

# Review Report

Report to AREVA NP for Contract 15TEEGN1019

Ref: LR-A/2015/APV1501000

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## 1. Executive summary

AREVA NP requested Lloyd's Register APAVE (LR-A) to "examine how and in which way AREVA Creusot Forge (ACF) quality assurance system, procedures, practices and organisation were and are used to demonstrate and to record the conformity of the products toward regulatory and contractual requirements."

Following meetings held at ACF on 19 and 20 May 2015, representatives of ACF and LR-A met at ACF in June and July 2015 in accordance with an agreed plan. The main technique adopted was interview with some audit checks. In preparing this report, analyses were carried out against the terms of reference for this review and against IAEA GS-R-3. There are six general conclusions, 38 detailed conclusions and 14 recommendations in the report.

Attention is drawn to three areas which require particular focus by AREVA:

### (1) Quality systems and root cause analysis of all negative findings including non-conformances

In general since 2010 activities at ACF are well-organised and controlled. However records of internal audits from 2011 to 2014 demonstrate that there are consistently over 40 negative quality-related findings each year. Comprehensive root cause analysis has not been performed by ACF. In addition, the 96-day target time for closing the non-conformances generated within ACF continues to be exceeded. This indicates that wider and common issues requiring management attention may not be recognised within ACF.

The April 2015 Management Review of AREVA HE emphasised attention to closing non-conformances but it is not clear if resources are available for this to happen and whether a comprehensive root cause analysis is planned, or if the consequences of that root cause analysis will be addressed and implemented. The report also recommends that negative findings in internal audits should be recognised and managed irrespective of whether they are classed as non-conformances, observations or areas for improvement.

The report recommends an evaluation to decide if ISO 9000, ASME and SAP systems are sufficient for the business in which AREVA HE operates and / or if elements of these systems are counter-productive to quality and nuclear safety objectives.

### (2) Steelmaking

ACF does not specify steelmaking parameters relating to ladle preparation, degassing, pouring speed, ingot solidification control and chemical analysis. The report recommends reconsideration of the interface with the steelmaker for this and other concerns. The report also recommends using accredited laboratories for testing.

### (3) Qualification of plant and processes

The report recommends reviewing product qualification programmes and on completing qualifications for new plant and processes.

Overall, the review showed evidence of a quality and safety culture. Further reinforcement of this culture is planned by AREVA HE.

It is not possible to reach an overall conclusion of confidence in activities before 2010 from earlier Management Review reports. To increase confidence, further specific investigations would be required. The report recommends maintaining existing management and technical records to enable specific investigations that may be required in future.

## 2. Introduction

Lloyd's Register APAVE (LR-A) responded to an enquiry from AREVA NP to carry out a review of AREVA Creusot Forge (ACF). AREVA NP set the following objectives for the Review:

- "Examine how and in which way Creusot Forge quality assurance system, procedures, practices and organisation were and are used to demonstrate and to record the conformity of the Products toward regulatory and contractual requirements as well as international standards set by Creusot Forge's costumers and national safety authorities (hereinafter collectively referred as the "Requirements") including but not limited to:
  - RCC-M Code
  - French law and more specifically:
    - Arrêté du 12 décembre 2005 relatif aux équipements sous pression nucléaires (hereinafter referred as "ESPN")
    - Arrêté du 7 février 2012 fixant les règles générales relatives aux installations nucléaires de base;
  - ASME Code;
  - NSQ-100;
  - 10 CFR 50 app B, that is a law from the United Stated of America;
  - International Atomic Energy Agency Safety Guide IAEA GS-R-3;
- "Examine the technical relevance of all technical processes implemented at Creusot Forge in order to ensure that the review will lead to a comprehensive inventory of all potential issues.
- "Evaluate the proficiency level and the quality and nuclear safety culture within the current organisation."

The Methodology section of this report explains that the Terms of Reference in the AREVA enquiry and subsequent contract were developed into a programme of eight blocks for investigation mainly by interview. The Methodology section also refers to the analyses in Appendices 2 and 3 of the report, produced after the interviews were concluded. The tables in Appendix 2 demonstrate the extent to which the terms of reference were met and relate to some of the conclusions. The table in appendix 3 of the report relates to IAEA GS-R-3.

## 3. Methodology

An initial series of meetings held at ACF on 19 and 20 May 2015 considered the approach to collect facts related to the required deliverables grouped under eight blocks that had been part of the LR-A response to the enquiry. ACF agreed to prepare a plan of the availability of their personnel who would respond to the topics in the eight blocks. This plan is included in Appendix 1 to this report. Notes of this meeting are incorporated in the reports on each of the eight blocks in this report.

A series of visits was arranged in accordance with the plan and representatives of ACF and LR-A met at ACF. The technique adopted was by interview, accepting most of the material and information presented and occasional sampling in an audit technique. The selection of samples for audit was random and not intended to have statistical significance. The LR-A personnel involved were also experienced auditors and since they identified deficiencies, it is considered that the sample selections were useful illustrations.

At all stages of the interviews, at least one representative of LR-A was a fluent or native French speaker.

In preparing this report, analyses were carried out against the terms of reference for this review and against IAEA GS-R-3, included in appendices to this report. Since IAEA documents were not used directly by ACF, they were considered a useful external point of reference for this review. The annexes also

respond to specific deliverables and evaluation principles that were stated in the terms of reference for this review.

In seven of the eight blocks on the Report section of this document, there is a Discussion leading to Conclusions and Recommendations which are grouped later in the report.

## 4. Interim reports

Progress reports were issued by LR-A to the Steering Committee in advance of their telephone conference meetings on 19 June, 2 and 16 July 2015. LR-A took part in these telephone conferences.

## 5. Some terms used in this report

**ACF** refers to AREVA Creusot Forge

**AREVA HE** or **HE** refers to AREVA Heavy Equipment Division

**AREVA NP** refers to AREVA NP SAS, registered office at Tour AREVA, 1, place Jean Millier, 92400 Courbevoie, France

**ASME** refers to the American Society of Mechanical Engineers Codes

**ESPN** refers to the French Arrêté du 12 décembre 2005 relatif aux équipements sous pression nucléaires

**KPI** refers to Key Performance Indicators

**LR-A** refers to Lloyd's Register Apave Limited registered office at 71 Fenchurch Street, London, EC3M 4BS. UK

**NDT** refers to Non-destructive Testing

**QA** refers to Quality Assurance

**RCC-M** refers to Design and Construction Rules for Mechanical Components of PWR Nuclear Islands, published by AFCEN

**Steelmaking** includes all aspects of manufacture of liquid steel through ladle processing to casting and solidification of ingots.

Note: Steelmaking is currently carried out by ArcelorMittal Industeel in a factory adjacent to ACF.

**TOFD** refers to Time of Flight Diffraction

Note: this is an NDT technique

## 6. General discussion

This report gives an overview of a wide range of activities, some of which are quantifiable (e.g. statistics from internal audits) and others which are subjective (e.g. safety culture).

Although there has been a documented quality system with formal procedures and associated documentation for some 10 years at ACF, the report only includes some details and indicates trends for the period from 2004 to 2010.

The objectives of this review have therefore been met for the period after 2010. If answers to specific questions relating to the historic situation prior to 2010 are required, they would be more efficiently answered by *ad hoc* investigations.

In most cases, responses to questions were accepted based on statements put forward by the ACF personnel or by their illustrations from those paper or electronic records that were presented. Some responses were explored in more depth using an audit technique. In an audit, some of the responses would be classed as non-conformances or other negative findings. However it was not the purpose of this review to carry out an audit and the deficiencies were not reported as such: they were simply drawn to the attention of those involved. It was not intended to check that action was taken on the specific deficiencies as part of the review.

It is generally accepted that quality systems in line with ISO 9001 and / or the ASME Code as held by ACF, indicate a basic management system. However over-emphasis on procedures and compliance and following routines such as internal audits for their own sake may detract management's focus from business objectives. One of the Recommendations in this report is to evaluate if ISO 9000, ASME and SAP systems are sufficient for the business in which AREVA HE operates and / or if elements of these systems are counter-productive to quality and nuclear safety objectives.

See General conclusions and Detailed conclusions 1 and 2.

## 7. Reports from interviews, evidence, and sampled activities and records for Blocks 1 to 8

### (a) Block 1: Codes, Standards, Specifications and Design

#### Enquiries and orders

From earlier meetings with ACF personnel, the review team was uncertain about how enquiries and orders for large contracts were received into AREVA. At a late stage in the review, processing of enquiries and orders was explained more clearly in a meeting with a representative from St Marcel who explained the system which related the requirements in PED and ESPN to the Essential (and Influential) parameters and incorporated feedback of achieved results in qualification tests. There was therefore a formal system for hazard analysis in conjunction with design departments at AREVA NP and the AREVA manufacturing organisation using an empirical but professional approach which satisfied the Regulations. A view was expressed that that the current empirical approach could be improved if a more systematic methodology would be accepted by the French Authorities. It is unclear if the concerns had been fully discussed with the French Authorities. It was stated that, before 2010, the AREVA approach was professional but with less formality.

Dependant on the requirements in each market, the ACF system addressed ISO 9001, ASME III, RCC-M, 10 CFR 50 and requirements for RSA (South Africa). National Safety Rules were followed but IAEA Safety Guides were not used directly.

On receipt of an order, an Inquiry Order Review is completed depending on the expertise of those involved e.g. QA Manager, Planning, Process, Product Manager and NDT Level III on points which were raised at the bidding stage in respect of technical capability and other risks. Final acceptance is by Project Manager or Finance. A financial risk assessment is also carried out. The template used as a checklist in Planning contains main headings of Analysis, Metal, Forging, Temperature, Machining, Heat treatment, Testing, NDT, Marking and Miscellaneous. It addresses potential risks and measures to be taken. It is completed for every order and uses the expertise of the department.

Design by AREVA in Paris is organised through AREVA HE. The net result is that designs specify steel grade, mechanical characteristics, dimensions and surface quality and any restrictions that apply to the code or specification used. ACF contributes knowledge of plant capability to minimise technical or commercial risk. The key stages are assessed by mechanical test results, metallography and NDT.

#### Steel design hazards

Steel specifications usually refer to recognised codes and standards. However the association of hazard from the ingot to the hazards in the forged product were not taken into consideration by ACF. Examples of hazards which might be expected to apply are failure to meet specified limit of metallic and gaseous elements in the steel, and inadequate control of solidification process leading to adverse segregation, inclusions or voids.

#### Thermomechanical processing in including forging design:

Additional TTT curves are being prepared in collaboration with Arcelor. An example was noted showing Ac3 and Ac1 temperatures and effect of cooling in water, oil or air in relation to formation of martensite or bainite. Where there is a likelihood of distorted grains requiring additional heat treatment, additional thickness is arranged so that heat treatment can be carried out before final machining.

#### Planning

Programme Technique de Fabrication (PTF) states Principal and Essential parameters and which parameters do not require client approval if they are changed. Note: Essential parameters relate to qualification tests.

#### Control of parameters

Steelmaking is under surveillance by AREVA.

In the forge, there are shop traveller sheets which include requirements for reports and sign off stages. Note: SCADA system does not currently record rotation by the manipulator or automatic measurement of product dimensions. A separate system exists for recording pressure and number of blows by the forge.

#### **Discussion**

In addition to commercial matters, activities at ACF comprise technical, metallurgical, managerial and motivational matters, which in the case of components for nuclear application in particular, is overlaid by a regulatory framework.

Pre-contract enquiries and order acceptance involve ACF but in respect of design, the inter-relation of other parts of AREVA in design and hazard analysis (a particular requirement of the Pressure Equipment Directive and of ESPN) it appears that ACF previously regarded these matters as handled by other parts of the organisation, with ACFs main input being practical constraints. An aspect which was not investigated totally in the review was whether the responsibilities of the manufacturer under PED and ESPN lay with ACF or another part of AREVA. Hazard analysis is carried out in AREVA but it appears that some constraints are experienced in AREVA by the requirements placed on them by the French Authorities. It is possible that a better approach could be developed which met the Authorities' requirements in a superior way.

See Conclusions 3, 4, 5 and 10

## (b) Block 2: Qualification and routine testing

### Qualification

For new products, a qualification document is prepared and agreed with the client. For products which have been made previously, a qualification document is prepared and agreed with the client. Examples were seen where the product was considered to be "similar" to previous products but the criteria for similarity were qualitative. When a revision to the product specification is proposed or requested, the original qualification is not always revised. This may result in "creep" through the cumulative effect of a series of "minor" changes being considered acceptable without requalification. ACF does not carry out additional qualification tests unless agreed by the customer.

### Installation and qualification of the new press

The overall objective of installing the new 9000 tonne press seems to have been achieved successfully as an engineering project, dedicating sufficient resources, taking account of human factors (e.g. training, written instructions) and involving maintenance, production and technical functions. Records of the training documents, of Modes Opératoire and Programme Particulier d'Essai (PPE) and of final acceptance were not centralised and may be difficult to access in future.

With regard to qualification of the new press, ACF stated that the only changes are efficiency-related with the same overall controlling parameters of deformation ratio, dimensions and start/finish temperatures. ACF stated that the lower number of reheats will be beneficial to grain size but had not yet verified this. Other technical benefits from the new press were the possibility of processing materials like Inconel and that the manipulator increases the range of products that could be made.

### Qualification and associated metallurgical aspects

ACF stated that qualification of process was by qualification of product and that decisions regarding lifetime of the component such as corrosion resistance, creep resistance and resistance to irradiation come from ACF's customer. The "customer" was later interpreted as often being other parts of AREVA.

The main purpose of forging is consolidation, dimensional shaping, grain size and orientation and initiation of new grains. Forging ratio is the main control during forging. ACF works to a minimum forging ratio of deformation of 3 and decides the forging sequence for dimensions. Forging temperature in relation to the material was stated to be decided by the customer with minimum values set by ACF. Characterisation is from rings flame cut transversely from the forging.

The effect of reheating on grain size was understood by ACF. Three methods used for assessing grain size are: Metallography (main method), Replica (for specific issues) and Ultrasound where there is a problem with permeability. Ultrasonic techniques are being developed for assessing grain size. Grain size is a characteristic for qualification of products but there is insufficient experience at ACF with austenitic materials. Grain size was stated to be measured on all pieces. See also comments on Block 4.

### **Discussion**

In most industries, qualification testing is used to establish the range of acceptable variations in a product and / or process and it is revalidated at periodic intervals. In respect of heavy forgings, it is technically and commercially difficult to apply conventional means of sectioning and testing the range. Elsewhere in this report there is coverage of ACF's work on mathematical modelling or simulation. However the current situation at ACF depends on conventional qualification testing and there is a subjective element in accepting if a product is sufficiently similar to previous ones that were proven and if processes continue within the proven range. Irrespective of any technical acceptance by clients that qualification is not required, only ACF is in possession of all the facts concerning product and process. This report reaches conclusions about the potential for "creep" through a series of minor changes in process which, if viewed overall, might require requalification, particularly in the light of the installation of the new press with increased throughput and reduced numbers of reheats.

Metallurgical and engineering aspects of the technology of forging are well-established. Possible improvements include better control of casting and solidification processes to increase homogeneity of the starting material and through better understanding of the processes of deformation by forging



affecting grain size and orientation, and closure of voids. The report concludes that the present state of knowledge could be presented in a clearer way to those responsible for activities on a day to day basis.

**See Block 4 of the Report section and Conclusions 6 to 10 and 33.**

### (c) Block 3: Sub contracting

Contractors are evaluated by Quality Department annually, and the resulting approved supplier list states the duration of validity. Contractors are controlled by Purchasing department.

Technical department prepares specifications for ingots. There is a Quality Plan for every (ingot) purchase order with notification points. Surveillance reports check that purchase order Quality requirements are met.

#### ACF Audit of Industeel

The report of the audit of Industeel on 2015-01-22 states that Industeel is certified to ISO 9001:2008 by DNV, valid to 02 June 2017. The scope of the DNV certificate does not refer to laboratories. The ACF audit report records that Industeel decided not to apply for Accreditation of their laboratories to ISO 17000 series. Two areas for improvement noted in the previous ACF report of their audit of Industeel were that there had been no evaluation of the supplier of ferroalloys and there was no source inspection in respect of carbon and sulphur levels. Steps had been taken to rectify this. The other point related to the availability of orders for castings for pump shells. It was transformed into a non-conformance during the 2015-01-22 ACF audit because there had been no progress but it was subsequently closed as a result of changes planned to the management of the area for castings.

#### Control of ingot manufacture by ACF

There is no ACF specification for control of bringing ladles into service. Degassing times, ladle pouring times and ingot mould removal times and temperatures are monitored during ACF surveillance but acceptable ranges are not specified by ACF.

#### Quality improvement initiatives

Quality improvement initiatives are underway in 2015 with some suppliers which are Small and Medium-sized Enterprises (SMEs). With one there had been issues where alternative materials required agreement and a wish to improve traceability with reduced risk of error. Improvements were also made also with a supplier of small forgings.

### Discussion

Initiatives are being taken to improve the performance of SMEs supplying ACF. The main supplier to ACF is Industeel. From the time in history when steelmaking and the forge were parts of the same organisation, there is familiarity within ACF of the steelmaking process. In respect of pressure equipment and nuclear applications, it appears that the pressure and nuclear-related hazards associated with the products have not been considered recently in respect of steelmaking. There could be more than one means of control of identified hazards but the parameters should at least be specified by ACF. In addition, Industeel laboratories are not accredited to ISO 17000 series, yet ACF relies on the results of sub-contracts to Industeel for spectrographic analysis and determination of hydrogen content.

See Conclusions 10, 11 and 12.

### (d) Block 4: Process control

A formal system exists for quality planning and shop travellers. The quality and planning functions appear to work effectively but there may be overlapping activities. It is understood that the main difference between the present system of shop travellers and that used in 2005 is that the numbers of reheat cycles are now stated.

The "traveller" system to prescribe and monitor jobs appears to work satisfactorily but may be subject to change as the SAP project proceeds. The traveller system is also applied to rings cut off for samples but it did not specify the dimensional requirements e.g. notch tip radius, to be used for Charpy impact test pieces. The ACF personnel involved were however aware of the different requirements in the ASME and

RCC-M codes. Other aspects including preparation, identification and/ traceability of samples for testing were good. It was noted that data from the laboratory tests were entered manually in records.

The Planning department had carried out a limited analysis of recorded problems. The causes of problems and the associated risk was calculated as *Severity x Occurrence x Detectability*. The analysis identified priorities and the results showed improvement in cases where actions have been taken. Although the criteria used are not exactly in line with those for Essential and Principal parameters in RCC-M, that correlation may be a possible future development. The approach could also be applied to interfacing functions at St Marcel and Industeel.

During a tour of forge and machine shops, forging of an ingot on the 9000 tonne press and manipulator was seen. Control points were noted. Personnel briefing stations were observed during shop visits: their purpose related to the safety culture in ACF. The plant had been divided into 13 areas for safety and the "Scope" project involved people in their own safety and the safety of others. The arrangements put in place indicate a positive approach to the manufacturing process, to capitalize experience, to optimize production and to master variability in production parameters. Data capture at the press involved the Ferroton system.

The ACF Laboratories are independent and new equipment was noted for chemical analysis including determination of gas content, tensile testing, impact and drop-weight testing, and metallography. Although the testing software is currently integrated in the equipment, previous practices for verifying software used with test equipment were unclear. Data is entered manually even though the laboratory equipment is automated. In addition there can be delays in communications between the laboratory and the quality function. Some improvements in sample storage were being made but the length of retention of samples was uncertain, unless the storage time is specified by the client.

Checking of magnetic field strength for the equipment used in magnetic particle inspection was not carried out. A (new) vertical ultrasonic non-destructive testing machine was noted. It was unclear if results of previous tests affected by a verification problem with this new equipment had been investigated. Also the state of progress in acceptance of TOFD was uncertain. It was unclear if winter storage of consumables used in penetrant testing was acceptable to current requirements.

The approach to grain size control is unclear with differing responses to questions about it. See also comments on Block 2.

Non-conformities and corrective actions are monitored but the objective of limiting the delay in closing corrective actions within 96 days (i.e. 3 months) is significantly exceeded.

### Discussion

Process control is mainly an objective concept and some deficiencies were found in its application. However there is a subjective element about the extent to which it should be applied. On one hand it is positive to note the independence of the laboratories, even though data entry could be automated to improve accuracy and efficiency. On the other hand implementation of data from the SCADA system was not regarded as a control on the process for consistent application. Moreover it was difficult to reach a conclusion if one of the basic metallurgical controls of grain size was used consistently.

**See Block 6 and Conclusions 9 and 13 to 25**

**(e) Block 5: World class aspirations**General

It was noted that ACF would like to maintain a position with other major world players such as in respect of on-time delivery.

An analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT) for the strategic plan related to the size of equipment required by the (niche) market and the manufacturing plant capabilities required, e.g. new press and capability to handle special alloys. Themes included better control and better ways of working.

Partnerships were being considered with other steelmakers and aerospace sectors.

Manpower weaknesses had been identified in respect of critical numbers in specialisms including metallurgy, numerical analysis and shop floor management.

The review noted that AREVA's confidential strategic plans are developing taking account of current market conditions, AREVA's capabilities and requirements for quality, safety, delivery etc. There are associated performance objectives.

SAP Project

Following a test run in March 2015, SAP will roll out for full implementation at ACF in January 2016, following a slightly longer programme at St Marcel where additional work had to be done. This will use ACF's existing MRP and shop traveller system. No new hardware is required and the system will be similar to that at several other AREVA sites.

Maintenance

ACF's Maintenance department focuses on preventative maintenance for weekly, monthly and annual maintenance. Critical equipment includes presses and other forging equipment, forging furnaces and HP pumps. The SCADA system is not considered critical to operation of the press. Achievement of maintenance plans depends partly on availability of production plant and personnel. Maintenance did not appear to relate to product risk concepts. Inventory control applies only to large items. Risk-based (plant) inspection, ISO 55001 or other asset management standards are not used.

**Discussion**

The confidential nature of strategic plans and market forces make it difficult to provide a fully objective commentary on World Class aspirations. It is however suggested that although ACF has few direct competitors, it may be possible to benchmark aspects with other world class players who are not in competition, e.g. aspects such as for production planning, research, information technology and laboratories.

**See Conclusions 26, 27 and 28**

**(f) Block 6: Management tools**

Overview

The nature of systems prior to the take over of Creusot Forge by AREVA in 2004 were not assessed in this review. Since 2004 the ACF culture was described as “we will manage” but the sustainability of this is now being questioned within ACF.

When acquired by AREVA, some €200m was invested and four companies were integrated to a new culture. There are some 300 people at Le Creusot and 900 at St Marcel. In 2015 Creusot Forge was integrated with St Marcel as (AREVA) Heavy Equipment with a slimmer management structure, and fewer senior personnel at ACF. The Management Committee has been reduced from 12 to 6 and support functions merged. Operational Safety was stated not to have been changed.

In response to questions about the impact of the change on Key Quality Indicators, it was noted that there was an increased number of non-conformances including those from Notified Bodies. The lead time for closing non-conformances had also increased, attributed by the senior management to there being less flexibility and the recent remoteness of the management.

In response to questions about the management of the Safety Culture in the organisation, the Occupational Safety culture remained high but there had been pressure from customers on the wider safety culture, with a more recent emphasis on a Quality and Safety culture programme, including one hour per week per person spent on this, down to operator level. The extent to which this related to nuclear safety culture was unclear. The “Purpose” program aimed to improve aspects in 56 entities over a 2-month period e.g. NDT reports to be 100% right first time. Quizzes were set for operators. General information was spread about the quality indicators in use. “Tool box” talks take place. People were indoctrinated on ASME and on ESPN.

Management review contains statistical indicators such as delivery time, occupational safety, efficiency of equipment maintenance and inspection.

Internal audits

In 2004, the audit was by process across 4 SFARSTEEL companies. The brief report referred to ISO 9001 and raised only two “minor” non-conformances. A report of an audit of Creusot Mécanique referring to ISO 9001 was more detailed.

In 2005, the audit covered Calibration, referred to ISO 9001 and raised two procedural non-conformances and one observation.

The audit in 2007 referred to ISO 9001 and RCC-M. Five observations and seven Areas for Improvement were raised.

The audit in 2008 referred to ISO 9001, RCC-M, ASME and 10 CFR 50. Five observations and seven Areas for Improvement were raised. A wider scope and greater depth was evident from the report.

Internal audit findings 2011 – 2014

	2011	2012	2013	2014
Observations	21	19	27	20
<b>Observations only on quality matters</b>	<b>18</b>	<b>10</b>	<b>15</b>	<b>14</b>
Non conformances	0	0	1	0
“Points sensibles” i.e. areas for improvement	47	40	27	35
<b>Quality – related areas for improvement</b>	<b>41</b>	<b>33</b>	<b>23</b>	<b>30</b>
Strong points	7	12	11	5
<b>TOTAL of Quality-related Observations and Areas for improvement</b>	<b>59</b>	<b>43</b>	<b>38</b>	<b>44</b>
<b>AVERAGE number of Quality-related Observations and Areas for improvement</b>	<b>46</b>			

Root cause analysis has not been implemented over the annual average of 46 observations and areas for improvement raised in internal audits in the past four years.

#### 2008 Audit of ACF by St Marcel

This referred to 10 CFR 50. The report was quite thorough when compared with other reports.

#### Management review

Annual management review documents were available for the period: 2005 – 2015.

The report of the June 2005 review concludes: "The system is performing and adapting. It responds to the requirements of codes and standards applied by SFARSTEEL ... ISO 9001 ... It responds in particular for Creusot Forge to the requirements of ASME III Div 1, 2, 3 etc. For internal and external audits, increase in the number of remarks from 90 to 154 and number in course of treatment increased from 41 to 74."

The reports of the reviews in February 2006 and 2007 conclude: "The system is performing and adapting. It responds to the requirements of codes and standards applied by SFARSTEEL ... ISO 9001 ... It responds in particular for Creusot Forge to the requirements of ASME III Div 1, 2, 3 etc." Reports for both 2006 and 2007 recommend improvement in level of quality and speed and to the numbers of people, both with identical wording.

In 2015, the Management review took the form of a one-day meeting covering Creusot Forge and St Marcel. The report of the review meeting in April 2015, (involving some 20 persons) states that the review will lead to a plan of actions for 2015. The review was well-prepared and the meeting was attended by relevant representatives during the day. In respect of quality at ACF, the Management review notes the need for an improvement in the delay in treatment of internal quality incidents. Generic causes of non-conformances were made the object of action plans for quality improvement to be followed monthly. The senior management stated that management of Corrective Actions ought to be revitalised in 2015 to accelerate the delay in treatment and an open systematic approach to take action to prevent recurrence. Diagnostics for both St Marcel and Le Creusot sites include Quality, Health, Safety and Environment. It is unclear if action on non-conformances will be adequately resourced.

Earlier in 2015 ASME Manuals were merged for Le Creusot and St Marcel. ISO 9001 manuals are being merged and the processes are being merged under SAP. See appendix 4 for details of the history of the ASME manuals.

#### Prioritising improvement initiatives

There is a six-weekly meeting of the Technical / Production Committee which considers the analysis of technical and commercial performance for each group of jobs or month. Satisfying customer and regulatory requirements are considered more important than achieving financial objectives.

The Technical committee reviews investments and developments. The July 2015 meeting identified a need for a project manager to drive investments through e.g. Laser measurement device for measuring finished products.

#### **Discussion**

The investments by AREVA in both plant and culture at ACF are apparent. Although the merger of ACF and St Marcel in AREVA HE appears beneficial to pre-contract and design stages, its effect in respect of non-conformances and audit findings in manufacturing are uncertain. Management reviews from the early years indicate that either most matters were satisfactory or that the reviews were not sufficiently critical of activities.

**See Conclusions 25, 29 to 33.**

### (g) Block 7: Recruitment and training

The HR function for AREVA HE is centralised. It has implemented a comprehensive approach to the formalisation of job requirements and addressing training needs to enable personnel to fulfil job requirements with KPIs and grading of competence. Annual assessments are also carried out.

There are spread sheet databases for personnel in production, maintenance, non-destructive testing, planning etc up to first (lowest) level of management. The spreadsheets show the planned and actual numbers of job holders at the respective levels of competence. In the case of the Forgemaster, qualification, certificates were seen. However the records for the Forge Expert were not available although the job holder was involved in approval of "Forgerons" documents. It was noted that there were differences between HR and Line Manager databases with regard to Forgerons.

Job descriptions as agreed by line managers, state responsibilities but the responsibilities were communicated the employees through the annual performance assessment. This may result in employees having a different understanding of their responsibilities.

In the period 2007 to 2015, 169 personnel had left ACF, of which over 50 had retired. From 2006 to 2015, 249 personnel had joined ACF. 2008 was the year of greatest intake. The current complement at ACF was around 300 personnel.

The present system for assessing competence had been in use since 2013. There are three levels in the matrix of competence which is matched to job requirements for all levels of personnel. For example, the competency evaluation report is used to formalise the level of authorisation of inspectors to their tasks. Archived matrices dating back to 2005 stated which personnel were assigned to specific tasks but since they were not examined in detail in the review, it is not possible to conclude if they were formally acknowledged as having the appropriate competency. However, following the request raised by the Steering Committee, a spreadsheet for 2007 was reviewed. It showed competences as binary attributes 1 or 0 for each person as at 2007-12-10. The names of the individuals in three of the eight jobs for which there were three people or less which were considered critical were checked. The person in the chemical laboratory and the foundry expert are still in post. The third person involved in the mechanical testing laboratory had left the post.

Training needs are discussed with Department Heads. With regard to succession planning, there was awareness of recruitment and transfer needs but actions plans were not totally formalised. Although not fully explored during the review, the process for knowledge management and knowledge transfer were not completely clear.

A separate system exists for recruitment, competence and training of managers above level 1.

The Quality function carries out induction training. The system is well-established and includes competencies in technical, quality system and regulations. The comprehensive system for indoctrination is planned and repeated every 24 months. The programme includes ACF activities, strategy and market overview, and explains why quality of forgings is important in general and in particular for nuclear safety. Moreover it addresses the safety culture principles for individuals, and the place of the Regulations, Codes and Standards. The database is used to plan and record completion of the indoctrination. The database indicates that repeat indoctrinations are overdue for several people, with some extremely overdue.

See Conclusions 33 to 35

## (h) Block 8: Research and development

The Strategic Orientation Committee representatives include operations, technical, commercial and corporate R&D functions. At its latest meeting in July 2015, Research sheets had been presented for topics on the ACF R & D Roadmap (which is in the HE Performance Plan). Topics include:

- INGOTS – Solidification, hot tops etc,
- FORGING – Void closure etc,
- HEAT TREATMENT - Simulation using ThosT software etc,
- NDT – Active control of forging etc,
- MACHINING – Active instrumentation of tools etc

The Research work programme comprises a road map of ACF's own needs, competitors, and trends in the scientific community. There is a dedicated team of 5 or 6 people and sub contracts with universities, with some collective sponsorship of Ph D students mainly working on microstructure, recrystallisation and key closure. Modelling tools are used to study heat treatment using ACF's own competence in numerical simulation. There is also work in conjunction with the Arcelor Research Centre to optimise casting. There is a monthly technical meeting with steelmakers.

With regard to data capture, a database exists using heat analysis and final characteristics and to follow forging and machining records.

The review concluded that the basic technology of forging ingots is understood. Numeric simulations and modelling are on-going as a lower-cost method of investigation, instead of sacrificial destructive testing of full products.

It is unclear if findings and conclusions from R&D are always implemented in production – e.g. using the control charts for mechanical properties with warning and action limits, in Production.

This department is paid for largely from the HE budget. Since priorities change if there is a need for works support instead of research, it seems that this is mainly a works-support function.

### Discussion

Activities on the R&D Roadmap represent a useful contribution to the knowledge base in AREVA but production pressures for investigation of problems may detract from achieving the plans. It was also evident that some results were not implemented or brought to completion.

**See Conclusions 36, 37 and 38**



## 8. General conclusions

- (I) The review achieved its objectives subject to the following qualifications:
  - (I a) In respect of the "comprehensive inventory of all potential issues", it should be noted that the review was limited to the scope covered and the availability of personnel. There may be additional issues prompted by the review process and by this report for AREVA to develop.
  - (I b) Evaluation of the quality and safety culture is subjective and based on the evidence provided or readily visible. This evaluation was not subject to rigorous testing at all levels throughout the organisation.
- (II) The review showed that, since at least 2010, there is evidence of a quality and safety culture and currently, activities at ACF are well-organised and controlled.
- (III) It is not possible to reach an overall conclusion of confidence in activities before 2010 from earlier Management Review reports. To increase confidence in the period prior to 2010, further specific investigations would be required.
- (IV) Records of internal audits from 2011 to 2014 demonstrate that there are consistently over 40 negative quality-related findings each year and the 96-day target time for closing the non-conformances generated within ACF continues to be exceeded. This indicates that wider and common issues requiring management attention may not be recognised within ACF. The April 2015 Management Review of AREVA HE emphasised attention to closing non-conformances but it is not clear if resources are available for this to happen and whether a root cause analysis is planned, or if the consequences of that root cause analysis will be addressed and implemented.
- (V) ACF does not specify steelmaking parameters relating to ladle preparation, degassing, pouring speed, ingot solidification control and chemical analysis.
- (VI) Product qualification programmes rely on assumptions that there are sufficient similarities to existing products and / or customer acceptance that qualification or re-qualification is not required. This also relates to qualifying new plant and processes where certain assumptions about acceptability of existing qualifications have not been demonstrated. Additionally some qualification processes did not seem to have been driven to completion.

## 9. Detailed conclusions

- 1 There has been a documented quality system at ACF with formal procedures and associated documentation for some 10 years.
- 2 The ISO 9001 and ASME systems may detract from a comprehensive management system through focussing on compliance issues rather than a system for the management of regulatory and other aspects related to the product application.  
**See also conclusion 26 and Recommendation b.**
- 3 The AREVA organisation integrated St Marcel and Creusot Forge under Heavy Equipment Division (HE) with effect from 2015. This has not adversely impacted the internal process for quality purposes.
- 4 ACF is now part of HE and understands its role in respect of analysis of risks.
- 5 The current empirical approach to hazard analysis may be improved if a more systematic methodology would be accepted by the French Authorities.
- 6 There is a risk that the cumulative effect of a series of "minor" changes are considered acceptable without requalification, since revisions to qualification documents were not assessed back to the original specification and qualification.  
**See Recommendation h**
- 7 The overall objective of installing the new 9000 tonne press has been achieved as an engineering project, dedicating sufficient resources, taking account of human factors and involving maintenance, production and technical functions. Records of the training documents, of Modes Opérateur and Programme Particulier d'Essai and of final acceptance are not centralised and may be difficult to access in future.
- 8 With regard to qualification of the new press, ACF believes that the only changes are efficiency-related with the same overall controlling parameters of deformation ratio, dimensions and start/finish temperatures. They believe that the number of reheats will be beneficial to grain size but have not yet verified this.  
**See Recommendations d and i**
- 9 The metallurgical aspects of the process are well-understood but it is not clear if they are documented in a way which can be applied by those operating the processes and carrying out tests.
- 10 Hazards and risks in forged products related to the ingot do not seem to be addressed.  
**See Recommendation c**
- 11 Industeel does not hold Accreditation of their laboratories to ISO 17000 series but they carry out analyses for ACF.  
**See Recommendations e and f**
- 12 In respect of control of ingot manufacture by ACF, there is no specification for control of bringing ladles into service. Degassing, ladle pouring times and ingot mould removal times and temperatures are monitored but acceptable ranges are not specified by ACF.  
**See Recommendation c**
- 13 A formal system exists for quality planning and shop travellers.
- 14 The shop traveller system is also applied to rings cut off for samples but it did not specify the dimensional requirements to be used for Charpy impact test pieces.
- 15 The quality and planning functions work effectively but there may be overlapping activities.

- 16 Assessments of the control and effectiveness of processes are carried out in relation to manufacturing.
- 17 Independence of ACF Laboratories is noted but some chemical analysis is sub-contracted to the steel maker. **See Recommendation f**
- 18 Preparation, identification and traceability of samples for testing was good.
- 19 The manufacturing plant had been divided into 13 areas for safety and the "Scope" project involved people in their own safety and the safety of others.
- 20 Previous practices for verifying software used with test equipment are unclear.
- 21 Data is entered manually even though the laboratory equipment is automated.
- 22 There can be delays in communications between the laboratory and the quality function.
- 23 The length of retention of samples is uncertain, unless the storage time is specified by the client.
- 24 There were several deficiencies in respect of non-destructive testing.
- 25 Non-conformities and corrective actions are monitored but the objective of limiting the delay in closing corrective actions within 96 days (i.e. 3 months) is significantly exceeded. **See Recommendations g and k**
- 26 SAP will roll out for full implementation in January 2016.
- 27 (Planned) Maintenance does relate to product risk concepts.
- 28 There is limited input of best practice from external organisations. **See Recommendation l**
- 29 Management review is conducted annually. It is not possible to reach an overall conclusion of confidence in activities before 2010 from earlier Management Review reports. To increase confidence in the period prior to 2010, further specific investigations would be required.
- 30 Root cause analysis has not been implemented over the annual average of 46 observations and areas for improvement raised in internal audits in the past four years. Also the root causes of other non-conformances do not seem to have been recognised. **See Recommendations g and k**
- 31 There is Management commitment but there are some doubts about the resources necessary for the quality system to function and develop. E.g. Resourcing action on non-conformances. **See Recommendations g and k**
- 32 Diagnostics from Management Review for the Le Creusot and St Marcel sites include Quality, Health, Safety and Environment.
- 33 The processes for knowledge management and knowledge transfer were not completely clear.
- 34 The HR function for AREVA HE has a formalised approach to stating job requirements and to addressing training needs to enable personnel to fulfil job requirements with KPIs and grading of competence. Annual assessments are carried out.
- 35 Induction training by the Quality function is well-established and includes competencies in technical, quality system and regulations. However, repeat indoctrinations are overdue for several people.
- 36 The basic technology of forging ingots is understood.

- 37 It is unclear if findings and conclusions from R&D are always implemented in production.
- 38 Personnel from the technical function carry out development work but their activities may be subordinate to production and not always implemented.

**See Recommendation j**

## 10. Recommendations

- a. Plan the actions, priorities and resources required to address all the General and Detailed Conclusions and Recommendations in this report;
- b. Evaluate if ISO 9001, ASME and SAP systems are sufficient for the business in which AREVA HE operates and / or if elements of these systems are counter-productive to quality and nuclear safety objectives;
- c. Actively reconsider the interface with the steelmaker in respect of specification and control of all relevant parameters and chemical analysis.
- d. Focus on achieving necessary qualifications for new plant and processes;
- e. Obtain accreditation for own test laboratories;
- f. Use only accredited laboratories for external testing where reliance is placed on the results;
- g. Recognise and manage negative findings in internal audits irrespective of whether they are classed as non-conformances, observations or areas for improvement;
- h. Review new and existing product qualification programmes to ensure that they are comprehensive and complete, and apply a similar approach for all future orders;
- i. Establish controls on processes in relation to grain size;
- j. Increase reliance on automation and dynamic instrumentation;
- k. Carry out comprehensive root cause analysis for all negative audit findings and other non-conformances;
- l. Identify other similar non-competitive businesses to share understanding and develop best practice;
- m. Maintain existing management and technical records to enable specific investigations that may be required in future in particular historical data after 2004 as well as more recent matters such as the findings of the LR-A Audit of ACF in 2012 and data on 18/20 MND5.
- n. Continue to promote the quality and safety culture.

# Appendices

Appendix 1 Programme and Timetable

Date	Theme	Subjects	LR-A reviewers	ACF representatives
19 and 20 May 2015	Introductory and exploratory meetings	1: Codes, Standards, Specifications and Design 2: Qualification and routine testing 3: Sub contracting 4: Process control 5: World class aspirations 6: Management tools 7: Recruitment and training 8: Research and Development	E Haynes (Project Manager), M Boutayeb, C Duparc, P Leaver, V Valencik	P Poret A-s Pomykala E Guyot M Lebault D Magnin S d'Hooge P Trioen V Bronet F Perdriest C Blin S de Monplanet
16 June 2015	Block 2 (1/2) Qualification and routine testing	Actions taken to approve the new 9000 t press against existing qualification. Decision not to qualify new press since it was concluded that it had no impact on product	C Duparc E Haynes	T Gauthier
		Criteria in deciding that there is "no change" i.e. no need for requalification of any product/process and records of scope of qualification in subsequent manufacture		E Guyot
17 and 18 June 2015	Block 7 Recruitment and training	Indoctrination, training program for personnel performing or managing activities affecting quality, including under ESPN / RCC-M	C Duparc E Haynes	P.Trioen / M.Jacquemot / C.Favre Felix + CSP (Pascale Picque/Jacques Plewa)
		Succession plan and transfer of competence		C Duparc E Haynes
		Competence criteria		
		Competence of technical personnel		
		Records at CF for personnel from 2006		
		Changes in personnel since 2006 (+ or -) associated with competences		
		How competence was managed before 2012		
		Job descriptions (job roles)		
Matrix of competence	C Duparc E Haynes	P.Trioen		
Annual assessments				
23 June 2015	Block 4 (2/2) Process control	Document control (including document change control)	J Hoblos V Valencik E Haynes	C Verot
		Process control (procedure exist, process sheet, operations records)		C.Verot, P.Trioen, M.Lebeault
		Qualification of personnel (where required) and the associated records		G.Tosetto, JM.Paris
24 June 2015	Block 4 (2/2) Process control	Identification and making	J Hoblos V Valencik E Haynes	C Blin
		Selection of samples and control		M.Lebeault, C.Verot
25 June 2015	Block 4 (2/2) Process control	Records retention and length of storage of samples and coupons	J Hoblos V Valencik E Haynes	T Gauthier
		Control of non-conformity and corrective action process		M.Lebeault C.Vero
25 June 2015	Block 4 (2/2) Process control	Calibration of measuring instruments	J Hoblos V Valencik E Haynes	C.Pistoia / G.Tosetto
25 June	Block 2 (2/2)	Acceptance / validation / qualification of automatic ultrasonic machine-who witnessed and approved it		
		Plans for acceptance of TOFD technique		

Date	Theme	Subjects	LR-A reviewers	ACF representatives
2015	Qualification and routine testing	Records of ultrasonic scans in machine shop Non-destructive testing : attenuation of ultrasonic signals to highlight and detect heterogeneities	J Hoblos V Valencik	JM.Paris / C.Pistoia / G.Tosetto
30 June, 1 and 2 July 2015	Block 3 Sub-contracting	Control of purchased item and services (including audit and inspection process) e.g. approved supplier list with duration of validity; ingot specifications; quality plans with notification points and evidence of surveillance by qualified personnel	J Hoblos V Valencik E Haynes	F Huard P Trioen
7, 8, 9 July 2015	Block 1 Codes and Standards, Specifications and Design	Interfaces with material manufacturer, vessel manufacturer and other parts of AREVA Involvement of CF in risk and hazard analysis of activities performed against key points in the CF process and key barriers that are critical to safety Bidding process, client requests technical treatment, contract review and transposition into process documents including process sheets and forging process design (number of press steps, rotation angle etc)	C Duparc E Haynes	E.Guyot, C.Verot  C.Verot / C.Blin / J.Merle and/or D.Rabau
21 July 2015	Block 8 Research & Development	Research programme and records of activities in the Strategic Research committee Examples of data analysis e.g. quenching (fixing a problem), decision flowchart of where an analysis is called for. Examples of modifications to chemical analysis	M Boutayeb E Haynes	I Robin Vastra
22 and 23 July 2015	Block 4 (2/2) Process control	Laboratory methodology Records retention and length of storage of samples and coupons Calibration of measuring instruments		E.Guyot / G.Tosetto T.Gauthier Y.Uzun
28 July 2015	Block 5 World class aspirations	World class aspiration and strategy plan; including comparisons with other forges e.g. Japan, China, (US, UK) ISO 55000 / PAS 55 Plans for data capture and automation of processes		F.Perdriset  L.Kowal P.Hauguet / F.Perdriset
29 and 30 July 2015	Block 6 Management tools	Management review process and KPI (from 2004 or 2006 data, as available) Internal audit process (including Lead auditor/auditor independency and qualification) Control and implementation of feedback from past experience and investigation Decision making process (linked to quality). How are improvement initiatives prioritised and agreed within AREVA NP Availability of competent people including for the correction of non-conformances How skill gaps are identified e.g. a need for additional skills in IT Actions taken to improve the organisation and the safety/quality culture (including human factors) since 2006	C Duparc E Haynes	P Trioen  C Verot E Guyot  P Trioen F.Perdriset,  F.Perdriset, SDM, P.Trioen

## Appendix 2 Analysis under the terms of reference for this review

See also Conclusions 1 – 38 In this report

Table 1: Analysis of product quality and monitoring of product quality

	Effectiveness of process In meeting and fulfilling goals, strategies, plans and objectives	Product quality and monitoring of product quality
General and development	<p>(+) AREVA's confidential strategic plans are developing taking account of market conditions, their capabilities and requirements for quality, safety, delivery etc. There are associated performance objectives.</p> <p>(+) SAP will roll out for full implementation in January 2016,</p> <p>(-) Preventative maintenance does not appear to relate to product risk concepts.</p>	<p>(+) Technical / Production committee meeting reviews the results of analysis of technical and commercial performance for each group of jobs or month. Satisfying customer requirements is more important than achieving financial objectives.</p> <p>The ACF R &amp; D Roadmap (5-year plan), is in the HE Performance Plan. It covers ingot solidification, numeric simulation (avoiding the costs of destructive testing of full products) etc</p>
Regulation and standards watch, Bidding, Contract review	<p>(+) The creation of AREVA HE in Jan 2015 removed the interface between ACF and St Marcel which had been previously regarded as a client of ACF.</p>	
Designing of the Products (including but not limited to choice of the relevant material, engineering the forging sequence)	<p>(+) There is a good understanding about the design process in AREVA at St Marcel e.g. in relation to PED and ESPN. There is a link to ACF for practical details of the process.</p> <p>(+) Inquiry Order Review completed on receipt of order. This involves many functions in ACF</p>	<p>(+) Designers specify steel grade, mechanical characteristics, dimension and surface quality and any restrictions that apply to the code or specification used. ACF restricts this in the knowledge of plant capability to minimise technical or commercial risk. The key stages are assessed by mechanical test results, metallography and NDT.</p> <p>(-) The system was less formal before 2010.</p> <p>(+) Further TTT curves are being prepared. There is understanding of desired transformation products and practical measures to allow for the effects of processing on possible distortion</p>
Qualification of the product (including but not limited to RCC-M M140 qualification, ESPN technical qualification)	<p>(+) For new products, a qualification document is prepared and agreed with the client.</p> <p>(-) For products which have been made previously, examples were seen where the aspects were considered to be "similar" but the criteria for similarity were qualitative. In relation to avoidance of "creep" through a series of "minor" changes being acceptable, it was not clear if all the revisions to qualification documents were assessed back to the original when a revision was proposed.</p> <p>(+) Programme Technique de Fabrication (PTF) states Principal and Essential parameters. Essential parameters relate to qualification tests.</p>	<p>(-) With regard to qualification of the new press, ACF believes that the only changes are efficiency-related with the same overall controlling parameters of deformation ratio, dimensions and start/finish temperatures. They believe that the number of reheats will be beneficial to grain size but have not yet verified this.</p>



	Effectiveness of process in meeting and fulfilling goals, strategies, plans and objectives	Product quality and monitoring of product quality
Manufacturing control		(+) PTF provides an identification of Codes & Standard essential parameters. (+) Formal systems exist for quality planning and shop travellers. Similar systems existed since 2005. (+) For 1300 MW between 2011 and 2013, the causes of problems have been analysed and the associated risk calculated as <i>Severity x Occurrence x Detectability</i> This indicates priorities and the results show improvement in cases where actions have been taken.
Forging	(+) Investment on new press Data capture is planned. Forge software will be used to model quenching	(+) Product-related hazards associated with forging are identified. Control measures are known and in place but are not yet at a maturity level.
Casting	See under Procurement	See under Procurement
Heat treatment		(+) Calibration systems were acceptable
Production of test specimens for mechanical testing		(-) The traveller system is applied to rings cut off for samples but that it does not specify the dimensions such as notch tip radius to be used for Charpy impact test pieces. (-) The length of storage of surplus test materials seems optional unless the storage time is specified by clients
Welding	Not applicable	Not applicable
Machining		The 2015-07 meeting of the Technical committee which looks at investments and developments identified need for a project manager to drive through the Laser measurement device for measuring finished products.
Mechanical testing	(+) Laboratory is completely independent in the transmission of results	(-) Control charts are not routinely marked up with results of tests
Non-destructive examination		(-) A memo dated 01.09.2014 regarding a drift of the semi-mechanized UT device. Two FNC (FNC FNC 13/097 and 13/098) were opened. This memo describes the new verification procedures. It is not known whether the checks conducted previously were impacted by this problem.

	Effectiveness of process in meeting and fulfilling goals, strategies, plans and objectives	Product quality and monitoring of product quality
Chemical testing		(-) ACF laboratory facilities are not fully utilised e.g. spectrometer (-) ACF does not carry out hydrogen analysis: this is left to Steelmaker
Selection and assignment of personnel	(+) The system for grading competencies dates from 2013. Matrices dating back to 2005 state competencies as "yes" or "no" e.g. as at 2007-12-10. (-) Job descriptions stated responsibilities but the responsibilities were communicated to employees through the annual performance assessment. This may result in employees having a different understanding of their responsibilities. (+) Succession planning takes place In the period 2007 to 2015, 169 personnel left ACF, of which over 50 had retired. From 2006 to 2015, 249 personnel had joined ACF. 2008 was the year of greatest intake. (-) Knowledge transfer may be an issue requiring further attention	
Procurement (including but not limited to procurement of the raw material (ingot)).	(+) Quality improvement initiatives are underway with 4 SME suppliers	(-) No formal product hazard analysis is engaged particularly in relation to ingots (-) Steelmaker's laboratory is not accredited to ISO 17000 series but is carrying out analyses accepted by ACF (-) There is no specification for control of bringing ladles into service (-) Degassing, ladle pouring times and ingot mould removal times / temperatures are monitored but ranges are not specified by ACF
Management review	(+) Management reviews are available back to 2005. (-) Similar wording is used between 2005 and 2007 e.g. "The system is performing and adapting..." In 2005, it notes an increase in no of remarks from internal and external audits. In 2006 and 2007 they recommend improvement in level of quality and speed and to the numbers of people.	
Internal audit	(+) Internal audits are conducted annually. (-) Root cause analysis on the negative findings in internal audits from 2011 to 2014 which average 46 each year has not been carried out.	
Non-conformances and corrective action	(-) Non-conformities and corrective actions are monitored but the objective of limiting the delay in closing corrective actions within 96 days is significantly exceeded.	

Codes used in table: (+) positive point, (-) negative point; No code - relates to future plans or activities

**Table 2 Specific responses to deliverables stated in the terms of reference**

Deliverables	Summarised responses
An evaluation (the "Evaluation"), which principles are defined hereinafter, that shall cover the Products produced by Creusot Forge from Nov 1 <sup>st</sup> , 2004	Specific archive records relating to manufacture and testing are available and there are some databases. However, in general it is not possible to provide a comprehensive evaluation of the historical situation and culture at ACF prior to 2010.
A diagnosis of the technical relevance of the processes implemented at Creusot Forge;	<p>There has been significant investment at ACF but some of the activities do not produce returns on that investment. Areas where this is the case are in the laboratory, and ultrasonic testing. Additionally, efforts invested in the technical function are not directly utilised. Examples of this are the control charts for mechanical properties and limited FMEA studies.</p> <p>An area of concern is control of the steelmaking and chemical analysis both of which are mainly sub-contracted.</p> <p>Since January 2015, changes in the management structure under AREVA HE will integrate the design process to advantage but some elements of the remoteness of the management may be detrimental</p>
A diagnosis of the mastery of the quality and the way to demonstrate such quality;	The current quality management systems in ISO 9001 and ASME are recognised by competent external bodies. They rely on documented procedures to control activities and may not necessarily allow sufficient scope for flexibility and detract effort from people management and nuclear safety objectives. It is surprising that the number of negative findings from internal audits and non-conformities raised internally have not been questioned by the external bodies, possibly relying too much on the existence of the system rather than its results
A diagnosis of the proficiency of the current organisations;	The current organisation is professional and committed but may lack sufficient vision of alternative approaches as a result of the unique technology and market
A diagnosis of the level of quality and nuclear safety cultures of the current organisations;	The current level of product quality is demonstrated by objective test results and measurements, The safety culture is assessed qualitatively as acceptable and possibly better than in other heavy industries. However no comparison was made the safety culture with others manufacturing forgings for nuclear applications
Recommendations on how to improve the current situation.	See Recommendations a) to n) in this report

**Table 3 Specific responses to evaluation principles stated in the terms of reference**

Evaluation principles	Summarised responses
An analysis of the Requirements and their changes during the Timeframe. This analysis is a keystone taking into account the ESPN has been gradually applied during the Timeframe;	Until the formation of AREVA HE, ACF seems to have relied on other parts of AREVA for high level considerations, limiting their input to practical constraints. The principles and requirements seem to have been understood by personnel at St Marcel. Since 2010 the degree of formality applied at St Marcel was stated to have increased.
An analysis on how the Requirements have been implemented in Creusot Forge documentations such as internal documentation, subcontracting specifications or technical qualification programs;	Manufacturing activities at ACF have developed progressively and the documentation revised periodically. There are some concerns that requalification has been presumed not to be necessary, particularly where clients have agreed.

Evaluation principles	Summarised responses
<p>An analysis of the process of selection of the manufacturing methods, their technical relevance, and of the justification of such choices;</p>	<p>Sub-contracting specifications for steelmaking could be more comprehensive.</p> <p>The main metallurgical considerations in manufacture seem to be understood but the extent of specification and control of grain size may require further consideration in relation to reheat processes.</p> <p>The results of investigations of the problem associated with hydrogen content has led to additional controls. An empirical value on hydrogen content in steel related to the final product has been introduced.</p>
<p>An Analysis of the implementation of the Requirements through any kind of activities related to the Products. Such activities can be either performed internally within Creusot Forge or subcontracted</p>	<p>The main sub-contractor is Industeel for supply of ingots and castings. The report notes concerns over the specification and control of activities at Industeel. The report also noted that the Industeel laboratories are not Accredited to ISO 17000 series and ACF sub-contracts some analysis to the Industeel laboratories.</p>
<p>The activities that have to be analysed notably include:                      Regulation and standards watch,                      Bidding,                      Contract review,                      Designing of the Products (including but not limited to choice of the relevant material, engineering the forging sequence),                      Qualification of the product (including but not limited to RCC-M M140 qualification, ESPN technical qualification),                      Manufacturing control,                      Forging,                      Casting,                      Heat treatment,                      Production of test specimens for mechanical testing,                      Welding,                      Machining,                      Mechanical testing,                      Non-destructive examination,                      Chemical testing,                      Selection and assignment of personnel,                      Procurement (including but not limited to procurement of the raw material (ingot)).</p>	<p>All of these aspects formed the main investigations and the conclusions as stated in this report.</p>
<p>The activities that are related to the technical qualification of the Products and to the monitoring of the manufacturing shall be analysed also</p>	<p>See comments above in this table and elsewhere in this report</p>
<p>An analysis on how the Requirements are implemented in the actual practices</p>	<p>Requirements are usually stated in terms which can be understood in manufacturing, without reliance on source documentation.</p>
<p>An analysis on the traceability and justification of the implementation of the Requirements</p>	<p>Traceability is acceptable</p>
<p>An analysis of the actual data recording during all stages (manufacturing, qualification and monitoring and the relevance) and the relevance of such recording;</p>	<p>Manual data recording is acceptable. The report recommends increasing reliance on automation and dynamic instrumentation;</p>
<p>An analysis of the process on how the final</p>	<p>Final results are referred elsewhere in AREVA. It is</p>

Evaluation principles	Summarised responses
conformity of the Product to the Requirements is stated and justified;	unclear where the responsibility lies for issuance of certification.
An analysis of the processes of quality risks' identification, processing and mitigation, related to actual manufacturing methods of the Products	See comments earlier in this appendix regarding former reliance on other parts of AREVA.
An analysis of the processes of discrepancies' identification and processing;	The process for recording non-conformances is established but targets for resolving them are not met. The root cause or causes of negative findings from internal audits have not been established by ACF.
An analysis of the communication process with customers and safety authority and the analysis and implementation of their requests;	No adverse comments were made in respect of communications with customers but there are comments in this report about communications with the national safety authority.
An analysis of the level of maturity in term of quality and nuclear safety culture of the current organisation.	The level of maturity was noted in this report.

### Appendix 3 Analysis against the philosophy and some requirements in IAEA GS-R-3

The results of the review were analysed against the philosophy and some requirements in IAEA GS-R-3 to take an overview of the general situation at ACF.

Clause	Requirement (summarised)	Status in general terms, aside from detected deficiencies
1.1 and  2.1  and  2.8	<p><b>INTRODUCTION – BACKGROUND</b> A management system ... integrates safety, health, environmental, security, quality and economic elements.</p> <p><b>MANAGEMENT SYSTEM – GENERAL REQUIREMENTS</b> A management system shall be established, implemented, assessed and continually improved... The main aim of the management system shall be to achieve and enhance safety by: —Bringing together in a coherent manner all the requirements for managing the organization; —Describing the planned and systematic actions necessary to provide adequate confidence that all these requirements are satisfied; —Ensuring that health, environmental, security, quality and economic requirements are not considered separately from safety requirements, to help preclude their possible negative impact on safety.</p> <p><b>DOCUMENTATION OF THE MANAGEMENT SYSTEM</b> shall include the policy statements of the organization and descriptions of: the management system; the structure of the organization; the functional responsibilities, accountabilities, ... of those managing, performing and assessing work; the processes and supporting information that explain how work is to be prepared, reviewed, carried out, recorded, assessed and improved.</p>	<p>The overall management system embraces some of these elements but the ISO 9001 and ASME systems may detract from a comprehensive management system which should be relevant to the business in which ACF operates</p>
3.1 and  3.3  and  3.11	<p><b>MANAGEMENT COMMITMENT</b> Management... shall demonstrate its commitment to the establishment, implementation, assessment and continual improvement of the management system and shall allocate adequate resources to carry out these activities.</p> <p>Management at all levels shall demonstrate its commitment to the establishment, implementation, assessment and continual improvement of the management system and shall allocate adequate resources to carry out these activities.</p> <p><b>PLANNING</b> Senior management shall ensure that the implementation of the plans is regularly reviewed against these objectives and that actions are taken to address deviations from the plans where necessary.</p>	<p>Evidence seen at all levels of Management commitment but there are some doubts about the resources necessary for the system to function and develop.</p> <p>(see also 6.16 in this table)</p>
4.3  and	<p><b>HUMAN RESOURCES</b> Senior management shall determine the competence requirements for individuals at all levels and shall provide training or take other actions to achieve the required level of competence. An evaluation of the effectiveness of the actions taken shall be conducted. Suitable proficiency shall be achieved and maintained.</p> <p>Senior management shall ensure that individuals are competent to perform their assigned work and that they understand the consequences for safety of their activities.</p>	<p>Systems for evaluating and communicating competence requirements exist. Training and indoctrination are carried out.</p>

Clause	Requirement (summarised)	Status in general terms, aside from detected deficiencies
4.4	Individuals shall have received appropriate education and training, and shall have acquired suitable skills, knowledge and experience to ensure their competence. Training shall ensure that individuals are aware of the relevance and importance of their activities and of how their activities contribute to safety in the achievement of the organization's objectives.	
5	<b>PROCESS CONTROL - DEVELOPING PROCESSES</b>	
5.2	The sequence and interactions of the processes shall be determined.	Shop traveller system for manufacturing
5.3	The methods necessary to ensure the effectiveness of both the implementation and the control of the processes shall be determined and implemented	Assessments of control and effectiveness of processes are carried out in relation to manufacturing
5.4	The development of each process shall ensure that the following are achieved: —Process requirements, such as applicable regulatory, statutory, legal, safety, health, environmental, security, quality and economic requirements, are specified and addressed. —Hazards and risks are identified, together with any necessary mitigatory actions...	Regulatory requirements are addressed by activities at St Marcel.  There are some doubts if final product hazards and risks associated with the ingot are addressed
	<b>PROCESS CONTROL PROCESS MANAGEMENT</b>	
5.6	For each process a designated individual shall be given the authority and responsibility for: —Developing and documenting the process and maintaining the necessary supporting documentation; ...	Personnel from the technical function carry out development but their activities may be subordinate to production and not always implemented
5.7 and 5.10	For each process, any activities for inspection, testing, verification and validation, their acceptance criteria and the responsibilities for carrying out these activities shall be specified. For each process, it shall be specified if ... these activities are to be performed by designated individuals or groups other than those who originally performed the work.	Independence of laboratories is noted but some chemical analysis is sub-contracted to the steel maker
5.9	The work performed in each process shall be carried out under controlled conditions, by using approved current procedures, instructions, drawings ...	Noted
6.1 to 6.3	<b>MONITORING AND MEASUREMENT, SELF-ASSESSMENT, INDEPENDENT ASSESSMENT</b> The effectiveness of the management system shall be monitored and measured to confirm the ability of the processes to achieve the intended results and to identify opportunities for improvement.	Management review is conducted annually.
	<b>NON-CONFORMANCES AND CORRECTIVE AND PREVENTIVE ACTIONS</b>	
6.11	The causes of non-conformances shall be determined and remedial actions shall be taken to prevent their recurrence.	The root causes of the negative findings in internal audits and other non-conformances do not seem to have been recognised.
and 6.14	Corrective actions for eliminating non-conformances shall be determined and implemented. Preventive actions to eliminate the causes of potential non-conformances shall be determined and taken.	
and 6.18	Improvement plans shall include plans for the provision of adequate resources.	It is unclear if there are any fundamental preventative actions.
6.16	Potential non-conformances that could detract from the organization's performance shall be identified. This shall be done: by using feedback from other organizations, both internal and external; through the use of technical advances and research; through the sharing of knowledge and	There is limited input of best practice from external organisations.

Clause	Requirement (summarised)	Status in general terms, aside from detected deficiencies
	experience; and through the use of techniques that identify best practices.	



Appendix 4 Document review – ASME QA Manuals

Title	Creusot Forge Quality Assurance Manual	Creusot Forge ASME Quality Assurance Manual	Creusot Forge Quality Assurance Manual	AREVA NP Creusot Forge Quality Assurance Manual	Corporate Quality Assurance Manual for ASME Section III Division 1 Nuclear Components and Parts
Reference	CF MQ 003	CF MQ 003 (E)	CF MQ 003	CF MQ 003	MQ-002-E
Revision	4.1	5 rev 0	6.10	6.1	A
Date	2005-11-17	2008-12-19	2012-02-06	2013-01-29	2015-05-05
Purpose :	Replaces Creusot Forge MAQ Ed 3 rev 1, 2004-05-01 Original edition 1, 1974-09-05	Replaces Creusot Forge MAQ Ed 4 rev 1, 2005-11-17	Replaces Creusot Forge MAQ Ed 5 rev 0, 2010-12-18	Replaces Creusot Forge MAQ Ed 06 rev 0, 2012-02-07	
No of Pages excluding exhibits	49	54	54	54	220
Scope	The Quality Assurance Manual Defines the Creusot Forge QA Program:		The Quality Assurance Manual Defines the Creusot Forge QA Program:	The Quality Assurance Manual Defines the AREVA NP Creusot Forge QA Program:	See below for index of facilities and scope merged as AREVA HE from 2015
Scope	Operations performed during melting and heat analysis			Operations performed during melting and heat analysis	
Scope	Test, inspections and treatments performed Receipt, identification, verification, handling, storage and shipment				
Scope	Qualification of Qualified Materials Organizations (QMO) and direct shipment		Qualification of Non Certified Materials Organizations (QMO) and direct shipment	Qualification of Qualified Materials Organizations (QMO) and direct shipment	
Scope	Approval and control of Source Material Suppliers (ASSM) and Subcontracted Service Suppliers (ASSS) Utilization of Unqualified Source Materials (USM)				
	The Creusot	The Creusot	The Creusot	The AREVA NP	

Title	Creusot Forge Quality Assurance Manual	Creusot Forge ASME Quality Assurance Manual	Creusot Forge Quality Assurance Manual	AREVA NP Creusot Forge Quality Assurance Manual	Corporate Quality Assurance Manual for ASME Section III Division 1 Nuclear Components and Parts
	Forge Quality assurance Manual: Is supplemented by a Quality Management ... Manual and  <i>(see next row)</i>	Forge Quality assurance Manual: Is supplemented by SFARSTEEL Quality Management ... Manual and  <i>(see next row)</i>	Forge Quality assurance Manual: Is supplemented by an ISO Quality Management Manual  <i>(see next row)</i>	Creusot Forge Quality assurance Manual: Is supplemented by an ISO Quality Management Manual and  <i>(see next row)</i>	
	a set of Quality Procedures ...that supplement the Quality Manual requirements Shall prevail in case of divergence with the Quality Management Manual or Quality procedures Shall govern, in the English version, for ASME Materials				

### Facilities and scope merged as AREVA HE from 2015

ASME Certificate		Location	Scope
N	STMA	St Marcel	Class 1, 2, 3 vessels, piping systems, shop assembly. Class 2 and 3 storage tanks Class CS core support structures
N and NPT	STMA	Chalon	Additional code activities: forming, spinning and heat treatments. Storage
NPT	STMA	St Marcel	Class 1, 2, 3 CS fabrication without design responsibility Class 1, 2, 3 CS with design responsibility for appurtenances Material organization supplying ferrous and nonferrous materials
NPT	ACF	Le Creusot	Class 1, 2, 3 CS fabrication without design responsibility Class 1, 2, 3 CS with design responsibility for appurtenances and supports Material organization manufacturing ferrous materials
NPT	ACF	Le Creusot – 3 other addresses	Shipping are and 2 machine shops
NS	STMA	St Marcel	Class 1, 2, 3 and MC fabrication of supports, with and without design responsibility

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