1999 EUROPEAN HOT LABORATORY SEMINAR

TRANSURANIANS INSTITUTE - KARLSRUHE
From the 13th to the 15th of October 1999

Hot Laboratory Reconditioning
Active Fuel Examination Laboratory
Basic Nuclear Facility No. 55 - LECA - CADARACHE

Title: Containment control and improvement elements

Summary:

The purpose of this lecture is to present the method implemented to define the containment system improvements applied to the INB 55 LECA.

1. Survey and status of the existing facility.

2. Analysis and comparison against the design guidelines and recommendations,

3. Overview of the envisioned improvements and limits of the method.

4. An embodiment example.

• CEA COMMISSARIAT A L'ENERGIE ATOMIQUE
(FRENCH ATOMIC ENERGY COMMITTEE)
DIRECTION DES REACTEURS NUCLEAIRES
(NUCLEAR REACTOR DIRECTORATE)
DEPARTEMENT D'ETUDES DES COMBUSTIBLES
(FUEL STUDY DEPARTMENT)
TEL. (33) 04 42 25 66 74 - FAX (33) 04 42 25 25 99
E-MAIL michel @decade.cea.fr

CEA/CADARACHE F - 13108 ST-PAUL-LEZ-DURANCE CEDEX FRANCE

Nuclear installations in operation: Control of the containment and methods for improving the associated systems

Abstract

Many nuclear installations in the world have been built in the sixties or seventies. Therefore, their design criteria comply with the safety requirements then in force. In the same time, these installations have been deeply modified and new equipment have been introduced or changed, to meet the needs of new research and development programs, and to take into account as far as practicable the evolutions of safety requirements occurred during this period.

Today, if these installations are to continue operation for a while, a safety review has to be carried out and, if needed, several modifications have to be done, in order to satisfy the safety criteria presently in force.

CEA, like other nuclear operators over the world, has defined a general methodology and associated rules to perform such safety reviews.

This paper intends to present, in a first part, how this methodology was applied in the different following fields: containment control, ventilation system design and fire hazard prevention. In a second part, an example of application of this methodology is presented: the renovation of LECA (Laboratory of Active Fuel Examination at CEA Cadarache).

1. Introduction

The safety analysis of an operating nuclear installations, is reviewed with the same methodology as new plants, in order to identify weak points and subsequent necessary reinforcements or modifications. This diagnostic permits either to renovate the installation, or to design a new one or to retain a combined or transitory solution. The appropriate solution is selected, taking into account the estimated life time of the installation, its impact on the environment in case of emergency situations, its operating flexibility and its final purpose. It also depends on the amount and nature of the necessary modifications, and the associated costs.

2. Risk assessment principle for operating installations

2.1 - General

The general methodology is illustrated on the enclosed figure.

This methodology is based on the usual safety analysis method, nevertheless taking into account the possibility of alternative solutions, in order to select the optimized solution resulting from the review of the following options:

- ❑ feasibility of the necessary reinforcements or modifications without weak point;
- ❑ associated costs, compared to the potential benefits, in terms of risk control;
- ❑ wherever the new safety requirements could not be met, compensatory solutions, aiming at improving the following parameters:
    - reduction of the risk (source term limitation, for example)
    - operational and maintenance procedures
    - surveillance programs
    - staff skills (special training)
    - intervention means, etc.

The aim of this methodology is to carry out a safety analysis identifying the potential hazards (risk and consequences) in the different operating modes : normal operation, incidents and accidental situations. The objective of this study is to demonstrate that all corrective measures, which are of technical type as well as of management type, will be sufficient to control any hazard, within the acceptable limits, with regard to the regulatory requirements in force.

2.2 - Steps of the methodology

The main steps of this methodology are:

- ❑ **Data collection**, in order to precisely know the state of the installation,

- ❑ **Risk analysis**, in the different operating modes:

  - normal operation
  - incidents,
  - accidental situations.

This analysis allows the potential failures of the installation to be identified.

- ❑ **Definition of the reinforcements** (or modifications) in the three following fields:

  - prevention,
  - surveillance,
  - safety actions.

This step includes the definition of alternative solutions or compensatory measures, where new regulatory requirements cannot be met.

- ❑ **Grading of the different measures.**

- ❑ **Validation of all solutions and selection of a set of consistent provisions.**

- ❑ **Review of the safety documents.**

3. Application of this method in the field of containment, ventilation and fire prevention [1].

In the field of containment, fire prevention and ventilation, the main safety objectives are to reduce the spread of contamination inside the installation and into the environment. These objectives lead to the definition of safety functions systems designed to cope, especially, with accidental situations.

To these safety functions are associated safety requirements, which are taken into account in the design, construction and operation rules for these systems as well as for the associated equipment. These safety requirements are adapted to the influence and role played by the systems or equipment for achieving the safety functions.

During an accidental situation, the objective is to control the movements of air which transports the radioactive particles and aerosols, in order to limit the dispersion of the radioactive contamination inside the installation and reduce the release into the environment. As a consequence, functional requirements are defined for the containment (static or dynamical containment), for the design of the structures (resistance of the wall of the rooms), the equipment (doors, transfer systems, service penetrations, ...), and material (filters, fire cutting valves, ventilation conducts,...) which participate to this function.

For a new installation, the approach starts at the design stage, that means with the technical measures to be selected for satisfying the safety requirements in order to meet the safety functions and the safety objectives of the installation.

For operating installations, the method is different. It is necessary to assess the state of the existing, to take into account experience feedback, to identify the weak points, and to define reinforcement or modification solutions in accordance with the local constraints.

In addition, a distinction should be made between the current safety review, which consist in continuously adapting installations to the evolution of the regulatory requirements, and periodical safety reviews which have to be done in case of major modifications of the installation, or changes in the research programs or every ten years as required by the regulatory authority.

The methodology adopted in this case is explained in the enclosed diagram.

Although this approach appears to be different (starting with the existing systems and from the observation of their operating modes rather than from the objectives to meet and the safety functions to fulfil), the aim is the same: to establish a liaison between the functional requirements associated to the general safety objectives, and the measures adopted to satisfy them.

The architecture of the safety analysis is the following [2]:

SAFETY APPROACH

Safety objectives: to limit the spread of radioactive contamination inside the installation and in the environment, as low as reasonably achievable under the regulatory limits.

⇨

Functional requirements for the static and dynamical containment (for example acceptable leak rates, permanency of ventilation or filtration, ...)

⇨

Failure modes of the containment function (specific modes, common mode).

⇨

Analysis of the potential failures of the systems, equipment or elements insuring the safety functions and identification of the sensitive points

⇨

Definition of appropriate measures for:

- reduction of the probability of occurrence of a failure (prevention)
- early detection of possible failures (detection)
- limitation of their consequences (mitigation)

⇨

Definition of the **authorized operation domain**

⇨

Definition of the **requirements concerning specific tasks**

⇨

Definitions of the requirements concerning **organization and management systems**

Annex 1 presents additional explanations on the methodology used to perform the safety analysis for operating installations.

Annex 1 : Methodology recommended to implement a safety analysis for operating installations

◆ **Key points appearing in the periodical safety review**

In an operating installation, the constraints connected to the architecture of the rooms and their structures, the use of all kind of materials, the organization of the ventilation systems, and the geographical location of the equipment makes it difficult or even impossible to modify the main design of the installation. So, it is in general necessary to compensate modification actions by the reinforcement of other protective measures such as surveillance or intervention actions.

◆ **Brief description of the method**

The safety review aims at improving hazard prevention.

This review is based in a first time on the defence in depth method, taking into account the specific aspects of the installation in terms of safety requirements, complemented by experience feedback analysis. The final objective is to improve risk prevention. For that, the approach includes four steps.

1) First step: Identification of the sensitive rooms, with regard to the fire risk

During this analysis, the key following aspects are considered:

- Identification of sensitive rooms is done considering possible interactions between rooms via the ventilation ducts for example. Ii such a case, al adjacent rooms shall be considered as « sensitive ».
- The sensitivity of the rooms is appreciated, in connection with the research and operation programs: temporary or continuous sensitivity.
- When there is a potential for a fire to destroy an equipment or a train of a safety system, the existence of a second train (redundant equipment or system) as well as the potential for this equipment or train to be destroyed by the same fire are checked. If there is a potential for the whole system or equipment to be destroyed by the same fire, the room in which this equipment or whole system is placed is also be considered as a « sensitive room ».

2) Second step: Characterization of the fire in the « sensitive rooms »

For each room (or group of rooms) identified as « sensitive », the characteristics of the most severe potential fire, taking into account the evaluation of the caloric potential of the concerned rooms (especially the fire load density), is defined in terms of maximal temperature, duration of fire, ...

This evaluation takes into account the following considerations:

- Fire protection devices are implemented in all « sensitive rooms ».
- All rooms in which the fire load density is lower than 400 MJ/m^2, can be excluded from this list of « sensitive rooms », if they do not contain hot spots or local equipment for which the fire load density is higher than this value. In the opposite, protection against fire will be implemented.
- For the evaluation of the fire load densities, a distinction is made between the caloric potential induced by the material directly in contact with the fire and the products hold in containers, for which the contribution to the fire is lower.

3) Third step: Implementation of additional protection measures and evaluation of their safety efficiency

In a first stage of this review, all measures able to improve fire protection (prevention, detection and mitigation) are implemented; this concerns design features as well as detection or intervention means.

For that, the following technical solutions are reviewed: reinforcement of the fire resistance of the structures of walls, reduction of the fire load, limitation of the amount of flammable material, use of additional filtering devices and fire cutting valves, ... as well as operational features such as reliable and early detection, appropriate intervention means, ...in order to limit the consequences of a potential fire event.

Annex 1 - Methodology recommended to implement a safety analysis for operating installations (continued)

It will be verified in a second stage, that all these protection features allow safety functions to be fulfilled, especially the containment of radioactive contamination. This analysis includes source term evaluation, that is the amount and characteristics (nature, physical form, ...) of radioactive contamination which could be released, taking into account the characteristics of flammable material, the ventilation modes, ...

The last stage, covers the evaluation of the environmental impact, taking into account the following parameters: potential for a release of radioactive particles, efficiency of the static and dynamical containment, filtration efficiency, deposit inside the ventilation ducts, atmospheric conditions, etc.

4) Fourth step: feasibility study; technical and financial considerations; purpose of the plant

The analysis of the additional protection features against fire can lead to different kind of situations:

- The modifications needed to meet fire prevention, according to the most recent safety requirements, <u>are not feasible</u>. In this case, a global « cost-benefit » evaluation is made, taking into account some extra considerations, such as strategic options concerning the future purpose of the plant, in order to define the modifications needed to cope with the observed deficiencies.

  In this situation, the alternative modifications to be done should be preferentially focussed on the following: reinforcement of the detection and intervention means (use of additional fire detection devices, installation of fire extinguishing equipment, ...), reinforcement of the operation and human surveillance program (special training courses, information of the operators, use of operational procedure specifying the need for limiting the fire load in the rooms, ...).

- The modifications needed to meet fire prevention, according to the most recent safety requirements, <u>are feasible</u> (technically and in terms of costs), considering the expected life time. In this case, a reinforcement or modification program is defined and submitted to the regulatory authorities.

- The modifications needed <u>are not feasible</u> in terms of costs compared to the expected life time. In this case, compensatory measures such as reduction of the source term, increasing of surveillance program, ... are implemented.

REFERENCES

[1] Recommendation n° 7 from the CEA/DSNQ "Protection against fire in nuclear installations others than reactors.

[2] Guide for the safety analysis of the ventilation systems and functions in the frame of nuclear installations under operation (Project).