
PERIODIC SAFETY REVIEW: MODIFICATIONS RESULTING FROM THE SECOND TEN - YEARLY OUTAGES OF THE FRENCH 1300 MWE PWRs

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Abstract:

Since the beginning of the 90's, in relation to the French regulatory context evolution that introduces the periodic safety review (PSR) concept, modifications implementation practices have turned to new approaches, introducing the "batching policy" concept.

Following this policy, the batch of VD2 modifications to be implemented on the 1300 MWe series results mainly from the conclusions of the safety studies performed in the framework of VD2-1300 PSR, initiated in 1997 and enclosed in 2005.

During the examination of the safety studies performed in the framework of VD2 PSR related to the 1300 MWe series, IRSN suggested that EDF would:

- complete the demonstration of the performance of the proposed modification aiming at improving the containment pressure reducing strategy applied to total loss of heat sink at cold shutdown states when the reactor vessel is opened,
- propose new modifications concerning internal explosions and spurious orders from the automatic monitoring and control device.

Finally, 45 modifications resulting from PSR or specific safety studies performed in the frame of PSR, which represent 75% of the global set of safety-significance modifications, will be set during the VD2 outages. The VD2 batch of modifications has been implemented on the lead unit in April 2005 and its implementation will continue over 9 years for the whole units of this series.

For the modifications of major safety significance, for which design principles may introduce either new risks on the safety demonstration or new technologies, IRSN has checked, before implementation, that there was no potential safety regression risk.

For other modifications, in case some potential safety risk exists during implementation or operation and requires requalification criteria validation or efficiency validation, experience feedback is analyzed before generalization.

At the end of this year, IRSN will finalize its examination.

1 INTRODUCTION

1.1 EDF MODIFICATIONS MANAGEMENT

In the past, EDF modifications management was adapted to each plant, depending on its particularities. Therefore, it was not possible to follow the shared evolutions of a given series.

Since the beginning of the 90's, in relation to the French regulatory context evolution that introduces the periodic safety review (PSR) concept modifications implementation practices have turned to new approaches, introducing the "batching policy" concept.

A batch is a consistent set of modifications based on modifications of the basic design which impact the general operation of reactors. It contains modifications to be implemented during outages and modifications that can be implemented on power. It is first implemented on a lead unit. After taking into account around one year operating experience feedback, the batch of modification implementation is then extended to all reactors of a given series.

Before the second PSR of 900 MWe series, EDF defined the 93 batch of modifications, mainly resulting in:

- Equipment qualification conformance under accident conditions
- Fire protection
- Piping supports
- Post-TMI improvements:
- Beyond design and severe accident emergency operating procedures,
- "Physical states related approach (so-called state oriented approach)" implementation and related state functions measurement improvements (use of primary coolant level sensor for primary water inventory and intermediate nuclear measuring channel for subcriticality)
- Risks at shutdown states: measures taken to lower risks at mid-loop operations
- Modifications related to GARANCE project (new fuel cycle management)
- Completion of protection against heterogeneous spurious boron dilution

Since 1998, EDF has engaged a strategy aiming at improving plants safety management through the stabilization of safety requirements, operating documents between the ten-yearly outages and periodic safety reviews. Therefore, batches of modifications resulting from PSRs (which, in practice, are asked to be performed every ten years) enable EDF to reach this objective.

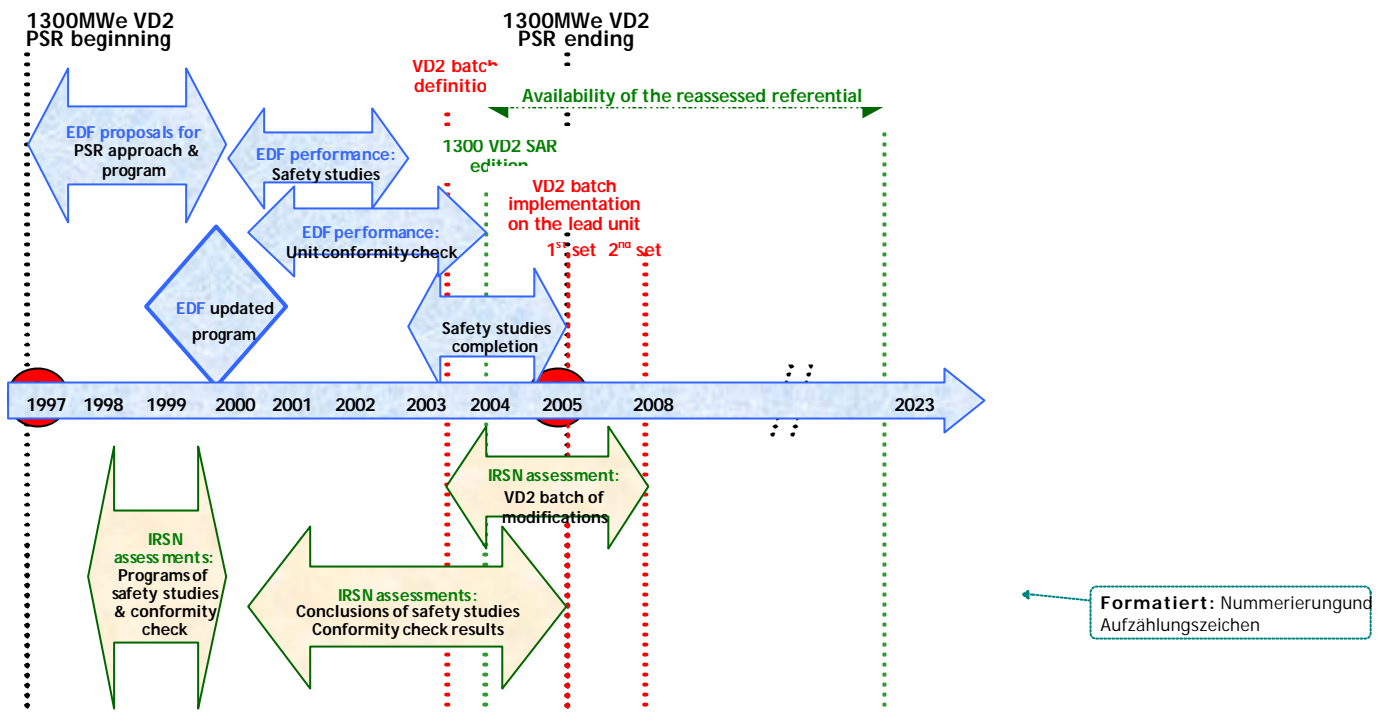
The batching policy implies that no new batch of modifications can be implemented on a unit before the previous one has been fully implemented (any exception must be thoroughly justified).

Taking into account the achievement of the implementation of the ten-yearly outages batches of modifications on French PWRs 900-1300 MWe series (which spreads over ten years), some modifications, presenting particular restraints incompatible with their setting up in batch (modification made necessary to improve safety, specific modifications implemented on a plant or an unit not related to the series characteristics) have specific individual scheduling.

Finally, it is important to specify that EDF modification management, such as presented here, is going to evolve taking into account the evolution of the economic context of production of electricity. To this end, EDF is setting up a new approach intended to evaluate the ratio safety benefit /cost of the modifications under consideration within the framework of the VD3 PSR.

1.2 THE SECOND TEN-YEARLY OUTAGES (VD2) BATCH OF MODIFICATIONS

As mentioned above, the VD2 batch of modifications and associated individual scheduling modifications (PID2) mainly result from 1300 MWe series VD2 PSR which has been performed since 1997, according to the major milestones listed hereafter:



1997 – 2000

- [1] Build-up of the program and the objectives
- [2] Compilation of the current safety requirement reference basis (so-called safety referential) to be used for the safety conformity examination. It is based first and foremost on the final safety analysis report (FSAR) and general operating rules (GOR).
 Safety requirements reference basis taken into account to perform 1300 MWe series VD2 PSR, corresponds to:
 - A reference construction state including the batch 93 of modifications and accident studies corresponding to GEMMES fuel management ;
 - An operational handling taking into account emergency operating procedures (EOP) based on 2nd generation of state oriented approach (APE).

2000 - 2005

- [3] Conformity check, consisting in:
 - 2001 – 2004: Unit conformity check, in order to verify that effective conditions of the units comply with the design benchmark
 - 2000 – 2005: Conformity check studies, in order to verify that series design benchmark comply with the current safety requirements reference basis

2000 - 2005

- [4] Safety referential reassessment

2001 - 2002

IRSN investigated the safety studies carried out by EDF in the framework of VD2 PSR on the 1300 MWe series and presented the major conclusions to the standing advisory group of experts.

> 2002

- [5] Correction of identified discrepancies

July 2003

- [6] Definition of the second ten-yearly batch of modifications

Since July 2004

- [7] Reference documents updating (FSAR, GOR...) to match the reassessed safety referential

April 2005

- [8] Implementation of the second ten-yearly batch of modifications on the pilot (lead) unit

2004 - 2005

IRSN investigated the following aspects related to VD2 PSR of the 1300 MWe series and presented the major conclusions to the standing advisory group of experts:

- completion of the safety studies,
- results of the conformity check of the plants,
- verification that proposed modifications solve the weak points which were identified by safety studies,
- assessment of the updated FSAR.

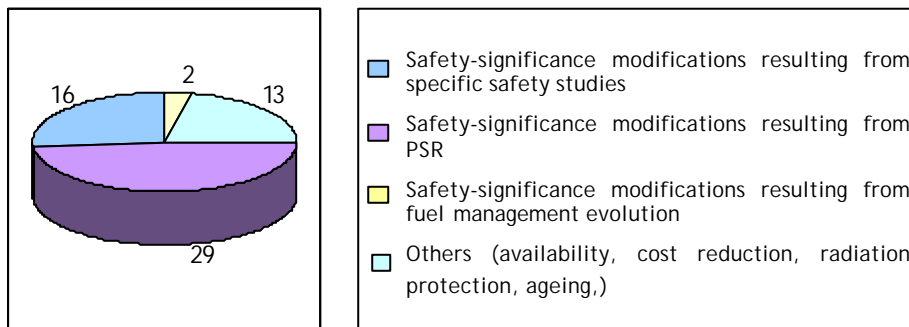
2 LIST OF MODIFICATIONS RELATED TO 1300 MWE VD2 BATCH

In July 2003, EDF submitted the first list of the 1300 MWe batch of VD2 and associated PID2 modifications to the Regulatory Body.

In June 2005, EDF submitted a new list.

Compared to the list submitted in July 2003, 10 modifications of safety-significance have been added. The latter list contains 45 modifications resulting from PSR or specific safety studies performed in the frame of PSR, which represent 75% of the global set of safety-significance modifications (see diagram below):

The batch of VD2 modifications and associated PID2 => 60 modifications



Safety-significance modifications resulting from PSR or from specific safety studies carried out in the framework of the PSR are related to the items presented hereafter:

1. Deterministic studies:

a. External / Internal hazards:

- **Impact of on-site flooding studies** on the risk of damaging equipment important for safety (IFS).

The proposed modifications concern either displacements or protection of electrical cables and boxes, sensor protection, making concrete structures and doors watertight.

- « **Seismic event** » **approach studies consequences** related to the risk of damaging equipment important for safety (IFS) (the targeted equipment) by non-seismic designed equipment (the aggressor).

The proposed modifications concern either operational arrangements, or displacements of the aggressor or the targeted equipment, or target protection.

- **Seismic behavior of electrical & safety auxiliary building (BAS-BL)**: floors flexibility analysis outcomes, taking into account seismic reassessment of ground response spectra of the sites complying with to the Safe Shutdown Earthquake (SSE) determined by means of the new Basic Safety Rule (BSR), RFS 2001-01.

The objective is to substantiate the ability of IFS facilities and equipment to operate in case of the defined SSE level seism. The proposed modifications aim mainly at strengthening tanks and piping supports, by reinforcing steel sections, adding or modifying current anchors.

- **Impact of on-site explosion studies (definition still in progress by the operator)**

In the framework of its examination of the studies that are related to VD2 PSR of the 1300 MWe series, IRSN suggested that the licensee perform:

- studies on the safety impact of bottled gas explosion with respect to the BSR which deals with the risks associated with the industrial environment and communication routes (RFS 1.2.d);
- assessment of useful means of prevention and mitigation.

Since this request has been extended to 900 MWe series in the frame of VD3 PSR, the treatment by the licensee (detailed here after) is generic.

After having identified the most dangerous gases which have to be taken into consideration, the location of the potential aggressors and the IFS targets, consequences are assessed by assuming three boundary scenarios.

According to the operator, 1300 MWe series is not concerned by the first scenario which consists of an over-pressure wave due to a single container explosion.

Concerning the other scenarios which are related to serial effects of internal fire (heavy gas) or external fire (transformer), the proposed modifications should consist of bunkering the bottled gas storage areas or shielding the transformers.

- b. The improvement of the emergency feedwater system (EFWS) start-up logic, in order to avoid steam generator overflow in the event of a steam generator tube break (SGTB).

The proposed modification results from the report that on the French PWRs, the design of emergency systems and signals of protection leads to an early filling of the affected steam generator in the event of a SGTB.

The dominant parameters which influence the risk of possible overflow of water of the affected steam generator are:

- leak-flow between the primary and secondary circuits which depends on the section and the position of the break as well as on the difference in pressure between these circuits
- the characteristic curve of the emergency core cooling system (ECCS) pump which determines primary pressure at the equilibrium
- the threshold of EFWS start up and the injected flowrate
- the amount of time the operator has to isolate the affected steam generator on the steam side (closing of the principal steam valve) and on the water side (isolation of EFWS) and to cool the primary circuit to reach the pressure allowing to stop ECCS, so as to eliminate the leak.

The aim of the modification is to limit EFWS flow on 1300 MWe series by starting only EFWS motor-driven pumps. The turbine-driven pumps are no longer activated as it is the case on 900 & 1450 MWe series.

- c. Extension of the third barrier integrity - Addition of nozzles and devices for leaktightness measurement of stop valves on the way back to the refueling water storage tank (RWST)

The proposed modification results from the report that, recirculation phase after loss of coolant accident (LOCA) presents radioactive risks to the environment due to possible RWST releases in the event there are leaks on stop valves located on ECCS and CSS recirculation lines, between the containment sumps and the RWST.

The proposed modification aims at allowing periodic leaktightness tests on the stop valves which are considered as weakpoints, in order to match the assumptions taken into account for the assessment of radiological consequences of basic design LOCA.

- d. Compliance of IFS equipment with qualification requirements, taking into account:

- Operating experience feedback has shown that existing arrangements didn't comply with current qualification requirements;
- New safety requirements associated with:
 - aggravating factor assumptions in accident studies,
 - inclusion of handling phase in accident studies,
 - reassessments of hazards (extreme cold, high energy line break (HELB) ...).

- e. Operating rules:

- Improvement of the containment pressure reducing strategy applied to total loss of heat sink situations, at cold shutdown states when the reactor vessel is opened (so-called H1-2 situations);
- Extension of the capacity of alarm panels to receive additional alarms from future batches of modifications.

f. Topics highlighted by operating experience feedback or know-how evolutions:

- **I&C modification aiming at allowing ECCS & CSS pumps to start up in the event of loss of on-site electrical power supply**, making possible automatic water make-up in shutdown states;

The proposed modification results from the report that, according to I&C basic design of the 1300 MWe series, priority is given to ECCS & CSS pumps shut off, if memory signals representative of injection and containment systems actuation are not present on diesel generators.

- **I&C evolutions of the letdown line of CVCS**, including:
 - The decrease of the threshold of automatic letdown shutdown in case of a high temperature (downstream non regenerative heat exchanger);
 - Improvement of loss of electrical supply on train B mitigation, by recovering the possibility of emptying the primary circuit, since operating experience feedback has shown it wasn't possible on design benchmark;
 - ...
- **Software upgrade of the core cooling monitoring system**, in order to take into account industrial process evolutions and apparent mistakes in primary water inventory calculation (see cooling state parameters calculation: *vessel level & boiling margin (DTsat)*).

- **Improvement of emergency turbine-driven generator (LLS) actuation.**

The proposed modification results from the report that, according to the basic design of the 1300 MWe series, actuation of both the emergency turbine-driven generator and the CVCS hydrotest pump power supply is not possible if total loss of electrical power supply does not result from simultaneous loss of LH 6,6 kV switchboards.

- **Completion of the automatic monitoring and control device (CONTROBLOC) upgrade** used for simple open-shut control of systems (IFS or not), in order to avoid spurious orders (which have often occurred since its first implementation) - **(definition still in progress by the operator)**

Following the technical instruction carried out by IRSN, within the framework of the VD2-PSR, EDF committed itself to check whether available indications in main control room could be sufficient enough to diagnose spurious orders from control rack and assess potential consequences of this situation.

As a conclusion to the extra studies performed since then, the operator has identified that one control rack could lead to spurious actuation of the EFWS A train.

When the unit is on power, the operator assessed that this situation could lead, in the event the operational team does not take appropriate actions, to EFWS tank draining within 6 hours.

The proposed modifications should consist of diversifying the surveillance by means of an additional control rack.

2. Using PSA in PSR:

- **Improvement of LH 6,6kV switchboards common cause failure mitigation:**

This modification results from the PSA performed in the frame of PSR. Indeed, it has been shown that LH 6,6 KV switchboards common cause failure initiator represented the second functional sequence of core damage frequency (CDF), with a share of 27%.

The proposed modification aims at avoiding turbine-driven generator failure which represents 80% of the measured risk value of LH 6,6 KV switchboards common cause sequence. Avoiding turbine-driven generator failure leads to save injection function to the reactor coolant pump seals .

Reliability improvement of injection function to the reactor coolant pump seals is then obtained by automatic switching of the CVCS hydrotest pump power supply.

3 IMPLEMENTATION PLANNING OF THE 1300 MWE VD2 BATCH OF MODIFICATIONS

NPP		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
VD2 batch P4 train	FLA				FLA 1 FLA 2						
	PAL	PAL2 (lead unit)	PAL 1	PAL 3	PAL 4						
	SAL			SAL 1	SAL 2						
VD2 batch P'4 train	BEL					BEL 2	BEL 1				
	GOL							GOL 1		GOL 2	
	PEN							PEN 1		PEN 2	
	NOG				NOG 1 NOG 2						
	CAT		CAT 1 (lead unit)		CAT 2		CAT 3	CAT 4			

4 MODIFICATION ASSESSMENT PROCESS

Learning from experience feedback for the assessment of the 900 MWe VD2 batch of modifications , the regulatory body (RB) defined - in 2002 - a new assessment process in order to apply a more efficient regulatory control.

For the modifications of major safety significance, for which design principles may introduce either new risks on the safety demonstration or new technologies, the licensee has to demonstrate, before implementation, that there is no potential safety regression risk.

For other modifications, in case some potential safety risk exists during implementation or operation and requires requalification criteria validation or efficiency validation, experience feedback is analyzed before generalization.

According to the assessment process, the licensee has to submit to the regulatory body some information dealing with design principles of the proposed modifications, prior to the implementation of the modifications on the lead unit.

- Synthesis (origin, technical aspects, ...)
- Risk analysis
- Human factor
- General operating rules impact
- Safety report impact
- Spare part management
- Radiation protection
- Test and qualification

5 CONCLUSION

Since the beginning of the 90's, (in relation to the French regulatory context evolution that introduces the periodic safety review (PSR) concept), modifications implementation practices have turned to new approaches, introducing the "batching policy" concept.

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