Problems with French European Pressurised Reactor at Flamanville

The EPR (European Pressurized Reactor) is the world's largest nuclear reactor with an installed capacity of 1,600 MWe. It has been developed by French industry as a new generation design that promises to be safer, more reliable and cheaper than reactors built in previous decades. It has been referred to and promoted as the flagship of a hypothetical nuclear renaissance. However, the first attempt to build the EPR reactor in Olkiluoto, Finland cannot be considered a success: since works started in 2005 the project has suffered from massive delays and cost overruns as well as technical and safety problems. The French supplier Areva decided to build a second EPR in France to demonstrate that the mistakes made at the pilot project in Finland will not recur in subsequent EPR builds. However the Flamanville EPR reactor is now following the same troubled route as its Finnish predecessor.

Chronology

In May 2006, the French utility EDF applied for authorisation to construct an EPR reactor at Flamanville, next to two already operating reactors built to an older design. Preparatory groundwork on the site was authorised and took place from August 2006 to December 2007. The programme consisted of:

- *blasting,*
- *excavation*
- *levelling the site to prepare the base which will support the EPR*

The Authorisation Decree for the Flamanville-3 EPR reactor was signed by the Prime Minister and published in the Journal Officiel on 11th April 2007. On 3rd December 2007, the first concrete was poured. Since then, work on the site has consisted of:

- *installing reinforcement,*
- *pouring concrete,*
- *pre-assembling the welded "metal liner" for the reactor containment*

Cross-referencing the work performed against the French Nuclear Safety Authority's (ASN) own assessment, it appears that all the these operations have encountered problems, often recurring problems.

The ASN decided to suspend concreting at the site on 21st May 2008 (this decision was made official on 23rd May). The ASN had already demonstrated considerable patience (it had been issuing warnings to the operator EDF for several months, but sufficient improvements were not implemented) before finally coming to the exceptional decision to stop the construction works.

The problems that prompted the ASN decision fall into three major categories:

- Organisation of work, quality control and oversight
- Reinforcement and concreting
- Metallurgy and welding.

In all these areas deficiencies have been repeatedly found, meaning that every aspect of building activity has proved problematic.

This document is a summary and breakdown of the various inspections that have been carried out by the ASN since the launch of the EPR site in Flamanville, and that led to the decision to suspend work at the end of May 2008.

A – Problems during preparatory work

1) The ASN issued warnings to the operator, EDF regarding lack of quality control and supervision.

Inspection 8th March 2007
The ASN wrote: "EDF management will nevertheless have to ensure that procedures for its actions and management practices are formalised." Regarding the need to formalise supervision, the ASN continues: "On the next batch of civil engineering work, you will ensure that procedures and management practices are approved before work commences." Yet even at this stage, when matters of management and supervision were being called into question, actual defects started to be noticed on the building site.

Inspection 9th May 2007
Concerning quality control of the backfill the ASN found: "the density of the backfill produced on site using crushed rubble from rock blasting did not comply with what had been anticipated: the density of the backfills produced approximated 2.5 instead of the planned density of 2.2. This anomaly was reported to the CNEPE…"

The ASN then wrote: "I ask that you give the reason why this change in the density of backfills, produced locally by crushing rocks, was only detected once work had started on the site, rather than during preliminary tests. "

2) Nonconformity of reinforcement of the concrete was reported.

Already in May 2007 - one year before these problems led to suspension of works – the problems with concrete reinforcement were detected.

ASN wrote: "An anomaly was detected in the course of this inspection: the lower reinforcement of the raft foundations near the concrete walls is laid out in groups of four juxtaposed horizontal bars. This does not allow for adequate concreting of the raft." Further in the report: "The reinforcement of concrete was performed in accordance with the working drawings, which were faulty".

This shows problems were introduced at the preparatory stage, flawed plans could only lead to defective work. These problems appeared as soon as work on the site began, well ahead of launching works directly related to nuclear power plant.

3) Even when blasting was carried out, not all went according to plan.

Inspection 9 May 2007
"Blast holes n°121 and n°139 were registered in a nonconformity form, as one of the vibration monitoring sensors indicated that the maximum speed threshold had been exceeded."

On 13th December 2007, the report indicates "overshoot during the blast on 29th June 2007".

4) Organisational deficiencies and inadequate supervision were consistently observed in the course of subsequent inspections.

Inspection 13th July 2007
ASN writes: "I ask that you comply within the shortest reasonable time with the requirements of the above-mentioned Order of 10 August 1984 by exercising supervision such that you may ensure that activities that have implications for quality are carried out

by individuals possessing the required skills, especially when a specific accreditation is needed."

Inspection 12 October 2007
ASN write: "I ask that you comply within the shortest reasonable time with the requirements of the Order of 10 August 1984 by specifying activities involving quality-control."

Inspection 25 October 2007
ASN writes: "I ask that you review the quality assurance system implemented on the site so as to ensure that activities with implications for quality are only undertaken if and when the conditions for their implementation are validated by said quality assurance system."

5) First problems of accreditation were recorded.

Inspection 25 October 2007
Regarding the installation of the device ensuring the imperviousness of the common raft, ASN writes: "In the course of this inspection, inspectors noted that one of the individuals involved in welding activities for the device insuring imperviousness did not possess the required accreditation."

The last inspection to take place during preparatory work - before the actual nuclear site was launched - did not show any improvements. In fact, one may wonder what led the ASN to allow the first nuclear concrete to be poured a few days after this inspection, despite the facts that the overall assessment was far from satisfactory; several of the problems encountered had become recurrent; and that EDF did not seem to be addressing these problems.

Inspection 29 November 2007
ASN writes: "B.1 Nonconformity to accepted engineering practice was detected in a reinforcement." There followed the same description as on 9th May 2007: "An anomaly was noted during this inspection as the arrangement of some of the peripheral groups of bars causes the juxtaposition of four horizontal bars (in the overlap areas): this does not allow for adequate concreting."

The critical issue of safety surfaced during the course of this inspection. This is highly relevant since in the later course of events, the ASN stated that problems mentioned up to this point did not have any impact on safety (more below on the issue of safety).

It is clear that the issue of safety came up during this inspection, which took place soon after the site was launched, or at least in the preparatory stage. Any defects occurring at this stage are liable to have an impact on safety. In the words of the ASN itself: "Inspectors carried out a sample inspection of memorandum ECFA 071114 index C, which defines the quality control plan for the production of the nuclear island's common raft. This memorandum indicates that you do not consider the installation of the geomembrane under the raft as an activity requiring quality control. However, this membrane has a twofold function **in terms of safety**: reducing infiltrations in case of an accident within the facility or in case of groundwater welling up."

In summary: This preparatory phase was already marred with difficulties in terms of organisation and supervision. In addition to that, defects were also reported (although EDF refuses to use term, which had nevertheless been used by the ASN).

B – During the "nuclear" site works

One might expect that from the moment the nuclear site works were to begin, the operator's attitude would change and become more rigorous. In fact, nothing has changed. The existing organisational problems have continued and the defects have accumulated. It is quite disturbing that EDF is incapable of correcting these problems.

Before the decision to stop the works in Flamanville was made, numerous inspections took place which identified chronic problems. Below is a list of some of the observations recorded at the time of inspections. It is not comprehensive, but it gives a clear picture that all areas of work undertaken so far have been repeatedly struggling with problems.

1) The concrete

Formulation

Inspection 3 and 4 December 2008

ASN writes: " A2. The concrete's formulation. Batch reports examined during the inspection showed E/C values were between 0.47 and 0.49. In the annex F of the NF EN 206-1 norm called 'recommendations for the limits of the composition of concrete' it is recommended that the ratio E/C should be under 0.45 for the exposure class XS3. Indeed E/C values over 0.45 are inadequate when it comes to limiting concrete cracking due to shrinkage, and ensuring durability in a marine atmosphere.
In accordance with my view concerning good building practice, already expressed in my letter following the inspection of 25/10/2007 (Ref: Dép-Caen-0955-2007), I ask you to respect a value E/C between 0.40 and 0.45 for concretes of XS3 exposure class, unless there is justification based on an incompatibility with safety demands."

Height of concrete pour

Inspection 3 and 4 December 2008

"A5. Height of concrete pour Inspectors have found that the height of concrete pour's specification i.e. less than 1.5 meters, has not been respected at the periphery of the raft foundation."

Cracks

Inspection 8 February 2008

ASN writes: "The inspectors observed the implementation of the method of injecting cracks in the HR raft in order to remedy a non-conformity." Apparenty, some cracks have developed in the base slab. It is surprising to find out about these cracks at this time and because these had not been mentioned previously.

The ASN inspector also commented: "I ask you to make sure that the treatment of non-conformities is carried out in accordance with the instructions set out in the method of operation. You should ensure that the remainder of the treatment is carried out in accordance with the instructions and you should send me the temperature readings which prove this. Clearly there was an additional problem that the temperature at the time of the filling of the cracks was below the minimum specified for that particular resin.

Non conformity in reinforcement
Inspection 5 March 2008

This inspection focused on the preparation for the concreting of block #2 of the nuclear island raft. This block corresponds to the zone of the nuclear island raft located underneath the future combustible (HK) storage building of the Flamanville-3. The safety of this building is therefore extremely important.

ASN writes: "As a result of the inspection carried out by partitioning, the organisation defined and applied on the work site for the preparation for this concreting operation is insufficient. More specifically, the quality of the reinforcement was not satisfactory because defects had been detected during the inspection, and yet authorisation to carry out concreting had already been given… During the visit of the block #2, inspectors and their technical staff have detected malfunctions in the existing reinforcement… Stirrups missing on the lower part, distance and lap lengths out of tolerance… I would like you to tell me how the concreting stage could have been launched with a reinforcement partially deficient."

Management of the concrete plant

The ASN has noted that values given for the quality of the concrete were on several occasions at the limit of authorised tolerance and that a few "batches" were even beyond acceptable tolerances. Here again, we can see that the problem goes beyond a problem of quality control and organisation, and is clearly a problem of know-how and competence.

Inspection 8 April 2008
Aggregate grading:
At the time of the construction of the raft of the reactor building, some of the concrete did not respect the required aggregate grading: "This resulted in the use for part of the raft foundation, of 27 m^3 of concrete for the concreting plant #1 and 9 m^3 for the concreting plant #3 out of aggregate criteria."

Batch out of tolerance:
"On inspection of concrete corresponding to the delivery ticket BL 2081, all 4 batches turned out to be out of tolerance regarding aggregates 0/1"

Concrete vibrating
For concrete to reach its required strength, it has to be "vibrated". The inspection states that: "The general specification of your contractor stipulates, regarding concrete vibration at the time of the pouring, that the concrete vibration has to be done every ten needle diameters in order to ensure a good homogeneity of the layers of concrete. In addition, the depth of vibration has to be sufficient to allow a homogenisation between the different layers of concrete pours… Inspectors observed that concrete vibration procedure of block 1B was not always rigorously respected."

There were also other problems mentioned, but this list is sufficient to show that all along the process all the operations were affected. In the process of making concrete, each operation has to be done correctly. Here, each one has shown significant defects.

2) Metallurgy and welds

Apart from works in the civil building, there has been only one other piece of work done at the Flamanville-3 construction site. It is the so caller pre-assembly of the steel liner – a vital part of the protection containment structure which protects the reactor. The second envelope includes this steel liner to guarantee its imperviousness and resistance. It is therefore essential for safety that this component is produced at the highest possible standard. But in Flamanville this work has been suffering problems.

The steel manufacturing company Tissot, based in Bordeaux, is in charge of the pre-assembly of the segments constituting a big cylinder, and these elements are then transported to be finally assembled on site at Flamanville.

Inspection 8 April 2008
The protocol from this inspection is especially interesting. It is certain that in most industries, a company would never be permitted to work in a non-accredited workshop.

To achieve quality welds in terms of imperviousness and resistance:
- **Welders must be qualified and accredited** for the particular type of work they have to do. You cannot weld pieces of a nuclear reactor or nuclear submarine as you would weld a plough or a wheelbarrow.
- **Workshops must receive a precise accreditation**. For example, to weld in optimal conditions, the ambient temperature and the temperature of the elements to be assembled are extremely important. To assemble two metal pieces it is often necessary to pre-heat them in order to guarantee a real fusion instead of a simple "gluing".

Defects listed during the inspection and answers from EDF concerning this problem of liner remind one of the list of defects one is likely to find in the work of apprentice welders. EDF notes: "it seems important to us to remind you that the kind of defects found through X-ray testing are mainly due to a lack of fusion and sticking; and, to a lesser degree, to slag inclusions. Such defects are typically those of semi-automatic welds."

ASN's answer: "Inspectors noticed that the contractor had not applied for the accreditation of his liner fabrication facility on the site at Flamanville. To date, liner pre-assembling operations have been carried out without the required qualifications…" This ASN letter also indicates that all parties concerned have been aware of this situation since 26 November 2007, but that "The situation continues despite the fact that defects were discovered right from the beginning."

Inspection 19 February 2008
ASN wrote already in February that: "The inspectors noted that a quarter of the pre-assembled base of the liner showed welding non-conformities… The check check revealed the workshop's lack of qualification as of 26 November 2007... This situation persisted even though welding non-conformities were revealed on the first piece of work – non-conformities which called into question the workshop's qualification in terms of the reference documents."

As the ASN did not stop production of the liner a non-accredited workshop is still allowed to produce defective welds for a vital element of the reactor. **The ASN should have stopped not only the work in concrete, but also the liner construction.**

C – The response from EDF:

In view of all these inspection letters from the ASN, Greenpeace has asked EDF to provide copies of all correspondence that the company exchanged with the ASN in order to meet its demands. A month later, EDF gave access only to part of responses, not including those that relate to the concrete.

However, even from couple of answers to the ASN it is quite clear that EDF's definition of "nuclear quality standards" differs from that of the National Safety Authority. EDF's approach is to explain to the ASN that its inspectors are mistaken.

For example, in relation to testing of the raft of the reactor, ASN inspector wrote: "I ask you from now on to consider this test as part of the quality requirements." To that, EDF answered by explanation of the test itself and concludes that it does not consider the ultra sound test to meaningfully contribute to the nuclear quality standard.

Another example is that EDF insists on applying of national standards, whereas the ASN demands European standards, which are in fact more restrictive.

D – Keeping to schedule at the cost of quality

On December 3rd 2007 the first "nuclear concrete" was poured. This was highly publicised by EDF. Given the problems encountered on the first EPR construction in Finland, it was imperative for EDF to keep strictly to time schedules and costs in France. As far as costs are concerned, it's not yet possible to evaluate them, either for the public or for prospective clients of the EPR. On the other hand, work on the site is behind schedule. Pressure has been intense right from the beginning, and trade unions have complained about it in public on several occasions.

The ASN itself is worried about it. The protocol from the inspection of October 25th 2007 contains a very important sentence:

"With regard to the recorded discrepancies during the inspection, the inspectors consider that EDF should give priority to respecting the conditions assuring quality rather than to respecting the time schedule."

The protocol from inspection on December 3 and 4, 2007, contains similar remark: **"I note however that the specifications for this test, as well as the analysis of the results obtained, were produced in haste without any quality assurance process."**

E – It is indeed safety which is at stake

According to the press agencies, Thomas Houdré, the ASN department head of Caen, declared: "Technically, these defects do not raise safety issues". At the same time, he noted that concreting was suspended in areas "important for the safety of the future reactor" - or as is known more precisely, the nuclear island and the pumping station that are suffering problems with steel reinforcement.

Also, on its website, ASN writes that the order to stop work does not concern "works which are not on the safety list". It is quite clear from this that only those related to safety are concerned – this shows that the problems were potentially impacting nuclear safety.

Reading various ASN letters, it is obvious that defects and non-conformities found in areas such as the reactor support base or the containment liner are directly linked to nuclear safety.

Notes:

Full English translation of selected ASN letters can be downloaded here:

- December 2007 inspection: http://www.greenpeace.org/international/press/reports/asn-nuclear-safety-authority-2
- February 2008 inspection: http://www.greenpeace.org/international/press/reports/asn-nuclear-safety-authority
- March 2008 inspection: http://www.greenpeace.org/international/press/reports/asn-nuclear-safety-authority-3

Contacts for additional information:

Yannick Rousselet, Greenpeace France, tel. +33 685 806 559

Jan Beranek, Greenpeace International, tel. +31 651 109 558