FANC
federal agency for nuclear control

Flaw indications in the reactor pressure vessels of Doel 3 and Tihange 2

Frequently Asked Questions

SITUATION

1) Is there a present danger?

It is in any case essential to remember that the reactors Doel 3 and Tihange 2 are shut down for outage and that the fuel has been discharged from the reactors. There is therefore no danger for the population, the workers or the environment.

2) What is the conclusion of your analysis of the report the FANC received from Electrabel in December 2012 ? What is going to happen with Doel 3 and Tihange 2?

At this very moment, the FANC sees no elements that would have to lead to a permanent shutdown of the Doel 3 and Tihange 2 nuclear power units. Nevertheless, it has asked for additional information from Electrabel before taking any decision on a potential restart. Only when having examined all the data, the FANC will be able to determine whether the safety margin is not impaired. (see also press release of 15 January 2013 and technical information note of 1 February 2013).

3) Why did you allow the analysis to be carried out by Electrabel instead of by totally independent experts? Electrabel is not neutral in this matter.

Electrabel is the licensee of the nuclear power plants and has the responsibility to demonstrate the safety of its installations. Electrabel has conducted a thorough analysis with the assistance of Belgian and international experts. These analyses took 5 months and a vast team of engineers of Electrabel has been working full time on this inspection.

The analyses performed by Electrabel have, in turn, been examined in detail by the FANC, by its technical subsidiary Bel V, by the external authorised inspection agency AIB- Vinçotte, and by the Scientific Council for Ionising Radiation (having mandated 4 specialised Belgian professors) and have been subject to advice from an international experts' panel. Furthermore, the Agency also called upon the experts of the regulators of several other countries to conduct a thorough analysis of the Electrabel file.

4) Why does it take several months?

Safety is of the utmost importance. The Doel 3 and Tihange 2 situations have been analysed expertly. Firstly by Electrabel, that had a vast team of engineers working full time on this case because the FANC wanted it to establish a safety case as complete as possible.

After having received the file from Electrabel, Bel V and AIB-Vinçotte conducted a technical evaluation. The Agency also called upon the experts of the regulators of several other countries to conduct a thorough analysis of the Electrabel file. Also the Scientific Council for Ionising Radiation (that mandated 4 specialised Belgian professors) and an international expert panel have given their advice.

Then, by mid-January, the FANC concluded that additional information and tests were necessary before it would be able to decide on a possible restart.

5) What additional information?

The Agency asked Electrabel to provide additional information and to perform some specific tests, such as, for example:

- The FANC asked Electrabel to perform a so-called 'load test'. This test is the only material test that can be performed on the reactor vessels themselves (other material tests are performed on samples of similar materials or samples presenting similar flaw indications). During these tests the resistance of the reactor vessel is checked under more severe conditions than during the normal operation of the reactor, by increasing the pressure on the reactor vessel. It will be investigated how these flaw indications react under this extra pressure and whether or not they evolve.
- During a load test, use is made of acoustic emission technology in order to verify whether the flaw indications are influenced by the pressure and whether or not a higher pressure causes a degradation of the materials. After the load test a new ultrasonic inspection of the reactor vessel is performed to verify that the flaw indications haven not evolved.
- The FANC also asked that tests would be performed on samples of similar steel elements that were manufactured for a nuclear power plant, but were not used because they presented similar flaw indications. These tests will check the mechanical strength.

6) When will the government decide on a possible restart of the nuclear power plants?

First of all, we have asked Electrabel to provide additional information. On the basis of this information, the FANC will be able to make a well-founded recommendation to the government. The government will then take the final decision. It is not possible to make any predictions with regard to the timing in this respect.

7) How serious are the flaw indications in the reactor vessels' steel?

These flaws were very probably generated during the casting and forging process of the vessels. These "hydrogen flakes" are present in the walls of the 20 cm thick reactor vessels.

For experts, these flaws are no unknown phenomenon. They can also appear in other steel constructions. But, since in this case, we are talking about a nuclear power plant's reactor vessel, we need to be extra careful because safety is of the utmost importance. This is the reason why Electrabel performed these comprehensive analyses that, subsequently, have been examined by the FANC.

At this very moment (January 2013), the FANC sees no elements that would have to lead to a permanent shutdown of the Doel 3 and Tihange 2 nuclear power reactors. Nevertheless, it has asked for additional information from Electrabel before taking any decision on a potential restart. Only when having examined all the data, the FANC will be able to determine whether the safety margin is not impaired.

For more information, we refer to the technical note of 15 October 2012 and the technical information note of 1 February 2013.

8) How large are these flaw indications? Where are they situated?

They are present in the metal walls and have an average size of 10 to 15 mm , and are as thin as a cigarette leaf.

9) For how long have these flaw indications been present in the reactor vessels?

Specialists presume that they were generated during the manufacturing process and have been there for thirty years. In the final inspection reports of the manufacturing of the pressure vessels these indications were however not reported. It seems that since then, they have not grown and have not been influenced by the nuclear reactions (irradiation of the reactor pressure vessel) during all these years.

10) There are several thousands of flaw indications?

We can describe them as little flat flakes (hydrogen-flakes) of which several thousands of indications have been detected in the metal walls of the reactor vessels. In the Doel 3 reactor vessel there are about 8000 indications, in Tihange 2 about 2000.

These flaws were very probably generated during the casting and forging process, at the production stage in the end seventies. In spite of the fact that these indications have not led to incidents over the past 30 years, the FANC wants Electrabel to perform additional tests. If these tests are conclusive, we can recommend the government to decide in favour of a restart of the nuclear power plants.

For more information, we refer to the technical note of 15 October 2012 and the technical information note of 1 February 2013.

11) In the documentation regarding the manufacturing of the reactor vessels these flaw indications were not reported.

The presence of the flaw indications detected in the summer of 2012 was not mentioned in the final inspection report regarding the manufacturing of the reactor vessel. However, according to the standards applicable at that time, the report was complete. Consequently, on the sole basis of the manufacturing file nothing can be proved with regard to these flaw indications, but all of the research experts are inclined to conclude that the hypothesis stating that the flaw indications were generated during the manufacturing process is the most plausible one.

12) Why were these flaw indications not detected sooner?

A new ultrasound measuring technique was used for the first time in June 2012 over the whole surface of the Doel 3 reactor vessel. This inspection was conducted by a specialist French firm on behalf of Electrabel. This is the first time in Belgium that the base material of the reactor vessel was tested (elsewhere than in the weld zones). The whole wall of the reactor vessel was also inspected, although the ASME XI standards only recommend inspection on sensitive zones.

13) Why was this issue not highlighted in the stress tests?

The stress tests focused on the resistance of nuclear power stations to extreme external phenomena such as earthquakes, floods (tsunamis), aircraft crash, loss of electrical power and loss of ultimate heat sink subsequent to such events, etc. which led to the events in Fukushima.

The situation of the reactor vessel is monitored according to strict regulatory schemes, that are followed to the letter.

14) Can the results of the stress tests still be considered valid?

Results of the stress tests are still perfectly valid. In any case they had an altogether different purpose.

15) How about the safety of the other nuclear power reactors in Belgium? Will they also be submitted to stringent safety tests?

The FANC asked Electrabel to speed up the planned ultrasonic inspections.

Given the recent decision to extend the operation of Tihange 1 by ten years, the FANC has already demanded that the same inspection be conducted on this unit early 2013. For Tihange 3 this inspection is planned by the end of 2013.

For Doel 4 and Doel 1 & 2 the specific ultrasonic investigations aimed at detecting potential flaws in the reactor vessel are planned as follows:

- For Doel 4, these inspections are planned in 2015, as initially scheduled;
- For Doel 1 & 2, these inspections are no longer planned to be performed (initially scheduled in 2015) given the fact that both units will then be permanently shut down.

16) Specialists pretend that worldwide there is a problem with reactors of the same type as Doel 3 and Tihange 2. How many other nuclear power plants are possibly in the same situation and what is the state of affairs there?

There are indeed other nuclear reactor pressure vessels that were manufactured in the seventies by the same company. FANC worked alongside regulators of the countries concerned to provide them with information about Doel 3 and Tihange 2. The FANC, however, cannot speak on their behalf but we know that several countries carried out inspections that were necessary to make sure that their power plants are safe. Up to now, similar flaw indications were not found in other reactors.

17) What % of the total nuclear energy capacity in Belgium do Doel 3 and Tihange 2 represent?

The two nuclear power plants represent about a third of the nuclear energy capacity. They provide at about 15 to 20% of the total electricity production in Belgium.

18) The two nuclear power reactors have now been inoperative for several months. What is the current situation of the electricity supply in our country? Will we be confronted with an energy shortage in case a restart is not possible?

We think this is rather a question for the State Secretary of Energy, since he has an overview of the energy supply in our country. We have to be able to work fully independently of economic or energy-related considerations. The FANC's mission is to supervise the safety of the nuclear power plants.

19) The FANC is always associated to nuclear energy, whereas its mission is much wider. Why would that be?

The FANC is indeed in charge of the supervision of different subsectors, such as, for example, the very close follow up of the medical sector, where ionising radiation is used as well, for example in X-ray imaging. The nuclear power plants however usually receive most attention due to the major social concern about the safety in this field.

BACKGROUND INFORMATION

20) What are the different levels of protection of a reactor?

To ensure containment of radioactive materials, there are three resistant, leaktight physical barriers between such materials and the environment so as to form a triple shield against radiation and to retain the radioactivity inside the installation in all circumstances:

First barrier: fuel cladding

The ceramic fuel pellet that retains most of the radioactive products within itself is encased in a sealed metal tube.

Second barrier: primary containment

This consists of a thick steel pressure vessel enclosing the reactor coolant system. The reactor vessel forms an essential part of this safety barrier.

Third barrier: containment vessel

The whole primary system (and other components of the reactor) is surrounded by a very thick concrete building capable of withstanding a certain stress and external accidents.

The Belgian nuclear power stations have a double-walled containment structure insulating the primary system and the active nuclear fuel that it contains from the outside world.

21) What is the function of a nuclear reactor vessel?

It is in the reactor vessel that the water of the main primary system flows through the core, where it is heated by the nuclear fuel. The water then transfers its heat to the secondary system in the steam generator before returning to the reactor. The generated steam goes to the turbines and electricity is produced.

The reactor vessel plays an essential part in three safety functions of the reactor:

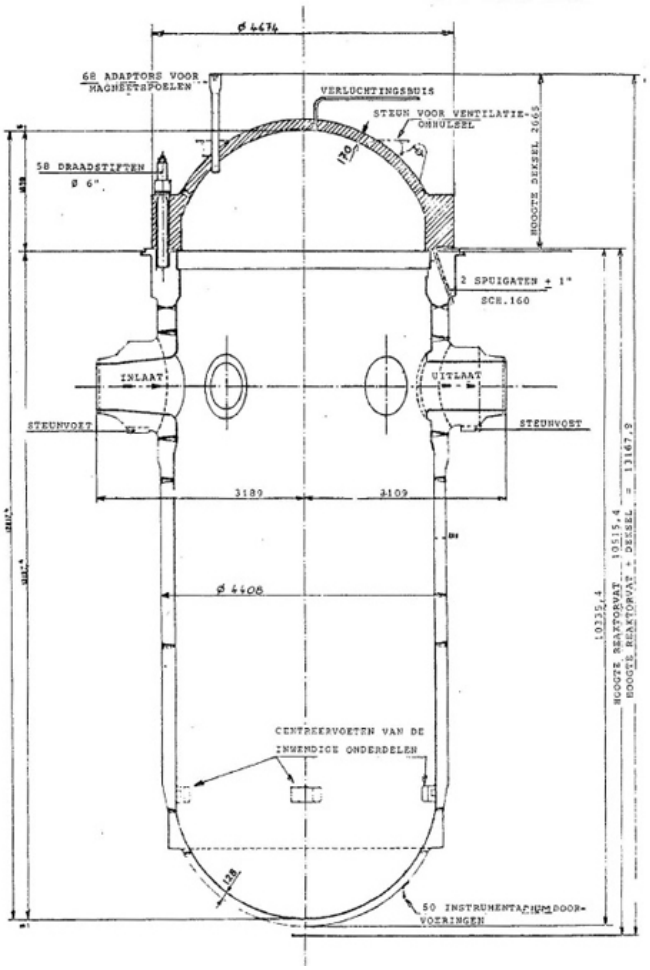
- confinement of the radioactive material;
- geometric criticality control;
- core cooling.

22) What does a nuclear reactor vessel look like?

A nuclear reactor vessel is a cylinder closed in its bottom section by a hemispherical base. In the upper section it is capped by a removable vessel head in the form of a sphere. This design gives access to the interior of the vessel after the reactor vessel head is lifted off and, in particular, to the fuel assemblies for their replacement.

The vessel head is held on to the body of the vessel with bolts screwed into the flange of the vessel, the nuts resting on the upper surface of the cover flange.

The three loops of the reactor coolant system are connected to the reactor vessel. The primary water runs in and out through 6 tubes.



23) How is a nuclear reactor vessel built?

The nuclear reactor vessel consists of a vessel shell or body and a vessel head. The reactor vessel is about 13 m high (vessel head included) with an outer diameter of 4.4 m and it weighs a total of 330 tonnes (vessel head and bolts included). The walls of the cylindrical part of the vessel are up to 20 cm thick.

The reactor vessel is made of forged and low-alloy steel components. The main components of the vessel (shell rings, flanges and tubes) are obtained by metallurgical forging and machining operations. These parts are welded together and protected from corrosion by a thin inner stainless steel liner (approx. 7 mm), generally consisting in two layers. At the end of construction the resistance of the reactor vessel is checked with a pressure test conducted at a pressure higher than the maximum operating pressure. These tests are conducted in accordance with the American ASME standards.

24) How is a vessel inspection carried out?

Every 12 to 18 months Belgian nuclear power stations are subjected to an inspection of their installations and repair and maintenance operations. During this outage the reactor is shut down and the core is partially refuelled.

During these outage periods the so-called ‘operating’ inspections are conducted to check the good condition of the reactor vessel (mainly weld zones between vessel elements). Non-destructive ultrasound measuring techniques are used. These inspections are carried out in accordance with standards developed for metallurgy by the American Society of Mechanical Engineers (known under the name of Standards ASME XI).

The routine inspections are carried out according to the rules of the international code ASME XI. The complete inspection cycle is ten years: after each period of 10 years all the sensitive zones have been inspected.

Are inspected on this occasion: zones prone to cracking, e.g. zones subjected to high (mechanical and thermal) stress that could lead to cracks. These are primarily weld zones (between the rings, etc.) and duct tubes in the reactor cooling circuit.

25) Who conducts this inspection?

The inspection is conducted by Intercontrole, a specialist French company (member of the Areva Group) that inspects annually a large number of reactor vessels in accordance with the requirements of the ASME code (mandatory and complementary) and feedback from experiences in the area.

This inspection is followed-up by an Authorized Inspection Agency for pressure nuclear vessels (AIB Vinçotte International in Belgium) that must agree on the conclusions set out in the report.

26) What is the role of the FANC in this inspection?

The results of the inspection by Intercontrole, followed-up by the l'AIA, must be sent to Bel V and then to the AFCN. The latter makes the final decision whether to authorize (or not) the restart of the unit.

27) What does "ASME" mean?

The *American Society of Mechanical Engineers* (ASME) is an international organisation including several thousand engineers with a view to cooperation and sharing of technical expertise. It is involved in a wide range of activities in the broad field of mechanical sciences. ASME is structured in different geographical sections, i.e. twelve for the United States and one foreign section, itself divided into four sub-sections, including one for Europe.

Among their activities the members of ASME develop codes and standards relating to mechanical engineering that are updated on an annual basis.

Section XI of the ASME standards contains rules for inservice inspection of nuclear power plant components.

28) Why not just repair the reactor vessel?

Any repair to the vessel is practically impossible and, according to the AFCN, is not the option to take, because it is feared that such an operation would create new stress in the vessel walls, which must absolutely be avoided.

29) Why not just replace the reactor vessel?

A replacement of the vessel is extremely difficult (high radiation dose, etc.) and has never been done anywhere in the world.