Reactor support services
Supplying solutions.
Supporting success.

...to the global nuclear industry.
Rolls-Royce provides a broad range of technology-independent reactor support services and solutions spanning: inspection and analysis; engineering support; repair and component replacement.
Reactor support services
Expertise to help you shape and secure a nuclear future

With more than 50 years of experience in designing, building and operating civil and naval nuclear plant, Rolls-Royce is ideally positioned to help you optimise the future of nuclear energy by maximising the safety, availability and performance of your plant while minimising unplanned outages.

Working together with operators and utility owners worldwide we focus on our customer’s success. We do this by delivering comprehensive suites of engineering services that support critical investment projects and meet customer’s demands for plant availability, predictability, long-term operation and improvement of existing plant.

Over the past five decades our nuclear capability has expanded and developed as nuclear technologies have advanced. Today, our expertise in the technologies that are driving forward the nuclear, aerospace, defence, marine and energy industries worldwide stands ready to work with you to achieve outstanding operational excellence far into the future.

Specialist techniques to manage, enhance and extend the lifetime of nuclear power plants.
Total solutions in support of reactor operation

A complete portfolio of reactor services and solutions, helping customers to achieve optimal lifetime performance.
Rolls-Royce offers tailored engineering solutions in support of total lifetime management of critical asset investment.

**CONSULTANCY SERVICES**
- Safety case engineering
- Regulatory support
- Analysis:
  - CFD
  - Stress
  - Thermal
- Lifetime management:
  - I&C obsolescence management
  - Ageing management
  - Asset management
  - Long term operations engineering support
- Training
- Equipment Heath Monitoring (EHM)

**REACTOR SERVICES**
- Inspection and retrieval services
- Material sampling
- In-situ component maintenance
- In-situ component repair
- Metallurgy
- Reactor chemistry services
- Special purpose machinery - design and manufacture
- Manipulator design
- Remote operations

**DESIGN SERVICES**
- Systems engineering
- Mechanical component design
- Process design
- I&C design
- Reverse engineering
- Assessment of components
- Design verification and validation
- Design justification & substantiation
- Fuel handling equipment design
- Remote monitoring systems
- Custom inspection and retrieval tooling

**REACTOR COMPONENTS**
- Manufacturing of new/ replacement mechanical ASME N components
- Active component refurbishment
- Component repair
- Safety I&C system supply and modernisation
Consultancy services

Worldwide capability to master the toughest technical challenges

- Safety case engineering
- Regulatory support
- Analysis:
  - CFD
  - Stress
  - Thermal
- Lifetime management:
  - I&C obsolescence management
  - Ageing management
  - Asset management
  - Long term operations engineering support
- Training
- Equipment health monitoring

Rolls-Royce can be trusted to deliver a responsive service to customers in support of emergent requirements, minimising downtime and maintaining continued operations.
Nuclear industry regulations and requirements present a significant challenge for site licensees. Gaining and keeping licence to operate is paramount. With an in-depth understanding of the regulatory processes that must be compiled with, Rolls-Royce can offer customers continued support.

We specialise in the production and justification of reactor and plant safety case and periodic reviews.

We offer an integrated approach to environmental management, ensuring that the best practicable abatement technologies and environmental protection requirements are specified and implemented. Environmental hazard identification and risk assessment is a key part of our project delivery encompassing radiological and environmental impact assessment and radiation dose modelling.

Rolls-Royce provides support to major refurbishment and maintenance projects. We have managed lifetime extensions to more than 50% of the UK’s submarine fleet and have developed a robust methodology for justifying and managing continued long-term operations incorporating:

- Baseline data review
- Components & systems assessment
- Risk based balance of investment
- Risk based in-service inspection

Our engineering analysis capability is second to none in disciplines including materials, metallurgy and mechanical design of reactor cores, criticality analysis and design, and stress and thermal analysis. These techniques are specifically required to monitor and analyse the ageing mechanisms within the plant in order to justify the ongoing structural integrity of the facility.

We have developed and deployed an I&C obsolescence management programme with EDF, aimed at significantly reducing the risk of future I&C unavailability at all 58 nuclear reactors in France.
Consultancy services

Safety case engineering

Description:
The operation of a civil nuclear facility is subject to regulation under the conditions of a licence or permit. The licence holder has a legal responsibility to demonstrate nuclear safety throughout the life-cycle of the facility (ie design, build, commissioning, operation, decommissioning etc). The accepted methodology for demonstrating nuclear safety is the development and continued maintenance of safety cases.

Rolls-Royce safety case engineers are experienced in the preparation of safety cases at all stages in the life-cycle of a facility, including supporting new build licensing. Once a facility is operational, Rolls-Royce can provide the support to maintain a safety case to reflect ongoing operations and modifications; and can undertake periodic safety case reviews.

Applications:
- Supporting the design and licensing for a new build facility, including the production of:
  - Preliminary safety case
  - Pre-commencement (construction) safety case
  - Pre-inactive commissioning safety case
  - Pre-operational safety case
- Support in the through lifetime management of a safety case, including:
  - Periodic safety case review
  - Updates to safety case to reflect refits, plant modifications
  - BAT reviews
- Independent Nuclear Safety Assessment (INSA) on behalf of:
  - Reactor designers and operators
  - Regulatory authorities

Regulatory support: Licensing and regulatory process

Description:
The civil nuclear industry worldwide is regulated under national legislation to ensure that activities related to nuclear energy and ionising radiation are conducted in a manner which adequately protects people, property and the environment.

Rolls-Royce has the capability to support and guide applicants and regulators through the licensing processes. This utilises our worldwide experience of all aspects of safety case and environmental engineering. If niche skills or experience are not available in-house, Rolls-Royce manages the procurement and input of specialist subcontractors to deliver a complete solution.

Whilst the principal focus of the licensing and regulatory process is on nuclear specific legislation, other non-specific general legislation also needs to be addressed. Rolls-Royce engineers have a broad ranging skill set encompassing the full range of the regulatory regimes that may be applicable. For example, a variety of licences/permits may be required to cover construction related activities or on-site disposal of non-radioactive wastes.

Applications:
- Supporting operators in the licensing of new build facilities
- Supporting the reactor vendor in understanding local regulatory requirements and advising on possible design revisions
- Ensuring ongoing compliance with relevant standards and legislation
- Providing guidance on the establishment of a national nuclear framework to enable new build (ie in countries new to the civil nuclear industry)
Lifetime management:
I&C obsolescence management

Description:
Maintaining nuclear plant involves cost-effectively implementing upgrades, managing I&C obsolescence, and coordinating systems for maximum efficiency. Employing a proactive approach to obsolescence management to connect current operations with a focus on the future addresses these issues and adds value to your business.

Rolls-Royce helps customers protect critical asset investment by providing I&C obsolescence management and long-term support services.

Services include:
With more than a decade of experience that includes a large class 1E installed base, we design nuclear long-term support services that improve operational safety, security and efficiency:
- Digital upgrades and a proven plan that meets stringent outage schedules
- Class 1E instrumentation and control platform with the flexibility to meet functional and safety requirements of current and future architectures
- Fleet-wide standardisation solutions for controls and plant process computers
- Obsolescence management
- Reverse engineering for customised solutions
- Change management expertise
- World-class support, from engineering design through installation to long-term commitment of the service phase
- Long term support: a dedicated through-life solution designed to help our customers manage plant condition, optimise operating life and maximise plant value while improving safety

Lifetime management:
Ageing management

Description:
Ageing management ensures the availability of required safety functions throughout the full service life of the nuclear power plant. A comprehensive ageing management plan will proactively take account of changes that occur over time and with use. This enables utility operators to better address and manage the physical changes of the systems, structures and components which have degraded in performance or become obsolete over time and with use.

Rolls-Royce has extensive experience in the management of ageing issues in nuclear plants both through its support to naval reactors and civil plants. We can offer a comprehensive package including inspection and sampling to determine actual plant state, repair strategies (including difficult to access areas of the plant) and safety case justification.

Services include:
Rolls-Royce approach to ageing management adopts a proactive suite of tools to minimise cost, schedule and risk:
- Inspection package with comprehensive procedures and provision of results and recommendations
- Repair work and safety justification support
- Management of on-site resource
- Dedicated interface with plant owner for plant management
- Detection of negative effects to ensure safety margins are not reduced significantly
- Monitoring of effects before loss of integrity becomes a concern
Consultancy services

Analysis: Computational fluid dynamics

Description:
Rolls-Royce has extensive capability in applying computational fluid dynamics (CFD) for root cause analysis, safety case justification and design optimisation tasks for in-service civil nuclear applications. CFD provides a more realistic understanding of operational performance, allowing better optimisation of design margins.

Applications:
We have experience in applying computational fluid dynamics analysis to model a wide variety of applications. Some examples of which are:
- Flow behavior in complex geometries
- Heat transfer
- Pressure
- Particle trajectories
- Multi phase flows

Customer training

Description:
Rolls-Royce customer training is the modern solution to providing a cost saving and life change insurance for people and production equipment utilised in today’s world. From the first day of start-up, we support customers in optimising their capital investment. Introductory and continuing training and education is needed to reduce downtime, increase fuel savings, reduce liability risk and cost, and extend the life cycle of the equipment.

Whether the training you need is isolated to control systems, support systems, or the entire package and process, Rolls-Royce has the solution to providing cost and life-saving insurance for people and production equipment utilised in today’s world. Rolls-Royce provides professional training services in support of the unit sale.

Instructors are experienced in the field and in the classroom. A professional training consultant is provided to help the customer training department identify and target personnel training needs and work to coordinate the most effective program of training to support equipment operation, reliability and safety. Technical training programmes are designed to provide the customer with a comprehensive understanding of Rolls-Royce equipment. Training programmes are customised and site specific.
Equipment health management

**Description:**
Equipment Health Management (EHM) consists of a set of mathematical models and techniques that aim to monitor equipment and detect potential anomalies, with enough time to undertake remedial action, prior to functional failures occurring. This can be a powerful method of avoiding the impact of failure and can enhance and augment more traditional reliability and maintenance systems. Effective use of EHM techniques can deliver customer value through improvement of availability, resource allocation and cost control.

Within Rolls-Royce, EHM has constituted a very important tool not only to enable the company to deliver world-class services to the aerospace industry but also to obtain benefits that can be worth many times the project investment. Rolls-Royce has translated the benefits of the EHM approach into other industries.

**Applications:**
Equipment Health Management is most often applied to rotating equipment such as turbines, motors and pumps. However, provided appropriate input from operators, a large variety of nuclear equipment and systems can potentially be addressed. Currently, Rolls-Royce is engaged in using its EHM experience combined with its nuclear engineering know-how to develop an EHM service for the civil nuclear industry.
Reactor services
Enhancing value, safety and profitability

- Inspection and retrieval services
- Material sampling
- In-situ component repair
- Metallurgy
- Reactor chemistry services
- Special purpose machinery - design and manufacture
- Manipulator design
- Remote operations

Whether meeting requirements planned well in advance or providing a rapid response to emergent problems, we will work with you to achieve minimised downtime and optimal performance.
Rolls-Royce has extensive expertise in monitoring, inspection, ageing management, technical support and analysis techniques.

The inspection techniques we deploy are unique to our customers, because no two challenges are quite the same. We address considerations such as components, materials, dose reduction and the space envelope as well as much more.

Our novel and highly efficient non-destructive materials sampling and in-situ repair techniques have satisfied the most stringent regulatory requirements and have supported extended operational lifetimes.

Rolls-Royce has developed some of the most complex engineering solutions for advanced in-service inspection, retrieval and repair techniques that allow access to remote and irradiated locations.

Whether meeting requirements planned well in advance or providing a rapid response to emergent problems, the same level of quality and attention to detail is applied.

Integrated support services and niche engineering capability tailored to meet customers individual needs.
Reactor services

In-service inspection & non-destructive examination services

Description:
Whether it’s the remote manipulation of a replicating end-effector or a surface inspection using a dye penetrant, Rolls-Royce offers customers a holistic service from initial planning through to in-depth analysis of findings and solution development.

Our highly specialised team of experts provide technique development, inspection manipulator design and development, safety justification, the production of inspection procedures, on-site implementation and comprehensive analyses of results. And if needed, we can rapidly provide solution development for emergent operational challenges.

Applications:
- Visual inspection (including metallurgical methods)
- Magnetic particle testing
- Dye penetrant inspection
- Phased array ultrasonic inspection
- Ultrasonic inspection
- Eddy current inspection
- Computed radiography inspection
- Surface detection inspection and metallurgical replication
- Underwater replication
- Electromagnetic interference monitoring
- Irradiation damage analysis (3D atom probe)
- Noise and vibration examination
- Alternating current field measurement
- Alternating current potential drop

NDE metallurgy - replication and inspection

Description:
Nuclear plant operators and owners make use of a broad range of manual and automatic replication techniques developed by Rolls-Royce to help them solve complex and difficult inspection problems. High-definition replication of surfaces, working with bespoke application and surface-preparation tools, allows the customer to gain ultra high-quality results from surface examination in remote locations, with comprehensive results analysis handled well away from the high-dose environment.

Replication provides in-depth benefits:
- The ability to inspect inaccessible surfaces - in air or underwater - indirectly by visual and microscopic techniques, including high magnification scanning electron microscopy
- The extraction of auto surface particles by the replica material also provides a means of analysing surface contaminants
- The ability to record size measurement and detect location data in very high dose areas
- A permanent record of the site of interest, allowing defect monitoring over time by comparison with previous replicas
- A range of acetate and putty-based replication media to suit different applications

Applications:
- Remote replication of boiler tube surfaces - stainless steel
- Remote replication of titanium heat exchanger welds - off shore platform
- Internal surface bolt hole replication valves, engines, control rods - marine applications
- Inspection cupro-nickel alloy heat exchanger tubes

*Underwater replication of an etched weld specimen*
*Higher magnification SEM image of crack on replica showing oxide on intergranular facets*
**NDE - ultrasonic testing**

**Description:**
Rolls-Royce utilises ultrasound principles to inspect a wide range of different components. We have developed a number of bespoke, automated scanners to reduce inspection time and cost, while at the same time improving the accuracy, speed and reliability of the inspection. Data is automatically recorded and analysis is completed remotely to reduce the exposure of personnel to ionising radiation.

Latest technological development by Rolls-Royce include comfortable ultrasonic phased arrays, delivering significantly improved accuracy and versatility. In contact ultrasonic inspection, it is essential to maintain coupling between the transducer and the component under test. When using conventional ultrasonic techniques it is not always possible to maintain contact and achieve 100% test coverage of components with phased array device that allows reliable ultrasonic inspection of components with complex geometries.

**Applications:**
- Conventional pulse echo
- Time of flight
- Phased arrays

**NDE - eddy current (ET)**

**Description:**
Rolls-Royce has over 20 years experience in the research, development and application of eddy current examination. We offer customers a complete solution from bespoke manipulator design to on-site implementation. Our team of specialists provide high quality evaluation using the latest mathematical modelling packages.

ET techniques and solutions provided by Rolls-Royce offer:
- Simple manual methods
- Specialist array probes for SG tube and header integrity inspection
- Inspection of bifurcations
- Inspection of large or inaccessible surfaces

**Applications:**
The detection of surface breaking and near surface defects for:
- Delayed hydrogen cracking (DHC)
- Environmentally assisted cracking (EAC)
- Erosion, fretting and weld thinning
- Fatigue cracking
- Stress corrosion cracking (SCC)

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![Manipulator with ultrasonic probe for automated UT inspection](image1)

![Ultrasonic microscopy is employed to detect and size defects in surface coating](image2)

![Conformable Phased Array UT](image3)
Reactor services

Noise and vibration condition monitoring

Description:
Rolls-Royce has extensive experience in the field of noise, vibration and condition monitoring, with expertise spanning a multitude of specialist techniques and capabilities. Our ability to draw on engineering expertise from the wider Rolls-Royce Group has enabled us to work collaboratively to solve complex issues.

Applications:
We have a proven track record in the following applications:
- Measurement, analysis and reporting of complex noise and vibration problems
- Finite element model validation
- Vibration acceptance testing
- Measurement of structural parameters (model analysis)
- Condition monitoring of rotating machines
- Large volume (lots of channels) data collection in harsh/remote conditions
- Shock tests
- In-situ dynamic balancing of rotating assemblies
- Design and implementation of noise reducing structural modifications

Remote visual inspection, monitoring and retrieval

Description:
Rolls-Royce is a world-leader in the development of remote visual inspection (RVI) capabilities and tooling to meet challenging customer demands for the remote inspection, monitoring and retrieval of foreign objects.

For the inspection of nuclear reactor components during plant operation, Rolls-Royce has developed a range of turnkey systems for high integrity inspections of both civil and nuclear naval plants, especially with difficult access due to physical or hazardous environments.

Services include:
- **Rapid response service**: a dedicated rapid deployment of RVI team, equipped with a range of the latest portable inspection and retrieval equipment
- **Comprehensive inspections**: inspections of high integrity components such as steam generators and facility piping to support continued safe use. Detailed inspection reports are produced together with supporting digital imagery in line with specific customer requirements
- **Foreign Object Search and Retrieval (FOSAR)**: FOSAR is a specialised service offered by Rolls-Royce. FOSAR is performed in any facility component or system in which unwanted items create the potential to cause mechanical damage. The purpose of this service is to determine cleanliness, anomalous conditions and to locate and remove foreign objects. Inspection capabilities include:
  - Steam generators
  - Reactor vessels
  - Facility piping
  - And much much more...
- **Submersible remotely operated vehicles (SROVs)**: Rolls-Royce offers practical experience in using SROV as an inspection platform for high integrity RVI inspections of ponds, vessels and large bore pipework, both nuclear and non nuclear. Laser referencing techniques allow defect sizing

N&V laboratory testing

Turbo generator NV model analysis
Nuclear materials and chemistry support

Description:
Rolls-Royce has over 50 years of specialist working knowledge in the fields of nuclear materials, chemistry and corrosion. We offer technical services across the entire reactor plant lifecycle, from design to decommissioning. This includes conceptual design, start-of-life definitions, through-life (TL), plant life extension (PLEX) and plant decommissioning activities. Preparation of safety justifications and through-life management plans form an integrated part of our offer.

Services include:
- Materials selection, validation and predictive models
- Manufacture (casting, forging, hot isostatic pressing (HIP) and welding) and finish forming (machining surface treatments)
- Development of chemistry specifications and modelling tools
- Operational plant support
- Repair and modification
- Decontamination
- Decommissioning
- Safety case production

Electron backscatter diffraction on A508 grade 3 class 1 material

Heat tinting trial of a high strength low alloy steel (time increasing left to right, temperature increasing top to bottom)
Reactor services

Special purpose machines

**Description:**
From feasibility assessment through to conceptual and detailed design, development and implementation, Rolls-Royce can provide innovative solutions to problems utilising a wide range of purpose-built machines and mechanisms.

Multi-disciplined teams of Rolls-Royce experts encompassing non-destructive examination; remote visual inspection; noise and vibration; rig design and welding metallurgy work together to design the complete solution for each of our customers' individual needs.

A well-developed process linking concept design through to implementation allows the designer to be the machine builder, developer and on-site machine operator. High performance quality is assured with the particular emphasis on ease of installation, operation and maintenance. So the customer can rely on a single technical point of contact with in-depth knowledge of the whole project.

**Applications:**
**Portable special purpose cutting machines**
Various single-point and multi-point portable cutting machines have been designed and built to suit different applications. In particular, cutting and dressing machines have been designed for:
- Remote or ‘hands-on’ operation
- In-air underwater use
- Cutting carbon steel, stainless steel or non metallic components

**Welding machines**
Bespoke orbital welding machines have been designed and built to cover components with an internal bore of 10mm to those of 2 meters external diameter. Weld procedures are developed and qualified using in-house welding engineer and metallurgical support.

**Material sampling machines**
Whether supporting Plant Lifetime Extension (PLEX) justification, material characterisation or defect analysis, material sampling is a powerful method of rapidly and conveniently obtaining supporting information.

Using our SSam™-2 surface sampling capability, small ‘button’ shaped samples can be extracted from components - often without any detriment to its future use and operation. A small low stress raising dimple, with good surface finish, is all that is produced as a result of the scoop sampling process. Larger samples can be obtained by a variety of mechanical processes, and various machines and cutting processes have been produced for these purposes.

**Surface defect inspection and replication**
The application of remote visual inspection equipment or ‘putty’ replication material is often used to search for surface breaking defects and to establish the extent and cause of such flaws. A great deal of experience has been built up in designing equipment to apply these techniques - either in-air or underwater. Equipment has been designed to prepare the surface of the material, through polish and etching processes, as well as carrying out the inspection itself. Metallurgists work alongside engineers in interpreting the results of on-site inspections.

**Remote manipulation of end effects**
Examples of manipulator design and build projects include ultrasonic inspection of aero engine internals, remote visual inspection of reactor power plant, precise manipulation of a suite of different end effectors (eg machining, polishing, etching, replication, shot peening, grit blasting, welding) to the inside of pressure vessels, tube plugging of steam generators, material sampling of a reactor support structure 26 meters below the pile cap.
Example of a Rolls-Royce remote manipulator

Underwater scoop sampler

Remotely operated internal pipe polishing machine

Underwater bandsaw

Example of a high magnification SEM image of a replication specimen.
Rolls-Royce has established an excellent reputation in the provision of world-class engineering services established through the design of pressurised water reactor power plants and ancillary systems. We have the design capability to meet ASME and RCC-M codes for nuclear and non-nuclear applications.
We work closely with our customers in the development of clear requirements leading to the design, analysis and production of component and system definitions and specifications. Rolls-Royce provides complete product lifecycle solutions from initial conceptual design through to full requirements, design, development, manufacture/production, testing and provision of through life technical support.

Our analysis expertise includes design optimisation, operating parameter assessment and modelling of abnormal events. We operate and support a number of licensed sites and our expertise in design, analysis and specification development delivers design solutions which meet with site licensing compliance.

The company has a broad range of industry standard design and analysis tools, and the design capability to meet ASME and RCC-M codes for nuclear and non-nuclear applications.

Rolls-Royce capability is supported by:
- Fluid system and process engineers - covering nuclear and non-nuclear systems
- Component designers - including pressure vessels, valves, heat exchangers, mechanisms
- Control and instrumentation engineers - providing complete high integrity analogue and digital control solutions and instrumentation design
- Installation designers - product integration including pipe layout, component supports, thermal insulation and radiation shielding design
Design services

Design, analysis and specification

**Description:**
Rolls-Royce world-renowned design expertise is supported by a multitude of technical and engineering disciplines and specialist personnel. These include materials, welding engineering, non-destructive testing, and manufacturing engineers, designers, analysts, chemists and physicists. All providing expertise across a broad range of engineering disciplines.

**Applications:**
Our expertise in design, analysis and specification is applied to the design and development of:
- PWR nuclear systems and equipment
- Chemical decontamination systems
- Active waste treatment systems
- Transport and storage containers for active products
- High-integrity pressure vessels and mechanical components
- Control and instrumentation for high reliability requirements
- Bespoke design solutions to meet specific customer requirements

Process and systems design

**Description:**
Over its 50 year history Rolls-Royce has established a broad spectrum of capability and experience in the development of nuclear processes and systems design for a range of reactor technologies. We offer standardised products that have evolved from our experience, but specialise in providing customised solutions to meet the often unique and challenging requirements of the nuclear industry. Our research and development capabilities enable development of novel process solutions and subsequent validation testing for system design use.

**Applications:**
- Primary coolant circuit decontamination
- High level waste solid liquid separation systems
- High level waste vitrification
- Sludge retrieval equipment
- Ion exchange decontamination systems
- Radwaste encapsulation facility
- Active effluent treatment plant
- Pressure vessel cooling and treatment plant
- Pond water and spalled oxygen treatment
- Flask decontamination equipment

D154 facility
Mechanical component design

Description:
Rolls-Royce can provide complete product life cycle solutions from initial conceptual design through to full requirements, design, development, manufacture/production, testing and provision of through life technical support.

The company has a broad range of industry standard design and analysis tools and has the design capability to meet ASME and RRC-M codes for nuclear and non nuclear applications.

Services include:
- Structural integrity
- Thermo mechanical knowledge
- Finite element analysis
- Fatigue
- Vibration
- Acoustics
- Fracture mechanics
- Robust design, optimisation and probabilistics
- Seismic dynamics
- Impact and shock analysis
- Non linear material damage
- Residual lifetime assessment

Instrumentation & control design

Description:
Rolls-Royce understands the challenges of successfully managing the design, manufacture, procurement, operation and in-service support of nuclear reactor I&C systems.

Life-cycle:
Our design capability encompasses every stage of a single component or whole system life cycle. We can offer initial concept design, R&D, requirements capture, supply chain management, project management, commissioning, operational support and in-service support for a wide range of nuclear island I&C equipment and systems.

Obsolescence, configuration management and ageing issues will be key considerations in achieving a 60-year plus design life for new build nuclear power plants. Rolls-Royce can provide configuration management solutions and identity technologies which will help utility operators achieve the required life period safely and efficiently.

Nuclear component supply chain:
We have designed and tailored our unrivalled nuclear component supply chain to provide quality electrical and electronic components which fulfil the necessary requirements identified during the requirements capture process.

Applications:
Rolls-Royce engineers design services can provide a supporting role to reactor vendors in applying and proving compliance of codes and standards to their design, to ensure a smooth transition through design acceptance such as the UK NII’s generic assessment process.

We can apply our I&C design capability to many areas within the nuclear island, including:
- In-core instrumentation
- Reactor protection safety system
- Primary circuit instrumentation
- Equipment health monitoring
- Emergency power supply solutions
- I&C systems to IEC61513 & 61511
- Control room interfacing
Reverse engineering

Description:
An ageing fleet drives the need for plant lifetime extension (PLEX) and the requirement for balancing through-life justification costs with equipment replacement strategies. In many instances replacement components are obsolete and original OEM suppliers are no longer available. So consideration is given to replacing equipment with identical components redesigned against an original design specification. Rolls-Royce has considerable design and analysis expertise, knowledge of nuclear codes and in-service equipment operation experience and is able to provide a like for like product with a full justification and safety case. Rolls-Royce:

- Re-establishes an ASME compliant design, including all substantiating documentation. The level of effort is dictated by the quality of documentation available for the original component. Rolls-Royce creates and certifies new design reports and drawings that demonstrate ASME Code compliance and we work with the original supplier to ensure functional and performance requirements are met.
- Controls the supply of pressure boundary materials to ensure that they are properly certified for use in nuclear facilities, and come from a supplier on our Approved Supplier List.
- Oversees the manufacturing and ensures the required non-destructive examination is performed in accordance with qualified procedures.
- Performs the final Code required testing, and verifies that other performance testing has been done.

Applications:
This is particularly beneficial to customers in addressing obsolescence challenges, or where the original OEM no longer maintains a valid QA program for supply of nuclear components.

Fuel handling equipment design

Description:
Rolls-Royce has proven expertise in the field of active fuel handling, radioactive waste handling, management, transportation and storage. We are committed to developing custom designs and equipment to address the unique and challenging needs of our customers.

We have a wealth of experience in the delivery of tailored solutions covering high-level waste vitrification, filtration, decontamination, heating and cooling, shielding, packaging and handling. Equipment operation in these radioactive environments demands extreme reliability and ease of maintenance.

Currently, Rolls-Royce operates and maintains two fuel storage ponds on behalf of the UK MoD and has undertaken a variety of fuel handling activities, including fuel transfer operations and post irradiation examination. As part of these activities, Rolls-Royce has developed a number of novel techniques to remotely handle, cut, examine and measure fuel assemblies.

Applications:
- Fuel flask transfer (in-pond)
- Post-irradiation examination
- Fuel mock-up operation - simulation and training
- Fuel handling equipment design, manufacture and licensing
- Nuclear transport container design, manufacture and licensing
- Radioactive waste disposal and retrieval

A Rolls-Royce designed and operated fuel storage pond
Remote monitoring systems

Description:
At Rolls Royce we understand your need for a safe, secure and efficient work environment. We also realise that an out of the box solution may not be the best way to solve all of your remote monitoring needs. Our premiere Network Video Management software (NVMS) provides customers with custom video management solutions designed to fit your needs and adapt to your facility as it continues to grow.

Applications:
NVMS creates a unified remote monitoring system throughout your facility. With fully expandable capabilities, NVMS is a total solution that can tie in multiple needs with one system. Use NVMS to monitor:
- ALARA / ALARP (dose reduction) job coverage
- Hazardous area monitoring
- Containment areas
- Walk downs
- Security
- Outage support
- Access points
- Multiple job coordinations

Custom inspection and retrieval tooling

Description:
Not all inspections can be completed with standard tooling. In some cases, due to limited access, hazardous conditions or other inhibiting factors, custom tooling may need to be designed to complete a task. Rolls Royce specialises in the development of custom tooling and processes to meet specialty inspection and retrieval needs. Our rigorous design and development program will bring you from start to finish of the solution building process, ensuring a final product that meets your exact standards and needs.

Rolls Royce provides complete solutions with all specialty designed retrieval tooling. This service includes:
- Tooling design
- Qualification with premium mock ups
- Process design
- Training
- Tooling deployment
Reactors components

Delivering mission-critical success for our customers

• Manufacturing of new/replacement mechanical ASME N components
• Active component refurbishment
• Component repair
• Safety I&C system supply and modernisation

Rolls-Royce has the experience and capability to help customers proactively manage nuclear plant repairs and the mobility to respond rapidly to emergent repair work.
At Rolls-Royce we design, procure, manufacture, inspect, test and certify pressure vessels, components and structures that comply fully with nuclear codes and standards such as ASME Section III and RCC-M.

Often, refurbishment options offer customers a cost-effective alternative to new components. Rolls-Royce offers a comprehensive suite of repair and refurbishment capabilities for nuclear plant. Our engineers are experienced in both in-situ repair of primary components and pipework, and repair and refurbishment where the scope of service includes the safe removal, shipping, repair and return of both active and inactive nuclear components. Our extensive experience in the area of active component refurbishment covers:

- Control rod drive mechanism
- Nuclear steam supply system pumps
- Neutron source containers

**Instrumentation and control:**
Rolls-Royce is a world-leader in the design, manufacture and re-engineering of both analogue and digital instrumentation and control for all reactor types.

We have undertaken upgrades across a number of operating reactors and developed formal obsolescence strategies using a combination of analogue and digital expertise. These technological advances enable Rolls-Royce to help customers manage the introduction of new systems and ensure that they meet local licensing requirements.

**We have developed a proven model for active refurbishment**
Reactor components

New/replacement mechanical ASME N components

Description:
Rolls-Royce is proud of its ability to apply proven world-class engineering and manufacturing techniques to produce high quality, cost efficient solutions for customers. We have the capability to manufacture a range of components and systems for the nuclear steam supply system (NSSS) across all reactor technologies.

At our facility in Canada, we supply nuclear process components such as flame arresters, y strainers, heat exchangers and flow measurement equipment, in addition to process skids and a variety of specialty systems.

Our quality assurance programme is based upon the requirements of RCC-M and ASME NQA-1, and meets the regulatory requirements under 10CFR50 Appendix B, ASME sections III, VII and IX.

Our expertise can assist you in three key areas:
- We can build to original print
- We can design for manufacture and,
- We can act as your procurement specialist

Products and engineered systems:
- High pressure, high quality vessels to 5 meters diameter
- Low pressure, high quality vessel to 5 meters
- Heat exchangers
- Integrated-head package
- Reactor pressure vessel internals
- Control rod drive mechanisms
- Fuelling machine valve station & rehearsal facility
- Failed fuel location system
- Ion exchange decontamination system
- Solid liquid separation system
- Flame arresters
- Y strainers

Active component repair and refurbishment

Description:
With extensive experience in support of both the UK’s naval nuclear submarine programme and civil nuclear reactors worldwide, Rolls-Royce is highly experienced in a range of in-situ repairs, active refurbishments of contaminated and active equipment and the replacement of failed, worn or obsolescent parts.

Our facilities are designed to handle the receipt, strip, inspection, assembly, testing and dispatch of active nuclear components including main coolant pumps (MCP) and reactor pressure vessel (RPV) heads. Rolls-Royce has a team dedicated to the design and manufacture of nuclear transport containers, who work closely with the customer to help meet their transport requirements in line with any regulatory demands.

Applications:
- Transition weld full repair
- Aqua and chemical cleaning
- Post-weld heat treatment
- Non-destructive examination/remote visual inspection
- Metallurgical support
- Obsolescence management
- Equipment calibration and asset configuration control

Noise and vibration analysis of a refurbished MCP

Internal weld dressing machine

Equipment refurbishment
Component repair: integrated and discrete test rigs

**Description:**
Rolls-Royce is a world leader in engineering and component testing. Our dedicated nuclear rig development and test laboratory facilities are specifically designed and utilised in support of our civil nuclear and naval nuclear programmes.

**Applications:**
Our test rigs have been specifically designed for the following test applications:
- Fully integrated non-active test rig for loss of coolant accident testing
- Integrated pressurised test loop for the testing of refurbished pumps
- System and equipment interface test rigs
- Interface test rigs utilise the service from a pre-existing fully integrated rig, such as electronics control and instrumentation (EC&I) system or peripheral safety systems

Component repair: remote tooling and handling systems

**Description:**
Throughout the life cycle of a nuclear reactor, utility operators must perform inspection, maintenance and refurbishment operations in high radiation environments. Rolls-Royce has amassed a wealth of experience in the design and manufacture of customised tooling equipment to help customers meet these challenges, from precision operation on the reactor core, to manipulation of tooling and components for reactor refurbishment.

With all tooling and handling systems, careful consideration is given to technical specifications and design requirements encompassing complex movement, controlled drive forces, speeds and desired accuracies. With in-house machining and testing facilities, Rolls-Royce can provide a rapid response in the development of high-reliability equipment to meet your emergent challenges. We will provide a team of specialist engineers to provide on-site support during the installation and subsequent commissioning of the equipment.

**Products and systems:**
- Calibration facility and tooling station
- Fusion reactor RAV
- Remote transfer vehicle
- Customised cutting tool
- Remote tool carrier
- Workable tool delivery system
- Telescopic arms
- Utility arm deployment system
- Vitrification facility load lowering device
Reactor components

Instrumentation and control system and supply

Description:
Rolls-Royce market leading digital safety and non-safety I&C integrated solutions are based on technology that combines hardware electronic and software components to produce a unique digital I&C platform for both new nuclear power plants and the refurbishment and obsolescence management of existing plant systems.

All our products and system solutions comply with the strictest international nuclear standards and regulations. Our unrivalled knowledge of plant design and operations allows our solutions to integrate seamlessly with our customers’ processes. Rolls-Royce has the global capability to design, manufacture, supply, fit and support I&C systems on almost any reactor type, anywhere in the world.

Products and engineered systems:
Our I&C products and systems include:
- Digital safety systems utilising patented Spinline™ technology
- Reactor protection system
- Nuclear instrumentation system
- Engineered safety feature actuation system
- Diesel load sequency system
- Control and monitoring system
- Rod control system
- Rod position indication system
- Boron meter
- Reactivity meter
- Digital radiation monitoring system
- In-core instrumentation system
- Plant process computer (BWR and PWR)

Instrumentation and hardware:
- Neutron detectors
- Pressure transmitters
- Displacement transmitters
- Temperature probes
- Pressurised heater control
- Reactor trip breakers

Services:
- Long term support
A tailored solution to address your individual needs

We understand that ensuring safe, sustainable and reliable electricity generation that contributes significantly to achieving global CO2 targets is central to your business strategy. That’s why we make it our business to offer a truly value-added service that is tailored to your needs.

Rolls-Royce can draw on its worldwide expertise to develop bespoke solutions to address your particular needs for planned major and minor outages. We can also work closely with you to develop a lifetime management plan designed to ensure that your critical asset investment is optimised for the duration of its planned lifetime and beyond.

And the real added value you can rely on from Rolls-Royce is our ability to draw upon our group-wide capability of multi-disciplined engineering excellence to deliver a flexible, responsive and integrated approach to address your emergent, unplanned needs.

When you face unexpected operational challenges, we can deliver a technically viable and fully validated solution that will minimise costly downtime and get your plant operational as quickly as possible.

When you’re looking to optimise your generation capacity and at the same time minimise cost and risk, look to a partner you can trust to deliver a solution tailored just for you.
A responsive solution to address your individual needs:

Initial Multidisciplinary Team mobilised to:
- Contain
- Quantify
- Evaluate
- Inform

Concurrent Engineering to minimise plant down-time:
- Safety Case
- Design/Justification
- Development of Tools & Techniques
- Implementation Plan & Training
- Specialised Support

Justify continued Through Life Operation:
- Safety Case
- TLMP

Minimised downtime and optimal operational performance for the customer

24hrs 7 days a week response service so your emergent challenges are addressed immediately...
Providing the power for over 600 airlines, 160 armed forces, 2,000 marine customers - including 70 navies - and delivering energy solutions for customers in 120 countries makes Rolls-Royce a truly global and trusted partner. We have established a worldwide network of 28 University Technology Centres across Europe, Asia and the USA and over the past five years we have invested £4bn in research and development to ensure that we are at the forefront of innovation.

By building on our established strength in the energy markets and with some 2,800 employees in the nuclear business, across Europe and North America, we are well positioned to help our customers succeed in meeting the challenges of an expanding market.

A deep understanding of our customer’s needs and a continued investment in technology has enables Rolls-Royce to become a world-leading provider of power systems and services for use on land, at sea and in the air. With over 38,000 skilled employees in offices, manufacturing and service facilities in 50 countries across the world, we are well places to support you.

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