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Lupold, Timothy

From: Collins, Jay
Sent: Tuesday, August 07, 2012 1:14 PM
To: Lupold, Timothy; Hoffman, Keith
Subject: FW: Potential problem on the reactor pressure vessel (RPV) of the Belgian Doel 3 NPP
Attachments: RPV control in France_2.doc

fyi

From: CROMBEZ Sebastien [mailto:Sebastien.CROMBEZ@asn.fr]
Sent: Tuesday, August 07, 2012 12:30 PM
To: Petteri.Tiippana@stuk.fi; pierre.briegleb@belv.be; jcb@csn.es; Hardies, Robert; Collins, Jay; Kirk, Mark; dietmar.Kalkhof@ensi.ch; kees.desbouvrie@minvrom.nl
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Subject: RE: Potential problem on the reactor pressure vessel (RPV) of the Belgian Doel 3 NPP

Dear all,

Please find enclosed ASN answers to your questions. We focused on French manufacturing experience feedback because, in a few cases, large amount of flaws which seem quite similar to those detected in Doel 3 were observed in France. Theses flaws were detected and the components rejected before end of manufacturing.

Do not hesitate to ask in case you have something to clarify or to ask additional questions.

ASN will attend the meeting planned on 16th.

Best regards

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Sébastien Crombez

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Objet : RE: Potential problem on the reactor pressure vessel (RPV) of the Belgian Doel 3 NPP

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please find our answers to your four questions in the attached file. Do not hesitate to ask in case you have something to clarify or to ask additional questions.

Unfortunately, due to regulatory activities related to outage at Loviisa NPP, we are not able to send our expert to the proposed meeting on the 16th. Anyhow, we would be interested on any follow-up on this issue.

Best regards

Petteri Tiippana
Director
Nuclear Reactor Regulation
STUK

From: Briegleb Pierre [mailto:pierre.briegleb@belv.be]
Sent: Wednesday, July 25, 2012 10:40 AM
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Subject: Potential problem on the reactor pressure vessel (RPV) of the Belgian Doel 3 NPP

Dear Sirs,

We are now facing in Belgium a potential problem on the reactor pressure vessel (RPV) of the Doel 3 NPP.
Non-destructive examination revealed a lot of "indications" that need to be confirmed by another inspection technique (ongoing).

We would like to have your feedback, experience and advice regarding this potential problem. You will find hereunder a more comprehensive background and some questions we would like to answer.

Best regards,

Pierre Briegleb
National Project Coordinator
Bel V – Subsidiary of the Federal Agency for Nuclear Control (Belgium)

Potential problem on the reactor pressure vessel

Belgian pressure vessels are inspected according to ASME XI. Volumetric inspections of the beltline zone are normally limited to the circumferential welds and surrounding heat affected zone and base material, within the limits settled by the code.
Additionally, as a result of the experience at Tricastin, inspections aiming at detecting possible underclad defects in the pressure vessel beltline region are planned for all Belgian plants. The first inspection of this kind took place at Doel 3 this summer.
These inspections are performed with a qualified method and encompass the whole height of the vessel beltline region. This means that we inspect cladded base material in zones where no volumetric in-service inspection was performed up to now.

At Doel 3, according to the Owner, no underclad defects were detected.
Nevertheless, lot of defect indications of an apparently different type were detected by this UT-inspection aiming at detecting underclad defects, especially in one of the three forged rings (SA-508-cl.3). These indications appear to be laminar flaws, more or less parallel to the inner/outer surface of the pressure vessel, located in- and outside the inspected zone where underclad defects were looked at. Obviously, it is not possible to justify those indications on a one-by-one basis by means of an analytical evaluation according to the App. A of ASME XI code requirements.

The inspection method which revealed the presence of those defects has been qualified for detecting underclad defect.
An inspection of the whole height with the qualified method used to control the beltline welds started on the 16th of July; the results should not be available before begin of August. Similar inspections will be performed at Tihange 2 during the month of August.

In the absence of any other explanation at this stage, the Owner supposes to be in presence of fabrication defects.
The Doel 3 and Tihange 2 RPVs were forged by Rotterdam Dockyards (RDM), which according to the Owner provided some 24 vessels in Europe and the US. NUREG 1511 – Suppl. 2, p. 7-3, identifies 8 US units with RDM forged rings. Other European countries possibly concerned are Spain, Switzerland, the Netherlands (Borssele, Dodewaard), and probably others, not identified by Bel V at this stage.

Some questions:

1. Are there in your country RPVs (forged rings) fabricated by Rotterdam Dockyards (RDM)?
2. Is there any known concern with respect to fabrication defects in those rings?
3. Did you perform volumetric inspections in the beltline region which could have detected laminar defects in the beltline base material (a) during fabrication (b) in-service? If the answer is yes, describe which inspection (type, extent, frequency) and the corresponding results.
4. Do you perform inspections aiming at detecting underclad defects? If so, describe which inspection (type, extent, frequency) and the corresponding results.

1. Are there in your country RPVs (forged rings) fabricated by Rotterdam Dockyards (RDM)?

No, forged rings for French RPV's were forged by Creusot-Loire Industrie.

2. Is there any known concern with respect to fabrication defects in those rings?

Different types of manufacturing flaws were detected in forged components manufactured for French nuclear plants. A precise study was performed by ASN in 1985 concerning main type of defects which led to components rejection between 1980 and 1985. These types of flaws are:

- Inclusions: some pressurizer shells, SG tubesheets, and RPV nozzles were rejected due to this type of defect
- Forging flaws (decohesions, cracks): some RPV nozzles, RPV closure head, SG tubesheets and RPV shells were rejected due to this type of defect
- Hydrogen induced flaws (also called segregation cracks): 14 components were rejected due to this type of defect between 1983 and 1985. SG tubesheets, RPV shells (forged from a hollow ingot), SG bottom heads, RPV flanges, and SG support rings were concerned

In 1968 and 1969 a RPV shell and a RPV flange were rejected due to hydrogen induced cracks (components manufactured for foreign projects).

This year, 2 SG shells for French SG steam generator replacement program were rejected due to a large number of hydrogen induced cracks. These shells were forged from a hollow ingot: one of them contained about 5000 indications and the other one about 700 indications between 2 and 6mm (size estimation based on NDE results). Indications on the second shell were located on two lines on the opposite sides of the shell: it is supposed to be due to combined factors including presence of Hydrogen with critical concentration and stresses caused by a "round shaping" operation performed at a too low temperature.

We used the term "hydrogen induced flaws" for cracks due to hydrogen concentration in segregation areas. These flaws appear between a few days and a month after qua lity thermal treatment. Their shape can be intergranular or transgranular. Their orientation is parallel to the grain flow (with variations of about 10°).
Regarding French manufacturing experience feedback, only hydrogen could explain such a large number of laminar flaws in a shell. We observed that when hydrogen induced cracks are found in a component, several hundreds or thousands of cracks can appear, with a surface size about $50mm^2$.

3. Did you perform volumetric inspections in the beltline region which could have detected laminar defects in the beltline base material (a) during fabrication (b) in-service? If the answer is yes, describe which inspection (type, extent, frequency) and the corresponding results.

In service inspection aims at detecting and sizing undercladd defects and flaws in welds (see next answer)

The manufacturing flaws described previously were detected by non-destructive testing performed during manufacturing.

Concerning Creusot-Loire Industrie, ultrasonic testing has been performed during manufacturing since the 50's. A non-destructive testing with both straight beam and 45° angle beam techniques has been required from the beginning of manufacturing (1970 [1]), has been described in dedicated procedures since 1976, and has been introduced as a requirement in the RCC M code since 1983.

After rejection of a significant number of components in the early 80's, ASN performed a large review of the results of the non-destructive testings performed between 1980 and 1985. This review aimed at detecting defects that could have been hydrogen induced cracks.
For this purpose, a "surveillance area" corresponding to the area where segregations may occur was defined. Every group of indication in that area was supposed to be hydrogen induced cracks. For example, Framatome rejected components with a group 20 or 30 indications between 3 and 4mm (size estimatation based on NDE results).

ASN reviewed the results of control performed on more than 300 components and concluded that they were confident in the inspection performed by Creusot-Loire. But ASN also conclude that it was impossible with this type of control to make a difference between inclusion and hydrogen cracks without taking into account manufacturing parameters (hydrogen concentration, duration of gas stripping heat treatment,...) and considering separately isolated indications and group of indications.

The orientation of hydrogen induced cracks makes ultrasonic control with the straight beam technique at 0° efficient for their detection. Detection criteria was based on the backwall echo loss and corresponded to defects with a diameter of 3mm (expertise of real hydrogen induced cracks detected with UT signal corresponding to 2 to 4 mm diameter defects showed that UT signal underestimated the flaws size: real size was between 3 and 6mm). Detection criterion was set to 2mm. Then, in 1992 this criteria evolved and is now based on reflectivity of a flat bottom hole.

In order to detect manufacturing flaws, non-destructive testings are required at final quality heat treatment stage but they were often performed twice, at different stages, on the same component: at preliminary heat treatment stage and at final quality heat treatment stage.

4. **Do you perform inspections aiming at detecting underclad defects? If so, describe which inspection (type, extent, frequency) and the corresponding results.**

In service inspection to detect undercladding flaws has been performed since 1989 (Fessenheim 1 first decennial outage) but first concerned only welds. From 1991, a control of all the RPV core shells has been required by ASN. Since 1998, this examination is performed on each RPV shell at the second ten years outage. It is renewed at the 3rd ten years visit.

Techniques evolved since 1989 and testing method is currently qualified to guarantee the detection of a 5*25mm defect. The inspection concerned the first 20, 25 or 30mm through wall extent from the interface between cladding and parent metal of the shell depending on the process used). Most shells have been inspected several times.
37 undercladding defects were found, 20 on Tricastin 1 RPV. 12 RPV are concerned. A few other types of defects were found but no crack or laminar flaw. No French RPV can be compared to Doel 3. We asked EDF to give us more precise information about other defects detected to date.

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[1] First version of the CPFC (general requirements for manufacturing, inspection and welding)