http://www.wise-paris.org • e-mail : secretariat@wise-paris.org
31-33 rue de la Colonie F-75013 PARIS • Tél. +33 1 45 65 47 93 • Fax +33 1 45 80 48 58

Briefing

FAILINGS IN NUCLEAR SAFETY AT EDF
The case of Cattenom

Briefing CAT1
Version 1..3 September 2001

Author: Yacine B. FAÏD

Key words: *Sealing Failures – Fuel – Valve – Safety – Cattenom*

Content :

Annexes available in French only:

FAILINGS IN NUCLEAR SAFETY
The case of Cattenom

Summary

After a 7-month shutdown, during which the Operator discovered damage to the fuel on a scale that had never been experienced before on any French reactor, Unit 3 at the Cattenom nuclear power station restarted on 9 September 2001. France's Nuclear Safety Authority actually gave the green light for its restarting on 31 August 2001, despite the fact that the enigma of the phenomenon that caused the damage has not been solved yet.

After intervention by members of the parliament of Luxembourg, Luxembourg's Minister of Foreign Affairs stressed to the French authorities "*that a meeting of the Joint Franco-Luxembourg Commission on Nuclear Safety should be convened as quickly as possible."*

In all, 92 fuel rods –containing uranium and constituting the first level of containment of radioactive material– were damaged. Some were completely broken, allowing radioactive material to be disseminated into the primary cooling fluid. This represented a "*first*" in the numbers of sealing faults, given that five to ten faults are observed on average per year *in all* of the 58 reactors in the France. The usual annual figure of 0.1 rods was multiplied by 1000.

Serious damage to fuel elements can lead to risk of jamming of the control rods and therefore to loss of control of the chain reaction, with potentially grave consequences for reactor safety.

In October 1999, just a month after restarting of the reactor, an abnormal level of radioactivity was detected in its primary cooling water and, on 6 September 2000, the "*Serious Cladding Failure"* level was reached. The safety authorities were only informed of this situation on 18 October 2000, a delay judged "*inadmissible*" by the authorities.

In spite of the high level of leakage and recommendations from the safety authorities to bring forward shutdown of the reactor, the management of the Cattenom power station preferred to keep it running. Prior to shutdown of the reactor, the power station's management was unable to provide an accurate assessment of the number and gravity of faults. This error of foresight will have long-term repercussions, especially for radiological protection and management of the Unit 3 buildings.

Several hypotheses have been put forward to explain the appearance of these faults. In addition to wear and vibration, the presence of a possible "*migrating body*" or even the possibility of a "*manufacturing defect*" have been suggested. And, while "*the immediate cause linked to vibration fatigue*" has been identified, this does not make it possible to "*confirm or exclude potential factors with certainty.*"

In parallel with this situation, EDF informed the Safety Authority, on 12 March 2001, that it had detected a generic fault in valves in the emergency cooling system in 12 reactors in the 1300 megawatt-of-electricity (MWe) series (including those of Cattenom); a fault that could affect their satisfactory operation in case of accident. More precisely, this flaw affected the re-circulation system supplying the emergency spray and injection systems, of fundamental importance in the concept of nuclear safety. EDF's analyses led to the conclusion that there was a risk of jamming in case of "*serious accident or high-magnitude earthquake.*"

Shortcomings in the area of nuclear safety on EDF sites, characterized by a "*persistent lack of rigor*" have been observed on numerous occasions by the Safety Authority. The case of Cattenom appears to constitute a serious example.

2. Leaks in fuel assemblies

2.1. The facts[1]

Located in the Lorraine region, on the edge of the Moselle, close to the borders with Germany and Luxembourg, the Cattenom power station comprises four 1300 MWe reactors. Operation of the power station includes regular replacement of the spent fuel contained in the cores of its reactors. Re-loading with new fuel assemblies, usually of one-third of the reactor, requires shutdown of the reactor for several weeks. (***Annex 2***).

It was after such a shutdown, and one month after its restarting, that –in October 1999– personnel at the Cattenom power station detected "*an increase in radioactivity in the primary cooling water*"[2] of Reactor No. 3. The first analyses, made on site, revealed a sealing fault in a fuel assembly "*in its third irradiation cycle*."[3] In July 2000, observation of a regular increase in radioactivity levels led EDF to suspect the occurrence of one or two new faults in "*new assemblies in the second irradiation cycle and located in the center of the core*," and to suspend load following[4].

The July–September 2000 period coincided with a malfunction of the automatic rinsing system for the liquid-radioactive-effluent discharge pipes, causing Cattenom to discharge radioactive effluent into the Moselle river and to therefore fail to satisfy conditions for dilution on three occasions. According to the DSIN[5], failure to respect the conditions for discharge of liquid radioactive effluent as defined in authorizations justified classification of the incident at level 1 on the International Nuclear Event Scale (INES).[6]

At the end of August 2000, the Cattenom power station decided to take a proactive stance and to "*anticipate the application*" of Technical Operating Specifications (TOS)[7] "*that stipulate weekly alpha measurements as soon as the value for iodine-134 exceeds 5000 MBq/t*[8]", which was not *a priori* the case.[9]

These suspicions were confirmed when, on 6 September 2000, the level of alpha emitters in the cooling circuits reached the threshold of 4 becquerels/liter (Bq/l), known as the Serious Cladding Failure (SCF) threshold. Three different measurement methods for alpha emitters, specified in three laboratories including that of Cattenom, then gave four results varying from 1.6 Bq/l to …30 Bq/l (***Annex 2***).

Informed of this situation on 18 October 2000, the DSIN asked "*the Operator of the Cattenom power station, in November 2000, to examine the possibility of an early shutdown of the reactor in order to limit the consequences of primary activity on radiological protection during shutdown of the unit, and on the environment*"[10].

---

[1]See ***Annex 1*** for chronology of events.

[2]Telephone communication with Cattenom power station's press office, 17, 28 and 31 May 2001.

[3]Period during which the fuel is used in the reactor in operation. A fuel assembly, depending on the management, will undergo three or four 12 to 18 month cycles.

[4]Load following: alteration of regime allowing variations in reactor power and adaptation to demand from the electricity distribution grid.

[5]DSIN : Direction de sûreté des installations nucléaires, Nuclear safety authority.

[6]DSIN press communiqué, www.asn.gouv.fr, 1 March 2001.

[7]Technical Operating Specifications: operating modes to be respected by nuclear installation operators.

[8]MBq/t = Megabecquerel/tonne or 1 million becquerels per tonne.

[9]Alpha radiation and iodine-134 are by-products of nuclear fission. Their presence in the primary circuit indicates cracking in fuel cladding.

[10]DSIN press communiqué, www.asn.gouv.fr, 11 June 2001.

Qualifying the "*absence of information to the Nuclear Safety Authority on the first phenomenon observed since June 2000, and especially since 6 September when the SCF threshold was reached, as inadmissible,*" the Regional director of the DRIRE[11] recommended that EDF should consider "*a shutdown for repair of the leaking fuel before the scheduled shutdown*", which was to take place at the end of February. He also required "*an analysis of the environmental consequences of maintaining reactor power*" if it were kept running until the scheduled shutdown.

The position of the safety authorities notwithstanding, and basing its decision on operating rules, the Cattenom power station "*preferred to pursue operation of the reactor as planned.*"[12]

Reacting to the DRIRE letter, EDF explained that the SCF value was "*not a TOS criterion*", adding:

> "*The approved text does not mention the 4 Bq/l alpha activity threshold… It is not linked directly to reactor operation … Informing the Safety Authority was not required under the Technical Operating Specification.*
>
> *Nevertheless, we recognize that in the interest of relations between the DRIRE and the Operator, this information could have been communicated earlier.*"[13]

In the end, the Operator decided to bring forward shutdown of Unit 3 by a month, programming it for 27 January 2001. The damage found on 15 March 2001 was far more extensive than the Operator's predictions. Twenty-eight assemblies were found to be damaged, with an average of three damaged rods: 26 assemblies in the third cycle, two in the second. In all, 92 damaged cladding tubes were found, 18 times more than the five or six such defects observed *on all 58 of France's light-water reactors.* As many as 18 cracked rods were found in a single assembly, out of the 265 making it up. The rods showed "*longitudinal and circumferential cracking as well as 'sunburst'*[14] *blistering."* The DSIN then confirmed classification of this incident at level one on the INES.

2.2. Measured communications

In terms of communication, information to the public, supposed to be "*continuous and regular*[15], was only forthcoming in December 2000. Further, after discovery of the extent of damage, in March 2001, EDF's approach was to play down the incident. In spite of the number of sealing defects, unprecedented in all of the history of nuclear power stations in France, both EDF and the DSIN described the number of defects found in Cattenom's Unit 3 as "*unusual*", adding that this type of defect could appear five to ten times per year in the installed base of power stations. This 'unusual' number was nearly 1000 times greater than the annual average of 0.1 defective rods per reactor. An instance of 'misinformation' by omission.

2.3. Reactions from Luxembourg

The events at Cattenom provided a reaction from the Green parties in the Luxembourg and European parliaments, reproaching the Cattenom power station with having kept Reactor 3 in operation from the moment there was a presumption that defects were present to the scheduled shutdown for overhaul.

---

[11]Letter from Mr François Gaucher, Regional Director DRIRE to Director of Cattenom Power Station, 8 November 2000.

[12]DSIN press communiqué, www.asn.gouv.fr, 11 June 2001.

[13]Letter from management of Cattenom power station, 23 November 2000, to Mr François Gaucher, Head of nuclear installation division at DRIRE, in reply to his letter of 8 November 2000.

[14]*Flash infos*, 5 April 20001, Cattenom power station, Trade Union press.

[15]EDF press communiqué, http://nucleaire.edf.fr/, 9 July 2001.

After a press conference[16], to which WISE-Paris was invited as expert, the Luxembourg Greens addressed a letter, on 21 June 2001, to the Government of Luxembourg asking it to obtain "*clarification of the problems observed on Reactor 3.*"[17]

In response to this request, Luxembourg's Minister for Foreign Affairs stressed to the French authorities that " *a meeting of the Joint Franco-Luxembourg Commission on Nuclear Safety should be convened as soon as possible.*"[18] Among other things, the Commission should examine "*the modalities of trans-boundary provision of information in case of operating incidents.*'

2.4. Behind the scenes of the events

In the light of the events described above, three comments can be made concerning the management of Reactor 3.

First, the power station management chose to act unilaterally. The evolution of damage to fuel cladding between October 1999 (the start of observation of contamination of primary coolant) and October 2000 was monitored without the safety authorities being informed. It was only a month after the SCF threshold was exceeded that the situation was finally revealed. Commenting on similar lacks of information, the Curien Report stated, in 1999, that EDF often tended to present the safety authorities with "*the 'fait accompli', by adopting an industrial risk strategy.*"[19]

Second, the choice of keeping the reactor running constituted an error of foresight. Despite a high threshold of contamination of the primary system, when iodine-134 activity indicated that "*fuel was beginning to disseminate into the primary coolant*" and, despite extensive operational feedback on the risk in terms of radiological protection and radioactive releases, at no time did EDF consider early shutdown of the reactor as a preventive measure. Shutdown was only brought forward by one month.

Finally, it is clear that the extent of the damage was seriously under-estimated. The management of the power station maintained that "*assessment of the condition of cladding of 26 October 2000 confirmed the presence of two to four defects.*"[20] In fact the sealing defects discovered had nothing in common with EDF's estimate. Serious questions are therefore raised about the actual effectiveness of alarms and indicators, which did not allow the number of defects to be detected.

2.5. Risks for safety and security

Such damage to fuel cladding represented an unprecedented situation as far as the norms for operation of a nuclear power station are concerned, as it had never been envisaged. The situation engendered consideration of additional immediate and in-operation risks of jamming of the control rods, to sustained presence of radioactive substances in the buildings. Not to mention the possibility that a secondary incident, compounding the first, could have had more serious consequences.

2.5.1. Jamming of control rods

One imaginable consequence of damaged fuel rods is jamming of the control rods as they drop into the reactor core.

---

[16]Press conference, 18 June 2001.

[17]M. Claude Turmes, member of European Parliament, quoted in La Voix du Luxembourg, "*Déi Gréng tirent la sonnette d'alarme" (the Greens sound the alarm)*, 19 June 2001.

[18]Luxembourg Ministry of Foreign Affairs. Letter to Mr Jean Huss, MP, Mr Claude Turmes, member of European Parliament, 4 July 2001.

[19]Commission for monitoring of nuclear safety and associated communications. Curien Report, 8 March 1999.

[20]Letter from management of Cattenom power station, 23 November 2000, to Mr François Gaucher, Head of nuclear installation division at DRIRE, in reply to his letter of 8 November 2000.

Correct operation of control rods, for which the drop period is timed and is an integral part of the basic safety systems, is of fundamental importance in controlling the chain reaction and therefore for shutting down a reactor (***Annex 2***).

Unlike the IPSN, which has stated that "*there is, at present, no operational feedback or identified scenarios that imply significant interaction between damage to fuel rods and the integrity of the guide tubes*"[21], the DSIN has clearly identified a causal link between control rod malfunctions and distorted fuel cladding.

Two examples seemed worthy of concern for DSIN. First the case of Paluel, where automatic tripping of Reactor 3 on 14 October 1995 was characterized by incomplete insertion of a control rod cluster[22]. Then, at Belleville on 6 April 1996, a cluster on Reactor 1 that "*should have participated in 'smothering' of the nuclear reaction remained in the raised position.*" This "*unexplained*" incidence of jamming was classified at level 2 on the INES "*given that emergency shutdown is required from the point of view of safety.*"[23]

While accepting that this type of incident represents a "*serious threat to control of the nuclear reaction*"[24], the DSIN explained that:

> "*distortions in fuel assemblies have been observed on several reactors, in France and elsewhere, leading to retarding or even difficulties in inserting control rods. Analysis of these incidents led to incrimination of increased friction between control rod clusters and the fuel assembly guide thimbles into which they are inserted, resulting in distortion of the latter.*"

Whether due to increased burn-up rates or to "*reactor operating conditions and a series of changes made by manufacturers to assembly skeletons*", the manufacturer, FRAGEMA, preferred "*reinforced*" assemblies introduced in 1998 into reactors with GEMMES management.

This operation did not therefore concern third-cycle assemblies which have the most sealing defects in Cattenom's Reactor 3, and which were loaded into the reactor in 1996.

2.5.2. Radioactive contamination

Fuel cladding is the first of three barriers between the radioactive material and by-products of nuclear fission and the outside world, the other two barriers being the reactor vessel and the containment building (***Annex 2***). Any rupture of the cladding tube implies release of radioactive material into the primary system.

The presence of radioactive particles, and especially of alpha emissions, in the system carrying the primary coolant can lead to "*the contamination of areas or even of operatives and their equipment*" with an increased risk "*for movements of personnel or equipment, spreading contamination beyond the controlled area and even beyond the site.*"[25]

The tasks of the maintenance operatives carrying out the ten-yearly shutdown for overhaul of Reactor 3, on 27 January 2001, were thus not only made more complicated but involved management of an additional risk for the operatives. The reactor building was "*evacuated four times*" after detection of alpha emitters in the atmosphere. This same risk will be present during subsequent reactor shutdowns "*given that the radioactive material in the primary system will not be eliminated before several cycles.*"[26]

EDF affirms that the operatives carrying out the maintenance work during shutdown of the unit were not contaminated and maintains that no release of alpha emitters was observed outside of the reactor building.[27]

---

[21]Letter from IPSN to WISE-Paris, 15 June 2001.
[22]Classed at level 1 on INES. DSIN Activity Report, 1997.
[23]DSIN Activity Report, 1997.
[24]DSIN Activity Report, 1996.
[25]DSIN, Nuclear Safety in France in 2000, 2001 edition.
[26]DSIN press communiqué, www.asn.gouv.fr, 11 June 2001.
[27] EDF press communiqué, http://nucleaire.edf.fr, 9 July 2001.

2.5.3. Radioactive releases to the environment

Contamination of the primary system caused difficulties in management of the gaseous and liquid effluents discharged from the Cattenom power station. During shutdown of the reactor, EDF found a level of contamination such that the primary coolant fluid had to be treated for more than three weeks, "*whereas this operation usually takes a few days.*"

On 1 February 2001, a gaseous discharge exceeded the radioactivity alarm threshold. The DSIN has admitted that "*gaseous discharges from the Cattenom site* [have] *increased significantly following the fuel defects*", and added:

> "*by way of illustration, for the two-month period between 1 January and 28 February 20001, gaseous discharges from the site were as high as for the whole of the year 2000 for rare gases and represent almost twice the 2000 level for discharges of halogens and aerosols*."[28]

2.5.4. Management of radioactive waste

The radio-elements present in the primary system will raise additional difficulties in management of wastes such as contaminated filters and tools. Special precautions will be necessary to sort the waste containing alpha emitters, as well as to respect the criteria for radiological protection relating to their disposal. During dismantling, there could also be additional difficulties in handling of apparatus having been in contact with the primary coolant and for which contamination will be higher than normal.

Handling of damaged fuel cladding for inspection will also be far from easy, given the "*risk of rod breakage.*"[29]

2.5.5. Economic cost

According to EDF[30], the loss of earnings alone since 9 May 2001, date at which the reactor should have restarted, to 17 August (start of reloading) is around FrF100 million, given the daily cost of reactor shutdown, estimated at FrF1 million. This does not include the additional cost due, in particular, to the special measures introduced for radiological protection of maintenance operatives and which could re-occur in subsequent shutdowns, amounting to FrF20 million.

This cost balance could increase if account is taken of all the complications that radioactive contamination may have engendered in terms of precautions that must be taken in the future, not only for unit shutdowns but also for decommissioning of the site.

2.6. The causes according to EDF

"*The scenario proposed by EDF*" to explain loss of fuel sealing on Reactor 3 is "*the occurrence of fretting (vibration fatigue fault) in the lower parts of rods, at the level of the lower grid […] leading to a crack or disseminating rupture of a rod. The cause of the vibration phenomenon is not determined.*"[31] These were the conclusions of the meeting on sealing faults, organized between representatives of EDF and the safety authorities at the end of June 2001.

From the start of the investigations, the Operator seemed to give precedence to the vibration-stress solution, also known as 'fretting'. Mr Dominique Minière, Director of the Cattenom power station, proposed that the cause of leaks was linked to "*friction and to vibrations in the lower grid*", without discounting other possible causes, "*damaged grids"* for example.[32]

---

[28]DSIN press communiqué, www.asn.gouv.fr, 11 June 2001.
[29]Minutes of ASN, DES, EDF meeting, 29 June 2001.
[30]EDF, Cattenom power station press office, telephone communication, 17 August 2001.
[31]Minutes of ASN, DES, EDF meeting, 29 June 2001
[32]Quoted by WOXX, 20 April 2001.

The initial elements of the investigation did reveal "*sealing problems linked to vibration*", without stipulating the origins of the vibrations. EDF suspects these vibrations to have caused "*more sustained*" friction between the rods and the springs restraining them, eventually leading to cracking.

Restricting itself to the notion of vibration –even though its cause remained unknown– EDF immediately discounted any other hypothesis for explanation of the occurrence of sealing faults. Thus, anything that could be linked, directly or indirectly, to operation of the power station (too-rapid power build up) and/or to the search for its profitability (GEMMES management and load following) could not, must not, be the answer.

2.7. The position of the safety authorities

While EDF was able to "*identify the immediate cause of defects, linked to vibratory fatigue*" this does not, according to the DSIN, make it possible to "*affirm or exclude potential factors with certainty.*"[33]

The IPSN expressed similar caution, stipulating that "*the specific conditions that led to the phenomena observed at Cattenom-3* [were not] *identified*", and that the nature of the damage experienced by the rods could be attributed to "*a variety of causes: migrating bodies; wear due to vibration; a manufacturing defect; etc.*" Several factors could also have contributed to accentuating the vibratory aspects, such as "*failing conditions of fuel rod support, special types of flows linked, for example, to loading of assemblies of different designs into a single core, etc.*"[34] Therefore, several hypotheses could be envisaged to explain the phenomenon.

2.7.1. Equipment fault?

According to the DSIN, "a *defect in the rod cladding alloy or failed weld between the cladding and lower and upper end plugs*" can lead to a loss of sealing at the start of irradiation. The hypothesis was plausible, all the more so as a recent defect linked to a quality flaw in cladding already existed. A cladding failure was detected, in August 2000, on Reactor 2 of the Nogent-sur-Seine power station. Investigation subsequently revealed a quality control problem on numerous tubes in the Paimbœuf manufacturing facility, admitted belatedly by Framatome, the parent company of CEZUS (Compagnie Européenne de Zirconum), the cladding manufacturer.[35] However, denying any connection with that incident, the DSIN replied that most of the "*assemblies in question are old, in their third operating cycle.*"[36]

The French group Framatome, which provided the leaking assemblies to Cattenom 3 from facilities at Pierrelatte, Dessel and Romans, associated with EDF in order to resolve the vibration enigma. Framatome put forward no theory, explaining its position by the fact that the "*incident occurred in a reactor and during operation*" and saying that, as a consequence, the supplier "*can no longer comment.*"[37]

For EDF and the safety authorities, "*no manufacturing flaw likely to explain the defects has been found*."[38]

2.7.2. Defective grid?

The DSIN has evoked defects in the grids supporting the fuel assemblies, which have already caused loss of sealing (in 1994 and 1995 in particular) due to wear of the cladding caused by vibrations in contact with the springs supporting the cladding in the lower grids.

---

[33] Mr Thomas Maurin, Power Reactors Division, DSIN. Letter to WISE-Paris, 18 June 2001.
[34] IPSN, letter to WISE-Paris, 15 June 2001.
[35] WISE–Paris, "*L'Affaire CEZUS, Contrôle qualité de combustible nucléaire hors service*", 20 December 2000, http://www.wise-paris.org/francais/nosbrevesarchives/index.html.
[36] Mr Alain Delmestre, DSIN, telephone communication, 2 May 2001.
[37] Framatome, Press Office, telephone communication, 17 May 2001.
[38] Minutes of ASN, DES, EDF meeting, 29 June 2001

2.7.3. Foreign body?

The DSIN, like the IPSN, has put forward the hypothesis of "*the presence of small foreign bodies in the reactor core*" Carried by the fluid, and with the aid of the pressure in the vessel, foreign bodies have been at the origin of some of the defects discovered in the past, before assemblies were fitted with anti-debris filters.

2.8. Other hypotheses

2.8.1. Load following?

Changes in regime, or load following, allow adaptation of the reactor power to the needs of electricity consumption. In an article, published in *La Tribune*[39], the CGT trade union explained that these variations in regime, accentuated after June 2000, could be at the origin of cracks observed in rods. The variations in reactor power could cause expansion and contraction of cladding which could eventually lead to cracking.

Although it recognized that several causes could contribute to cladding damage, the CGT concluded that "*thermal shocks*" resulting from changes in regime could have weakened components.[40]

Commenting on similar operation of Reactor 1 at the Golfech power station, in 1997, the DSIN explained that "*the time during which power can vary is limited so as not to place too high a load on the fuel cladding which could be damaged in the event of sudden and accidental power variation*."[41]

The same comment was made by the DRIRE which, in view of the weekly reports for the period from 27 December 1999 to 17 July 2000, noted that Reactor 3 at Cattenom was subjected to "*frequent power variations going as far as shutdown, especially at weekends.*" The DRIRE also noted that these power variations "*could lead to high loads on the fuel.*"[42].

Without giving more details, and not taking account of extended operating periods after 1996, EDF replied that a statistical study "*at the end of 1980, period during which operation with grid matching increased significantly for all French reactors, did not reveal any evidence of special behavior of the fuel operating in grid matching mode.*"[43] EDF added that:

> "*for over 20 years, in France and elsewhere, no cladding failure has been identified on a PWR*[44]*, that could be attributed to too high a load on fuel during operation, especially failure due to pellet-cladding interaction.*"

It should be noted that no Operator other than EDF practices such a high level –for both frequency and continuous power levels– of power variations; it is therefore less surprising that precedents abroad are not found.

2.8.2. Too rapid power build up?

On 4 November 1996, when Reactor 3 was in its re-start phase after loading, which took place in October 1996, EDF noted a too rapid build up in power which is not only contrary to TOS but can also "*damage*" the fuel rods, according to the DSIN.[45] Twenty-six of the 28 defective assemblies were loaded a few months before this incident, during the first loading of Cattenom 3 within the framework of the GEMMES program.

---

[39]La Tribune, *Inquiétude autour de la centrale nucléaire de Cattenom (Worries surrounding Cattenom power station)*, 19 April 2001.
[40]Mr Denis Cohen, CGT, telephone communication 14 June 2001.
[41]DSIN, *Contrôle*, December 1997.
[42]Letter from Mr François Gaucher, Head of nuclear installations division at DRIRE, to Mr Dominique Minière, Director of Cattenom power station, 8 November 2000.
[43]Letter from management of Cattenom power station, 23 November 2000, to Mr François Gaucher, Head of nuclear installation division at DRIRE, in reply to his letter of 8 November 2000.
[44]*Pressurized Water Reactor*.
[45]DSIN, *Contrôle*, February 1997.

However, according to EDF, this incident could not cause "*sealing failures.*" The only argument put forward is that cracks have already been observed on second cycle assemblies. A somewhat limited argument, given that 26 out of 28 affected assemblies were third cycle. The safety authority has stated that "*there was no development of primary activity following this incident*", and therefore excludes any direct link with the faults discovered by EDF in March 2001.[46]

2.8.3 Extended operation?

In 1996, EDF introduced GEMMES management –which includes operation extended to 18 months per cycle– for the Cattenom reactors and for those of the other four 1300 MWe series sites. The periods of irradiation of fuel were extended from 12 to 18 months. In order to optimize burn-up during the three cycles, the level of enrichment of uranium in the fuel was raised from 3.7 per cent to 4.2 per cent of the fissile isotope uranium-235.

The IPSN maintains that, to date, there is no correlation between damage to fuel and load matching, GEMMES management, or reactor operation. The CGT, for its part, does not discount that extended operation, which keeps fuel elements longer, can contribute to an aging effect on components, as the prolonged stay of assemblies in the core implies "*greater mechanical and thermal loading.*"[47]

2.9. Restarting of the reactor

In spite of the absence of a valid explanation for damage to fuel cladding, EDF formulated a proposal for restarting, on which the DSIN placed the condition of preparation of a program of inspection of assemblies intended for re-loading, prior to re-loading into the unit. Expert examination of 16 rods from second cycle assemblies revealed traces of wear on two assemblies at the bases of rods, most probably from the support grid, due to a "*thermo-hydraulic*" phenomenon.[48]

Re-loading of Cattenom 3 was authorized on 13 August 2001, with one-third of first cycle fuels already in place, one-third of new fuel, and one-third of second-cycle fuel from reserve assemblies. The DSIN having refused re-loading of assemblies that had been through more than one cycle in the reactor, EDF decided to transfer those in reserve from Units 1 and 2 to Unit 3.[49]

While EDF claims to be able to diagnose the origin of vibrations that caused the sealing defects in assemblies with the reactor in operation, the criteria that the Operator put forward for monitoring and, possibly, management of new defects that could occur after re-starting, have not received approval from the DSIN which is still examining the analysis carried out by IPSN.

Thus 'diverging' points of view have appeared as to the approach in the event of discovery of new defects. The DSIN "*considers that, given the uncertainty as to the cause of the phenomenon and therefore its possible re-occurrence, a criterion for early shutdown is indispensable.*" All the more so because the alpha activity, as proposed by EDF, is "*not very reliable*" and the measurement of iodine-134 has become non-representative given the dissemination of radioactive matter in the primary fluid. EDF estimates that monitoring of the evolution of radioactivity during the cycle could make it possible to determine whether or not the reactor can be kept operating.[50]

---

[46] Mr Thomas Maurin, Power Reactors Division, DSIN, letter to WISE-Paris, 18 June 2001.
[47] Mr Denis Cohen, CGT, telephone communication, 14 June 2001.
[48] Cattenom power station, Press Office, telephone communications, 17, 28 and 31 May 2001.
[49] The replacement assembly must have the same characteristics as the replaced assembly, especially in terms of burn-up rate.
[50] Minutes of ASN, DES, EDF meeting, 29 June 2001.

3. A generic defect in injection circuit valves

3.1. Importance of emergency systems

Leaking fuel assemblies were not the only difficulty confronting EDF at Cattenom. On 12 March 2001, the Operator informed the Safety Authority of the detection of a design flaw in valves in an emergency cooling system of 12 reactors (the 1300 MWe series) –including those at Cattenom– able to affect their correct operation in case of accident. The flaw concerned the re-circulation system, a system which supplies the spray system and emergency injection system and is consequently of capital importance for nuclear safety (***Annex 8***).

The re-circulation systems have two electrically controlled valves, installed outside of the reactor building (therefore beyond the reactor building, the third containment barrier) allowing circulation of water to the primary cooling circuit in case of accident. These valves are closed during normal operation. However, EDF fears that, in case "*of serious accident or high magnitude earthquake*", after an increase in temperature of the fluid and therefore of temperature, the valves –located downstream of the sump that collects the lost coolant in case of leak– would no longer be operational, whereas they are supposed to open automatically to allow re-injection of the water into the primary coolant system. The consequences in case of accident could be very serious, as the re-circulation system serves precisely to cool the core in a closed-circuit configuration when the water resources are exhausted after a major leak in the primary system.

EDF proposed to the safety authority that it (EDF) would modify these valves in the five power stations concerned by the flaw in several stages. Implementation of the first stage of a new system is, according to the DSIN, completed and "*the risk of jamming of the valves in case of accident can therefore now be discounted.*" Nevertheless, this is not a final modification which, for its part, should be implemented over the coming year.

This incident, generic in nature, was classified at level 2 on the INES by the Safety Authority on 27 April 2001. It should also be noted that the sump of Reactor 1 has, for some time, been undergoing repairs to remedy flaking of paint which could have blocked the re-circulation system lines (INES 2). Additional verifications have shown that other Units could be affected (six in all, out of eight subject to expert examination in July 1991. Fifteen 1300 Mwe Units were operating at that time). The filters of the RIS (safety injection system) or spray devices of the EAS (containment spray system), located downstream of the sumps, could also be blocked by circulation of residues, concrete rubble and/or debris from broken component.

4. Flaws in the safety culture

The year 2000 was to be a pivotal year for EDF which decided to "*launch a new approach to improve day-to-day safety.*" The DSIN committed to supporting the generating company in this task, after having effectively observed that "*some actions for return to conformity or implementation of modifications necessary for safety of installations are still insufficiently reactive and sometimes reveal a lack of foresight on the part of EDF.*"[51] In fact, "*day-to-day operation of nuclear power stations continues, sometimes, to suffer from a certain lack of rigor […] due to failings in organization, unclear breakdown of responsibilities, and a lack of control.*"

At the start of the year, EDF was boasting about improved safety in nuclear installations in 2000. In support of this, the company put forward the argument that "*the number of significant events remained stable in 2000 whereas demands on operation had increased significantly.*" It nevertheless remains that the number of level-1 incidents in nuclear power stations is clearly increasing: from 116 in 1999 to 134 in 2000. Numerous incidents have been classified due to lack of safety culture.

In 1999 and at the start of 2000,[52] the Dampierre power station particularly attracted the attention of the safety authorities owing to major malfunctions due, for the most part, to "*worsening human and labor relations.*" A meeting had to be organized on 28 September 1999, between the director of the Safety Authority, trade union leaders and all of the site personnel "*to indicate to them the NSA's position and calling on them to 'get a grip on themselves'.*" For six months, the nuclear power station was placed "*under reinforced surveillance, resulting in an increased presence of inspectors on the site.*"[53]

Legal rulings have also underscored the failings in safety management. On 26 June 2001, the director of the Tricastin nuclear power station and EDF were, respectively, given a suspended one-month prison sentence, and fined FrF500,000 for "*involuntary injury*" and "*breaches of Labor Regulations.*"[54] A member of personnel was irradiated on 11 March 1999 while working in a "*red*" area of the reactor; he was working in the area without authorization[55] and received a high dose rate of 340 millisievert/hour.[56] The shutdown revealed failings on the part of the power station's management, underscoring the lack of organization of work in a manner that would "*ensure accident prevention*"; "*failures*" in terms of implementation of safety instructions; and incidences of "*failure to respect*" labor regulations and the rules for their application.[57] The DSIN classified this incident at level 2 on the INES, "*given the exceeding of the regulatory limit for exposure to ionizing radiation.*"[58]

Although the management of the Cattenom power station did not waive rules or procedures, is not the fact of having kept the reactor in operation in spite of the progressively increasing damage to fuel cladding –made evident by exceeding of monitoring thresholds– in contradiction with the "*cautious and questioning attitude among the men and women operating the installations*" that EDF professes to wish to foster in order to improve the safety culture?

Is there not a contradiction with EDF's aim, i.e. greater rigor on the part of the Operator to "*avoid loading the technical defenses consisting* [in particular] *of the three safety barriers (fuel cladding, reactor vessel, and containment)?*"

---

[51] DSIN, *Nuclear Safety in France in 1999.*

[52] EDF, *Bilan du Parc Nucléaire d'EDF*, Manpower, the artisans of progress, Press Conference

[53] DSIN press communiqué, www.asn.gouv.fr, 26 March 2001.

[54] Ruling by Tribunal de Grande Instance de Valence (Valence Court of Justice, France), 26 June 2001.

[55] Red Area: area in which irradiation dose equivalent rate may exceed 100 mSv/h, to be compared with an annual limit of 10 mSv *per year*.

[56] The regulatory limit for workers exposed to radiation was then 50 mSv per year (since reduced to 10 mSv per year).

[57] WISE-Paris, *EDF and a plant manager in the dock for failing to meet safety requirements*, http://www.wise-paris.org/english/intro/ournews/news7.html.

[58] DSIN, *Contrôle*, June 1999.