

Fire Protection and Risk Analysis

Nuclear Power Plants and Facilities

EFFECTIS' EXPERIENCES

Recognized as an official fire testing institute since 1972, Efectis is a reference expert in the nuclear field, regarding fire testing, fire safety engineering, and the fire behaviour of construction products. Efectis France has more than 20 years' experience in the nuclear field, and has worked extensively on fire safety in nuclear plants, becoming a major partner of French nuclear operators for all fire safety related issues.

Efectis, some figures:

- 4 laboratories and 10 fire resistance furnaces
- More than 150 experts in fire safety
- More than 10,000 fire tests since its creation
- More than 900 fire tests per year
- More than 1,000 on-site diagnoses per year



EFFECTIS' SERVICES

- **Qualification of passive fire protection** according to European and International standards (EN, DIN, ISO, IMO, BS, ASTM, UL, FM)
- **Establishment of performance diagrams of passive fire protection**, according to the EPRESSI method,
- **On-site diagnoses** to attest the fire resistance performance of fire protection systems and products.
- **Maintenance of products** (assessment of ageing conditions, degree of fire resistance and establishment of action plans to maintain the fire resistance performance),
- **Fire risk analysis and fire modelling studies** (assessment of nuclear safety degree in case of fire and appropriate fire protection solutions),
- **Fire behaviour and stability studies** of structural elements of nuclear facilities based on :
 - Standard ISO fire-curve analysis
 - Real fire-curve analysis
- **Fire safety design** of nuclear facilities and assistance to the design of fire protection systems (active and passive),
- **Training** in nuclear fire safety standards (NFPA, AFCEN, etc.).

THE FLAMANVILLE EPR PROJECT

Qualification of passive fire protection:

Efectis has performed all the fire resistance tests of fire products for the French and Chinese EPRs (doors, penetration seals, dampers, linear joint seals, fire protection flaps, wrapping fire protection, floor drains, etc.) according to the combination of actions (water tightness, airtightness, earthquake, displacements, fire resistance, durability, interoperability of fire protection products for maintenance).

Performance diagrams according to the EPRESSI method:

Efectis is at the origin of the EPRESSI method through a R&D program for EDF. Its aim is to assess the fire resistance performance of products under real fire conditions in order to justify its effectiveness in relation to the degree of fire risk in NPP.

EPRESSI is today accepted by The Nuclear Safety Authority and defined by the ETC-F code. Efectis has established all the performance diagrams of fire products for the French and Chinese EPRs.

Fire and waterproof-seismic tests:

Efectis has carried out tests to assess the fire resistance of penetration seal systems after seismic loading. The ultimate goal of this testing program was to establish a comparative analysis and to determine the influence of seismic loading on fire resistance and waterproofing.

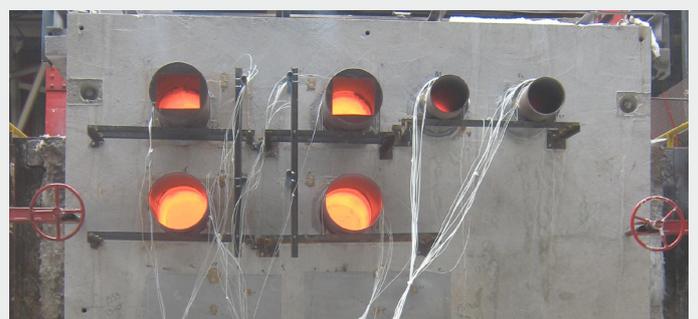
On-site diagnosis:

20 laboratory assessments of special configurations for EPR NPP construction have been performed, in order to attest the fire resistance performance to the Nuclear Safety Authority.

Fire risk analysis:

Efectis has performed fire scenario models within the framework of the EPR Flamanville vulnerability study to determine the thermal stress on strategic targets inside the reactor building.

This study consisted in evaluating the fire spread risk across the reactor building in real fire scenarios, and determining the thermal stress on 250 nuclear safety targets. All the scenarios consisted in fires of leaking oil in a reactor coolant pump (GMPP) with a modelling of over 1.5 million meshes.



Fire test on penetration seals

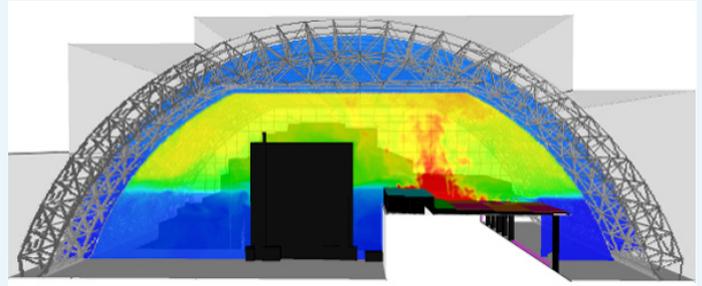
THE SAFETY CONFINEMENT ARCH OF CHERNOBYL NPP

Efectis performed the fire stability study on the steel arch structure covering the Chernobyl NPP unit 4 based on:

- Real fire scenarios
- Fire resistance tests to validate the fire behaviour of cladding by experimental approach.

The overall study was submitted for validation to The State Fire Safety Department and to Ukrainian experts (The Institute of Engineering Thermo Physics of the Ukraine National Academy of Science).

Through different steps of validation, Efectis was able to prove its scientific capabilities and know-how in a specific and complex context.



Fire development modelling (FDS)

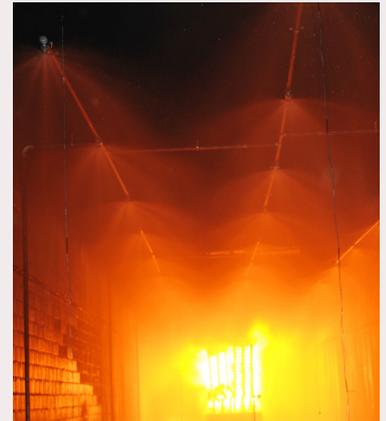
DESIGN AND QUALIFICATION OF ACTIVE FIRE PROTECTION SYSTEMS FOR NPP APPLICATION

For many years, Efectis team has acquired expertise in the design and specification of active fire protection systems, with engineering and testing researches. Recently, Efectis has designed 6 active fire protection systems for EDF, in order to increase the fire safety level of lubricating oil warehouses.

That consisted in:

- Defining the equipment specifications
- Performing the pipe stress calculation
- Designing systems based on risk assessment and standards

Efectis has also designed special fire suppression systems for nuclear applications. In particular, a double water curtain has been tested, in order to replace the passive penetration seals which were installed at the entrance of stream tunnels connecting the reactor building to the engine room.



THE CIGEO PROJECT

Since 2012, Efectis has been involved in the Cigéo project led by Andra, the French Agency for Radioactive Waste Management. The Cigéo project is designed to allow deep geological disposal of spent fuel and of high-level and intermediate level long-lived waste.

During the industrial design stage, Efectis was in charge of fire safety design for the CIGEO project during the preparatory phase of the project, including:

- Fire risk and comparative analysis of different design solutions
- Definition of basic requirements fire safety
- Assessment of the subcontractors' technical offer for the design phase

Andra used the skills of the Efectis laboratory in order to determine the fire resistance specifications of the concrete protective packaging of radioactive waste. 2 full-scale fire tests were performed in order to justify fire resistance efficiency under the standard ISO fire-curve and real hydrocarbon fire.

Efectis is currently responsible for the technical approval of all fire risk assessments during the design phase (2013-2016), including:

- Establishment of the fire risk analysis method for the CIGEO project
- Technical approval of fire risk studies for 4 years

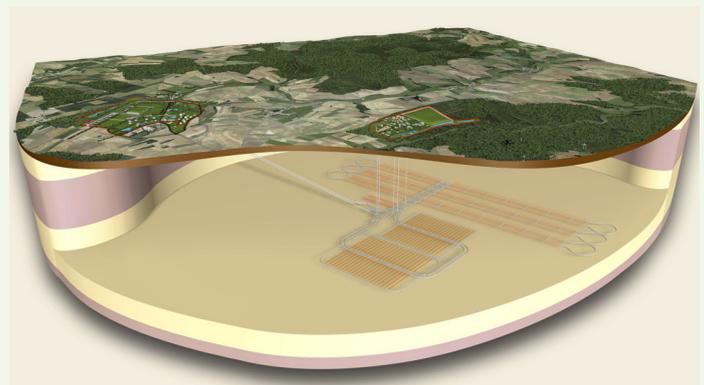


Diagram of Cigéo facilities © Andra



Espace Technologique Bâtiment Apollo
Route de l'Orme - 91193 Saint Aubin - France

Contact
Arnaud Rabilloud
arnaud.rabilloud@efectis.com
+33 (0) 632 92 25 31

www.efectis.com

Efectis is a fire science company and covers all fire safety expertise in testing, modeling, certification and inspection around the world.

In order to provide safer life environments, the Efectis teams expand their skills to other safety domains such as structures solidity, pathology assessments of materials, components and systems, life prediction and durability for new and ancient buildings and infrastructures.

Efectis Group. Safety issues. Solved.