Office for Nuclear Regulation

Regulatory Research Annual Report 2016/17

About us

The ONR is the public body set up under the Energy Act 2013 as the independent, statutory regulator of nuclear safety, nuclear security, and conventional health and safety at GB nuclear sites.

This includes the existing fleet of operating reactors, fuel cycle facilities, waste management and decommissioning sites and licensed defence sites.

In addition ONR regulates the design and construction of new nuclear facilities, nuclear security at civil nuclear facilities and the transport of nuclear and radioactive materials. Furthermore we work with the international inspectorates to ensure that safeguards obligations for the GB are met.

ONR's mission is :

"To provide efficient and effective regulation of the nuclear industry, holding it to account on behalf of the public".

Delivering a safe and secure nuclear industry is the responsibility of the duty holders we regulate; it is ONR's responsibility to ensure they comply with the law.

Why we do research

The Energy Act 2013 enables ONR to carry out or commission research in connection with its purposes and supports delivery of its vision of being an exemplary regulator.

The nuclear landscape is changing rapidly, with the nuclear industry poised to expand as plans to design and build several new nuclear power stations and emergent Small Modular Reactor (SMR) technology develop.

With this changing landscape it is important that ONR positions itself to ensure it can adequately meet the challenges.

Research plays a critical role in our understanding of a wide range of complex, often unique challenges. ONR's research needs differ from many organisations in that they support its independent regulatory decision making and ensure our regulatory processes remain robust. This needs to be based on objective scientific and technical understanding of the safety and security issues that may arise.

"As director of ONR's Technical Division, a role encompassing ONR's research portfolio, I am pleased that our research is delivering benefits to our stakeholders and ourselves as we carry out our regulatory activities.

This annual report describes the research activities we have conducted in the past year. The case studies show how our research strategy has helped support ONR's enabling regulatory approach, in addition to informing the development of relevant good practice".

Anthony Hart

Our research and development

How it's organised

Providing **advice, support and co-ordination**, all ONR's research activities are funneled through a discrete leadership function, ensuring transparency and accountability.

ONR's research objectives are contained in its research strategy published in August 2015. This states that :

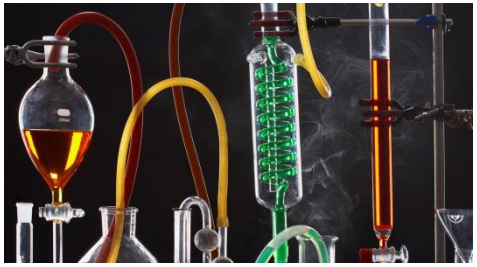
''ONR will use research to support its independent regulatory decision making, based on objective scientific and technical understanding of the safety issues. The main objectives of the strategy are to ensure that ONR's inspectors form their regulatory judgements confidently and effectively using sound, up to date scientific and technical information''.

ONR follows a rigorous process to identify research needs and opportunities, determine associated costs and measure progress. ONR does not commission research to support the commercial development of nuclear technologies. We do not carry out research in areas for which other public bodies have regulatory responsibilities, or are responsible for providing authoritative advice.

Potential research needs and opportunities, to achieve ONR's objectives, are identified through **ONR's 15 specialisms**, including :

- Fault Analysis
- Human and Organisational Capability
- Mechanical Engineering
- Radioactive Waste/Nuclear Liabilities
- Radiation Protection and Criticality
- Process and Chemical Engineering
- Security
- Structural Integrity

The procedure



Research proposals pass through a selection procedure, utilising defined **principles and criteria** to screen and prioritise our research proposals and check they are aligned with ONR's strategy.

Research proposals carried forward are translated into specifications and then discussed with our stakeholders, for example, the environment agencies, the Nuclear Decommissioning Authority, the wider nuclear industry and key research providers.

This seeks to deliver **maximum value** from our research activities, ensures duplication of work is avoided and promotes the sharing of good practice as widely as possible.

Research proposals that have successfully progressed through the above process are added to the **Regulatory Research Register.**

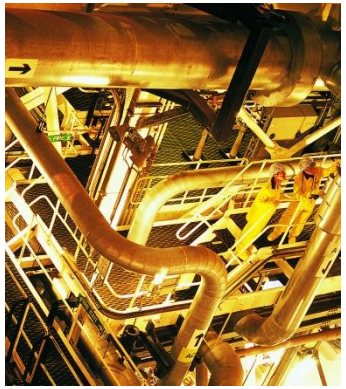
The costs

To deliver maximum value from our research activities, we seek to **collaborate** with other key research funders.

In 2016/17, ONR had **53** research projects and proposals in its Regulatory Research Register, amounting to approximately **£1.2 million.**

Of the 53 we identified, **11** proposals for action this financial year amounted to **£0.5 million** expenditure.

A further **£48,000** was allocated for attendance and participation in research activities, such as conferences, seminars and other related engagements (both national and international) together with membership subscriptions for various research topic groups.



In previous years, ONR's Structural Integrity specialism (particularly its Graphite research programme) was managed as a separate research activity. For 16/17 this activity has been merged with our wider regulatory research.

Case study 1 Radiation protection risks arising from using non air-fed suits

Challenge

- Non air-fed suits with respirators are used widely throughout the nuclear industry.
- Risks to non air-fed suit wearers from heat stress are arguably higher than those of air-fed suit wearers.

Investigation

- Four volunteers took part in trials in four conditions at two environmental temperatures (25 and 35˚C).
- Individuals were subject to 120 minutes of activities, followed by 20-30 minutes of standing and undressing to simulate decontamination. These activities were typical of those carried out during nuclear activities.
- Heart rate, deep body temperature and skin temperature were monitored.

Typical Results

- Heart rate increase can limit activity times more than core body temperature.
- Typically it took more than an hour to cool to “normal” levels after removing the suits and leaving the test chamber.

Future Work

- Larger scale studies for statistical significance.

Safety Intelligence Gained

- Use heart rate monitors with alarms.
- Only ask workers to undertake one entry per day to allow sufficient resting time.
- Ensure good hydration and rehydration is available.
- Tight controls warranted over non air-fed suit activities when using non permeable PVC suits in high temperature environments.

Typical non air-fed suit with respirator

Case study 2 Graphite core ageing

Challenge

- The GB fleet of Advanced Gas-cooled reactors (AGR's) are the only operating graphite moderated, carbon dioxide cooled power generating reactors in the world.
- The graphite core undergoes ageing behaviour, which limits its operational lifetime.
- This complex behaviour is difficult to predict with certainty and is not fully understood.
- The majority of fundamental research and understanding of graphite ageing is now limited to the single licensee of the AGR's.
- This creates a potential regulatory challenge for ONR since much of the information we might need in order for us to form an independent view on the continuing safety of the AGR's comes from the same sources as the licensee has used to make its own safety decisions

Investigation

- In anticipation of late life ageing issues, ONR began funding independent nuclear graphite experts from academia and industry in early 2000. The aims were to develop an independent understanding of the specific issues posed by graphite core ageing, to identify knowledge gaps where assumptions and uncertainties exist and to assist ONR in its task of determining the adequacy of the licensee's methodologies which support its safety cases.

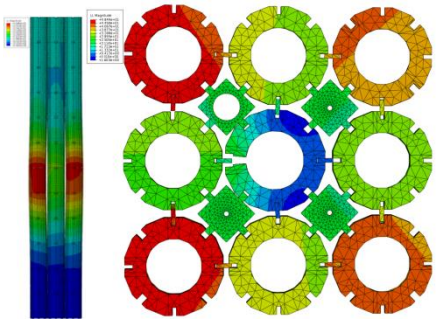
Typical Results

- Development of independent models for dimensional change and material property evolution.
- Development of independent models of the rate of core ageing based on inspection data.
- Development of 2D and 3D models to investigate implications of graphite ageing on core distortion.

Safety Intelligence Gained

- Identification of inherent uncertainties which are present in predictions of graphite core ageing.
- Advice to ONR in determining whether the licensee has made reasonable assumptions and appropriately accounted for uncertainty in its predictive models of graphite core behaviour.
- Advice to ONR in determining whether the limits and margins within the licensee's graphite core safety case are adequate to support continued safe operation.

Graphite core stress model



Case study 3 Prediction of Pressurised Water Reactor fuel behaviour in faults

Challenge

- The correct prediction of Pressurised Water Reactor (PWR) fuel behaviour during faults depends on the selection of an appropriate heat flux criterion which is the critical heat flux (CHF) for the reactor core regions that are subject to change in the coolant flow conditions.
- The spacer grids provide a constant flow area between the adjacent fuel pins and bind them into fuel assemblies. The fuel pins are about 4m long and tend to bow due to irradiation within the reactor core, so the spacer grids of two neighbouring assemblies could touch each other – thus changing the coolant flow along and across the fuel assembly.
- The challenge for ONR is to form a view on whether the available results from experimental tests can be adequately scaled to reactor geometry, and whether there is merit in doing two phase flow computational fluid dynamics analysis for correct representation and evaluation of the risk from touching spacer grids (TSG) during design basis faults.

Investigation

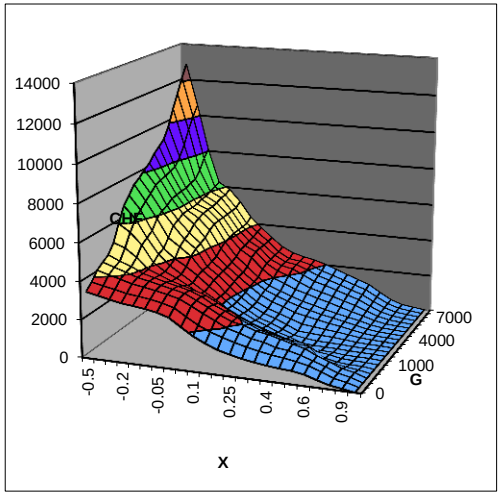
- Identify the base phenomena defining the CHF limit for both flow reduction and overpower fault conditions in the PWR core, considering the potential for TSG.
- Review the options (methods, tools and models) that are currently available for CHF prediction and their development status.
- Recommend a reasonable strategy allowing ONR to assess the adequacy of safety margins in set points for CHF mitigation, applied in current or proposed GB PWR's.

Safety Intelligence Gained

- It is now feasible to better quantify the uncertainty in CHF for boiling conditions, though further research is needed to do this with precision for dry-out.
- ONR now has an enhanced objective basis for critical assessment of the safety cases for PWR type stations.

Typical Results

- The adequate representation of single-phase effects in the fuel assembly is now possible and existing models are already qualified against specific experimental data.
- For two-phase conditions, the uncertainty is larger, but reasonable models now exist and could be used to predict CHF for these conditions. For the case of dry-out, the effect of interaction between the liquid film and the spacer grid is a source of uncertainty. A focused programme of observation / measurement could reduce this.



140 bar: Critical heat flux, (CHF, kW m-2) dependence on mass flux (G, kg m-2 s-1) and quality

Published work

- Completed work that has been commissioned by **ONR** is published on our website
- Projects completed by **industry** may be published externally, subject to commercial confidentiality tests.

Our Community

ONR is represented on many wider research panels. This enables us to improve our outreach and communications with GB and international bodies to share information in the interests of improving nuclear safety and security worldwide

Output delivered from these groups is available :

OCED/NEA - https://www.oecd-nea.org/nsd/csni/
https://www.oecd-nea.org/nsd/cnra/
https://www.oecd-nea.org/mdep/

NDA - https://www.gov.uk/government/publications

Evaluation

- Our research evaluation process is still to be finalised, but we are developing a strategy in which we review the regulatory impact and value for money when our projects are completed.
- As we enter a new financial year, our research team will continue to identity ONR's needs to ensure that we are equipped to meet the regulatory challenges arising from the evolving nuclear industry. This will include reviewing our strategy and identifying areas that are framed around innovation and technology.

Find out more

If you're interested in finding out more about our work, you can :

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