

Laboratory Research and Development Capabilities (UK)

Our Laboratory and R&D Capabilities

Jacobs' expertise is supplemented by extensive laboratory and R&D facilities in the UK and Europe. We provide a range of research, analysis, testing and bespoke engineering solutions for sectors including nuclear, aerospace, clean energy, infrastructure and oil and gas.

Our technical and delivery expertise enables us to create innovative and fit for purpose solutions to engineering challenges, supporting any asset.

- A 12,000m² laboratory hub in Warrington, complemented by facilities in Cumbria, Harwell, Humberside and Slovakia
- Specialist scientific laboratories, test rigs, workshops and high height flexible facilities
- More than 700 technical experts and practitioners
- Exceptional expertise in materials, chemistry and structural integrity
- Advanced robotics and remote operations capability
- Independent Assurance to clients in high hazard industries

To speak to our team or for more information, please contact:

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Integrated Technology Solutions

Enabling technology and innovation to deliver cost-effective solutions for our clients.

We are a client-focused technology independent solutions provider, tackling the most complex challenges. Our world-leading laboratory and engineering test facilities enable us to set new technical standards, demonstrate the latest thinking and deliver the seemingly impossible.

Our world is changing and so must our knowledge and imagination - innovation is at the heart of what we do. Innovation is collaboration - we identify the best technology provider, large or small, to meet the challenge. We are an integrator, enabling new technologies to market through collaboration with academia and trusted partners.

We inspect to understand the challenge, we design to address the challenge, we test to overcome the challenge, and we train and deploy to deliver the solution to the challenge.

Engineering Development

Our designers and engineers develop innovative concepts to solve clients' problems. Then they take those concepts through optioneering, design and manufacturing. Using our own extensive laboratories and test rig space and, where appropriate, a network of partners from small medium enterprises to leading academic experts, we develop fit-for-purpose integrated solutions.

Services

We deliver complete solutions to complex problems. Our team of scientists, engineers, technicians and craftsmen work with our clients to understand problems and offer solutions through experience and innovation. We are involved at all stages of concept, prototyping, design, testing and implementation, utilising skills including mechanical design, robotics, software, instrumentation and controls systems.

Our extensive engineering laboratories enable us to produce mock-ups for equipment trialling, integration, operator training and client approval.

The facilities incorporate:

- 10t, 7.5t and 2t cranes

- 3000m² of laboratory space
- 1500m² of dedicated rig space
- 25m head room
- Machine shop
- Fabrication shop
- Electrical control and instrumentation workshop
- Assembly areas

Our engineering solutions and mock-ups can be very simple or complex. We strive to use fit-for-purpose engineering solutions and by using our own resources and facilities, we can develop solutions in stages, adapting where required to get the best technical solution.



Robotics and Remote Operations

During more than 50 years of work on nuclear power reactors, where key areas of the plant are inaccessible because of radiation hazards, we have developed a comprehensive remote inspection and remote engineering capability. We perform maintenance and inspection on parts of plant where standard methods will not work. We design and manufacture tooling where required, including bespoke remotely operated vehicles (ROVs).

Our robotics capability is being deployed to support multiple industries.

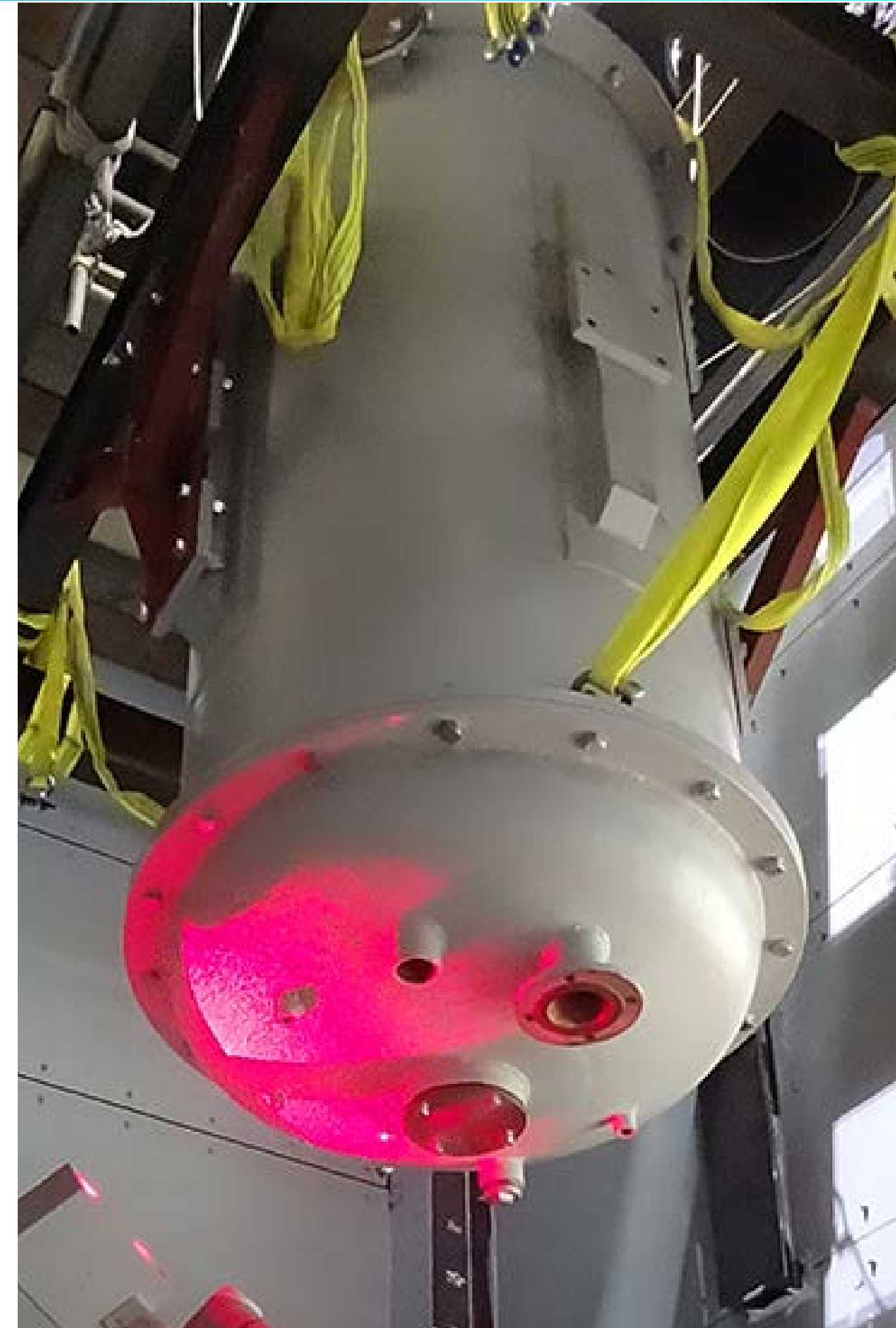
Services:

- Robotics design and testing
- Remote handling, intervention and measurement
- Concept, mechanical, software, test and environment and infrastructure design
- Noise, vibration and laser profilometer surface measurement
- Photogrammetry
- Research and development

- Remote visual inspection analysis and video processing
- Long-term test programmes
- Prototyping
- Development rigs

We design and build our own bespoke ROVs for challenging applications at major nuclear decommissioning sites including Sellafield in the UK, such as:

- High mobility tracked ROV (e.g. able to step over pipework and other large obstructions) for remote intervention in congested or debris-strewn areas
- Heavy duty wheeled ROV for deploying floor cleaning/decontamination tools, waste drum marshalling etc
- Submersible crawler ROV to clean waste or debris from wet silos and other underwater areas
- Magnetic ROV for climbing on carbon steel surfaces for remote inspection and intervention
- Pipe crawlers for internal inspection of pipework



Materials and Components

We provide a wealth of experience and capability in materials and component characterisation, inspection, testing, integrity assessment and qualification.

Our facilities for materials science include United Kingdom Accreditation Service (UKAS) accredited testing laboratories and the UK's High Temperature Facility, which is hosted and managed by Jacobs. Our advice plays an essential role in ensuring safe, reliable and cost-effective operation of our clients' facilities, underpinned by qualification of materials, equipment and inspections.

Materials and Component Testing

Testing is essential both to determine the physical and mechanical properties of raw materials and components, to evaluate strength, hardness, elasticity and fracture toughness, and to assess resistance to the conditions in which they are expected to operate.

Using fractographic and metallographic examination techniques, our materials scientists carry out a wide range of tests to determine physical properties and microstructure to characterise unidentified materials.

Our mechanical testing laboratories evaluate materials behaviour at temperatures from -196°C up to in excess of 1000°C using techniques such as:

- Fracture toughness
- Fatigue endurance (low and high cycle fatigue)
- Thermo-mechanical fatigue (cycling of load and temperature)
- Testing in environments including vacuum, gases, low and high temperatures
- Fatigue crack growth
- Creep (rupture, creep strain and crack growth)
- Charpy impact and hardness

- Tensile/strain curve extraction

These tests can be undertaken to all relevant British Standard (BS), European Standard (EN), International Organisation for Standardisation (ISO) and American Society for Testing and Materials (ASTM) standard test piece designs or using bespoke designs to suit particular requirements, including the use of material from ex-service or as-manufactured components. We are also able to perform material testing in inert environments (vacuum or inert gas) and in aggressive gaseous or aqueous environments.

Our large-scale testing laboratory houses general purpose test machines with load capacities up to 2.5 meganewton.

In addition, we design, build, and operate bespoke rigs to conduct customised tests on components simulating loading conditions. The rigs have fatigue capability and can be configured to apply load in off-axis or bi-axial modes.



Low and High Temperature Testing

Research into the performance of materials at low and high temperatures and in unusual environments is vital for many industries, to predict performance and to inform the selection of advanced materials for use in new and innovative concepts.

Services

Jacobs is a member of the UK High Temperature Facility (HTF) Alliance and manages the HTF located at our Birchwood site.

Testing offered by the HTF includes, but is not limited to:

- Tensile testing (loads up to 100 Kilonewton (kN) in tension and compression)
- Fracture testing (loads up to 250 kN and in the temperature range -196 to 1000°C)
- Creep strain/rupture (loads up to 30 kN)
- Creep crack growth (loads up to 30 kN)
- Testing in environments including vacuum, gases, low and high temperatures
- Strain and load-controlled low cycle fatigue initiation (loads up to 100 kN in tension and compression)
- Fatigue crack growth (loads up to 100 kN in tension and compression)

- Creep-fatigue initiation/growth (loads up to 100 kN in tension and compression)
- Thermo-mechanical fatigue initiation/growth (loads up to 100 kN in tension and compression)
- Miniaturised tensile/creep/fatigue testing (loads up to 10 kN)
- High cycle fatigue endurance/crack growth (up to 100 Hertz test frequency and loads up to 10 kN)

To enable detailed analysis of tests the rigs can be equipped with the following analytical instrumentation:

- Digital image correlation for full field strain measurement (especially useful where welds are present)
- Acoustic emission monitoring equipment for monitoring crack initiation and propagation
- Potential difference monitoring equipment for monitoring crack initiation and crack growth



Environmental Testing

Our testing laboratories are internationally recognised for measurement of crack growth, crack initiation, fatigue endurance and surface degradation for materials exposed to extreme environments, including liquid and gas at specific temperatures, pressures and acidities.

In addition to being leaders in nuclear materials, our knowledge extends to aerospace applications and materials including aluminium and magnesium alloys.

Using test facilities designed and constructed in-house, we constantly strive to match or surpass the leading facilities in the world through innovation and market awareness reviews.

To complement our test facilities, we also offer consultancy services which can provide advice on material degradation, identification of knowledge gaps in the state of the art and setting up and delivering research programmes.

We have expertise in material degradation experiments, testing materials and electronic components in gamma radiation environments, along with other set conditions such as temperature, humidity and gas concentration.



Equipment and Material Qualification

Equipment Qualification (EQ) is vital to ensure reliable, predictable and safe operation of safety related systems. Jacobs takes a programmatic approach to ensure that equipment can perform its designated function and safety role on demand, in mild, harsh and accident environments, throughout its operational life.

Services

As a member of the EQ Services Alliance, we provide a wealth of expert support and advice on materials selection and qualification plans as well as testing strategies and programmes - all designed to establish, preserve and upgrade your equipment qualifications. Our services include:

- In-depth knowledge of qualification of materials and equipment to globally recognised standards
- Qualification of structures, systems and components through dynamic and seismic analysis using a range of techniques/analyses (linear, non-linear, soil structure interaction, vibration, blast, impact)
- Bespoke testing programmes and rig build

- Expertise in the operation and maintenance of existing plants, including consultancy services on seismic assessments, plant walk-downs and maintenance schedules
- Extensive experience of the qualification of EC&I equipment, including programmable electronic systems and SMART instruments in line with SC45a standards for Class/probabilistic targets and IEC safety integrity levels
- Extensive facilities covering a range of CE testing services and CE Notified Body certification services

Equipment Qualification testing facilities;

- Thermal ageing ovens
- Irradiation ageing facility
- Environmental aging and testing
- Seismic testing (via partners)



Advanced Non-Destructive Testing Services

Non-destructive testing (NDT) is an essential element in the safe operation of all kinds of industrial plant.

In safety cases for safety-critical components, NDT is often necessary to measure a detectable defect size and compare it with the maximum tolerable size. Jacobs provides a one-stop shop for independent advice and consultancy on NDT, including research, development, consultancy, qualification and related services, coordinated by our Monitoring and Inspection Design (MID) team. We provide a complete service which saves time and cost by avoiding downtime. Our solutions cover non-standard areas and novel methods and techniques, including advanced ultrasonics.

Services:

- Inspection modelling and design undertaken by a team of experts using various NDT modelling tools including CIVA, MUSE, RAYTRAIN and OPERA software
- R&D relating to novel NDT methods for flaw detection, sizing and characterisation and materials degradation monitoring
- Specialist inspection system development for site applications
- Application of advanced ultrasonic phased array, eddy current and other NDT methods
- Online monitoring systems
- Design and production of test specimens
- Inspection training
- Human reliability studies

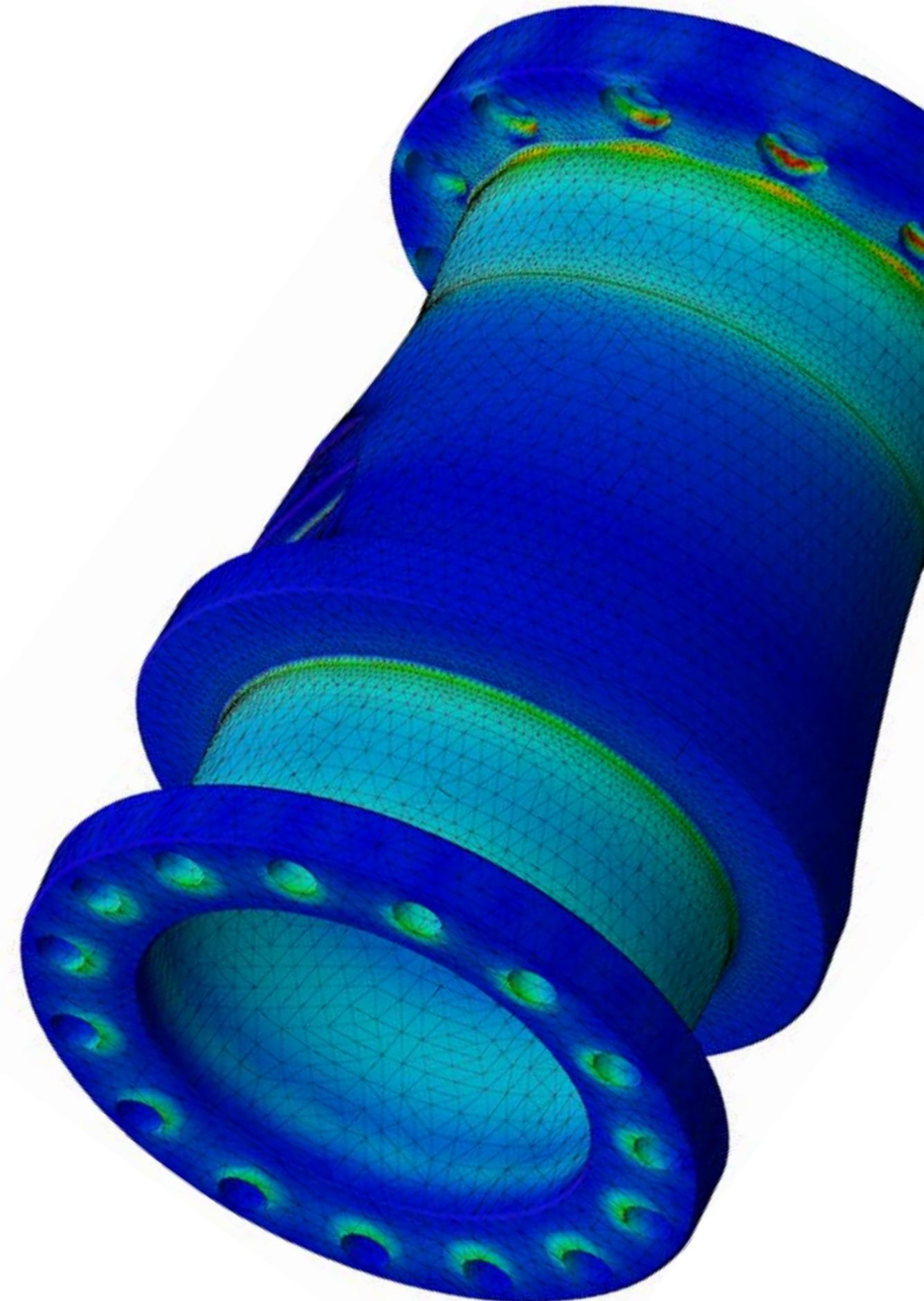


Structural Integrity and Finite Element Analysis (FEA)

Our specialists in structural integrity and finite element analysis enable clients to understand a variety of risks from mechanical and thermal stresses and fracturing to heat transfer, vibration and seismic movement. We also carry out impact assessments and non-destructive testing of defects.

Services:

- Finite element analysis
- Analysis of mechanical stresses, fracture (elastic, inelastic and cyclic cracked-body analysis), limit load/plastic collapse, heat transfer, impact, seismic and vibration, thermal stresses and welding residual stress simulation
- Finite element analysis capability in:
 - ABAQUS
 - FLUENT
 - ANSYS
 - FEAT
 - SYSWELD
 - Code ASTER
- Simulation studies
- Impact damage assessment (compared to R3)
NDT modelling of defects, containment
- Vibration analysis
- Thermal analysis
- Seismic and dynamic analyses
- Probabilistic methods
- Environmental fatigue
- Cyclic loading and fatigue
- Creep damage and rupture
- Fracture mechanics (R5, R6 and BS7910)
- Design codes (ASME, RCC-M)



Specialist Modelling and Analysis

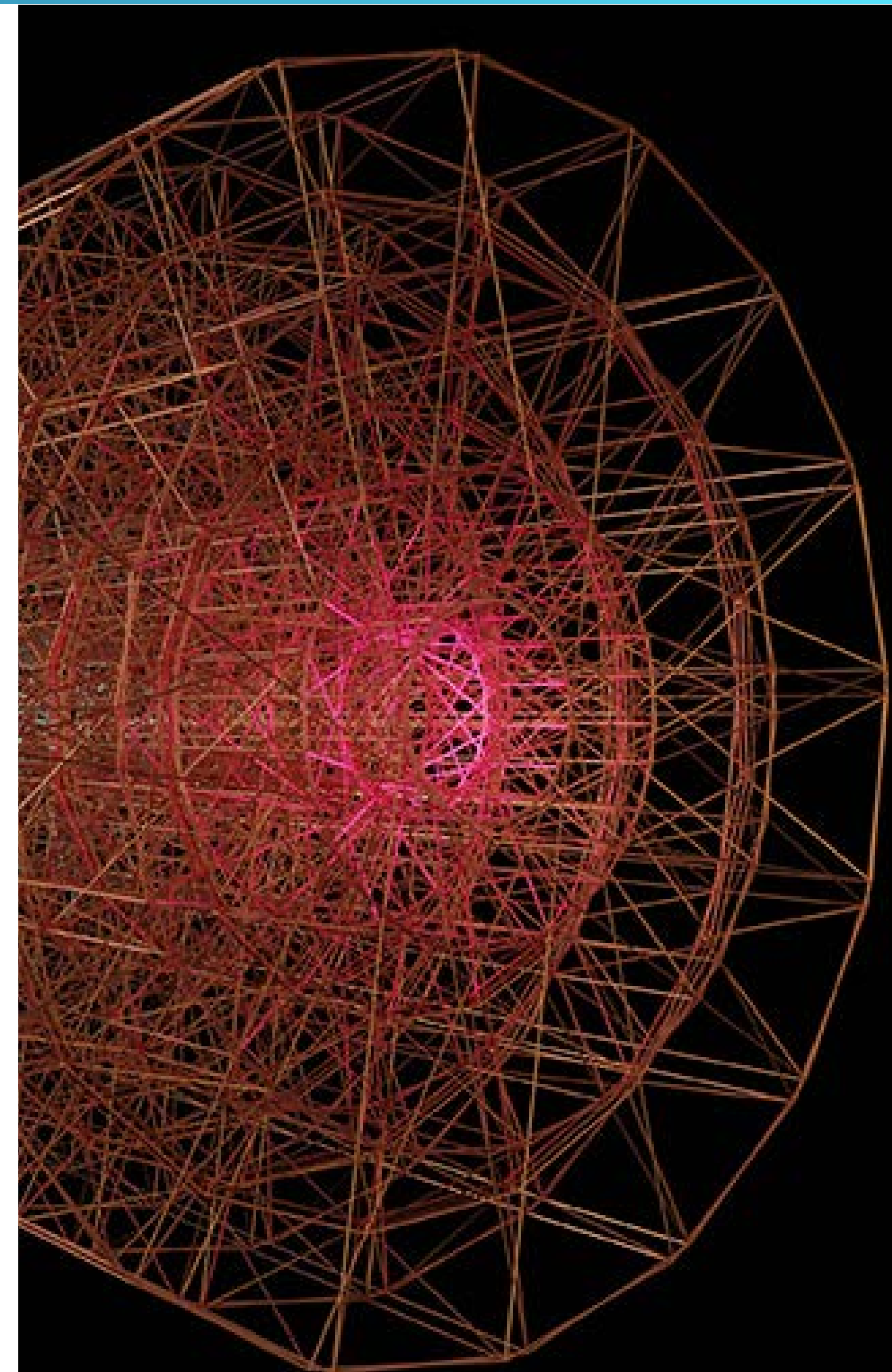
Modelling and analysis takes many forms, but the overall aim is to calculate the impact of forces and environmental conditions to which the component parts of a structure may be subjected, spot potential weaknesses and take action to prevent or mitigate accidents.

Specialist modelling of gas, heat transfer, fire and liquid flows is an important tool in understanding what might happen in accident scenarios. We undertake failure investigations anywhere in the world, using our full forensic analysis facilities and the ability to test components in realistic environments, pressures and temperatures.

We offer a specialist modelling and analysis capability to help our clients tackle complex problems across a range of industries including oil and gas and environmental protection.

Services:

- Flow velocities and induced loads
- Heat transfer in complex geometries as part of thermal analysis or structural assessment
- Heat transfer phenomena including thermal radiation, natural convection and ventilation studies
- Fire spread and smoke movement, mixing of fluids or gases, modelling complex fluids, such as sludges and slurries
- Modelling multi-phase flows and transport of solids and droplets
- Sensitivity studies to investigate a range of fire phenomena
- Fire suppression
- Explosions including blast and thermal effects
- Fire risk and hazard assessment



Assurance

Our laboratory capabilities are intrinsically linked to our key role providing assurance for safety-critical industries.

In high-risk industries and projects of national importance, we protect client interests by providing full lifecycle quality, security, and Independent Assurance solutions, integrating use of our unique laboratory infrastructure.

Independent Assurance

Independent Assurance (IA) is an important activity in high-risk industries, demonstrating to regulators and other key stakeholders that technical proposals and activities have been subjected to independent scrutiny and challenge. Securing IA support provides the challenge necessary to give our clients confidence in the safety, cost, scheduling, and reliability of their projects.

Independent Assurance provides constructive challenge to processes, decision making, design and behaviours. Adopting IA helps to confirm that regulatory, safety and environmental requirements and standards are being met. As well as recognising potential problems, IA will identify possible causes, provide independent guidance on resolution, give confidence in good practice, and support continuous improvement.

Services

Jacobs' IA model is designed to provide clients with the confidence necessary to understand and manage risk in a proportionate manner. We provide IA support tailored to your requirements, from specific subject matter experts through to a complete IA managed service. Our integrated approach covers:

- Independent Technical Assessment (ITA)
- Independent Nuclear Safety Assessment (INSA)
- Advice to Design and Safety Committees
- Pre-Regulatory Review and Assessment

The Jacobs IA team is a 'ring-fenced' service, operating apart from the main business to demonstrate the separation needed for true independence. We act as the 'client's friend', providing an impartial, expert, second opinion.

Our IA professionals and subject matter experts bring broad and deep experience across all technical areas, plus reach back into Jacobs for extended safety and technical support.



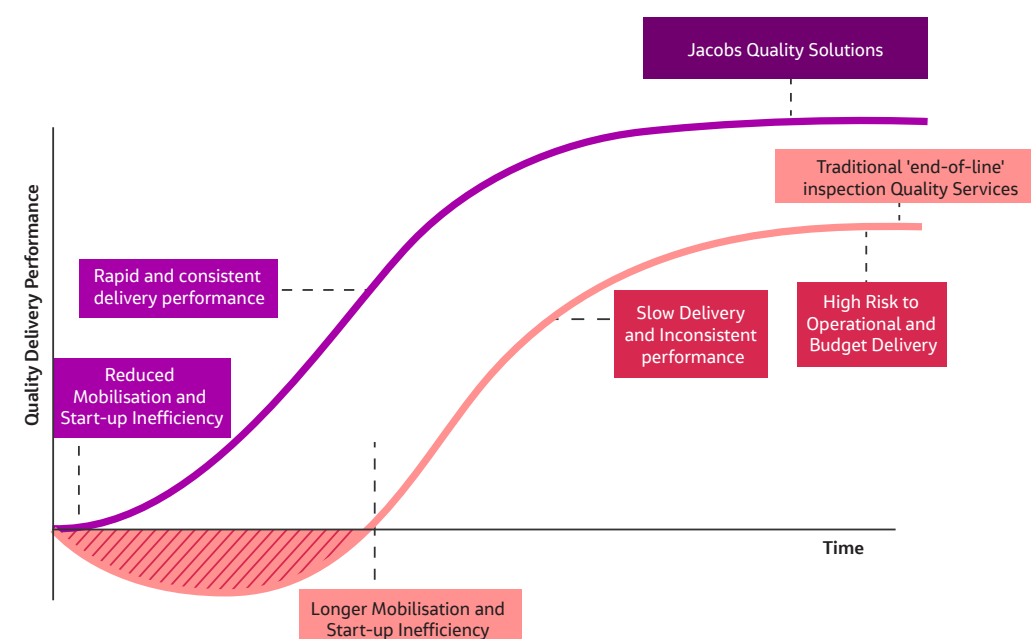
Quality Solutions

Quality and project lifecycle solutions for the future of our industries.

Our quality and project lifecycle solutions capability, born out of our rich heritage of experience in the nuclear and defence sectors, assists our clients to overcome the quality challenges on their projects and programmes which can often lead to time and cost escalations. As industry embarks on new project lifecycle phases and capital programmes, our solutions can provide the correct level of oversight, controls, resources and assurance to enable a 'lean' right-first-time approach, commensurate of quality grading requirements.

Our quality and project lifecycle solutions provide an agile and progressive approach, with an emphasis on collaborative relationships to create industry-leading partnerships with our clients. As practitioners of ISO 440001:2017 we aim to create positive and productive relationships through Joint Relationship Management Plans (JRMP), which ensure sustainable relationships between clients, the supply chain and ourselves.

Our solutions include the provision of standard inspection services, the deployment of subject matter experts to resolve complex issues in addition to our specialist **Inspection and Validation Centre (IVC)**, **Equipment Qualification Service Alliance (EQSA)**, **Independent Assurance (IA)**, **Monitoring and Inspection Design (MID)** and **Predictive Maintenance (PdM)** capabilities. We can mitigate risk within your project lifecycles by integrating Health, Safety and Environmental (HSE) and the correct level of controls and resources into quality delivery.



Human Factors

Human Factors (HF) are recognised as a leading factor in ensuring the safe operation of hazardous facilities. It has been reported that human error is implicated in 80% to 90% of all major accidents.

Our HF team has extensive international experience across high hazard industries, providing a comprehensive range of consultancy services and regulator support.

At Jacobs we support our clients by minimising the potential for human error and we focus on identifying factors that affect human performance whilst assessing their likely impact on business efficiency. We recognise that smart HF management reduces the potential for injuries and occupational ill health. The benefits of early intervention allow an organisation to meet regulatory requirements, enhancing safety and avoiding costly re-design.

We have an extensive team of skilled and experienced HF staff including specialists, engineers and managers. Our team has an in-depth knowledge of UK and international safety standards and guidance.

We have experience working in highly regulated Major Accident Hazard (MAH) industries, which include nuclear, chemical, oil, and gas. Work within these areas has involved safety culture assessments, safety critical task analyses, HF training, development of a Human Factors Investigation Toolkit (HFIT) and involvement in incident/event investigations and regulatory understanding and adherence. Within nuclear specifically, we have extensive experience with the application of The Office for Nuclear Regulation (ONR) HF Safety Assessment Principles (SAPs) and the development of HF aspects of nuclear safety cases. All Jacobs' team members attend and complete our in-house safety case training which draws on our breath of experience across the industry.



Inspection Qualification

We operate the UK's only accredited independent Inspection Qualification Body for existing nuclear power plant and new build nuclear sites.

Our Inspection Validation Centre (IVC) provides independent assessment and qualification of inspections applied to critical components of nuclear power plant. This process ensures high confidence that the inspections applied will detect and reject any defects of concern and that the critical components go into service and operate without risk of failure due to presence of defects.

Assessment is carried out via technical review of inspection documentation followed by practical assessment of the procedures, equipment and personnel.

Services:

- Failure in these components cannot be tolerated, and Inspection Qualification (IQ) is key part to demonstrating the safety case
- Typically, these components cannot be replaced, and any such failure would limit the life of the plant.
- The IVC is a UKAS Accredited to ISO/IEC 17020 Type A Qualification Body
- We have over 35 years' experience of developing and providing independent inspection qualification of high integrity components
- Our experience of UK and international regulatory regimes and requirements is without parallel



Chemistry

When safety, cost or time pressures mean that your samples can't get to our laboratory, our laboratory can come to you.

Our experienced chemists provide support at our clients' sites, including in emergencies, backed up by reachback into the rest of our organisation and its wealth of analytical skills and experience.

As well as chemistry support, this extends to water treatment services, ion exchange resin sampling, chemicals storage surveys, and remote sampling.

Radiation Services

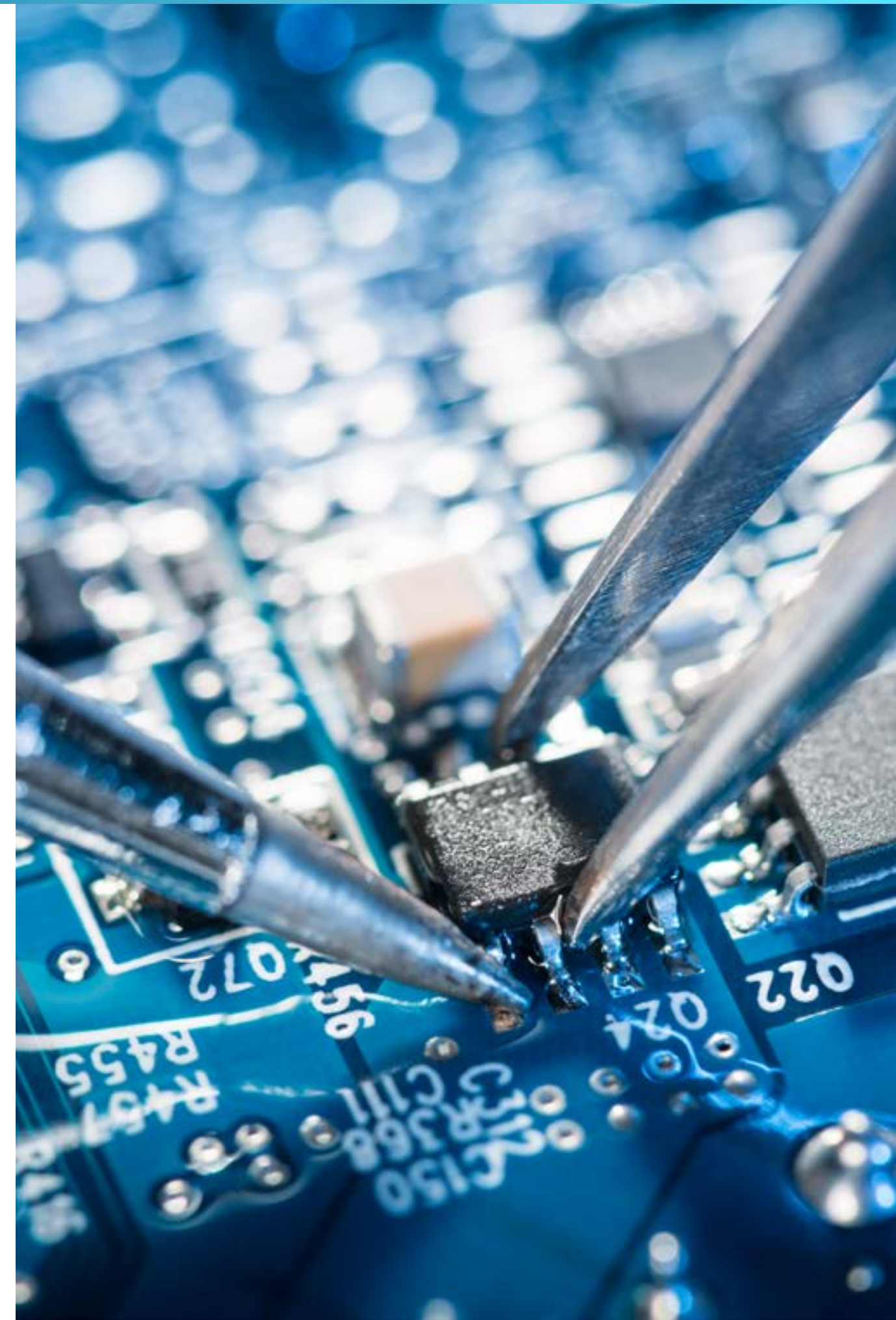
Jacobs provides experimental design, characterisation and interpretation enabling clients to plan for the long-term impact of radiation on material properties and component functionality.

Located at the heart of the Harwell Space Cluster in Oxfordshire, our experts offer full scale specialist support across several industrial sectors such as nuclear power generation, decommissioning, waste studies, defence, space and robotics. We help our clients get more from their high value assets by improving design, increasing output, extending asset life and demonstrating safe operation.

Our services:

- Focused research, technical solutions and independent assessment of material or component radiation resilience under hostile operational environments
- Design experimental programmes to best meet our client needs and offer cost-effective solutions

- Provide guidance on achieving representative qualification testing to either international standards or bespoke methodologies
- Facilitate and support accelerated ageing programmes incorporating factors such as enhanced low dose rate sensitivity (ELDRS) and linear energy transfer (LET)
- Modelling and consultancy services to complement our experimental capabilities by developing and refining predictive models of radiation effects on a variety of materials and components
- Ability to draw on international experts in the field of radiation effects on materials and components
- Project management services ranging from individual component testing to the implementation of large research programmes



Chemistry Consultancy

More than 150 experienced materials and chemistry professionals support our clients by sharing their knowledge and experience of chemistry and processes, not just analysis.

Services

We provide a chemical analysis service including:

- Surveys of water quality for boilers, stator water and discharge consent
- Fouling issues (cooling water systems and standby fuel/diesel tanks)
- Ion exchange resin reviews, testing and generation of specifications
- Corrosion surveys, corrosion failures
- Steam sampling reviews
- Material compatibility evaluation for materials in harsh environments
- Full laboratory back-up support with the latest equipment
- Analysis of greases and oils

We support on-site activities with experienced chemists who have reach back and immediate access to our laboratories for:

- An end-to-end managed chemistry service using senior site experienced chemists (located on site) to assure chemistry quality support and on-hand advice to commissioning engineers
- Water treatment services and audits of site waters
- Ion exchange (IX) resin sampling
- Plant surveys to review storage of various chemicals
- Review of 'as built' drawings for plant reviews
- Remote sampling capability
- Consultancy, design and scientific laboratory services for concrete structures in the nuclear, oil and gas and other high hazard or safety critical industries



Radiochemistry

Jacobs operates one of the UK's largest independent radiochemistry laboratory facilities for all aspects of radiochemical and radionuclide analysis. The laboratory is accredited by the United Kingdom Accreditation Service (UKAS) for a diverse range of analyses and matrices.

We provide analysis for nuclear operators and site licensees, decommissioning contractors, contaminated land consultants, local authorities, regulators, water companies and defence and scientific establishments. We undertake statutory radionuclide environmental monitoring programmes involving radiometric and radiochemical analysis of a variety of environmental samples such as sediment and soils, herbage and vegetation, building materials, asbestos, metals, solvents, milk, marine life, water, biota and bulked nuclear power station effluent. We use a range of analysis techniques including high-resolution gamma spectrometry, gross alpha/beta, carbon-14, tritium, strontium-90, sulphur 35 and plutonium isotopes. Characterisation of samples is used to underpin waste disposal options either to conventional landfill or radioactive waste repository facilities.

Jacobs provides a 'one-stop shop' with a combined radiochemical and chemical analysis service on both radioactive and out-of-scope samples. Our electronic in-house Laboratory Information Management System (LIMS) tracks all sample data from arrival through to reporting and archiving, and our experienced, multiskilled team can also offer consultancy support, training, research and development services.

We support environmental impact assessments for nuclear new build projects by providing radiometric and radiochemical analysis of environmental samples to support the baseline assessment. This usually includes radiochemical analysis of marine water, groundwater, surface water and land quality assessment programmes. Analyses carried out included high-resolution gamma spectrometry, gross alpha/beta, carbon-14 and tritium. We also provide waste characterisation analysis to support most of the current Nuclear Decommissioning Authority (NDA) decommissioning programmes.



Polymer Testing

Our internationally renowned experts are leaders in understanding the impact of thermal effects on key materials and components, from organic materials to electronic devices.

Services:

- Analysis of polymers including elastomers (seals, O-rings, gaskets), resins and adhesives (coatings, foams), polymeric cable insulators and other thermoplastic polymers
- Knowledge of polymer technologies to assist in a more cost-effective solution for repair scenarios
- Focused research, technical solutions, and independent assessment of material properties and testing under hostile operating environments such as air, vacuum, water and process liquors, temperature, irradiation
- Guidance to identify suitable commercially available polymeric technologies and products
- Development of innovative, in-situ parameter measurement and monitoring whilst materials are exposed to thermal ageing
- Identification of polymer technologies for sealing cracks
- Evaluation of modern industrial coatings and foam products for on-site application



Construction and Commissioning Support

The construction and commissioning phases of any major new build project are critical. During these phases it is vital to ensure that no activities or foreign materials could compromise downstream operations or the plant safety case. We have over 50 years' experience of ensuring reliable and experienced chemistry support throughout these phases.

Services:

- Preparation of guidance manuals and documentation for construction and commissioning phases
- Integration of chemistry/water chemistry considerations into commissioning procedures and contractor's documentation
- Provision of an on-site mobile laboratory to ensure quick and efficient analysis to support commissioning engineers and to mitigate project delays
- Providing an end-to-end managed chemistry service using senior site experienced chemists (located on site) to assure chemistry quality support and on-hand advice to commissioning engineers
- Defining and providing on-site monitoring of water chemistry, surface cleanliness, flushing operations and materials compatibility
- Provision of chemists to support chemistry discussions at daily construction/commissioning meetings



Radiation Protection

We are a Health and Safety Executive (HSE)-approved Corporate Radiation Protection Adviser (RPA) body

Our radiological support to industrial and nuclear sectors includes:

- X-ray fluorescence (XRF) equipment
- X-ray inspection systems used in manufacturing processes
- X-ray systems for security scanning
- Thickness and level gauges
- Radiography
- Sealed radioactive sources
- Laboratory testing of radioactive material
- Work in radon affected areas
- Non-destructive gamma spectrometry analysis

Our Radiation Protection Advisers (RPA), Radioactive Waste Advisers (RWA), and Dangerous Goods Safety Advisers (DGSA) help clients to comply with all environmental permit conditions, regulations and legislation relating to the use, notification, registration, storage and transport of radioactive material.

They also advise on legal and operational matters including development of radiation safety management plans, radiation risk assessments, local rules and training requirements.



Failure Investigations and Assurance

Learning from experience is key to understanding why power plants and other industrial processes fail.

We can undertake equipment, systems or component failure investigations in most environments.

Services:

- Full materials specification capability covering all metals, alloys and engineering polymers
- Testing of polymeric materials such as gaskets, seals and O-rings in a variety of media to justify continued usage or new supply

- Full forensic failure analysis facilities with access to finite element modelling of failure modes
- Ability to test components

The support provided ranges from small scale laboratory corrosion testing, through to desktop material and corrosion reviews to on-site surveys and assessments.

We match our level of service to our clients' needs.





Jacobs