requirements are considered to be met if the properties of the materials are higher than the minimum values stipulated in the Decree. A manufacturer may however decide not to comply with these values if it can demonstrate that alternative measures have been taken to obtain an equivalent overall level of safety.

For the nuclear pressure equipment most important for safety, such as the main primary and secondary circuits of nuclear reactors, the 12th December 2005 Order on nuclear pressure equipment ("ESPN order") sets most restrictive values.

Compliance with these values is verified by means of destructive testing (tensile tests and Charpy impact tests) performed on sacrificial parts.

3 RPV upper and bottom heads steelmaking process

The Flamanville EPR RPV upper and bottom head were manufactured in September 2006 and January 2007 respectively by Creusot Forge.

Creusot Forge used the same process for the RPV upper and bottom heads, except the final thickness obtained after machining being different. The steelmaking process consists in crushing a conventional vacuum-poured forging ingot of 156 tonnes to obtain a disk with a useful thickness of about 450 mm. This disk is heat treated and then dished to obtain a spherical dome 330 mm thick.

The ends of the ingot contain high concentrations of undesirable elements such as carbon, which can degrade the mechanical properties of the steel. The manufacturing process should normally eliminate these zones.

4 The results of the technical qualification tests performed by Area on the RPV heads of the Flamanville EPR NPP.

In September 2012, Areva submitted a proposal to ASN for performing destructive tensile and toughness tests on the RPV upper head, which was initially intended for another EPR project. Areva justified this choice by the fact that the two technical manufacturing programmes were comparable.

Areva carried out mechanical tests in representative zones, giving impact resistance[1] values of between 36 J and 64 J, with an average of 52 J, which is lower than the regulation limit (60 J).

Areva also measured the carbon content of a central core sample taken from this vessel head, which revealed a higher than expected carbon content (0.30% as opposed to a target value of 0.22%).

5 The future test programme

The tests performed so far point out deficient manufacturing quality control, with an impact on the mechanical properties of the materials. Areva is required to demonstrate that the phenomena in question on the RPV upper and bottoms head of the Flamanville EPR NPP are clearly identified, controlled and do not affect other areas of these components than those identified.

ASN will make a decision on the test programme, check that it is correctly implemented and examine the file to be presented by AREVA demonstrating the robustness of the Flamanville EPR reactor

[1] Impact resistance is the ability of a material to absorb energy under the effect of an impact. In the case of a reactor pressure vessel, this property is in particular important for withstanding thermal shocks, for example following the injection of cold water into the reactor coolant system.

pressure vessel. It will in particular call on the services of its technical support organisation, IRSN, and the Advisory Committee of Experts for Nuclear Pressure Equipment.

6 Exchanges with foreign nuclear safety regulators

ASN has informed its counterparts in other countries concerned by the construction of an EPR. Some of the RPV heads for the Taishan 1 and 2 reactors (China) were manufactured by Creusot Forge using a process similar to that used for the Flamanville EPR reactor pressure vessel. This is not the case with the RPV heads for the EPR in Olkiluoto, which come from another supplier.