendices dedicated to various regulatory contexts (for example UK, South Africa, China or Finland), to group every concern related to a given context in a single appendix.

This did lead to group Appendices ZU and ZZ, which were separate appendices in the 2007 edition, in a single appendix ZZ dedicated to the European PED, and to similarly group appendices ZT and ZY in a single appendix ZY dedicated to the French ESPN Order, described in [1].

Each of these updated appendices ZY and ZZ, as well as others under preparation, includes a section giving the correspondence between code provisions and regulatory demands, in order to facilitate the demonstration of conformance with the regulation, and a section covering the provisions to be specified in addition to the basic RCC-M requirements to fulfill the regulatory demands (this section covering the scope previously covered in appendices ZU and ZT of the 2007 edition).

The updated list of appendices is given in Table 2.

Reference [1] indicated that technical provisions which could be generalized to all equipment are integrated in the basic RCC-M sections, whereas more "formal" regulatory aspects were integrated in non mandatory appendices, applicable (or not) depending on regulatory context.

In application of this philosophy, pressure test conditions were integrated in the basic B, C and D.5000 chapters and updated according to the recent European and French regulations. This proved to be inappropriate.

First of all, some components may be ordered according to the previous regulations, which may be in conflict with the new ones (individual test pressure of 1.33 Pd instead of 1.43 Pd for the primary system, 1.5 Pd instead of 1.43 Pd for the secondary system, for example).

In addition, RCC-M requirements could also be in conflict with practices applicable in foreign countries, in particular where individual tests were covered by system tests (as is the case of piping systems). System tests conducted according to RCC-M could in this case be in conflict with individual equipment tests performed in shop, where such

equipment is built according to another practice and installed in the system.

Appendix	Title
Z I	Properties of materials to be used in design
Z II	Experimental stress analysis
Z III	Determination of allowable basic stress limits
Z IV	Design rules for components subjected to external pressure
Z V	Design of circular bolted flange connections
Z VI	Design rules for linear type supports
Z A	Rules for determining reinforcement of openings in Class 1 vessels
Z D	Analysis of the fatigue behavior of zones with geometrical discontinuities
Z E	Other rules for analyzing Class 1 piping under conditions requiring compliance with Level A criteria
Z F	Rules associated with Level D criteria
Z G	Fast fracture resistance
Z H	Acceptable rules for determining usage factor
Z K	Definition of surveillance program of irradiation effects on RPV material properties
Z S	Constructive requirements linked to in-service inspection
Z Y	Provisions applicable by way of the ESPN Order
Z Z	Provisions applicable by way of Annex 1 of the PED

Table 2: List of RCC-M Technical Appendices in addendum 2008

In cases where there is no justification for different test practices in different countries based on differences of quality, Afcen has estimated that such regulatory practices should be shifted to in non-mandatory appendices (ZZ for PED, ZY for ESPN Order), and that the basic test provisions in the mandatory sections should limit themselves to be consistent with internationally recognized practices (in this case, the 1.25 Pd test specified in the ASME III code).

The basic test provision in RCC-M 2008 is consequently consistent with ASME Section III, and eventual supplementary provisions shall be specified according to the regulation in force in the concerned country. From this point of view, the RCC-M is now in the same position as the ASME code.

Test provisions to be made in application of the PED (and the ESPN order referring to it) have also evolved in the 2008 addendum. According to the 2007 edition, the test pressure to be applied is the maximum value of:

- 1.43 times the design pressure,
- 1.25 multiplied by the ratio of the allowable stress at test temperature over the design stress at design temperature.

In case several materials are used for a given item of pressure equipment, the highest value of the allowable stress had to be taken into account. As this second condition may potentially lead to high test pressure values, in case of difficulty, where the pressure test could govern the dimensioning of the equipment, the test pressure may be reduced to a value consistent with the allowable stress of the material.

This proved to be a rather complicated process, and a consensus was obtained at European level on a more simplified rule, which led to a modification of EN 13445 Standard [5]. This rule consists in using the lower value of the allowable stress ratio in determining the second condition governing the test pressure determination. It has also been introduced in the RCC-M in its new place, i.e. in Appendix ZZ.

Other provisions, such as third parties intervention, identification of equipment, or procurement certificates, remain unchanged.

Materials and procurement

The development of material selection and procurement conditions constitute a significant part of the 2008 addendum content. These modifications may be classified in several groups:

The first set is related to the introduction of new grades, in particular of the 20 MND5 low alloy steel grade for large primary equipment construction. This allows procurements capable of fulfilling RCC-M and ASME provisions, in particular where an industrial anticipation is appropriate. This concerns in particular steam generators and pressurizers.

Another modification source is the integration of evolutions of standards referred to in the code. This concerns in particular procurement specifications M.5150 and M.5190, M.3316 (evolution of EN 10088-2 standard), H.2200 and M.1146 (evolution of EN 10216 for support components), or the evolution of stainless steel grades designation in B, C and D.2000.

Other evolutions concern regulatory conformance of material properties (on A%, Rm or KV), which were identified after 2007 edition issuing, such as in the general paragraphs of section II (M.100, M.200, M.300), and in procurement specifications M.3317.

Provisions on ultrasonic examination of forged parts are also covered, as well as final surface examination of class 1 parts, and inclusion cleanliness provisions in appendix ZY to conform to the regulation.

The other evolutions are essentially dedicated to facilitating code use (improvement of M.3402 specification, conditions for surge line bending in M.3321), integrating experience lessons (suppression of toughness provisions where inappropriate in M.3405, use of grades for valve rods above 250°C in M.5110), or optimizing technical provisions, for example where bars are procured according to M.2312 in an intermediate state, before final heat treatments, or to cover the possibility of polishing steam generators tubes using an automatic process (specification M.4103).

Design and analysis

Code evolutions related to design aspects concern writing improvements on weld design provisions in subsections B, C,

and related references in sections IV and V on welding and fabrication, introduction of flexibility on using other design examples than those described in the code for openings, and complements on B.3500 pressure-temperature series for valves referring to updated material grades.

Other evolutions have more significance:

B, C and D.6000 on overpressure protection have been updated following industry comments on these new chapters introduced in 2007 edition. It shall be recalled that these new chapters cover a scope equivalent to the one in the ASME III code, and are consistent with the French and European regulations, referring where appropriate to European standards.

Appendix Z.II on experimental analysis has been updated to take into account the work done in the context of French-German code comparisons. The basic technical provisions remain similar, but the appendix structure is improved.

In subchapters B, C and D.3100, a more clear presentation of the relation between plant conditions and component conditions (or between conditions and level of criteria to be applied to a given component depending on its intended function during such condition) has been introduced. The text makes clear that an engineering decision has to be taken in particular for emergency systems the "design condition" of which is to act during a faulted plant condition, thus clarifying responsibilities: the design of nuclear pressure equipments shall take into account the loading conditions specified by the User, which is in charge of the overall plant safety and consequently of the Safety Report. Applicable criteria are function of the role of the equipment in a given plant condition and shall be specified in the equipment specification. They are input data for the RCC-M application.

In updating this subchapter, Afcen took the opportunity to better describe the structure of the design sections of the code, and to re-introduce for class 1 equipment the upset condition category, leaving to the non-mandatory appendices the responsibility to group normal and upset conditions if required by the applicable regulation, following the approach previously described in this paper for pressure tests.

Examples of load combinations as well as writing improvements in the paragraphs on corrosion or consideration of cladding have also been introduced.

Pressure test requirements being directly linked to the applicable regulation have been transferred in appendices ZY and ZZ. The basic provisions in B, C and D.5000 are now limited to minimum provisions applicable in every case. Such test conditions are consistent with the ASME III code in the 2008 addendum.

Fabrication and examination

The most important evolution included in the 2007 edition and developed in [1] was the reference to EN-ISO standards for welding qualification, instead of the previous self-contained provisions, and the re-integration of chapter S.8000 on hard-facing in order to cover Cobalt-free processes.

Evolutions integrated in the 2008 addendum are more limited. They are mainly the result of standards evolution, of evolutions in other code sections, or text improvement for a better consistency of technical provisions. One can mention in particular:

- updating of grouping of low-alloy steel grades,
- consequences of B, C and D.5000 evolutions,
- revision of toughness requirements for a better consistency,
- text corrections on follow-up documents,
- range of validity of welders qualifications for nozzles welds.

Some evolutions are the result of experience, in particular:

- the introduction of flexibility on Iron content for hard-facing, subject to contractor approval,
- the non-mandatory character of qualifications for temporary welds subject to the condition that all consequences of such welds are removed,
- the possibility to keep the root passes in case a weld done using an automatic process shall be completely redone.

Radiographic examination conditions for high wall thicknesses have also been updated in order to reduce the exposure time to an acceptable value while keeping adequate quality guarantees.

FUTURE EVOLUTIONS

In parallel with code evolutions, synthesis justifications are prepared to evaluate code conformance with regulatory demands. The objective is to agree with the Safety Authority on the correspondence between code provisions and essential requirements in the regulation, and consequently on the complementary aspects to be covered in addition to the code.

Some of these aspects fall under the scope of appendices ZY or ZZ, or will be dealt with in future appendices dedicated to other regulatory contexts. Other provisions will remain under the responsibility of the Equipment specification.

In addition to these regulatory aspects, Afcen analyses continuously the interpretation and modification requests issued by code users. Among the modifications which are under preparation, one can mention in particular:

- the updating of the rule for allowable stresses determination for class 2 and 3 components. The ASME code did evolve in this field, replacing the safety coefficient 4 on ultimate tensile strength by coefficient 3.5. The opinion of Afcen is that, due to the requirement already introduced in the code which asks for a detailed analysis each time a fatigue risk is identified, one could justify using a similar allowable stress for every component class. Nevertheless, due to the need for a better consistency between international standards, it is likely that the 2009 addendum will include a re-evaluation of allowable stresses consistent with the current ASME practice.
- the need for consideration of environmental effects in fatigue evaluations. The evolutions shall consider the current

practices applied to running projects as well as the last R&D results in this field.

- the updating of Quality Assurance provisions in A.5000, referring to the updated editions of ISO and IAEA standards in this field [6].

INTERNATIONAL CODE COMPARISONS

In the current context of the licensing of new plant generations in an international context, it is important to facilitate the licensing process by conducting comparisons between practices in various countries.

Concerning codes and standards, such a work is done in the context of the MDEP (Multinational Design Evaluation Procedure initiative of OECD) between ASME code provisions and equivalent Korean, Japanese, or European codes, to start with.

A format has been agreed on, starting with the ASME III code structure and mentioning the corresponding sections of the other codes, such as RCC-M. Comments on differences are integrated with the objective to identify if these differences are justified by technical reasons, or if they are strictly related to regulatory approaches in force in the concerned countries.

When they are of a regulatory nature, the Afcen approach is to shift the corresponding provisions in the non-mandatory appendices dedicated to the applicable regulatory contexts (ZZ for the case of the European PED, ZY for the case of the French order on ESPN components).

When they are justified by technical reasons, one has to understand how such concern is handled according to various codes:

- In some cases, provisions covered in one code (the RCC-M for example) is covered in the Equipment specification in addition to another code (the ASME code, for example). In such case, one shall not forget to add provisions in the specifications when shifting from a RCC-M practice to an ASME-based practice. Examples of additional specifications may concern Carbon content for inter-granular corrosion prevention, limitation of Sulfur or Phosphorus content for toughness or ageing properties, Boron content for welding properties, Cobalt limitations for irradiation protection of personnel, specified mechanical properties, such as toughness properties for fast fracture prevention, specification of non-destructive examinations, or part qualification conditions where a risk of heterogeneity of chemical or mechanical properties of large parts is identified.

- In other cases, the approaches may be different due to different philosophies, but judged globally equivalent subject to specific conditions, which may also in certain cases correspond to contractor specifications. Typical examples are qualifications of processes or personnel. Such practices may be recognized as globally equivalent subject to requirements which remain compatible with code qualification conditions, such as on pre- or post-heat treatment conditions, welding precautions, or welding production coupons.

At the date of the preparation of this paper, this comparison work has yet to be discussed with the various bodies represented in the working groups and it is too early to draw definitive conclusions.

This work is nevertheless considered important by Afcen code committees in preparing code updating. The objective is to retain evolutions going in the direction of code convergence while maintaining quality objectives.

Comparisons of codes shall not be limited to the code themselves, but should integrate what is under specification responsibility according to the code application traditions.

CONCLUSION

The RCC-M Code is used as a tool for the design and construction of LWR nuclear programs in Europe and abroad.

The 2007 edition of the code intended in particular to facilitate ensuring conformance with the regulatory demands resulting from the new French and European regulatory evolutions, in a way sufficiently flexible to allow the same adaptation to different regulatory contexts, within and outside Europe.

In the 2008 addendum, this approach has been maintained and application experience led to shifting some provisions in regulatory context-dependent appendices, particularly as far as pressure tests are concerned.

Apart from these regulatory concerns, the code evolves continuously, in order to integrate the progress of the industrial practices, the return of experience, as well as the needs of new projects, the numerous evolutions of the standards to which the RCC-M refers, and the results of developments. The paper has mentioned examples of such code updates.

More generally, in the context of the MDEP initiative, code comparisons are being conducted with the objective to identify the reasons behind code differences.

This work is followed with a great interest by Afcen committees. Where differences are linked to regulatory contexts, the intention is to cover the corresponding provisions in the context-dependent non mandatory appendices. Where differences correspond to technical reasons, it is the opinion of Afcen that the corresponding provisions should be specified in addition to the code in case it do not integrate them, under contractor responsibility.

REFERENCES

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[2] RCC-M Code, 2007 edition plus 2008 addendum, AFCEN, Paris.

[3] Directive 97/23/EC of the European Parliament and of the Council of 29 May 1997 on the approximation of the laws of the Member States concerning pressure equipment, transposed in French legislation by the Decree n° 99-1046 dated december 13, 1999.

[4] French Order dated December 12, 2005 applying to nuclear pressure equipment.
[5] Amendment Nr.10 to EN.13445 Unfired pressure vessels standard – Part 5, November 2008.
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