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FRENCH ADMINISTRATIVE PRACTICE AND DESIGN CODES FOR NUCLEAR VESSELS

Roche, R.L. CEA CEN Saclay, 91-Gif-sur-Yvette (France). IRDI, DEMT

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I - INTRODUCTION

French regulations on boilers and pressure vessels have prevailed for a very long time, the first measure having been promulgated on 29 October 1823. On the contrary, Construction Codes written on a voluntary basis appeared more recently. It is to say that the enforcement by public authorities was very important in this field. It can be expected that some important changes will occur in the future (1992) as a consequence of the extention of the European commun market.

Restraining the attention to nuclear pressure vessels it must be pointed out regulations and enforcement by public authorities are more stringent than they are for conventional pressure vessels. Such a situation can be considered as obvious from the point of view of nuclear safety. Therefore, the first part of this paper will be devoted to regulations with a special attention to the decree of 26 February 1974 and to the practice of public authorities in this field with special attention given to the Bureau de Contrôle de la Construction Nucléaire (BCCN = Bureau of Inspection of Nuclear Design and Manufacturing).

The second part of this paper will deal with the French construction codes for nuclear components RCC-M (water reactors) and RCC-MR (elevated temperature design).

II - FRENCH REGULATIONS CONCERNING NUCLEAR PRESSURE VESSELS

Main basis

There are two different basis to this regulation. One is related to boiler and pressure vessel regulations [1], the other to nuclear safety regulations [2]. The essential part of regulations on nuclear pressure vessels is the decree of 26 February 1974 [3].

The main primary circuit of water type nuclear plants is governed by this decree. The term main primary circuit denotes the installation consisting of the overall pressurized enclosures (vessels and piping) containing the fluid directly heated by the energy liberated by the fuel, and which cannot be isolated with absolute certainty from the vessel containing the fuel. Hence the entire envelope of the pressurized primary circuit is governed by the regulations, except for the parts which can be isolated.

Practically, this decree requirements are applicable to other parts like secondary circuit or to other types of reactors.

The following presentation of these regulations is rather compact, more detailed informations can be found in preceding publications [4], [5].

Pressure vessel regulations, set forth by the public authorities, are of a highly liberal nature. While establishing a consistent group of safety measures, the authorities have no intention of substituting for the constructor or user, who assume full responsability for the safety of the vessel. Consequently, the French regulations do not constitute a construction code, and only establish criteria without imposing methods or rules. Owing to the very nature of the subject, the provisions of the decree of 25 February 1974, while adhering to the liberal tradition, are more precise than those of traditional regulations. The technical provisions of the decree were drafted by a working group* consisting of specialists in design, construction and operation of nuclear plants, in the manufacture and testing of heavy boilers and pressure vessels, together with nuclear safety experts. This group and its subgroups deliberated for over three years. The provisions

* This Working Group was chaired by General Inspector Y.BONNARD and the author of this paper was in charge of the W.G. secretariat.

adopted were examined by the permanent group of experts charged with investigating the technical aspects of safety in nuclear reactors. The provisions were finally submitted to the approval of the Commission Centrale des Appareils à Pression and the Commission Interministérielle des Installations Nucléaires de Base. The final regulations are in the form of a decree (setting forth mandatory conditions) accompanied by a circular. The latter contains the explanations, commentaries and interpretations necessary for the application of the decree's provisions.

Though being a set of vessels and pipings, the primary circuit must be considered as a whole for using regulations. Only one constructor for it, only one operator may be considered by the enforcement authority.

The scope of this document can be cut in two parts:

- Design and Construction,
- Operation and Maintenance.

<u>Design and Constructions</u> (part II)

A single legal person ("the constructor") is responsible for applying the regulations to the overall main primary circuit.

The main requirements are relating to design, materials choice, manufacturing, regulation and safety devices, quality control and testing.

Concerning design, regulations stettle only safety margins against modes of failure.

<u>Operation and Maintenance</u> (part III)

An other legal person ("the user") is responsible for applying the regulations.

Operating conditions must be strictly defined and all events must be carefully registered. It is interesting to point out that the decree requires the state of the circuit must be assessed all the lifetime (Article 38). As a consequence the fatigue usage factor sum (of the most critical parts) must be known all along the plant life. At the time of the publication of the decree, such an obligation was very new and unusual.

Comprehensive "in service inspection" must be performed before the beginning of operation, after two years of operation, and then every ten years.

III - ADMINISTRATIVE PRACTICE

For conventional vessels, the practice is rather simple. The manufacturer (and the user) is responsible of the application of the regulations. The role of the authority is to check if regulations are applied. Their relations are similar to the ones between a driver and the police. It is the driver's responsability to avoid overspeeding, and not the police responsability. When the vessel is achieved, the manufacturer has to show it to the administration (Service des Mines) with a small report (including a stress report), then the vessel is submitted to an hydrostatic test (1.5 times the design pressure). On the results of this test, of vessel inspection and of examination report, the administration (Direction Régionale de l'Industrie et de la Recherche - DRIR), allows the use of the vessel, and its representative put a stamp on it (in France, the shape of the stamp is a horse head). Because the attention given to nuclear safety, the practice for nuclear vessels (the main primary circuit) is more complex. Detailed indications on it can be found in references [6] and [7].

First, the constructor must inform the authority (Ministery of Industry) before the beginning of components manufacturing. From this point, the Bureau de Contrôle de la

Construction Nucléaire is in charge of the official inspection of design, manufacturing and erection of the primary circuit, and of checking the good application of the regulations by the constructor.

In the frame of this procedure, the constructor must prepare and present to the BCCN the following documents :

- "Design" file (description of the components, design specification, stress report...),

- "Materials" file (material specifications, reasons of material choice, experience on material using),

- "Manufacturing" file (manufacturing schedule, specification of manufacturing process - forming, forging, welding, procedures of workers qualification),

- "Monitoring, regulation and safety devices" file (system description, safety components specifications, etc...),

- "Quality Control" file (Non Destructive Examination specifications, Acceptance Criteria, and documents related to Quality Assurance).

Very comprehensive drafts of these files must be made available to BCCN before the manufacturing beginning. These documents are submitted to a very careful and detailed examination by the official authority (BCCN). The constructor must answer to the observations and comments, and amend the files when asked. It must be said that this process is very time consuming, but the experience has shown this method is very efficient for obtaining sound components.

In addition the BCCN is in charge of inspecting workshops activities, erection and testing. When it is no possible to get an agreement between constructor and BCCN, the question is sent to the Ministery level (to the SCSIN, office of inspection of nuclear safety) and submitted to the advice of the Section Permanente Nucléaire (SPN : advisory committee for nuclear construction).

Finally, when the results of the final test are known and the initial In Service Inspection has been performed, the BCCN report to the Ministery of Industry. This one, after having obtained the opinion of the SPN, give the agreement to the operation of the vessel (the main primary circuit). It must be noted that if this agreement, limited to pressure vessels, is needed for operation, it is not sufficient and other agreements concerning the safety of the plant are necessary before the plant may be put in operation.

When the plant is put in active service, the user (in France it is the national utility EDF) becomes the responsible for the application of the regulations. On the other side, it is the regional administrative office D.R.I.R. (in the region where the plant is located) which is in charge of checking the good application of regulations.

Most of the activity is devoted to evaluation of the state of the components, to the examination of incidents and to the prescribed inspections. As during construction time, all non solved questions are sent to the Ministery and the opinion of SPN is asked before official decision was issued.

IV - DESIGN and CONSTRUCTION CODE for WATER REACTORS COMPONENTS

As it has been said, French regulations do not constitute a construction code and only establish criteria without imposing analytical methods. Obviously, agreement between constructor and authorities needs a set of rules of good practice to avoid unfruitfull discussions. This is the object of French Codes for Nuclear Components. They are not mandatory but their use make easier the relations with enforcement authorities. The practice has shown that the observations made by them are of great value for amending codes rules.

As far as nuclear vessels are concerned the French Code is the RCC-M [8], [9], [10], [11].

The RCC-M (Design and Construction Rules for Mechanical Components of PWR Nuclear Islands)* represents one division of the French RCC Codification which also covers system design, electrical equipment, civil works, fuel assemblies and fire protection. The RCC-M Code deals with PWR mechanical components and the RCC-MR with fast breeder components.

French effort on Codification started in 1978. At that date 30 PWR plants were in operation or under construction and the French Practice was well established.

Rules corresponding to this practice have first been established by EDF and Framatome with the participation of the various manufacturers concerned with the code.

Since October 1980, the RCC-M is published and maintained by AFCEN (French Society for Design and Construction rules for Nuclear Island Components) which also publishes the rules for design and construction of fast breeder reactor (RCC-MR), electrical equipment (RCC-E) and fuel (RCC-C).

The French administration has been consulted for advice on the compatibility of the code with regulation requirements. The use of the rules thus established is approved by the fundamental safety rule (RFS) V.2.c. dated April 1981. In addition, the administration closely follows the code evolution.

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* The RCC-M is available in French and English from AFNOR (Association Française de Normalisation = French National Standards Institute), Tour Europe - Cedex 7 - 92080 Paris La Défense.

The first AFCEN Edition of the RCC-M has been published in January 1981. Three addenda have been issued in July 1981, January 1982 and December 1982. The second RCC-M Edition was published in January 1983. Four addenda to this edition have been published in July 1983, January 1984, July 1984 and January 1985. The third (1985) Edition of the RCC-M is now available.

RCC-M scope

The RCC-M code covers the following mechanical components of PWR nuclear islands:

- pressure components (vessels, heat exchangers, pumps, piping, valves): pressure boundary parts are dealt with together with other specific parts referred to explicitely in the code,
- storage and low-pressure tanks (volume J to be published),
- supports of pressure components and tanks,
- reactor internals.

The RCC-M covers the following matters:

- design: mechanical resistance of pressure boundary (functional requirements and performance tests for pumps and valves for instance are out of RCC-M scope) ;
- materials: materials selection, procurement technical requirements ;
- manufacturing: process qualifications ;
- examination: stage, method and extend, acceptance criteria ;
- hydrostatic tests for pressure components and tanks.

General organization

The RCC-M is applicable to safety related components and to components whose design pressure exceeds 20 bar or whose design temperature exceeds 110°C. The other components are subjected to conventional codes. The code defines three classes for the pressure components and for each class, gives a complete set of design and manufacturing rules. In addition class 2 and 3 small pressure components are covered by specific provisions.

The assignment of these levels to different components depends on their role with respect to plant safety and to their operating conditions.

Safety classification is made according to the RCC-P (design and construction rules for system design of nuclear power plants).

In addition, it should be recalled that all equipment forming the main primary system (as defined by the French order of 26 February 1974) is assigned a Class 1 classification.

In order to be sure of the good use of the RCC-M requirements, the AFCEN has organized a set of procedures to verify the users qualification.

V - DESIGN and CONSTRUCTION CODE for COMPONENTS OPERATING in ELEVATED TEMPERATURE RANGE (LMFBR)

From a lawyer point of view, pressure vessels regulations are not applicable to the components of LMFBR pool type (there is no sodium pressure). Only nuclear safety regulations are applicable, but for sodium vessels those regulations are used in a way similar to pressure vessels regulations for water reactors.

Obviously, RCC-M rules are not sufficient and rules for elevated temperature design must be added. This is the reason why a new code called RCC-MR was published by AFCEN [12] [13], [14], [15], [16]. Concerning the way it was written, it can be said that during the design and construction of Super Phenix, it became apparent that the commercial development of FBRs would require a suitable design and construction code.

The Tripartite Committee was created in March 1978 to this effect, under the aegis of the CEA, the EDF and NOVATOME. It is composed of experts from research organizations, manufacturers and operators, as well as nuclear safety specialists. The work of this committee resulted in the drawing up of the Code of construction for FBR components (RCC-MR) which was published by AFCEN. The draft was issued in December 1983, and the first edition appeared in June 1985 (it is available in French and English from AFNOR). Considerable work was required to assemble, clarify and examine the experience gained during the design, construction and operation of RAPSODIE, PHENIX and SUPERPHENIX, as well as the knowledge available in the literature, and this acquired by the major R n'D programs which accompanied the construction of these reactors.

We would stress that this code of construction is not a regulation. It is not imposed by the French Government. It has been drawn up by specialists on a voluntary basis. Its purpose is to provide FBR constructors and their customers with a clear and reliable definition of good practice. This code is open-ended and has undergone changes since the first issue. In particular, AFCEN set up a procedure enabling users to suggest improvements. To this day, more than 120 requests for modification have been examined, which demonstrates its capacity for adaptation to changes in FBR component technology, as well as its open-ended character.

VI - CONCLUSIONS

In France, the present technical advance and administrative practice of Nuclear Vessels Codes and Regulations are the result of the important nuclear program. At the beginning of 1987, seventy percent of electrical power was coming from Nuclear Plants and more than forty five units were in operation (including two Fast Breeder Units).

If at the beginning conventional regulations were used, drastic changes in the practice were accomplished during fithteen years. The present situation is characterized by use of code written on a voluntary basis and by a carefull inspection from the authorities in charge of Nuclear Safety regulations.

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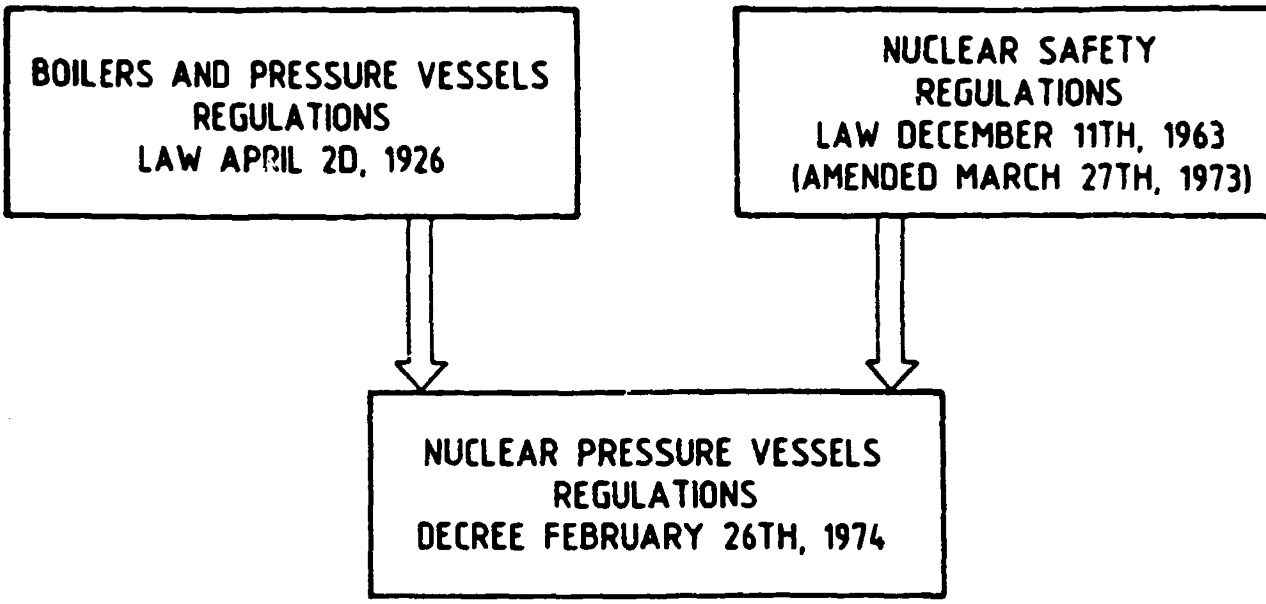

WATER COOLED REACTORS
MAIN PRIMARY CIRCUIT

FIG. 1

	RESPONSIBLE	ADMINISTRATION (MINISTERY OF INDUSTRY)
DESIGN, MANUFACTURING ERECTION	"THE CONSTRUCTOR" EX. : FRAMATOME	B.C.C.N.
OPERATION, INSPECTION MAINTENANCE	"THE OPERATOR" EX. : E.D.F.	REGIONAL OFFICE D.R.I.R.

FIG. 2

SCOPE OF THE NUCLEAR PRESSURE VESSEL REGULATIONS

1) DESIGN, CONSTRUCTION, INSPECTION AND TESTING

2) OPERATION, MAINTENANCE, IN SERVICE INSPECTION AND TESTING

OF

MAIN PRIMARY CIRCUIT (THE WHOLE PRIMARY PRESSURE BOUNDARY)

FIG. 3

<u>Regulations on nuclear pressure vessels</u>

1 st Category	<u>Fictitious situation</u> : loads constant with time, at least equal to the loads occurring in situations of the 2 nd category
2 nd Category	<u>Situations occurring during normal operation</u>, including operation at constant load, transients, and standard operating incidents
3 rd Category	<u>Exceptional situations</u> corresponding to very rare accidental conditions, the eventuality of which must be considered
4 th Category	<u>Highly improbable situations</u> governing the safety of the vessel

Fig 4

Regulations on nuclear pressure vessels

Mechanical loading

Constituent loads (mechanical actions):

- pressures
- external
  - forces
  - torques
- weight
- imposed distorsions
- strains caused
- differential expansions

Multiplication of mechanical loading by factor λ

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Multiplication of each constituent load by λ

The safety margin is defined by the multiplication factor λ applied to the loading leading to the damage considered

Fig 5

Regulations on nuclear pressure vessels

It is stated that pressure vessels and piping shall not undergo the damages given below, when subjected to increased loads obtained by multiplying 'he specified loads by the appropriate coefficients.

Damage	situation category			
	1 st	2 nd	3 rd	4 th
Excessive distorsion	1,5	-	1,2	-
Plastic or/and elastoplastic instability	2,5	-	2	1,1
Progressive distorsion (ratchet)	-	1	-	-
Fatigue cracks	-	1	-	-

Fig 6

General organisation of the RCC-M code

SECTION 1 : NUCLEAR ISLAND COMPONENTS

Subsection A : general requirements
Subsection B : class 1 components
Subsection C : class 2 components
Subsection D : class 3 components
Subsection E : small components
} pressure components (Subsections B to E)
Subsection G : reactor internals
Subsection H : supports
Subsection J : low pressure and atmospheric storage tanks
(to be published)
Subsection Z : technical appendices

SECTION 2 : MATERIALS

SECTION 3 : EXAMINATION METHODS

SECTION 4 : WELDING

SECTION 5 : FABRICATION

Fig 7

Classification of mechanical components

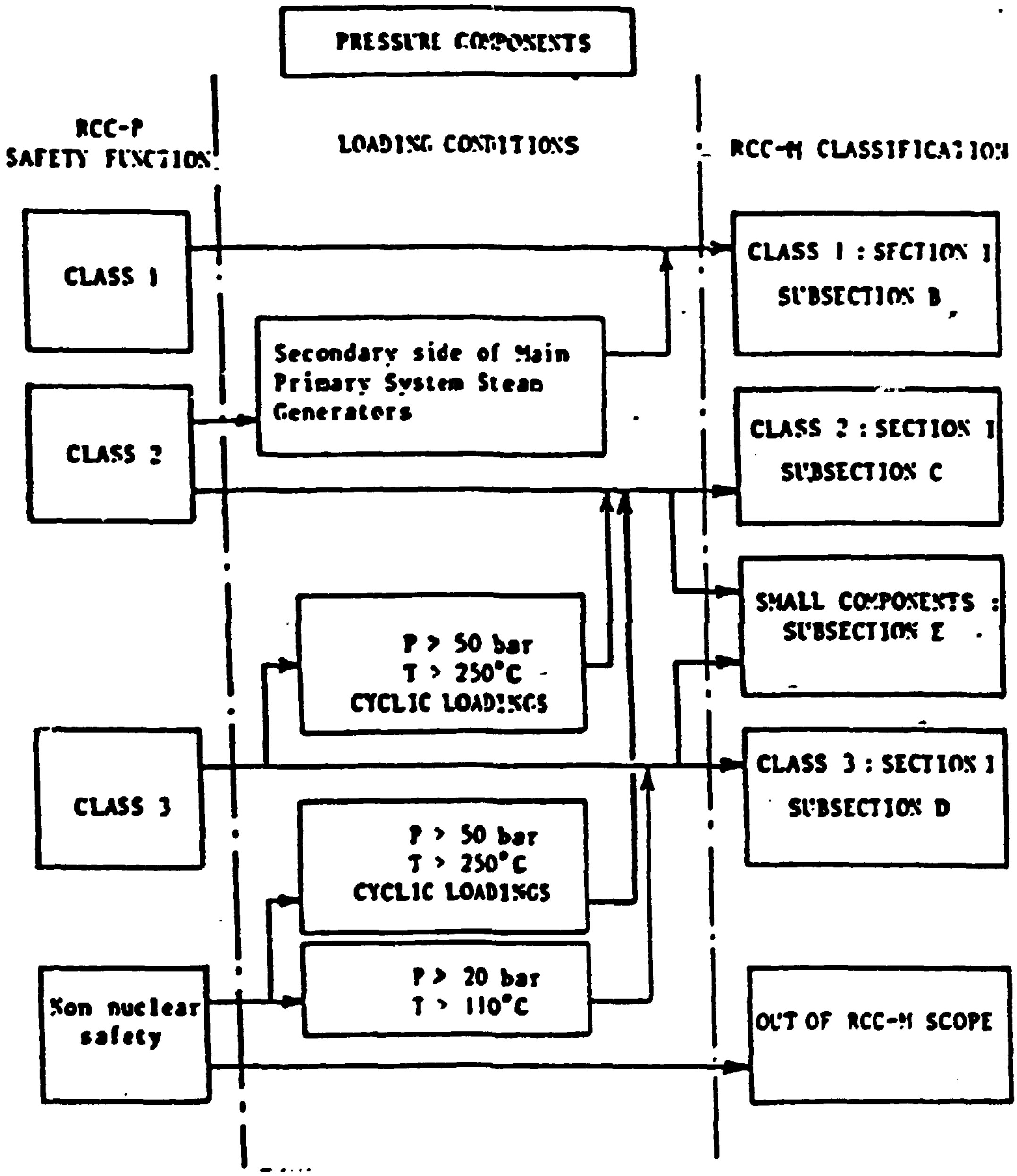

Fig 8