# PASSIVE FIRE PROTECTION

**T. Cerosky[1], V. Raillard[1] and R. Smith[2]**
[1] Nuvia Mecatiss , Morestel, France
tristan.cerosky@mecatiss.fr
[2] Nuvia International, Harwell, UK

## Abstract

The regulations for fire protection for nuclear plants in France have evolved with the development of the PWR fleet and are written by EdF. European wide standards have also been developed and with the implementation of European reactor designs around the world these standards have been transferred to other countries such as China. This paper examines these standards in relation to passive fire protection materials and components and the work required by companies producing products to meet them.

## 1. Introduction

Fire protection is an essential element of the safety design of nuclear reactors. There are 3 main objectives for any fire protection system

- Protection of people
- Protection of reactor safety systems
- Maintaining plant availability

Various codes and standards are used around the world to design systems to meet the protection requirements. This paper examines the development and application of the standards for the use of passive fire protection systems in the new generation of nuclear power plants with particular reference to the French nuclear fleet and the EPR.

## 2. Fire Protection Standards

The French nuclear fleet (see Figure 1) is composed of an evolving set of pressurised water reactors (PWRs).

The early reactors were subject to ENSIN/89031D in 1977 and then revised regularly up to Rev.97 for their fire protection requirements but by the N4 generation this had been superseded by RCC-I standards developed by Electricity de France (EdF). RCC-I [1] defines the overall approach to fire protection in terms of overall systems and levels of fire control measures but this regulation is now being superseded by ETC-F for the latest generation of European reactors, in particular the EPR [2].

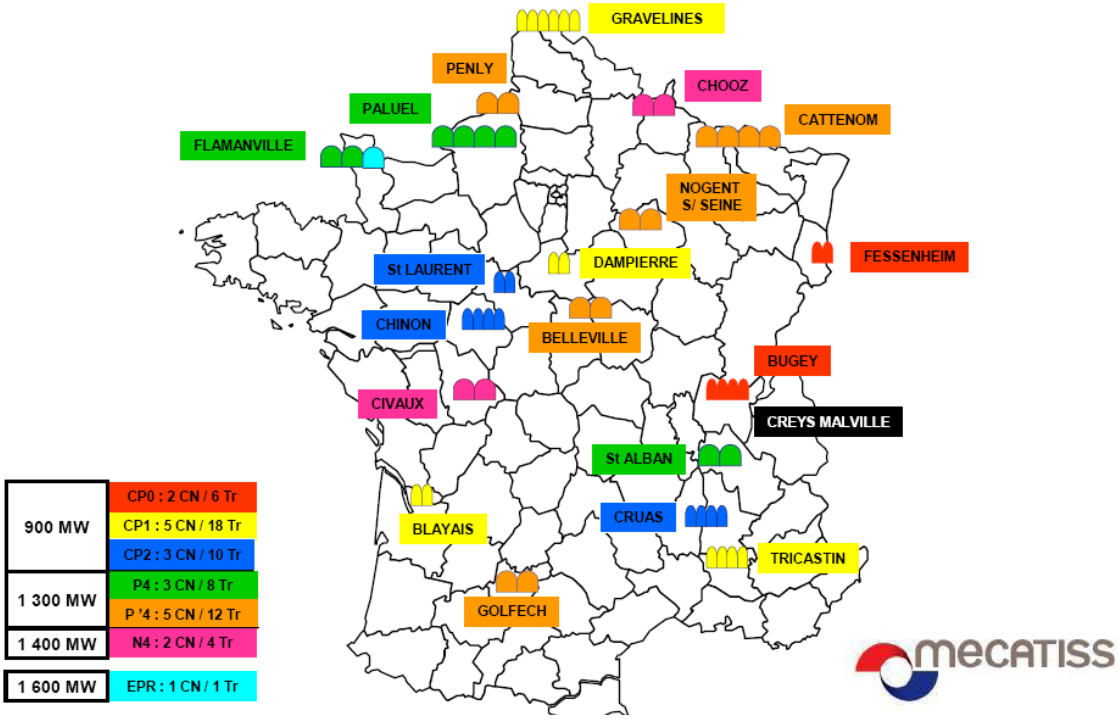


Figure 1 : French Nuclear Fleet

| Reactor Type | Fire Standard |
|---|---|
| CP0 Fessenheim | Fire Rules ENSIN/89031D (Rev.97) |
| CP0 Bugey | Fire Rules ENSIN/89031D (Rev.97) |
| CPY | Fire Rules ENSIN/89031D (Rev.97) |
| P4 | Fire Rules ENSIN/89031D (Rev.97) |
| P'4 | Fire Rules ENSIN/89031D (Rev.97) |
| N4 | RCC-I (Rev.97) |
| EPR | ETC-F (Rev 2006) Section G |

Table 1 The Evolution of French Fire Regulations with Reactor Type

## 2.1 RCC-I Design, Construction and Installation Rules for Fire Protection

RCC-I describes the fundamental approach to fire protection in terms of three components.

a) Physical Protection Systems

These are classified into 3 levels

Level 1 Fire prevention – design of plant and operations to minimise the risk of fire occurring by implementation of fire safety analysis and, for example, by minimising the use of combustible materials and using as much as possible equipment such as fire doors and fire retardant cables.

Level 2 Fire containment – the use of physical separation, fire retardants and passive fire protection to minimise the impact of a fire on the plant. In particular safety critical systems must be designed so that redundancy components cannot be affected simultaneously by the outbreak of a fire. This involves fire segregation of building layouts and the use of fire barriers. The heat release in each defined area must be less than 400 $MJ/m^2$.

Level 3 Fire Control – The aim is to grain control over the fire as soon as possible and will involve the use of fire detection, extinguishing and smoke control systems.

b) Vulnerability Analysis

Vulnerability analysis is used to assess the possibility of common mode failures (CMF). For example defining the redundancy items involved in safety related systems, the reliability of support systems, the probability of electrical failures and the use of mitigation systems.

c) Operator Procedures

Procedures need to be in place to clearly define the actions required in the case of the outbreak or suspected outbreak of a fire in the plant. This includes the procedures for the periodic inspection and testing of all the fire prevention systems.

## 2.2 ETC-F (European Technical Code – Fire Protection)

The Evolutionary Pressurised Water Reactor (EPR) project was started in 1989 through a joint venture between Framatome and Siemens (Nuclear Power International). The French and German utilities also participated in the evolution of the reactor as well as the involvement of the safety authorities (ASN in France and BMU in Germany) . One objective was to harmonize and further develop the outstanding safety standards in France and Germany and an organization was set up to develop common codes from the French design and construction rules (RCC) and the German KTA safety standards and DIN standards related to the EPR design. This led to the establishment of the EPR technical codes (ETC). As part of this development it was agreed to establish a new fire protection code, the ETC-F. [3]

ETC-F follows the principles of RCC-I in terms of the definitions of the levels of defence and analysis.

## 3. The Use of Passive Fire Protection to Meet ETC-F Requirements

The general concept of fire compartments is implemented in the design of all the buildings associated with the reactor systems. These compartments must be completely sealed with fire resistant sealing products for any opening or penetrations. In addition the concept of fire cells can be used in special circumstances. A fire cell uses separation and protective structures to retard the spread of fire.

ETC-F requires each building to be subdivided into fire compartments with the following characteristics;

- Redundant safety systems must be separated
- Areas with potential fire hazards must be isolated
- Protected escape routes for personnel must be provided.

The boundaries between the fire compartments need to meet these requirements

- Rated at 3 hours during operation
- Rated at 1 hour while non-operational
- Escape routes rated at 1 hour.

Materials and products supplied to seal the compartments must meet these requirements as well as other structural and operational design considerations.

## 4. Verification of Fire Protection Products

To meet the requirements of RCC-I and ETC-F the relevant European Standards (EN) for the fire testing of materials and components must be met. This requires both in-house testing capabilities for product development and verification by an accredited third party body. The hierarchy of standards is shown in Figure 2.

In addition EN 13501[5] defines the classification of construction products and building elements using data from reaction to fire tests.

## 5. Example Applications of Passive Fire Protection Systems

Passive fire protection products can be manufactured in a wide range of forms and can be customised to meet the specific fire resistant requirements. In addition the installation methods have to be designed to ensure that the fire properties of the final system meet the overall requirements. Figure 3 shows some applications and the various types of product used.

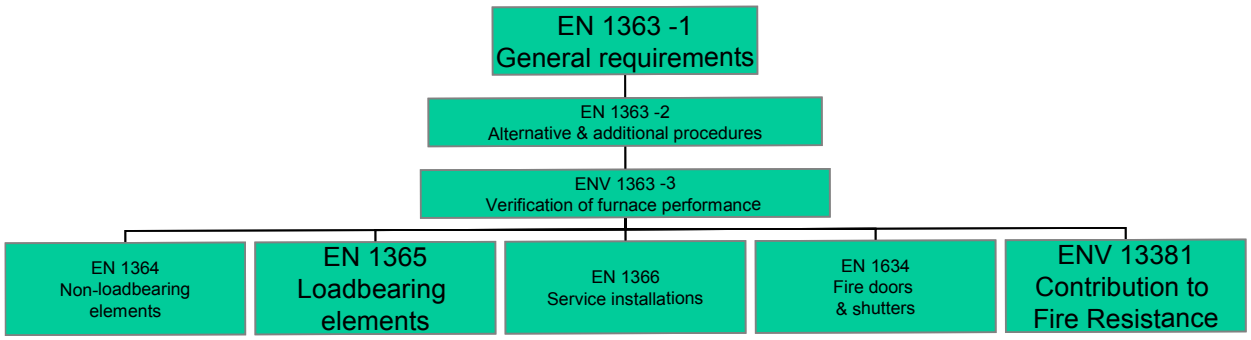


Figure 2 : European Fire Standards based on EN 1363-1 [4]

Figure 3 : Protection of Electrical Penetrations using Silicon Based Products

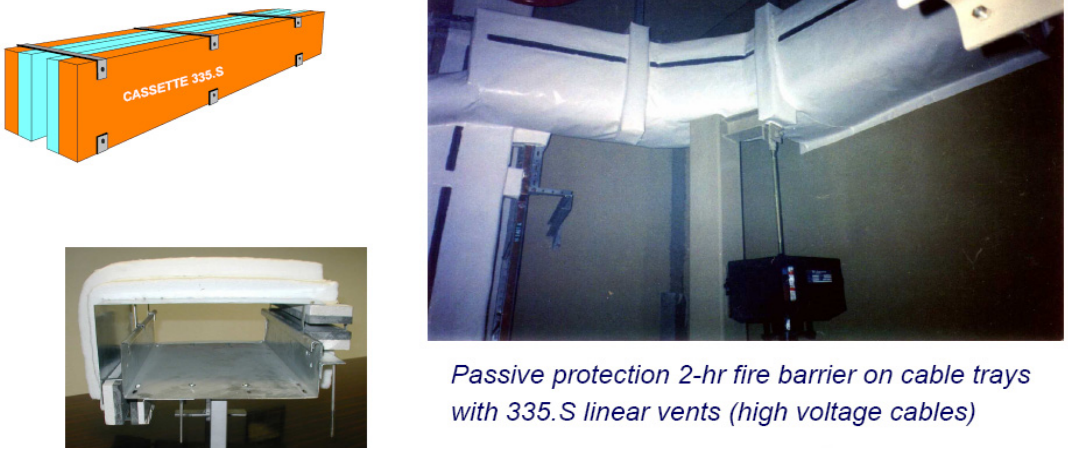


Figure 4 : Protection of Cable Trays

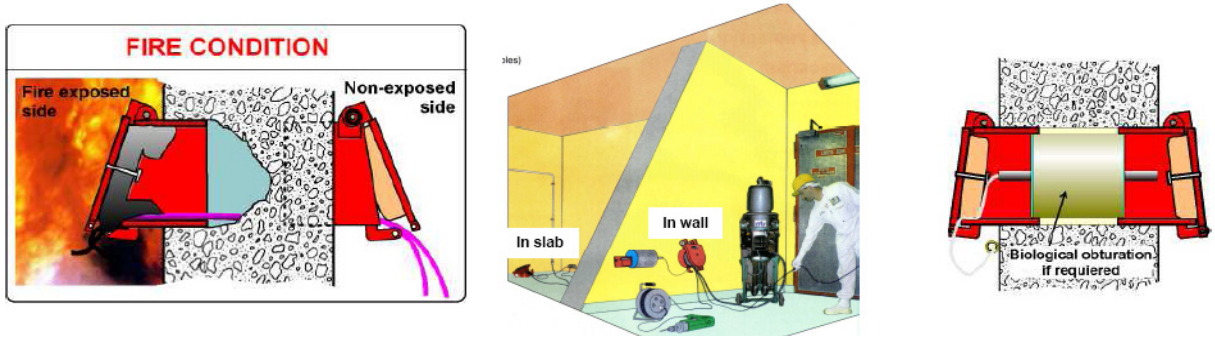


Figure 5 : Use of Penetration Devices

## 6. Conclusion

Passive fire protection plays a major part in the safety of French nuclear reactors and with the development of the current generation of reactors, in particular the EPR, there will be an increasing demand for products that can meet the relevant codes and standards.

## 7. References

[1] RCC-I, “Design, Construction & Installation Rules for Fire Protection Codes”, Rev 97

[2] ETC-F, “EPR Technical Codes for Fire Protection”, Rev 2006 Section G

[3] H. Bittner, “Olkiluto 3. Finland Some Highlights of the Fire Protection Design”, 5th International Conference Fire & Safety, Munich, Germany, 2004 March 11-12

[4] EN 1363-1:1999 , “Fire resistance tests - Part 1: General requirements”

[5] EN 13501-1:2007 , “Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests”