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WISE-Paris Briefing

THE CEZUS AFFAIR
A flaw in the quality control of nuclear fuel tubes

Briefing CEZ1
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Note: DSIN and ASN are identical

1. Summary of events

In August 2000, the operator of reactor No. 2 at the Nogent-sur-Seine power plant, 120 km from the centre of Paris, France, detected a cladding failure in the nuclear core (abnormal radioactivity in the primary coolant system). The investigation – carried out by Framatome, the fuel manufacturer, on request from EDF (France's electricity company) – revealed what can truly be described as "The CEZUS Affair". What is especially worrying is that the problem was discovered in the manufacturing plant 18 months after its start, and then concealed – i.e. it was not revealed to those concerned, neither French or foreign clients nor safety authorities – at a time when a competitor, the British company BNFL, was embroiled in a scandal over the quality control of plutonium-containing MOX fuel, which brought BNFL to the brink of bankruptcy.

From August 1998, the Compagnie Européenne de Zirconium (CEZUS), then a subsidiary of COGEMA and Framatome, experienced, a quality control problem in its plant in Paimbœuf, France, which manufactures zircalloy tubes for nuclear fuel assemblies, both uranium oxide and plutonium-uranium mixed oxide (MOX) fuel. Although the problem was discovered by the plant operators in February 2000, CEZUS' management did not communicate this to anyone, neither to the clients nor to the safety authorities. Officially, it was Framatome – as client and parent company (by then holding 100 per cent of shares) – that was informed and which communicated the incident to the DSIN (on 6 November 2000) and to its own clients, the users of the fuel manufactured with the some 900,000 cladding tubes produced during the period in question. According to information transmitted by DSIN to WISE-Paris on 16 November 2000, clients included EDF (which also informed DSIN on 6 November 2000) and nuclear operators in countries in Europe (including Belgium, Germany Spain, Sweden, Switzerland); North America (USA); Africa (South Africa); and Asia (China, Japan, South Korea,). The DSIN also stated that it informed the safety authorities in the countries concerned before the 10 November 2000. However, later, DSIN withdrew Switzerland, Japan and South Korea from the list (see point 6.).

The DSIN declared this "generic incident" as at "level 1" on the International Nuclear Event Scale (INES), which has seven levels. This was attributed to EDF for failing, as operator, to monitor its supplier's quality control system. The French safety authority – one of whose assistant directors considered that the event "*does not pose a problem for safety"* – would have placed the event at level 0 except for the fact of the "*long delay between discovery and declaration of the incident".* This same assistant director also declared that there had been *"no concealment"* of the information. However, the other assistant director of this same organisation considered, for his part, that "*such behaviour is entirely abnormal"* and concluded that, *"those who work in the nuclear sector do not have the right"* to behave in this way.

The delay in communication has had an irreversible consequence: the tubes affected by the quality control failure, identifiable within batches so long as they are not used, have **all** left the Paimboeuf plant and have been delivered, assembled and, for the most part, loaded into reactors. Thus, according to information provided to WISE-Paris by DSIN, the tubes manufactured for EDF, were used in 1,263 assemblies of which 1,140 (more than 90 per cent) have already been loaded into 49 of EDF's 58 pressurized water reactors. The situation is less

clear for dozens of other CEZUS/Framatome foreign clients. In the view of the DSIN, it is now up to the safety authorities of the countries in question – which have been informed – to take the necessary steps.

2. Presentation of the CEZUS plant in Paimbœuf

CEZUS[1]

CEZUS is now fully owned by Framatome. It is part of the "fuels" branch of the French group's "energy" sector. The group has five plants producing various zirconium-based products, including zircalloy sheets and tubes. One of these plants manufactures claddings for fuel rods used in light water reactors.

In 1998, production was still –partially for the period in question – carried out by a special company, Zircotube, which manufactured the thin tubes used for fuel assemblies, using zirconium supplied by CEZUS. CEZUS and Zircotube were then – like Franco-Belge de Fabrication de Combustible (FBFC) later made responsible for fuel assembly – owned 51 % by the Framatome group and 49 per cent by the COGEMA group. Zircotube was absorbed by CEZUS – of which Framatome became the sole shareholder in 1999[2] – in the year 2000.

Production

CEZUS specialises in manufacture, transformation and sales of metals such as zirconium and hafnium, and metallic alloys of zirconium (zircalloy in particular). The company is Europe's sole producer of zirconium and is the world leader for this activity. CEZUS is, in particular, the world leader in production of zirconium alloy tubes and has 45 per cent of the market for zirconium alloys for civil nuclear applications, especially cladding tubes for pressurised water reactors (PWR) and boiling water reactors (BWR).

Located in France's Loire-Atlantique region, close to the city of Nantes, the Paimbœuf site produces fuel claddings with zirconium alloy, used because of its resistance to corrosion and its permeability to neutrons. These tubes, which are filled with pellets of UOX (uranium oxide) and MOX (mixture of uranium and plutonium oxide) powder, form the first of three levels of confinement of radioactive material.

Quality control

Although its products are intended for use in nuclear installations, the Paimbœuf plant does not house any radioactive materials and is not, therefore, classed as an INB (French classification – "basic nuclear installation" or installation nucléaire de base). It is not therefore subject to DSIN monitoring. However, the DSIN can carry out inspections at Paimbœuf as part of monitoring control of its supplier by EDF. CEZUS is fully owned by Framatome which provides the nuclear fuels to EDF power plants, EDF being the nuclear operator subject to the safety requirements imposed by the DSIN and, especially, having responsibility for quality control in its sub-contractors' facilities, including Paimbœuf[3].

In assessing the quality control in suppliers' facilities, EDF bases its judgement on the suppliers' quality assurance systems. The CEZUS plant, from this point of view, seemed to provide all of the necessary guarantees: the Paimbœuf plant was ISO 9002 and ISO 14001

[1] See the data sheet on the CEZUS company, in Annex 4, or visit the Framatome website: http://www.framatome.com/framatome.nsf/internet/SectActEnergieNucle_VF (click on: "combustible nucléaire" then "unités et filiales").

[2] These developments, which we were not able to locate precisely in time, are consistent with the COGEMA and Framatome Annual Reports for 1998 and 1999.

[3] In this way, for example, the DSIN has carried out quality control inspections in Dessel, Belgium, which supplies EDF, but not at the ATPu in Cadarache, France, which only provides fuels to foreign clients.

certificated. Moreover, the safety authority, has expressed the view that "*everyone agrees that, until then, quality control [*in the plant*] had been good*".[4]

3. Origin and extent of the flaw in quality control of fuel cladding tubes

Quality in question at CEZUS

Incomplete inspection of cladding tubes in zirconium alloy (rods or tubes) intended for nuclear fuel assemblies was detected on 24 February 2000, at the Paimbœuf plant, during maintenance on the inspection equipment. Depending on sources, 800,000 or 900,000 tubes[5] – may be more - produced between August 1998 and February 2000, are concerned. Framatome[6] says that it "*remedied this fault*" on 6 March 2000.

The inspection in question is an ultra-sonic check on tubes. According to a DSIN[7] information sheet, its purpose is to "*check their dimensions (outer diameter, inner diameter, thickness, roundness) and surface condition (absence of cracks)".* According to DSIN's assistant director, Mr. Jérôme Goellner[8], the origin of the problem was that the mechanical part of the manufacturing process was starting up before the automatic checking instrumentation came into operation. The first tubes of certain batches (a batch comprises 600 tubes according to Framatome, 650 according to DSIN) are thought to have only been checked over two-thirds of their length. According to Framatome, of the 1,584 batches concerned, the defective inspection process affected "*around one hundred*" tubes over that period. Records of inspections would have allowed the batches to be identified. This was done by verification by an operator on a computer screen of hundreds of thousands of ultra-sound inspection recordings (a process described as "*artisanal*" by the DSIN's assistant director). Framatome then declared, in a press release of 9 November 2000, that: "*of the 900,000 tubes inspected over the period in question, results show that compliance with inspection criteria cannot be demonstrated for one-hundred of the them […]"*[9]. However, neither Framatome nor DSIN did give any assessment of the reliability of the "review" procedure, nor any indication of involvement of outside auditors.

National and international impact

The Paimbœuf plant did not inform the management of Framatome's fuels section when the inspection flaw was identified, according to DSIN: "*the plant's quality department, on the basis of a statistical assessment, considered the risk of non-compliance of tubes to be sufficiently low.*" Framatome would have been informed only on 6 November 2000. The statistical analysis mentioned is based on the level of detection of faults by the ultra-sound technique: according to Blanche Penaud, Framatome's press department manager, that level is 3%[10]. This reject level is only 1.5% according to Jérôme Goellner, who also said that the quality control flaw "*concerns, at a maximum, only 11 rods*, based on calculations by Framatome and EDF. These non-complying rods would be distributed randomly in the fuel assemblies manufactured and sold by Framatome.

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[4] Personnal communication, Jérôme Goellner, Assistant Director, DSIN, 16 November 2000.
[5] One Pressurized Water Reactor (as EDF's type) uses approximately 10,000 to 15,000 rods per year (turn over of one quarter to one third of the core). The 900 MW EDF's reactors contain 41,500 fuel rods, the 1300 MW some 51,000 rods.
[6] Framatome press release of 9 November 2000, see Annex A3.
[7] DSIN has posted a note "*a generic incident* in tube inspection". This is presented in Annex A5 and is available on the Internet at http://www.asn.gouv.fr/data/evenement/2000-44c.asp
[8] Personnal communication, Jérôme Goellner, Assistant Director, DSIN, 16 November 2000.
[9] Presented in Annex A3. It should be noted that this "bulletin", like those from EDF and DSIN, was not distributed to the press by fax or e-mail, it was simply placed, without announcement, on the organisation's website.
[10] Information provided by Framatome to WISE-Paris, by e-mail, 20 November 2000.

CEZUS produces fuel cladding tubes for both EDF and foreign clients. In fact, roughly half of CEZUS' production is for export. Framatome, the world leader for nuclear fuels, has manufactured (or provided components for) reactors for operators as diverse as Electrabel (Belgium), Kepco (Korea), Eskom (South Africa), Vattenfall (Sweden), etc., and also supplied them with fuel assemblies of Framatome design. CEZUS contributes to this programme by manufacturing fuel cladding tubes used in those assemblies. This is, therefore **a worldwide problem,** as it is evident that "*some [tubes] may also have been used in products intended for foreign reactors*"[11].

According to the DSIN, the tubes, in the main, went to production plants at Romans-sur-Isère (FBFC), Dessel in Belgium (FBFC/FCF/BN) and to COGEMA's Mélox plant producing MOX at Marcoule, France. Fuel assemblies are produced from several batches of tubes and it is not possible to know exactly which reactors have been loaded with possibly defective tubes. In November[12], the DSIN drew up an initial list of nine receiving countries (other than France). These include Belgium, China, Germany, Japan, South Africa, Spain, Sweden and the USA. The respective safety authorities were informed, according to DSIN, and Framatome declared, in its press release of 9 November, that it even informed "*without delay, clients within and outside of the Group.*"

In an e-mail of 6 December 2000 to WISE-Paris, Philippe Saint-Raymond, assistant director of DSIN, explains that "*cladding tubes from the batches were used, notably, in the manufacture of assemblies for Belgian, German, Spanish, South African, Swedish and American companies*" and also mentions "*a fuel plant in China."* According to Philippe Saint-Raymond[13], review of the records shows that the batches destined for and/or delivered to Japan do not form part of those not fully inspected. He did not, however, exclude the possibility that MOX fuel for Japan could have been manufactured in the Melox plant at Marcoule or Belgonucléaire, in Dessel, on the basis of incriminated tubes.

As for South Korea, according to DSIN, the tubes were sent with their inspection records, of which no copies were kept. A surprising practice.

Effects on the plutonium sector

The effects of CEZUS' quality control flaw on manufacture of MOX fuel remain uncertain. This problem may concern three plants: Dessel in Belgium; MELOX at Marcoule; and the ATPu at Cadarache, in France. The first of these is a Framatome group plant, which –as parent company – communicated the corresponding information to the DSIN. However, we have not been able to determine whether or not MOX production in Dessel has been affected by this problem.

It is also difficult to be precise about the impact on production at MELOX and in the ATPu. It seems, however, certain that MOX was manufactured with tubes not fully inspected, as DSIN's Philippe Saint-Raymond states that "*some batches of tubes not yet used, in particular in the MELOX MOX production unit, have been withdrawn from the production line"*[14]. The company MELOX stated in a written answer to questions submitted by WISE-Paris that during the 18 month period in question "the cladding delivered by CEZUS have been used by MELOX exclusively [underlined by MELOX S.A.] in order to respond to needs of the production campaigns for EDF [underlined by MELOX S.A.]. In fact, to this day, the only production carried out for the Japanese were done for the client NFI. The cladding used by MELOX for these first fabrications have not been fabricated by CEZUS". And: "As of this day, a remainder of a few dozen claddings, received during the period in question, have not

[11] See DSIN press release, in Annex A1, 10 November 2000.
[12] Personnal communication, Jérôme Goellner, Assistant Director, DSIN, 16 November 2000
[13] Personnal communication, Phillippe Saint-Raymond, Assistant Director, DSIN, 6 December 2000.
[14] E-mail of 6 December 2000.

been engaged on the fabrication lines of MELOX". [15] Nevertheless, we have no information on potential deliveries to Belgonucléaire's Dessel plant in Belgium, and further exports to other countries.

DSIN has not, according to Philippe Saint-Raymond[16], verified the situation at MELOX, especially the allocation to the installation's two production lines (PWR or BWR fuel). MELOX S.A. states that each single clad tube receives an "individual and unique bar code" before the fuel manufacturing process. This "labelling" would guarantee the "trackability" of each single tube.

4. The implications for safety

Consequences of quality control flaw

Ultrasonic inspection consists of a check on the geometry of fuel cladding tubes, as well as a check of homogeneity of the metal making up the cladding. Inspection serves to certify the behaviour once the fuel rods are assembled and then loaded into the reactor. A defect in geometry could lead to incorrect dimensions, residual dust or scratches causing interaction between the fuel pellets and cladding. A gap of around one-tenth of a millimetre is essential between the pellets and the metal tube, so that deformation of the pellets during normal reactor operation does not cause mechanical stresses in the tube, nor deform or rupture it. Once loaded into the reactor, the non-complying rods could possibly prevent full insertion of the control rods between the fuel rods, due to excessive curvature of the cladding tube. If metal (i.e. the zirconium alloy) is found to be heterogeneous, tubes may leak, i.e. there may be loss of sealing of the cladding due to weaknesses arising from inclusions in the metal, meaning a radioactive leak into the primary coolant system. This in turn leads to somewhat higher exposure levels to radioactivity for plant staff.

Impact on safety

The fact that according to Framatome's calculations, statistically only a few tubes would be defective, has led various actors to minimise the problem. According to Jérôme Goellner, assistant director of the DSIN, EDF's 900-megawatt (MW) reactors presents 0.04 per cent of defective assemblies, 0.13 per cent for the 1,300 MW series. According to DSIN's other assistant director Philippe Saint-Raymond, there are, at present "*20 ruptured tubes*" in the French nuclear power plants. As a consequence, for EDF, the quality control flaw comes within the envelope of "*normal background noise*". However, according to DSIN, it is precisely leaking tubes that would be the most serious consequence that could be engendered by the tubes that were incompletely inspected in the Paimbœuf plant. EDF, for its part, is also reassuring: as a leak in the primary system is detected immediately, there would be no possible risk of leak beyond the confinement. The other problems that the tubes could cause – if they are not exactly ignored – are greatly minimised. Regarding pellet-cladding interaction, the DSIN admits that this is to be avoided, but adds that consequences would not be serious.

A parallel with the BNFL affair is justified from this point of view: although nothing to date indicates dishonest activities, as was the case in England, the origin of the CEZUS problem is the same as that at Sellafield, i.e. a flaw in the general quality control procedures. Furthermore, COGEMA revealed, in the same way, on 30 March 2000 a "*problem which arose in a software*" concerning recording of inspection data at the Cadarache ATPu MOX fabrication plant[17]. In this unfavourable context for the MOX industry, COGEMA

[15] MELOX S.A., « Eléments de réponse techniques », réf : questions de X. Coeytaux, WISE-Paris, received by e-mail on 19 December 2000

[16] Personnal communication, Phillippe Saint-Raymond, Assistant Director, DSIN, 6 December 2000.

[17] A COGEMA bulletin of 30 March 2000 described the function of the software in question. This consisted of recording of "secondary tests" on statistical samples of MOX fuel pellets. This was a second check carried out after an initial automatic one.

immediately alerted the German electricity companies affected directly by the problem (Siemens and Bayernwerk). Falsification of quality control documents for MOX fuel in the BNFL plant implied safety problems of the same nature as those that could be engendered by non-complying tubes from CEZUS. The management of the German nuclear power plant Unterweser decided at the time to unload BNFL MOX fuel that was considered suspicious. Nevertheless, Framatome today sees as justified the initial appreciation of the plant's quality department, of March 2000, that: "*the risk of non-compliance of cladding tubes is sufficiently low as to not warrant action other than corrective action on the inspection unit*".

5. Parallel Chronology of Events: BNFL and CEZUS

The falsification of quality control recordings at BNFL's Sellafield MOX Demonstration Facility (MDF) was revealed in September 1999 and jeopardized the privatization of the group. Here are some key dates on both chronologies, the BNFL and CEZUS Affairs:

18 February 2000: The UK Nuclear Installations Inspectorate publishes a damning report questioning BNFL's management.

24 February 2000: The CEZUS staff detects the quality control problem.

28 February 2000: The BNFL CEO steps down.

29 February 2000: Sweden cancels a shipment of research reactor fuel to Sellafield, since the delivery had become, in the words of Environment Minister Kjell Larsson, "very difficult, if not impossible" to justify in the light of the BNFL scandal.

1 Mars 2000: Kansai Electric Power Company punishes Vice-President and five executives for failing to report on the BNFL problem.

6 March 2000: CEZUS has corrected the quality control problem and restarts the process lines.

Given the scope of the problem and the potential commercial implications, it certainly did not seem the best moment for the CEZUS management to make public the encountered quality control flaw.

6. Disturbing Open Questions

As of 20 December 2000, many questions remain unanswered :

1. While it seemed possible to determine the number of French reactors concerned (49), Framatome classified the information as to the destination of the incriminated tubes as commercially confidential and declined any communication on the issue. However, why was it possible to identify the individual reactors that have been loaded with the questionable tubes in France and not the ones in the other countries?

2. DSIN claims to have informed all of the safety authorities of the other countries concerned before 10 December 2000. On 16 November DSIN has transmitted to WISE-Paris a list of nine countries. On 6 December 2000, DSIN's Saint-Raymond told us that South Korea, Japan and Switzerland were pulled off the list. South Korea would have received the tubes with the unique original of the ultrasonic test recordings. Japan would have been ruled out after a manual reading of testing recordings. No reason was given for Switzerland. The statement does not make logical sense for several reasons. If the South Korean test recordings are not available in France, it is impossible to tell whether they received any questionable tubes. Japanese officials at the Ministry of Trade and Industry (MITI), at the Science and Technology Agency (STA), at the Ministry of Foreign Affairs and at the Nuclear Safety Committee have stated to a Japanese reporter that they were not informed by DSIN of anything. However, if Japan had been on the list to begin with, Japanese officials would have been informed of the problem before DSIN could pull Japan off the list. Confronted with that contradiction, DSIN declared that in their first declaration to WISE-Paris they had given us the three countries by mistake…

ANNEXES

A1: DSIN bulletin of 10 November 2000

A generic problem

A defect in the quality control of manufacture of cladding of fuel rods used in EDF's pressurised water reactors
(level 1)

www.asn.gouv.fr, 10/11/2000

On 6 November 2000, EDF informed the Nuclear Safety Authority of an incident regarding the quality of manufacture of cladding for fuel rods used in pressurised water reactors. During an internal manufacturing review, the manufacturer found that quality control had been incomplete on several cladding tubes produced at the CEZUS plant (Framatome), in Paimboeuf, France, between August 1998 and February 2000.

The Nuclear Safety Authority carried out an inspection in this manufacturing facility on 8 November last.

After a maintenance operation on two of the three machines used, it was found that the first tube of each batch was able to enter the inspection unit before the instruments were operating. The plant corrected this problem in March 2000, without informing Framatome's national departments nor the clients.

Around 800,000 cladding tubes were produced during the period in question. Given the inspection process used, the manufacturer estimates that several dozens of tubes were only partially inspected. Investigations are now underway to identify the EDF reactors in which they were used. Some of the tubes may even have been destined for foreign reactors. Framatome has accordingly informed the companies concerned.

From the reactor safety point of view, a defect in cladding can lead to loss of sealing of the fuel rods during normal operation. Rod integrity is monitored during operation, in particular by monitoring of the radioactivity in the reactor's primary coolant system.

EDF declared a significant incident which the Safety Authority classed as level 1 on the INES scale given the defect in the manufacturer's quality assurance process and the long delay between discovery and declaration of the incident.

A2: EDF communiqué of 10 November 2000

Quality assurance failure affecting fuel cladding tubes (Belleville)

www.edf.fr, 10 November 2000

On 6 November 2000, EDF was informed by Framatome of a quality assurance failure affecting ultrasonic inspection of tubes manufactured between August 1998 and February 2000, at the CEZUS plant at Paimboeuf, France. These tubes were intended for manufacture of fuel rods.

Examination of records for 875,000 tubes manufactured during the period, most of which were for EDF, has shown that, statistically, 11 tubes are likely to fail to comply with the ultrasonic inspection criteria. However, the sealing of all fuel rods is checked before loading into the reactor.

If, in spite of everything, some of the tubes in question were to lose their sealing, this would have no consequences for safety of reactor operation. Furthermore, this would be detected immediately as the radiochemical activity of the water in the primary coolant system is monitored permanently, in order to ensure that the authorised limits are respected.

EDF has not taken any special steps to modify deliveries of fuel and reactor operation.

Although no real impact on reactor operation is expected, EDF has declared an incident of class 1 on the INES to the Safety Authority.

A3: Framatome press release of November 2000

Fuel manufacturing quality control at Paimboeuf plant

www.framatome.fr, 9/11/2000

A specific monitoring action carried out by the fuels branch of Framatome ANP on stages in manufacture revealed inadequacies in the automatic ultrasonic inspection unit for cladding tubes manufactured at the Paimboeuf plant between August 1998 and February 2000. The first tubes of some batches (a standard batch contains around 600 tubes) was only checked over two-thirds of their length.

The problem was remedied as soon as it was discovered and, since then, tubes have been checked over their entire length. Based on a statistical assessment, the plant's quality department considered the risk of non-compliance of tubes to be sufficiently low to justify only corrective action to the inspection unit.

A systematic check of inspection records in the possession of Framatome ANP has now been carried out. The results indicate that of the 900,000 tubes manufactured during the period in question, compliance with inspection criteria cannot be demonstrated for a hundred of them over a part of their length. Given the statistical data on the numbers of tubes rejected by ultrasonic inspection, a conservative analysis leads to the conclusion that less than 10 non-complying tubes would not have been detected.

Even if the results of this verification do not contradict the plant's initial appreciation, the strict application of quality assurance procedures should, nonetheless, have led to clients, both within the Framatome group and outside of it, being informed immediately.
Without waiting for the final conclusions of the quality audit it has carried out, Framatome ANP's fuels branch decided to inform all of its clients, and to provide them with the basis for its assessment of this failure in its supplier's inspection process as soon as possible.

A4: Framatome data sheet on CEZUS

CEZUS (Compagnie Européenne du Zirconium)

www.framatome.fr

Management: Paul MAZOYER, General Director

Shareholders: Framatome (100%)

Production sites: Jarrie (Isère), Ugine (Savoie), Montreuil-Juigné (Maine et Loire), Rugles (Eure), Paimboeuf (Loire Atlantique).

Contact:
CEZUS
Direction Commerciale
BP 02
49460 Montreuil Juigne
France
E-mail: cezus@framatome.com

Activities:
CEZUS specialises in the manufacture, transformation and sales of metals such as zirconium sponge and products made from alloys of zirconium (sheets, bars, tubes, and thin tubes for nuclear fuel assemblies). These tubes, highly resistant to corrosion, constitute the first barrier within the reactor between the uranium and the environment.

Main features and references:
CEZUS is the only European producer of zirconium and is the world leader in the field. It is also the prime producer in the world of zirconium alloy tubes. It holds 45 per cent of the zirconium alloy market for civil nuclear applications. Around 50 per cent of its products are exported. All of the stages of manufacture of zirconium are fully integrated: from ore processing through to the final product..

Certification: ISO 9002 - ISO 14001 (at Jarrie and Paimboeuf - in progress for other sites)

A5: DSIN note on the CEZUS Affair: a "generic incident", December 2000

A generic flaw

A failure of quality control in the manufacture of cladding for fuel rods used in power reactors (level 1)

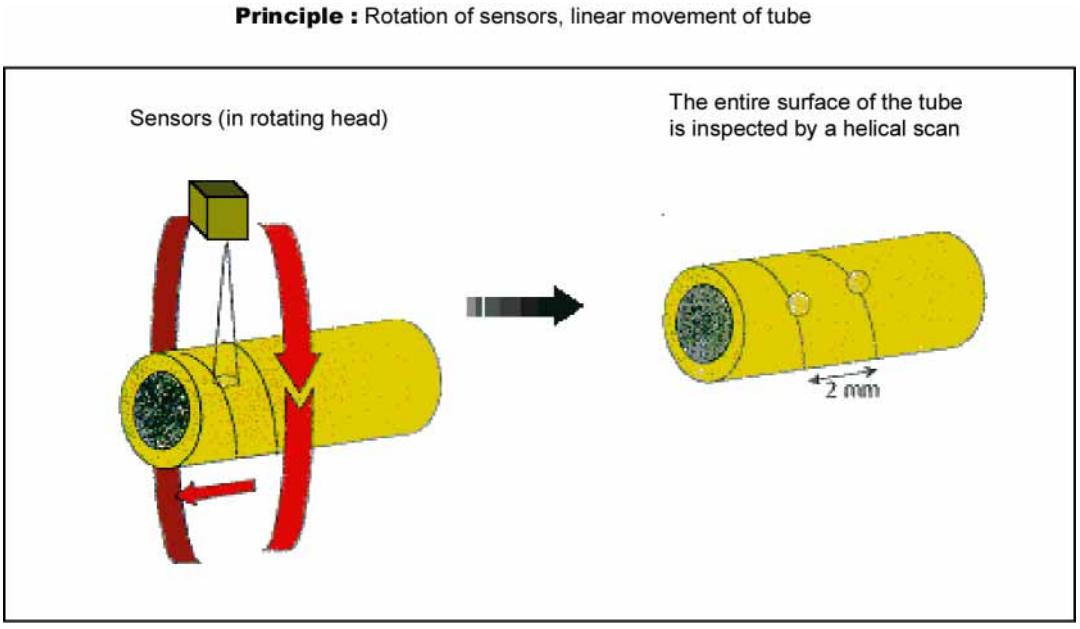
On 6 November 2000, EDF informed ASN (the French nuclear safety authority) of an incident that occurred in the manufacture of the cladding for fuel rods used in pressurised water reactors. During an internal manufacturing review, the manufacturer found that quality control had been incomplete for some cladding tubes produced in the CEZUS/Zircotube plant in Paimboeuf, France, between August 1998 and February 2000.

CEZUS, a subsidiary of Framatome makes tubes in zirconium alloy that are used as cladding for fuel pellets in the manufacture of nuclear fuel assemblies.

After a maintenance operation on two of the three inspection machines used, it was found that the first tube of each batch was able to enter the inspection unit before the instruments were operating. The CEZUS/Zircotube plant corrected this problem in March 2000, without informing Framatome's national departments nor its clients.

The principle of measurement

The machines provide an ultrasonic inspection of each tube to check that the dimensions (outer diameter, inner diameter, thickness, roundness) and surface condition (no cracks) comply with the hypothetical values given in the design documents for fuel rods and in reactor safety studies.



By way of illustration, a fuel rod cladding tube for a 900 MWe reactor measures around 3.8 metres and has a diameter of 10 mm. The technical methods used by Zircotube mean that more than 70,000 measurement points are checked by the inspection instruments.

The incident in figures

Around 850,000 cladding tubes were produced during the period in question. Given the inspection process used, the manufacturer estimates that several dozens of tubes were only

partially inspected. Correlation with the characteristic reject rate for the ultrasonic inspection used to characterise the quality of the CEZUS/Zircotube plant's manufacture shows that less than 10 tubes failing to comply with technical specifications have been supplied to Framatome's clients. In the absence of individual identification of tubes at this stage of manufacture, the un-inspected tubes may be in just about any of EDF's reactors, as well as in batches manufactured for export. There are around 42,000 tubes in a reactor.

Consequences of the incident for reactor safety

From the safety point of view, a defect in cladding can lead to loss of sealing of the fuel rods during normal operation. Rod integrity is monitored during operation, in particular by monitoring of the radioactivity in the reactor's primary coolant system.

The existence of leaking rods during irradiation is fairly common, although occurrence has reduced greatly since the introduction, 10 years ago, of anti-debris filters at assembly ends. The presence of a few rods with slight leaks does not pose a problem for safety. Only the production of effluents for the site and problems of radioprotection are increased slightly.

In accident conditions, the presence of such rods has no effect on control of the reactor to bring it to a safe condition and is not an aggravating factor for accidents, even in the worst case in which it is assumed that all of the probably non-complying tubes were loaded into the same core.

Action taken by the Nuclear Safety Authority

The ASN inspected the CEZUS/Zircotube facilities on 8 November 2000. In its initial analysis, the ASN noted that:

- the process of notification of manufacturing anomalies and incidents – as defined by EDF, Framatome and its subsidiaries – was not applied;
- quality requirements relative to the process of maintenance of inspection machines used for a qualified checking procedure (and one that is important for safety) are not specified;
- the requirements for qualification and authorisation of inspection machine maintenance personnel are not specified;
- EDF's monitoring of its supplier relates essentially to the supplier's quality system, to the detriment of the technical monitoring required by the Quality Order;
- the absence of individual marking of tubes does not allow for accurate identification of tubes not completely inspected or repaired.

The ASN has therefore asked EDF to reinforce monitoring of its supplier and to ensure that the supplier puts in place the corrective measures necessary to avoid re-occurrence of such malfunctions as quickly as possible.

The ASN has also informed counterpart organisations in other countries concerned by the problem.

The ASN classified this incident as level 1 on the INES, given the flaw in the manufacturer's quality assurance process and the long delay between discovery and declaration of the incident.