GRAPHITE IRRADIATION PROGRAMMES AT NRG

An update

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NUCLEAR RESEARCH AND CONSULTANCY GROUP

NRG is the nuclear service provider is the Netherlands. Operating a range of nuclear facilities on a single site with over 60 years of experience.



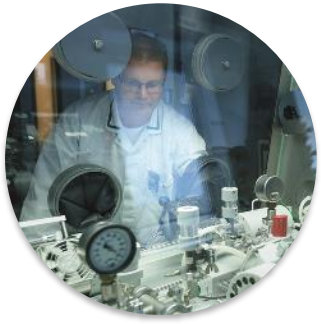
45 MW_{th} HIGH FLUX REACTOR



DECONTAMINATION & WASTE TREATMENT



HOT CELL LABORATORIES



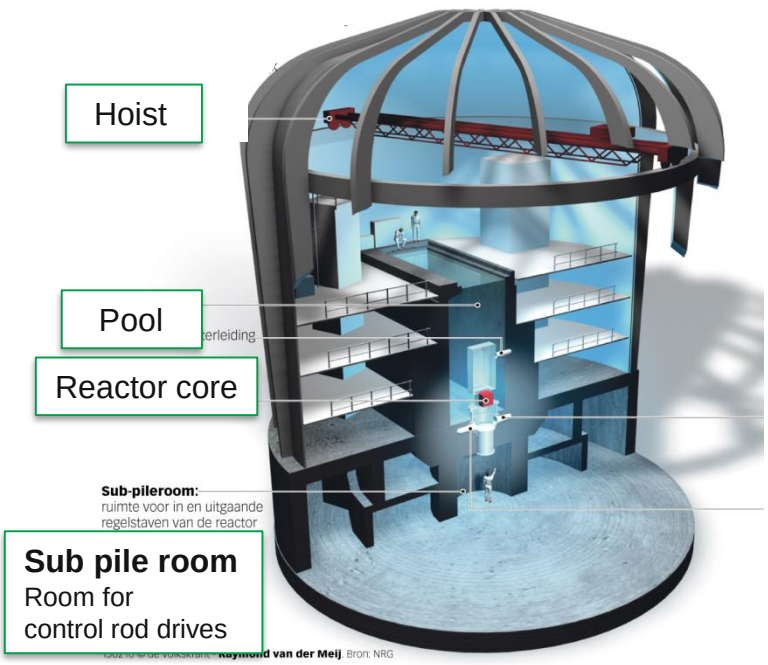
RADIOLOGICAL LAB: JAAP GOEDKOOP LABORATORY

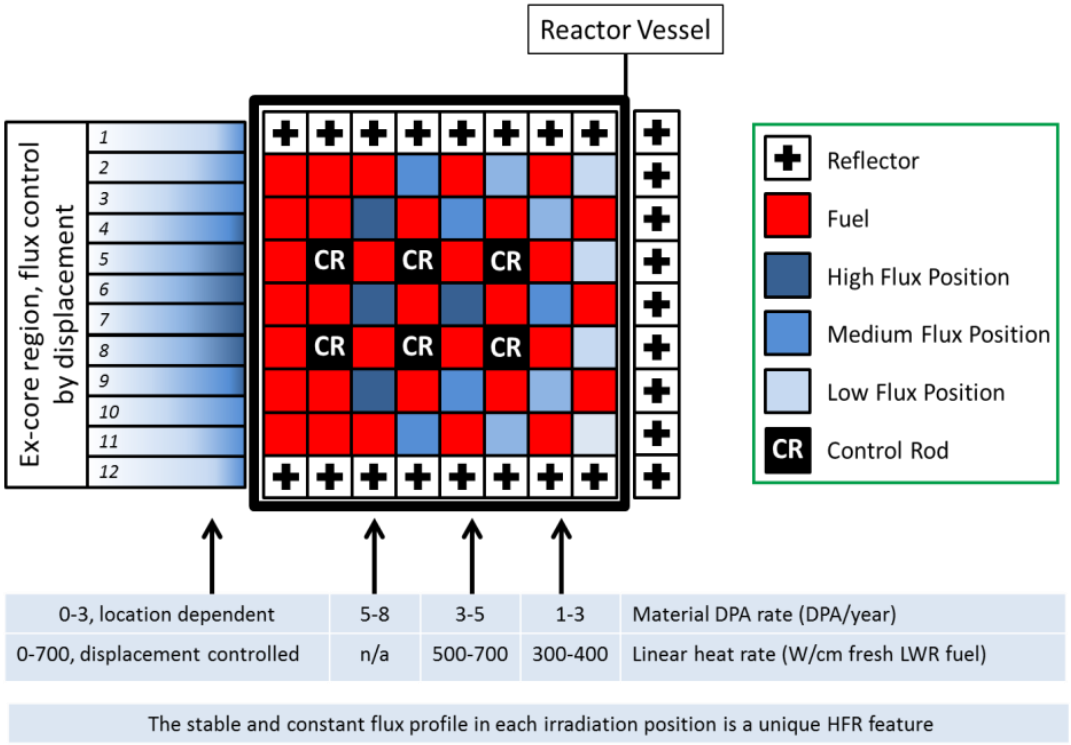


MOLYBDENUM PRODUCTION FACILITY

IRRADIATION IN THE HFR

The High Flux Reactor in Petten is a 45 MW_{th} tank-in-pool reactor used for material research and isotope production





OUTLINE

- History
- Dutch funded program
- Bilateral projects

PREVIOUS GRAPHITE PROGRAMS IN HFR PETTEN

Graphite (creep) experiments from 1968-1990

Important programmes from the past:

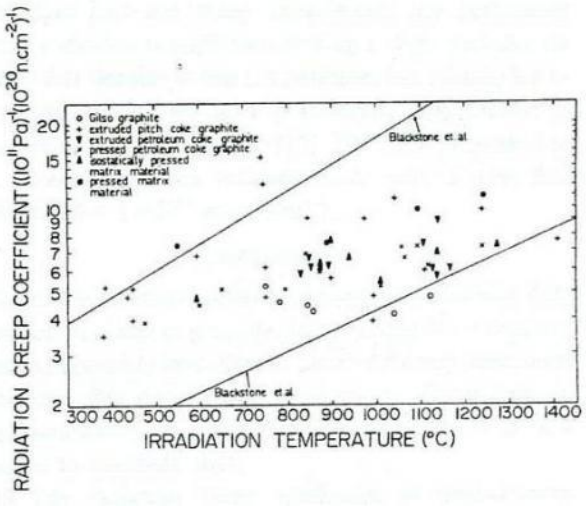
1. Dragon project,
2. German HTR programme

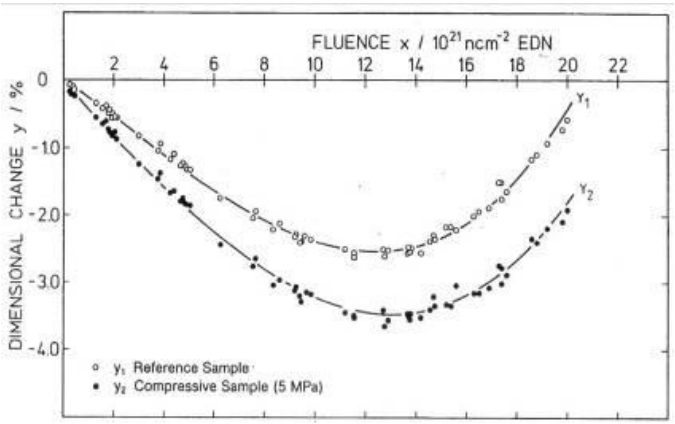
Various types of creep experiments:

1. Restrained shrinkage
2. Load controlled

2001- 2015

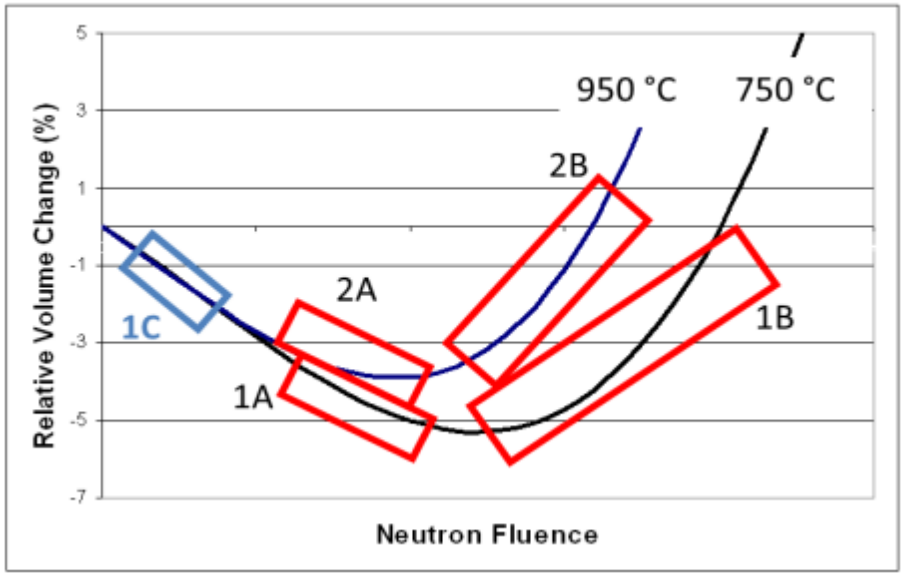
INNOGRAPH program for Eurpean HTR technology





HTR GRAPHITE IRRADIATION AT NRG

- 5 “INNOGRAPH” irradiations
- Modern-day HTR graphite candidates (10 grades)
- European framework programs (HTR-M, RAPHAEL, ARCHER)
- Low, medium, and high dose ranges to cover graphite behaviour beyond cross-over
- Re-load of active “A”-phase samples in “B”-phase for time-efficient acquisition high dose data



Schematic of INNOGRAPH irradiation campaign

2001-2006 HTR-M High Temperature Reactor - Materials 2006-2011 RAPHAEL 2011-2015 Archer Advanced Reactor for Cogeneration of Heat & Electricity-R&D

CURRENT DUTCH PROGRAM

Ministry of Economic Affairs of the Netherlands

Molten Salt Program

Development irradition technology to support M



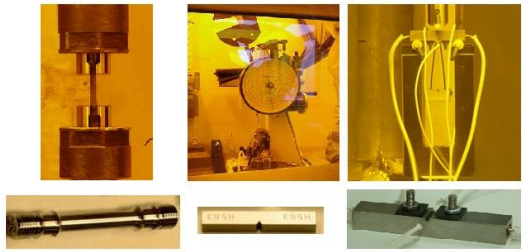
Fuel Creep:

- Development nieuw technique for online measurements of irradiation creep in fuel

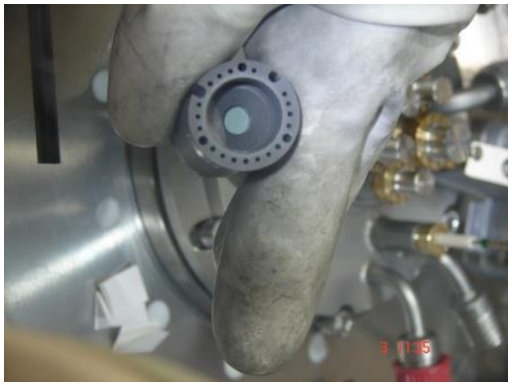


Strumat

- Reactor vessel steels for end-of life studies



MSR GRAPHITE – SALT INERACTION

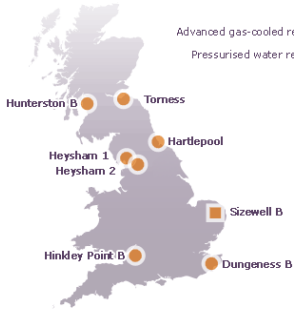


Filling SALIENT containers at JRC-ITU Karlsruhe

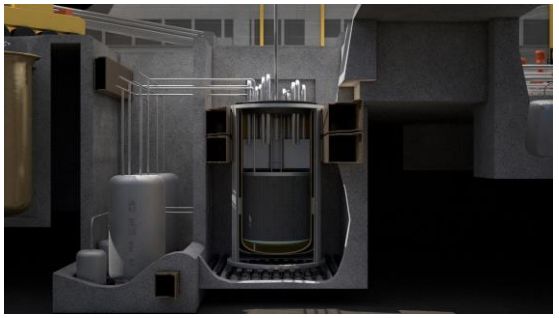
- Two years of irradiation in HFR (finished August 2019)
- Corrosion-resistant graphite crucible
- Salient irradiation facility has 4 graphite crucibles filled fluoride fuel salt
- Open container (through metallic filter) to accommodate FG release
- Wall temperature maintained at ~610°C monitored by 24

BILATERAL PROJECTS ON GRAPHITE

- **EDF Energy** (UK) EDF Energy operates Advanced Gas Cooled Reactors
  - BLACKSTONE (2006-2022)
  - ACCENT Creep (2013-2017)



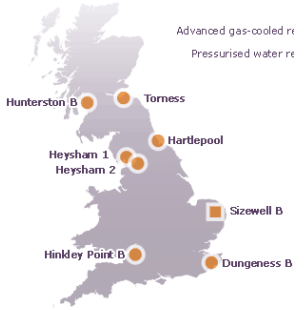
- **Terrestrial Energy** (Canada), Integrated Molten Salt Reactor
  - GAIA (2019 -2024?)



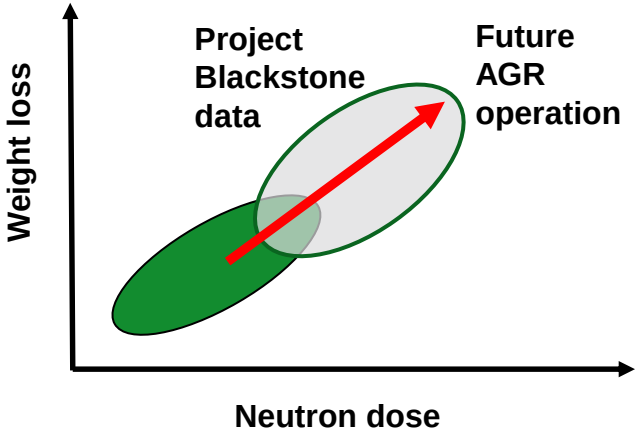
BLACKSTONE

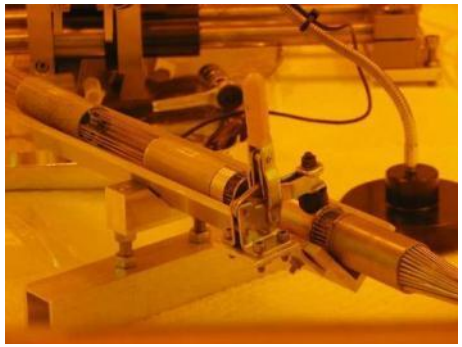
Supporting long life of Advanced Gas Cooled Reactors

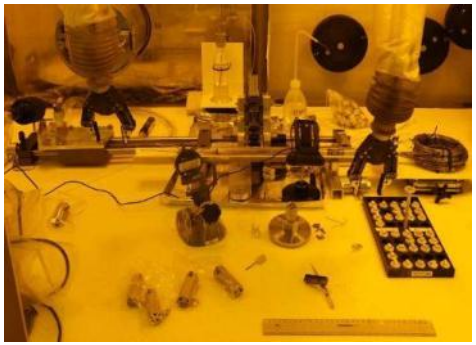
- EDF Energy operates Advanced Gas Cooled Reactors, supplying ~ 20% of electricity in the United Kingdom
- Graphite cores age with time due to neutron damage and radiolytic oxidation
- Accelerated ageing tests HFR to determine graphite properties ahead of actual AGR core structures
- Project started in 2006, currently (cumulative) life time of oldest AGRs is extended by 40 years
- Current work: life time extension of the 2 youngest AGR's





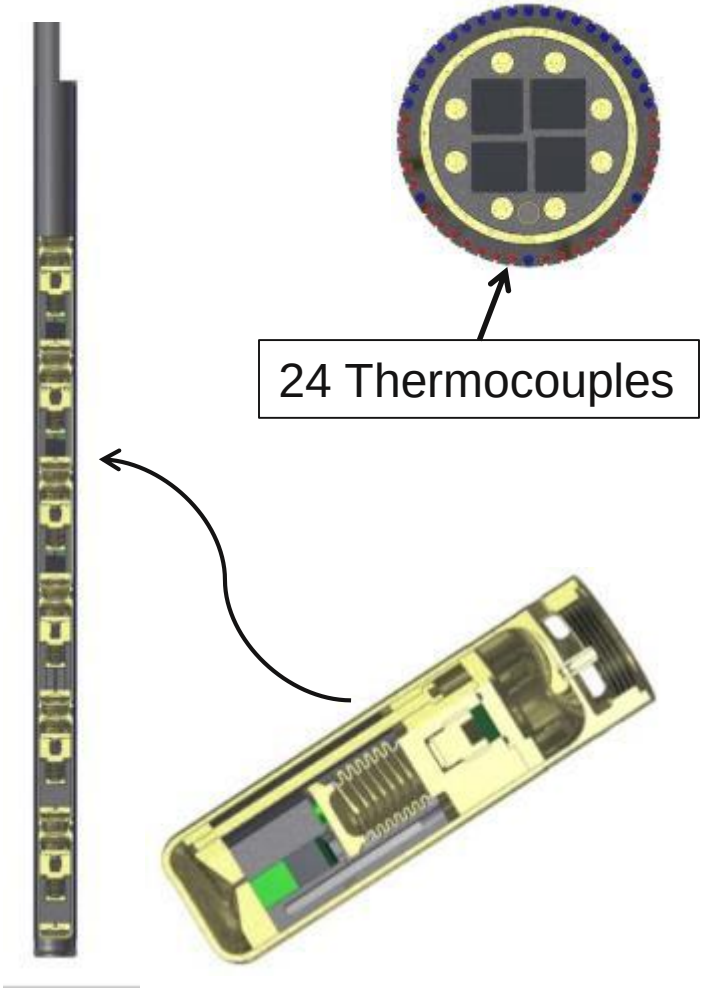






ACCENT

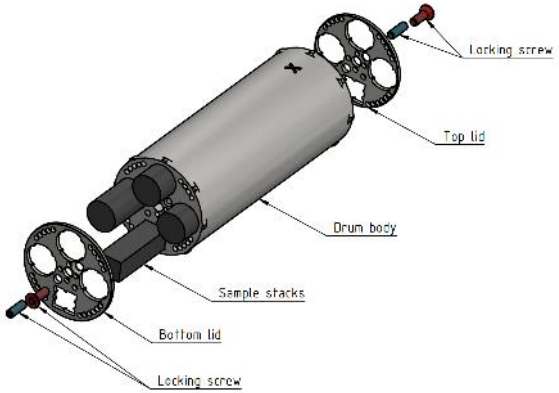
- 4 irradiations between 2013-2017
- Samples loaded in 6 modules
- Instrumented holder with 24 thermocouples for online temperature measurement
- Temperature control by:
  - modification of heat conductivity across gas gaps by changing gas composition in gap 2nd containment
  - vertical displacement of rig in core

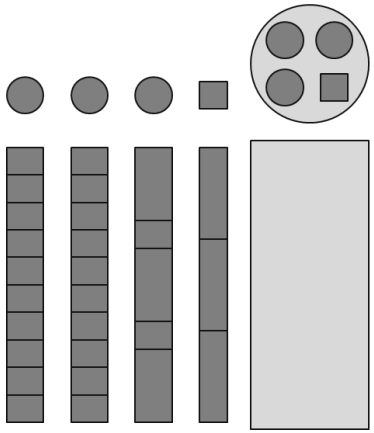


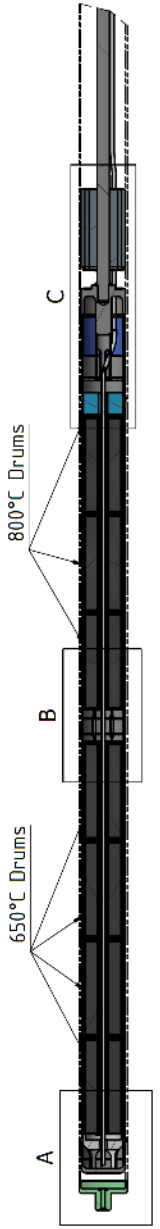
GAIA

TERRESTRIAL ENERGY

- One irradiation rig with 7 drums placed in HFR high flux position
- 200 specimens
- Thermal barrier to separate 650 and 800°C temperature zones
- Samples in inert He environment
- Online temperature measurement with 24 thermocouples
- Control of temperature by changing gas mixture in second containment
- Two irradiation steps (8+12







Thank you for your attention