EXPLAINING GRAPHITE

AT EDF ENERGY NUCLEAR SAFETY IS OUR OVERRIDING PRIORITY.

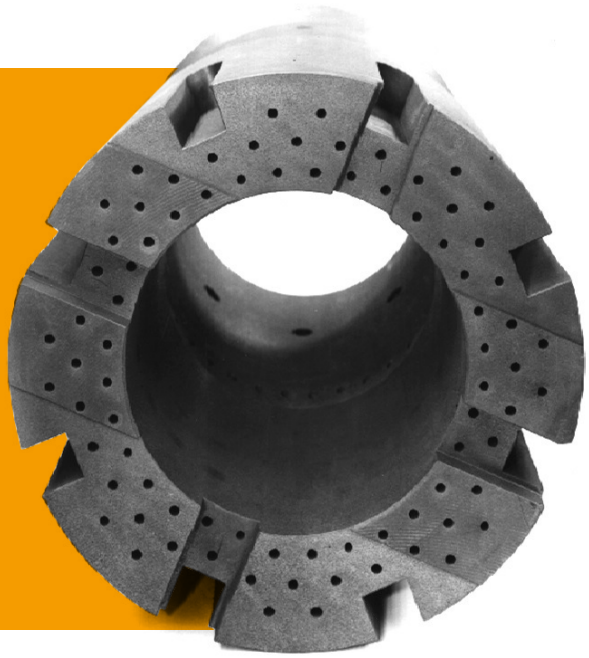
WE ARE WORKING HARD WITH OUR OWN RESEARCH TEAMS, UNIVERSITIES AND CONSULTANTS AS WELL AS OUR REGULATOR TO ENSURE WE HAVE A ROBUST UNDERSTANDING OF HOW OUR GRAPHITE AGES AND HOW OUR REACTORS MIGHT BEHAVE DURING A 1 IN 10,000 YEAR SEISMIC EVENT. THE FOLLOWING INFORMATION IS INTENDED TO ACT AS AN AID TO UNDERSTANDING THIS PHENOMENON AND THE WORK WE HAVE BEEN CARRYING OUT.

Graphite **Structure**

- Graphite bricks are used in the reactor cores of all 14 Advanced Gas-cooled Reactors (AGRs) in the U.K.
- The graphite bricks act as a moderator. They reduce the speed of neutrons and allow a nuclear reaction to be sustained. They also perform an important safety function by providing the structure through which CO_2 gas flows to remove heat from the nuclear fuel and the control rods used to shut-down the reactor are inserted.
- Our reactors are huge structures. Each one is 10 metres high, has a diameter of 10 metres and weighs 1400 tonnes – equal to 110 double decker buses.
- Each reactor core is made up of around 3,000 fuel bricks measuring 825mm high and 460mm external diameter which are all connected together, bound by a steel restraint and contained within a concrete pressure vessel which is over three metres thick.
- Uranium fuel is inserted into the reactor in a fuel assembly through channels in the graphite core. Control rods, containing boron, are also inserted through other channels in the core to control the reaction and also used to shut down the reactor. We have more than 80 control rods in each reactor but only 12 are needed to shut it down.

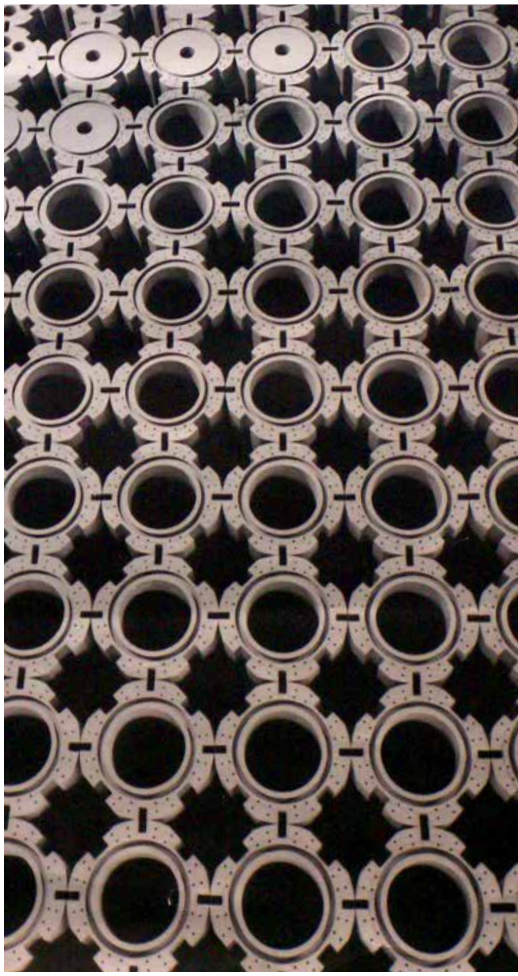
Graphite **Inspections**

- We closely monitor the condition of the graphite in our reactors. Graphite inspections are normally carried out during a station's statutory outage, which takes place every three years. Inspections are held more frequently at our longest-operating stations; Hunterston B and Hinkley Point B.
- We have been working over many years to fully understand and prepare for these late life changes to the reactor core and regular inspections at all our plants have provided a clear understanding of how the reactor cores age.
- The results of each of these inspections allow us to understand clearly how our reactor cores behave.
- There is no graphite in the newer design of reactors at Sizewell B, Hinkley Point C and the proposed Sizewell C.



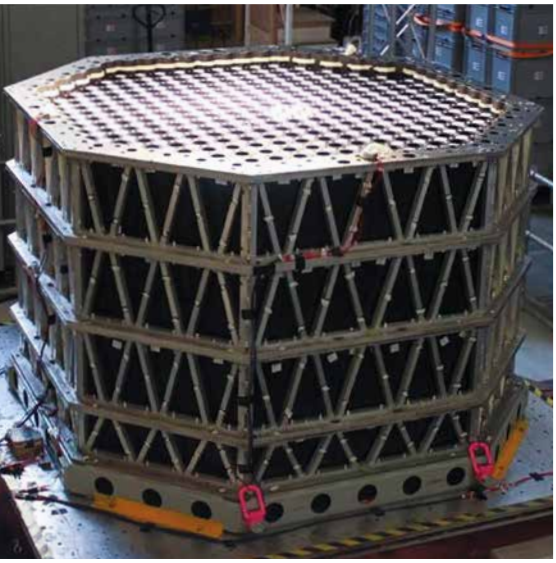
Graphite **Ageing**

- The internal stresses in the graphite bricks change over time and as a result we expect cracking to occur in some of the bricks as they age. This is a well-known phenomenon which was fully considered as part of the stations' design and included in our operational safety case.



Safety Margins

- Nuclear safety drives everything we do. This means we work within very large safety margins. This applies to graphite bricks too. Additionally our approach to safety means that we would stop operations long before anything which would affect the reactor's safe operation.
- The safety cases approved by the regulator do not define a boundary between safe and unsafe. There's a significant margin before the plant would be considered as unsafe.
- We operate with nuclear safety as our overriding priority and would not allow any of our reactors to operate if we had any concerns.
- Each reactor has around 80 boron control rods that are used to manage the unit. Only 12 are required to shut down the reactor, the others provide strength in depth.
- In the highly unlikely event that the number of control rods inserted into the reactor was unable to control the nuclear reaction our stations have a back-up system that would quickly inject nitrogen gas into the core and stop the nuclear reaction.



Graphite **Research**

- EDF Energy has a graphite research programme which benefits from the expertise of our own team of graphite specialists, along with expert academics at several universities across the U.K. This gives us extensive knowledge and understanding of how graphite ages in our reactors.
- We have been working over many years to fully understand and prepare for these late life changes to the reactor core and regular inspections at all our plants have provided a clear understanding of how the reactor core ages.
- We are working with leading consultancies and expert academics at universities across the UK including Strathclyde, Glasgow, Bristol, Manchester, Oxford, Sussex, Nottingham and Durham as well as with leading UK companies such as AMEC Foster Wheeler, W S Atkins and Fraser-Nash.
- We have spent more than £100m in the last five years and invested more than 1000 person years into research.

Further Information

The Office for Nuclear Regulation has produced some helpful background on graphite here:
http://www.onr.org.uk/civil-nuclear-reactors/graphite-core-of-agrs.htm