



CONTACT RECORD			
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Title / Topic: <i>(include level 1, 2, 3 or 4 if applicable)</i>	Review of Sizewell B (SZB) Lifetime Records in relation to forgings manufactured by Creusot Forge		
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Completed / Compiled By: <i>(name, programme)</i>	[REDACTED]		
Type of Contact: <i>(*delete not applicable)</i>	Meeting (EdF Nuclear Generation Ltd (NGL) Barnwood)		
Contact With: <i>(names, position, organisation)</i>	[REDACTED]		
ONR Staff: <i>(names, role, programme)</i>	[REDACTED]		
Summary / Key Points:			
See below for Conclusions and Recommendations			

Background

- On 29 April 2016 AREVA released a press statement announcing that a quality audit had revealed historical production monitoring **anomalies** on a number of components (forgings) manufactured at their Le Creusot plant (Creusot Forge), and that they were in discussion with the French nuclear safety authority, L'Autorité de Sûreté Nucléaire (ASN), on the matter. AREVA stated that at this preliminary stage no information had come to light that would jeopardise the mechanical integrity of the components and that a status report would be provided by 31 May 2016.

2. On 4 May 2016 ASN issued a press statement stating that the audit at Creusot Forge had been requested by ASN and that it had revealed **irregularities** in the manufacturing checks on about 400 components produced since 1965, of which about 50 were in-service on French nuclear power plants. The irregularities comprised inconsistencies, modifications or omissions in the production files concerning manufacturing parameters and test results.
3. Following these press releases, ONR contacted ASN for further information, and a teleconference was held with ASN's department for nuclear pressure vessels (who are leading on this work for ASN) on 11 May 2016 to discuss the matter further [REDACTED]. The meeting confirmed that ASN had initiated the review following recent quality issues at the plant, and although they had been notified of the inconsistencies, they only had limited technical information at that point in time. The nature of the inconsistencies were thought to be related to aspects such as material composition, heat treatment, mechanical tests, and most were judged to be of a relatively minor nature. The focus of the ASN discussions with AREVA was in relation to forgings used in the French fleet, but their understanding was that AREVA had not found any irregularities in the documentation for the forgings produced for Sizewell B or Hinkley Point C. AREVA committed to contact non-French Licensee's by 31 May 2016 if any anomalies were revealed in relation to their plants.

Affected components

4. The following forgings were supplied by Creusot Forge for Sizewell B project according to EDF Nuclear Generation Ltd (EDF NGL) records – 22 forgings in total. Note that the anomalies relate to the forgings supplied by Creusot Forge and not the subsequent fabrication of the Reactor Pressure Vessel (RPV) and Steam Generators from these components.

Reactor Pressure Vessel RPV (six main forgings plus eight smaller forgings)

- Head dome
- Closure head flange
- Vessel main flange
- Nozzle shell course (plus 8 inlet/outlet nozzles)
- Transition ring
- Lower dome

Notes:

- a. EDF NGL's lifetime records contain information on a second nozzle shell course manufactured by Japan Steel. Although it would have been clear at the time of manufacture which forging had been used, a review of lifetime records by EDF NGL in 2012 had initially indicated that the Japan Steel forging had been used for the Sizewell B. However, a subsequent review of the lifetime records confirms this not to be the case.
- b. The current RPV head is not the original RPV head. The original head was replaced during a refuelling outage in 2006 and the replacement head was manufactured from forgings procured for the original Hinkley Point C project. These forgings were made by Creusot Forge around the same time as the other Sizewell B specific forgings, and the records associated with these forgings are held by EDF NGL as part of the lifetime records for Sizewell B.
- c. The only forging for the RPV not supplied by Creusot Forge was the core shell course. This was supplied by Japan Steel.

Steam Generators (two forgings per generator, so eight forgings in total)

- Upper shell 1
- Upper shell 2

The other six forgings per steam generator were supplied by Japanese forging manufacturers.

Pressuriser (None)

The forgings for the pressuriser were supplied by Sheffield Forgemasters

Position with regard to the operation of Sizewell B

5. At the time of the announcement by AREVA and ASN, Sizewell B had already shutdown for its refuelling outage, so the concerns had no direct impact on nuclear safety. The planned return to service date was the end of May/early June. ONR advised EDF NGL that ONR would have to consider its position on the anomalies prior to issuing a consent to return to service [REDACTED]
6. NGL have therefore approached AREVA for information on the forgings supplied to Sizewell B and conducted an internal review of their position based on their own lifetime records and evidence from in-service inspections.

Approach to AREVA

7. EDF NGL approached AREVA with a view to obtaining confirmation on the position with regard to the SZB forgings by 20 May 2016 (ie confirmation required in advance of the 31 May date). They proposed [REDACTED] that if AREVA could confirm that the Sizewell B forgings were not affected then they would provide a statement in the Return to Service (RTS) documentation with regard to the anomalies, and a copy of the supporting statement from AREVA. If, however, anomalies were identified, then a separate justification would be required.
8. The current position is that AREVA has confirmed to EDF NGL by email on 20 May 2016 [REDACTED] that their initial screening to identify which records have potential anomalies has been completed, and that of those with anomalies, none relate to forgings supplied for Sizewell B. Notwithstanding this, AREVA also claim that where anomalies do exist, none would preclude the return to service of a plant.
9. NGL will therefore include a statement on the matter within the application for the return to service consent for Sizewell B and a copy of the AREVA email.

EDF NGL internal review

10. EDF NGL has reviewed the position on Sizewell B safety case based on their understanding of the independent checks which were undertaken at the time of manufacture, their own lifetime records, and the in-service examinations which have subsequently taken place. EDF NGL is confident that the safety case for Sizewell B is secure based on this evidence and an internal management brief provided an overview of this was provided to ONR for information in an email [REDACTED] EDF NGL plan to include the arguments on why it is independently confident that the safety case is secure in their RTS ISI (In-Service Inspection) document.

11. To further support this review NGL has undertaken work to re-examine the lifetime records they hold on these forgings. This was to satisfy itself that there are no obvious anomalies in the records provided by Creusot Forge. In addition NGL's internal regulator, Independent Nuclear Assurance (INA), is to undertake a review of the lifetime records looking at the rigour of the independent checks undertaken during manufacture and seeing to what extent the in-service inspection activities have added to the case. The scope of this review was provided in an email [REDACTED]

ONR review of Sizewell B lifetime records

12. EDF NGL made its Sizewell B lifetime records available to allow ONR to undertake an independent review of these records to provide additional confidence in advance of the return to service of SZB.

13. To this end, I attended the Barnwood site on 24 May 2016 to review the Sizewell B lifetime records in order to consider:

- the completeness of these records;
- any evidence of anomalies within their records; and
- an understanding of why the nozzle ring forging was mis-identified.

in the context of the Creusot Forge manufactured components, and

- to consider whether sample information should be obtained which may be subsequently cross checked with records held by Creusot Forge.

14. Details of the review are shown in Annex 1.

15. From the sample of records examined I conclude that:

- lifetime records are comprehensive and complete for the Creusot forgings;
- I found no significant anomalies;
- there was evidence of some non-conformances being recorded in the records which were subject to concession arrangements consistent with its quality assurance arrangements;
- with regard to inspection there is alternative evidence to support the quality of the forgings;
- the earlier identification of the origin of the nozzle forging was due to a shortfall in the organisation of the storage system rather than a failure to keep sufficient records.

16. Sample information can be requested from the EDF NGL records in the future should ONR choose to review data held by Creusot Forge itself, and no information was obtained for this purpose during my visit.

17. Whilst I was satisfied that the records were comprehensive and complete, access to the records relies on the use of an ageing microfiche system on which they are stored. I therefore recommended that EDF NGL consider alternative storage and retrieval systems to improve accessibility of the records and to ensure that the records in the systems will remain accessible for the station life and into decommissioning taking into account any life extension plans.

Discussion

Potentially affected forgings

18. Twenty-two forgings were supplied by Creusot Forge for manufacturing the RPV and SGs used in the Sizewell B project. Creusot Forge forgings were not used in the pressuriser. At ONR's request, EDF NGL undertook a further check to confirm that Creusot Forge were not involved in the supply of piping forgings for either the main steam lines or the main coolant loop [REDACTED]. I am therefore satisfied that EDF NGL have identified all the forgings used in Sizewell B that were supplied by Creusot Forge.

AREVA quality audit

19. The audit undertaken by AREVA was at the request of the French nuclear regulator. Whilst ONR has not been involved in the quality audit undertaken by AREVA, I think it is reasonable to assume that the audit has been undertaken with an appropriate degree of rigour.
20. I can therefore take confidence in the assurance provided by AREVA to EDF NGL that no anomalies have been identified in the records relating to the forgings supplied for Sizewell B. However, ONR has not ruled out the possibility of examining the records held by AREVA at some future date.

Quality controls in place at the time of manufacture

21. The manufacturing quality controls in place during manufacture are to ensure that the forgings are produced to a good quality with the necessary material properties and without significant defects.
22. The anomalies or inconsistencies found by AREVA and ASN have not yet been defined in detail, but the ASN press release talks of inconsistencies, modifications or omissions in the production files. This could therefore potentially affect compositional records, heat treatment records, mechanical test records and inspection records.
23. However, additional checks and controls were implemented at the time of manufacture of the Sizewell B forgings over and above the standard controls due to the high integrity levels demanded by the Sizewell B safety case for these components. This was as a direct result of the UK's Marshall Study Group report into Light Water Reactor design and ONR's predecessor (the Nuclear Installations Inspectorate at the time), was satisfied that these checks and controls were implemented. An Independent Third Party Inspection Agency (ITPIA) (Lloyds Register (LR)) was appointed to ensure suppliers' procedures have been approved and to carry out surveillance and witnessing activities [REDACTED].
24. From my review of the lifetime records associated with the Sizewell B forgings it is clear that these checks and controls are reflected in the documents supplied by Creusot Forge. All necessary documents are stamped up and signed by LR and there is clear evidence that where there is a non-conformity with a specification, then appropriate and documented concessionary action has been taken.
25. In addition it is recognised that the additional controls on material composition and checks on providing fracture toughness measurements for each forging would have increased the level of scrutiny of this work and reduced the likelihood and any anomalies in recording the data. In particular, the requirement for the measurement of fracture toughness properties for each forging was undertaken at the Creusot Loire technical centre, and was ground breaking for the time. It was therefore undertaken independently of the normal manufacturing routines and was the subject of

considerable interest from a number of expert parties thus reducing further the likelihood of any anomalies in the data being present.

26. In the case of inspection of the forgings, diverse and redundant inspections were undertaken at the time of manufacture which leads to the availability of documentation which is independent of Creusot Forge. For example, automated inspection work was undertaken independently of Creusot Forge and is not subject to any questions regarding anomalies or inconsistencies. Therefore the case that the forgings were supplied essentially defect free can be independently substantiated from the manufacturing records.
27. Separately, the extensive inspections that have been undertaken on the RPV during the current 10 year outage, and the previous 10 year outage need to be recognised. No reportable defects were found. Whilst these inspections were focussed on the welds, they do extend into the adjacent forgings. These inspection results provide further support to the case that the forgings are essentially defect free. (Note the extended inspection of the RPV core shell forgings undertaken at the current outage provides further confirmation that the core shell forging is defect free, but that forging was supplied by Japan steel, and so is not material to this commentary on Creusot Forgings).
28. Thus in terms of the material properties achieved for the forgings, reliance has to be placed on the quality of the records supplied by Creusot Forge in order to support the safety case. My view is that there is considerable evidence to support a view that there is a low likelihood of anomalies being present from a review of the historical records and that the material properties achieved the necessary specifications.
29. In terms of the forging being supplied essentially defect free, there is evidence independent of Creusot Forge to support this assertion.

Overall conclusions on the quality of the forgings

30. AREVA's confirmation that the current anomalies do not apply to forgings supplied to Sizewell B and my review of the lifetime records held by EDF NGL support my opinion the forgings supplied were of a good quality; that they would have met the required material property specifications; and that they were essentially defect free.

EDF NGL and INA response

31. EDF NGL had previously undertaken a detailed review of their manufacturing process and lifetime records for the forgings used in the RPV, SGs and pressuriser in 2012/2013 in response to the Doel 3/Tihange 2 hydrogen flaking issue. Whilst this review was focussed on steel making processes and the control of hydrogen, the review did provide a compelling set of arguments to underpin the quality of the forgings supplied for these vessels. ONR's assessment of the review for the RPV was published on ONR's website [REDACTED] EDF NGL also undertook a further review of manufacturing records in 2015 following the carbon segregation issues found on the Flamanville 3 RPV top and bottom domes, and also found good reason to be confident in the quality of the forgings supplied by Creusot Forge.
32. Even though EDF NGL had recently undertaken these reviews, it proactively undertook a further a review of the lifetime records, following the AREVA/ASN announcements, to establish a view on the quality of their records. EDF NGL has not identified any anomalies but it is currently pursuing the option of auditing records at Creusot Forge to provide further assurance. In addition INA has undertaken its own review of the

records held by EDF NGL with a view to establishing the reliance on Creusot Forge records and will be involved in auditing records at Creusot Forge if that takes place.

33. EDF NGL has also sought, and obtained, timely assurance from AREVA that the anomalies do not relate to Sizewell B forgings, and will provide a general overview of the integrity demonstration in the RTS documentation for Sizewell B following the current refuelling outage [REDACTED]
34. I therefore consider that EDF NGL has been proactive in considering and addressing the potential impact of these anomalies.

Overall conclusions and recommendations

35. Although ONR has not been involved in the quality audit undertaken by AREVA, this work has been undertaken at the request of the French nuclear regulator ASN. As such the audit should have been undertaken with an appropriate degree of rigour. I can therefore take confidence in the assurance provided by AREVA to EDF NGL that no anomalies have been identified in the records relating to the forgings supplied for Sizewell B.
36. In addition, from my understanding of the work that was undertaken at the time of manufacture to ensure the quality of the forgings supplied by Creusot Forge for the Sizewell B project; my review of the lifetime records held by EDF NGL; the in-service inspection results that have been obtained for Sizewell B at the current and previous outages; and the work that has been recently undertaken by EDF NGL to review their lifetime records; I am confident that the forgings supplied by Creusot Forge for Sizewell B are of good quality.
37. I am therefore satisfied that the Sizewell B safety case has not been affected by the recent announcements on these forgings.
38. **I therefore recommend that:**
- The recent announcements from ASN and AREVA on the forgings supplied by Creusot Forge does not impact upon ONR's decision to grant consent to re-start Sizewell B following the RO14 outage.
39. Clearly it is prudent to keep the matter under review. I support NGL's decision to review historical documentation at Creusot Forge to check for consistency with the supplied records and ONR should monitor this work and sample these records.

40. I therefore make the following recommendation:

- ONR should monitor the work undertaken by EDF NGL to audit records at Creusot Forge related to forgings supplied for Sizewell B and ONR should take the opportunity to sample historical documentation itself.

41. Whilst my review of the lifetime records held for Sizewell B concluded that they were complete and I did not find any anomalies, EDF NGL need to consider alternative storage arrangements.

42. I therefore make the following additional recommendation:

- NGL should implement alternative storage and retrieval systems to improve accessibility of the lifetime records for Sizewell B and to ensure that the records

in the systems will remain accessible for the station life and into decommissioning taking into account any life extension plans.

43. An ONR Regulatory Issue (suggested at Level 3) should be created to monitor progress and closure of the latter two recommendations.
44. In addition ONR should continue to monitor developments in relation to these historical anomalies. In particular, ONR should maintain its links with the ASN Department of Nuclear Pressure Vessels to monitor developments and understand the nature of the anomalies discovered.

1 ISSUES

1.1 Issues Raised

The Contact Record can also identify issues raised as a result of the Contact, normally the issues will be recorded against duty holders present. The issue could be raised due to a potential regulatory non-compliance, now or in the future. These issues should be recorded on the ONR Issues Database after the contact and subsequently tracked and managed. In general, these will be Category 4 issues that can be easily followed up via subsequent contact/interventions. More significant issues should be categorised higher and progressed in the usual manner. Please refer to the Regulatory Issues Management process.

No	Issue Title	Category	Issue Level	Licensee/Duty Holder Role	Owner (Inspector)	Completion /Review Date
4469	AREVA Forging Anomalies		L3	[REDACTED]	[REDACTED]	25 May 2017

1.2 Issues Closed

No	Issue Title	Category	Issue Level	Licensee/Duty Holder Role	Owner (Inspector)	Completion /Review Date

Circulation List

Organisation	Name / Responsibility	Date
Office for Nuclear Regulation	[REDACTED]	14 June 2016

Annex 1

ONR Review of SZB Lifetime Records

At the time of my visit the NGL metallurgy team had undertaken a detailed review of the lifetime records and in particular extracted information related to the nozzle shell forging which would be used for a visit which was being planned to AREVA Creusot works for Thursday 26 May. [REDACTED] would attend. The visit subsequently had to be postponed as AREVA were unable to host the NGL team on that date.

[REDACTED] gave an introduction to the SZB structural integrity safety case for the IoF components, and explained about the high level of quality assurance in place at the time of manufacture, the tighter compositional specifications, and the diverse and redundant inspections undertaken. I said that I believed that the SZB specific requirements over and above code compliance were as a direct result of the Marshall Study Group's recommendations on Light Water Reactors. I also explained that ONR were most interested in what could have changed as a result of questions over the provenance of the documentation provided with the Creusot forgings.

[REDACTED] gave an overview of the INA activities which have involved considering where the safety case would lie if there was doubt over the Creusot information. He considered that the inspection results would be secure due to the diverse inspections undertaken, and the difficulties would lie with the material composition and properties. Compositional problems could affect both material properties and thermal ageing. Confidence could be obtained for the Lloyds register certification of the composition and the mechanical tests, but if there was a major concern material samples could be analysed from archive material. GW noted that specifications were in place for these aspects but it was down to the people involved. The quality release documents for the forgings appeared good and there was evidence of corrective actions having been taken. Overall INA would be looking to issue a concurrence statement which would include this aspect on Friday 27 May.

I asked [REDACTED] what concerns he had with the records. He explained that the CEGB were not in direct control of the forging manufacture, and whilst he had no concerns with regard to the actual lifetime records, what was more difficult was piecing together the narrative of what happened at the time from the contractual documentation. The relationship was CEGB-Westinghouse-Framatome-Creusot Loire industries (Creusot Loire industries being a sub-contractor to Framatome, and who ran the Creusot Forge facility). [REDACTED] provided me with a copy of [REDACTED] which explains the interface arrangements for the procurement of the RPV including the use of Lloyds register as the ITPIA (and also the Independent Inspection Authority (IIA) in ASME terms).

The NGL library/info centre had been closed for the day to facilitate my review, and records were accessed from the microfilm viewer that was available in there. Scanned copies could be made of individual pages if required.

A 238 page document exists providing an index to the microfilms, [REDACTED]. This guide is essential to locating records, and proved to be very effective and accurate in identifying both the film reels and individual frames, the latter being essential as there are a few thousand frames on each film reel. A duplicate set of films is held at SZB and in a fire proof vault at Barnwood.

Whilst the equipment and index worked well on the day, it is obviously a cumbersome system to use and the documents are in negative form so are hard to read. [REDACTED] therefore provided an explanation of what the system held using paper copies printed out previously for the Nozzle shell course (to support their visit to Creusot Forge).

Copies of original documents from spool [REDACTED] were provided for my inspection and a small sample of these records were retained by me to demonstrate completeness of the records. The documents covered:

Chemical composition – in ladle and on part analysis. Notably the material specification to which they were working was clearly referenced, and whilst I did not cross check back, the tighter and extended material specification used for SZB was clearly apparent.

Mechanical test results – standard results for yield and UTS along with Charpy values. Interestingly one of the documents showed that there was a failure to achieve the specified UTS. There is a clear reference to concessionary action to address this. The lifetime records should contain this, but not in this case. NGL will follow up on the concessionary action with Creusot Forge, but the failure to meet the specification was only by a few percentage points and there is evidence of a second test which showed adequate UTS.

Fracture toughness testing was undertaken at the Creusot Loire research facility rather than at the forge. The requirement for measuring fracture toughness directly for each forging was a new innovation for the SZB forgings. Tests were undertaken at 43°C and 293°C. Full data is provided on the load displacement graphs. The K_{Ic} and J_2 values achieved were comfortably in excess of those required.

Manual UT results were available for the parent forgings both before and after quench and temper. One minor non-conformance was recorded, but again there was clear reference to the concessional action.

All the documentation dates from 1984/1985 and in all cases the LR stamp and signatures were present to confirm the values.

The documentation on the microfilms relates to the information pack provided by Framatome for the complete vessel. I therefore asked where the automated UT result for the forgings were kept. These inspections were SZB specific and undertaken by Babcock. ■ explained that they had the records for these on microfilm reels at Sizewell. He provided paper copies from those microfilms. The automated UT actually recorded a larger non-conformance than found by manual UT. This would have been subject to the required quality assurance concessionary arrangements at the time (it was three individual defects) but there was no reference to the concession. I also asked how someone would know that the automated UT records existed as they were not part of the main lifetime records. WB explained that the automated UT would have been noted in the Identified Reference in the SZB safety case on achieving RPV integrity (IR 5.3(1)), but I noted that not having a unified set of records was a limitation, and also the lack of a reference to the concession was a limitation. However, the records did confirm the existence of an automated UT on the forgings which was completely independent of the inspections undertaken by Creusot forge.

I enquired where the heat treatment information was stored as that had not been shown to me. ■ and ■ were unable to locate that information on the microfilms, but ■ believed it existed, but was just not properly referenced. They agreed to cross check this.

I asked to see the records for the forgings used for the SZB replacement RPV head – forgings manufactured for the original HPC. These are on NGL's CDMS system as .pdfs, and are notably easier to access. The records date from 1989 and did include information on the heat treatments and evidence of a non-conformance which was subsequently sentenced. This was useful in both showing that the heat treatment records do exist in the supplied lifetime records, but also that the lifetime records have been stored for the replacement head, and in a form that is much more easily accessible.

I asked to see microfilm records for the core shell forging. This had been manufactured by Japan Steel Works (JSW), and I was interested to see how their records would have been incorporated in to the lifetime records supplied by Framatome. The records were easily located. The compositional data and basic mechanical data were all supplied by JSW and signed off by LR. They were compatible with the information supplied by the Creusot forge, and the tighter compositional specification used by SZB could be seen. The fracture toughness test were undertaken the Creusot Loire research facility.

I then asked to see microfilm records for the lower transition region on the RPV. Again they were easily found. I looked at the records related to chemical composition; mechanical tests; fracture toughness, UT inspection results. Again there was a clear LR stamp and signature on each document and all aspects were within the required specification (including the UTS values) and the fracture toughness values were again well above minimum requirements. I was unable to see the automated UT results as these are not available at Barnwood.

I finally asked to see records for the Main Steam Line forgings. These were on a different microfilm, but that was located with ease and the necessary frames found. It showed a similar degree of rigour in the records and the material had been supplied by an Italian company. I asked to see the similar records for the Main Coolant Loop pipework. That posed a difficulty as that pipework is not classed as IoF and the lifetime records index available only covered the IoF components. [REDACTED] suggested it may be in the Balance of Plant lifetime records that have a similar index system. [REDACTED] agreed to follow this up.

I concluded my review of the lifetime records at that point.

[REDACTED] then talked me through the investigation they had undertaken as a result of the CR they had raised following the initial misidentification of the origin the nozzle shell forging for the work undertaken looking at the steel manufacturing processes applied for SZB following the Doel 3 hydrogen flaking issue. At that time they had thought the forging had been supplied by Japan Steel works (JSW), whereas the one used was supplied by Creusot forge (multiple nozzle shell forgings existed at that time).

The investigation was suitably thorough. It noted that the main interest at that time was the steel making route, and that was the same for both Creusot Forge and JSW, so the actual origin of the forging was not material to their conclusions. The confusion came from the independent manual UT records held in contractual documents for the forgings. This was a record from a British Engine inspection of the JSW nozzle shell forging, and led NGL to believe, along with some other misleading corroborative evidence, that, the JSW forging had been used for the RPV. Subsequent review of the lifetime records, and in particular tracing the 'heat' numbers from the castings used to produce the forgings (which carry all the way through the manufacturing process), showed that it was actually the Creusot forging which had been used.

I was satisfied with the explanation, but the error shows up limitations in the lifetime records storage system (note the system rather than the records themselves).