IMAGES OF REPRESENTATIVE CRACKING IDENTIFIED IN THE HUNTERSTON B REACTOR 4 GRAPHITE CORE INSPECTIONS

Contents

1. Introduction

Nuclear safety is EDF Energy's overriding priority and we will always ensure secure long term safety margins.

We operate in one of the most regulated industries in the world. The UK's nuclear safety watchdog – the Office for Nuclear Regulation – issues a site license for each of our stations. Under these site licenses, we are required to carry out planned maintenance and inspections on each reactor every three years. This is called a statutory maintenance outage. As the plant ages we also organise additional and more frequent inspections in areas of specific interest – such as the graphite in the reactor core which we know will be one of the factors determining the eventual end of generation.

At Hunterston B and Hinkley Point B – our longest operating nuclear stations - we are committed to increasing the frequency of graphite inspections to between 6 and 18 months in addition to the planned statutory maintenance outages. Similar inspections are carried out at our other AGR stations during their statutory outages which take place every three years. The other AGRs will undergo more frequent inspections as they age.

The graphite core at Hinkley Point B and Hunterston B (HPB/HNB) is made up of 308 fuel channels, each with a stack of 12 individual bricks.

Each channel is 10 metres high and has an internal circumference of 825mm. Each brick has a height of 825mm and a diameter of 263mm.

Our safety limits allow for cracks measuring up to 10mm on the inside of the brick. In this condition there is complete confidence that the reactor will operate safely with significant margin.The average crack size identified is 2mm on the inside.

2. Images from the inspections

The images shown in the attached examples are made up of a series of photographs taken within the fuel channels. As these images are taken in a confined space it is not possible to get a single image that shows the full extent of a crack, we have therefore used multiple images and 'stitched' them together to give an understanding of the size of the whole crack. Clearer images of cracks are available in **this video**.

The defects pictured show some of the smallest, the most extensive and also the most complex cracking. The camera films around 70mm from the brick surface and like close-up photos of insects it can make cracks appear larger than to the naked eye.

How the images have been chosen:

- A range across Reactor 4 (R4)
- A range of different fuel brick layers (L1-L12)
- All the major defect crack types
  - Including early life bore cracking and later life Key Way Root Cracks (KWRC)
  - A range of different crack widths

The images have been chosen across a range of brick layers where possible (some crack types are only present in certain layers). Each image is captioned with:

Station (HNB), Reactor (R4), Channel (XX:XX), Fuel Brick layer (BLX), year of inspection, defect description.

Keyway Route Cracks (KWRC) are axial cracks which run from the top of a brick to the bottom. They are an indicator of aging, occurring later in the reactor's life, and form from the outside of the thinnest part of the brick, the keyway, to the inside (the bore). We detected the first of these cracks in Reactor 4 of Hunterston B in 2014 and have been monitoring their progress closely since then. Due to the location of the cracks (in the keyways which help to key the bricks together) it is important to demonstrate that there is no significant core distortion and all control rods will operate as normal and shutdown the nuclear reaction.

During our inspections we also observe other types of crack. These include circumferential cracks which go round the brick, axial bore cracks which, like KWRC, travel top to bottom but form from the bore, or the inside of the bricks and lasso cracks which are curved around the circumference with a tail to the top or bottom of the brick. Many of these cracks occurred at the start of the reactor's life due to the first effects of irradiation. These cracks have been demonstrated to have no significance in normal operations and would not cause core distortion during a severe seismic event due to where they occur on the bricks, i.e. not in the keying structure. They are well documented, have been inspected over a long period of time and are stable.

3. Contributing to safety case development

A safety case is a document describing the safe operating requirements agreed with the regulator. The frequency of future inspections is one of the elements of the graphite safety cases for each of the reactors.

More frequent inspections allow us to gather as much real data as possible. This is analysed and modelled and reviewed independently to build thorough understanding of the condition of the core and demonstrate its ability to withstand a major earthquake.

With experts at the University of Bristol, we have built a quarter scale model of the reactor core, positioned it on a shaker table and subjected it to earthquakes. Computer analysis tells us what is going on and has given us the confidence we need to understand the state of the core and confirm we have large margins of safety.

Our findings are also peer reviewed by experts from universities, internal groups and the regulator who assess the models alongside the real inspection data.

Neither EDF Energy nor ONR, the UK nuclear safety regulator, would ever allow the Hunterston reactors – or any of our reactors – to operate unless completely satisfied that it is safe to do so.