Design deviations treatment on French NPPs
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IRSN identified many years ago the problem of the impact of the design deviations on the NPP safety and this is the reason why a specific assessment was carried out during the review of the operating experience feedback over the period 2006-2008.

Based on available information from the year 2008, IRSN carried out for all the 58 French reactors an assessment of all identified deviations.

**The objectives were:**
- to identify possible interactions between all the deviations and to assess as far as possible their consequences for the NPP safety, by evaluating their impact on every safety function,
- to find out whether they are always compatible with the Technical Specifications.
Since the year 2000, the check and control actions carried out within the framework of the safety review and the compliance checks for the second ten-year inspection brought to light important inconsistencies between the design of the installations and the Safety Requirements Reference State.

The generic character of these deviations and how they were dealt with led to either an extension of the running outage or to new mandatory outages in compliance with the TS. The consequence was a significant loss of electricity for the licensee (EDF).

In 2001, EDF decided to develop and to implement an adapted procedure to deal with specifically the design deviations, not only for generic issues but also for situations leading to important safety stakes.
For EDF, being in control of dealing with these design deviations constitutes a strategic objective of how to make the installations compliant again with the various existing Safety Requirement Reference States and codes.

Among all the deviations in the sense of the « French Quality Order », the design deviations constitute for EDF a particular category directly in relation with the design of the installations, but not in relation with:

- Security, radioprotection and environment,

- Pressure vessels subjected to the French law (Order of November 10th, 1999),

- Installations operating and operating rules concerned.
According to EDF, the detection of design deviations results mainly from:

1) Observations, reports or analyses on the installations further to compliance checks or further to normal check-ups (field inspections, implementation of the maintenance programs ...),

2) Queries, technical analyses, studies or tests carried out by the EDF headquarters.
The main causes of these design deviations generally result from:

- Weakness right from the start either due to design or manufacturing or assembly failures,
- An evolution of the Safety Requirement Reference States,
- Maintenance operations, installation modifications and/or ageing.

Finally for EDF, there are two kinds of design deviations:

- The defects right from the start discovered during reactor operation,
- The operation incidents (operating experience feedback).
According to the design deviations treatment policy of EDF, the deviations treatment contains globally 4 stages:

1. The discovery
2. The characterization
3. The treatment strategy
4. The repair works
The design deviations once detected by the NPP operators are reported through the information of the SAPHIR database or directly to the EDF headquarters by the local actors.

The objectives:
- To comprehend at national level the stakes associated at the detected design deviation compared to the first analysis led by the NPP,
- **To carry out a multidisciplinary analysis** of the problem,
- To define certain immediate compensatory measures according to the seriousness of the situation.
The objectives:
- To estimate the seriousness of the design deviations in relation with the possible impact on the safety functions (cooling, containment, reactivity and support systems),
- To assess the generic aspect.

This may lead to redefining the design margins on the basis of codified methods or by alternative approaches.

In both cases, realistic loads are taken into account.

The conservatisms and the combinations are also examined.

The goal of the alternative approach is not to demonstrate whether the deviation is left as it is in long-term, but to take position with regard to the risk of losing a safety function.
According to the conclusions of the characterization phase, the licensee shall select one of the following options:

- **Maintaining the design deviation** if the insignificant safety impact is justified,

- **Definition of compensatory measures with their implementation schedule**
  (operation, surveillance, temporary provisions),

- **Repair works** within a given delay with or without outage,

- **Reactor shutdown** by unacceptable substantial safety hazards.
The objective:
- **To re-establish the compliance** of installations with the Safety Requirement Reference State within **an acceptable time limit**.

According to **the complexity of the interventions** or **the industrial constraints** (in particular with generic design deviations), the licensee prefers to repair in 2 phases:

- Firstly, repair works on one reactor in the scope of improving the selected solution to solve the problem,
- Based on the experience feedback of the first repair works, the best solution is implemented for all reactors concerned.
From a process point of view, the design deviations treatment is in compliance with the process stipulated in the French Quality Order of August 10th 1984, covering the treatment of the full spectrum of deviations.

However for all deviations, it is important that the licensee shall have an overview of all the detected or alleged deviations and shall guarantee consistency of their treatment, under both aspects i.e. from a « interactions between deviations » point of view and from a « repair works deadline » point of view.
In practice, the licensee in France, but also worldwide, generally analyses the deviations separately, without taking into account their possible combinations.

The inspection of April 8th 2009 carried out by the French Nuclear Safety Authority with the support of IRSN proved the absence of consideration by the licensee of possible interactions between the design deviations.

The safety assessments of the licensee did generally not take into account the existence of deviation combinations and the licensee was not able to establish the most relevant deadlines for the repair works according to the possible substantial safety hazards.
Although **the majority of the design deviations are generic** and thus **treated by the EDF Headquarters**, there is a certain number of **discovered deviations** that remains **restricted to only one specific reactor or one specific site**.

The design deviation treatments are **under the responsibility of the local operator**.

At local level, in application of the EDF doctrine of the design deviations treatment, **the local operator shall provide an exhaustive and updated balance sheet listing all the existing deviations on the NPP**, to be able to define the best treatment solution and to carry out a relevant safety assessment.
In January 2011, based on the recommendation of the French Nuclear Safety Advisory Committee, ASN asked EDF to list all existing deviations for all the 58 NPPs in France from July 2011 on.

Considering the extent of the project and the manpower needed, EDF Headquarters was reluctant to commit themselves, at least for a balance sheet over such a broad perimeter. However, since the Fukushima accident, listing all the existing deviations together with the associated safety assessments became a top priority for EDF to demonstrate the acceptable safety level of the French NPPs.

The listing exercise is difficult and complicated to carry out. The licensee has to be equipped with structures and with means adapted to achieve this goal.
For the French Nuclear safety Advisory Committee of January 2011, IRSN listed, reactor by reactor, the known design deviations in relation with the operating limits and conditions and/or the TS temporary modifications.

The objective was to emphasis the potential safety consequences of their possible interactions.
The French regulations stipulate that to carry out special repair works and/or to operate in a reactor state that is not in compliance with the TS, the French licensee has to apply for a TS temporary modification.

The licensee must justify if the request is acceptable from a safety point of view, by providing a safety analysis and by specifying compensatory measures planned to be implemented during the temporary modifications.
The problem is that, **the existing design deviations are usually not considered by the licensee** when analysing the plan situation to formulate appropriate compensatory measures.

It is only on the basis of further specific safety assessments, that the licensee will be able to decide if, on the one hand, the plant state could be affected by discovered design deviations and on the other hand if his application for TS temporary modification is still acceptable from a safety point of view, once the impact and the combination of the design deviations are considered.

**The licensee has to question systematically the real plant situation in relation with all the existing design deviations and the necessary compensatory measures.**
The assessment of this invotory proves that there are generally 3 types of design deviations:

1. Firstly, the category of design deviations for which, there is a real or potential equipment/function inoperability during a certain accident situation or during normal operation under extreme weather circumstances, discovered by the operating feedback or by detailed analyses.
Secondly, the category for which the guarantee of seismic resistance is not acquired, because of a conception, manufacturing or assembling failure, or due to a degradation during normal operation.

The apprehension of the safety consequences is more difficult, because we speak of hypothetical inoperability, more and less likely, for which we shall however try, as far as possible, to carry out a deterministic analysis in a conservative way.
Finally, the category for which the qualification of the installations in accidental situation is questioned after an incorrect maintenance intervention, an inadequate modification or the non compliance with the qualification requirements.

1) The determination of safety consequences is difficult, on the one hand because of an unpredictable character of the design deviations and on the other hand because of the very important number of equipments concerned.
2) With this type of design deviations, the indispensable safety functions to control, to protect, to safeguard the reactor, as well as the operability of the accidental procedures are questioned.

3) In a pragmatic way, the analysis of this type of deviations is generally based on deterministic studies, but also based on very conservative postulates and possibly partially on PSA (if possible) to prioritize the repair works.
For each design deviation, the licensee guarantees that, considering the compensatory measures, the NPP safety level will be acceptable during the period needed for repair.

It is obvious that the compensatory measures defined for a design deviation should not be affected by other existing deviations (design deviations, LCOs or TS temporary modifications).

This is the reason why, for each assessment of TS temporary modifications, IRSN checks whether the general state of the installation is compatible with the proposed compensatory measures.

For all the design deviations, IRSN checks the acceptability of the treatment proposed by the licensee, especially if the treatment plan is consistent and appropriate to the substantial safety hazards.
The check and control actions carried out within the framework of the periodic safety review and the compliance check for the ten-year inspection of the French NPPs brought to light important deviations between the design of the installation and the Safety Requirement Reference State. These deviations need further specific assessments and a particular treatment policy. The ignorance and the difficulty to list all the design deviations make that usually the safety assessments of the licensee do not take into account the possible combinations and interactions between the design deviations and the other existing inoperabilities on the NPP. Since the Fukushima accident, listing and treating all the deviations became a top priority for the French licensee to prove the acceptable safety level and the reliability of the French NPPs.