DESIGN AND MANUFACTURE
IN-CELL REMOTELY OPERATED EQUIPMENT

EARLY ENGAGEMENT = GETTING IT RIGHT FIRST TIME

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ABSTRACT
The paper presents the importance of early engagement in the process of developing a specification prior to embarking on the full detail design and manufacture of remote handling equipment for use in shielded cells. The paper explains the methodology Aquila use in order to create an integrated supplier/user team which fosters a trusting relationship. The paper presents the project delivery process employed at Aquila which has been developed over the 30 years that the Aquila team have been involved in the nuclear industry. This project process works very effectively resulting in minimal re-specification and subsequent delays during implementation of the project.

The paper continues with some recent examples of this methodology with equipment designed for a suite of hot cells for the NNL in Cumbria, England.

The paper concludes by reinforcing the message of early engagement with the supply chain with the objective of specifying fit for purpose remote handling equipment for use in hot cells.

1. Introduction to Aquila

Aquila Nuclear Engineering Ltd, is a specialist company providing engineering solutions into the nuclear and nuclear medicines industry. We get involved at design concept stage right through to installation of the bespoke equipment. We offer solutions in the following nuclear categories:

- Containment & gloveboxes including in-cell processes
- Shielded facilities in concrete, steel or lead including in-cell processes
- Remote Handling including specialist machine systems, grabs and manipulators,
- Transport and packaging solutions.

This paper covers the process of early engagement which leads to the preparation of concept designs, prototypes, specifications, design development, detail design and drawing right through to hardware manufacture and supply of fit for purpose in-cell equipment.

Preparation at the front end is everything and in following this structured approach the outcome is far more likely to meet the user requirement specification with a fit for purpose solution.

This paper sets out these processes which have been tried, tested and proven by Aquila following over 30 years in the industry.
In-cell remotely operated equipment is a broad category covering all equipment that operates within the in-cell environment be it primary process or ancillary support items. The common requirement for in-cell equipment is that it has to perform a task in a safe and efficient

manner working within the constraints of restricted vision, access, dexterity, operating in a hostile environment and have the ability to be maintained.

2. Early Engagement - We see things early

At Aquila our engineers have been designing and delivering remote handling solutions for over 30 years and in that time we have learnt a lot. We don't simply take a brief and devise a quote. We probe, we question and we innovate. In fact at Aquila we have reputation of developing ingenious designs at the bid stage. This approach has served us extremely well since it demonstrates our depth of understanding to our clients. It also allows us to provide an accurate estimate to undertake the complete turnkey supply.

This approach fosters a good working relationship with our clients and creates a trusting environment. This environment facilitates an open dialogue and enables critical reviews leading to the development of specifications and design solutions.

In all cases we employ the Aquila Influence Diagram which identifies areas which may be required to meet the Functional Requirement Specification (FRS) and Design Requirement Specification (DRS) provided by the client.

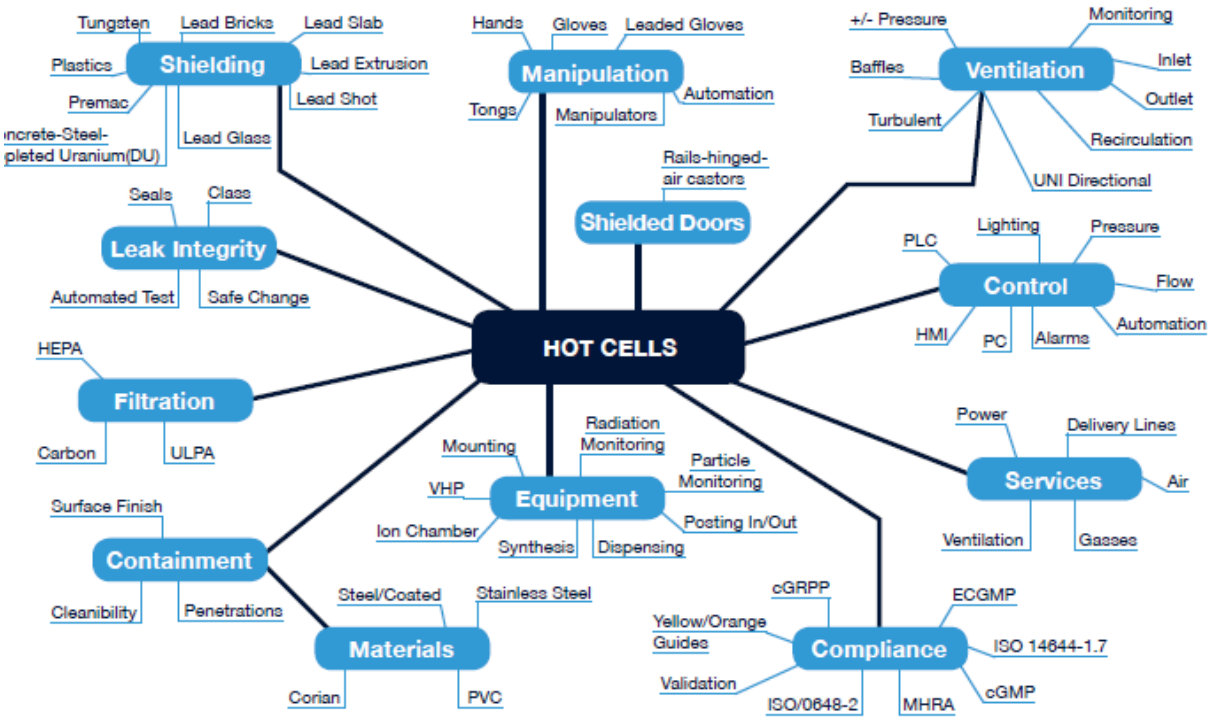


Fig 1. Aquila Influence Diagram

Once all parties have agreed the design concept and the most appropriate solution the project will move into implementation stage. The project efficiency and success will be largely determined by the application of the project process and the rigor to which it is applied to ensure all activities are undertaken and verified at each stage of the project. Aquila's ISO9001 Lloyds accredited quality system provides a series of procedures for each phase providing a project structure within which to undertake the works;

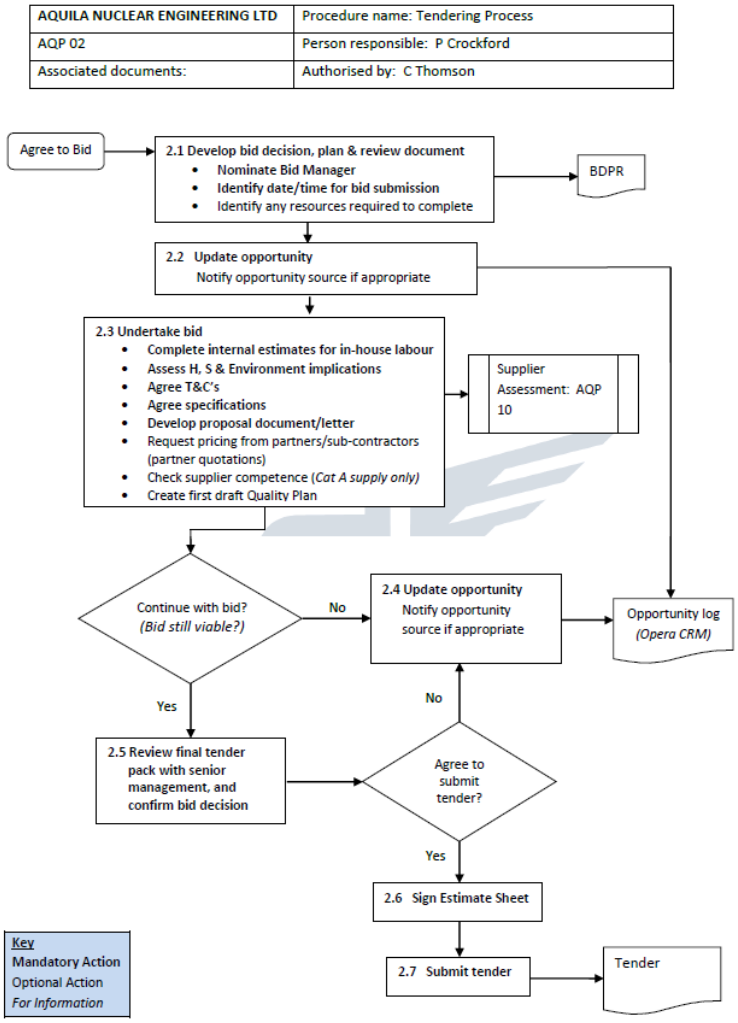


Fig 2. Aquila Quality Procedure AQP 002 Tendering Process

3. Project Delivery Process

Project execution will be specified in contract specific quality plans, these are generated, reviewed and approved by the client, they set out the scope of work, points of contact and responsibilities, document schedules, hold points, etc. In conjunction with an agreed contract program these document set the agreed structure under which the project is initiated, progressed and delivered.

Contract Program

A detailed contract program is developed to cover all aspects of the works, this forms the base line from which the contract is progressed and reported. The program generated by Aquila, reviewed and accepted by the client, execution of activities are the responsibility of all parties supplier and customer alike. Monthly progress reports are generated highlighting progress, issues and program.

Specification, design and supply process for equipment

The specification, design and supply process follows a format. It is the same for all applications and involves a rigorous systematic approach to the application of specification, review and verification ensuring that risk assessments, design challenge and mitigation is carried out on an ongoing basis. In-cell equipment has to be integrated into the wider systems to ensure they can be operated and are safe, the specification and design process is often iterative and requires engagement for all stakeholders to achieve the best design in an efficient manner.

Initial requirement specification will be supplied by the client and is their responsibility, these can range from a series of process or functional requirements through to a nominated equipment solutions. Technically this is the bases of the equipment supply and it is important to interrogate the requirement specification in detail undertaking a gap analysis and initial risk assessment, any discrepancies agreed.

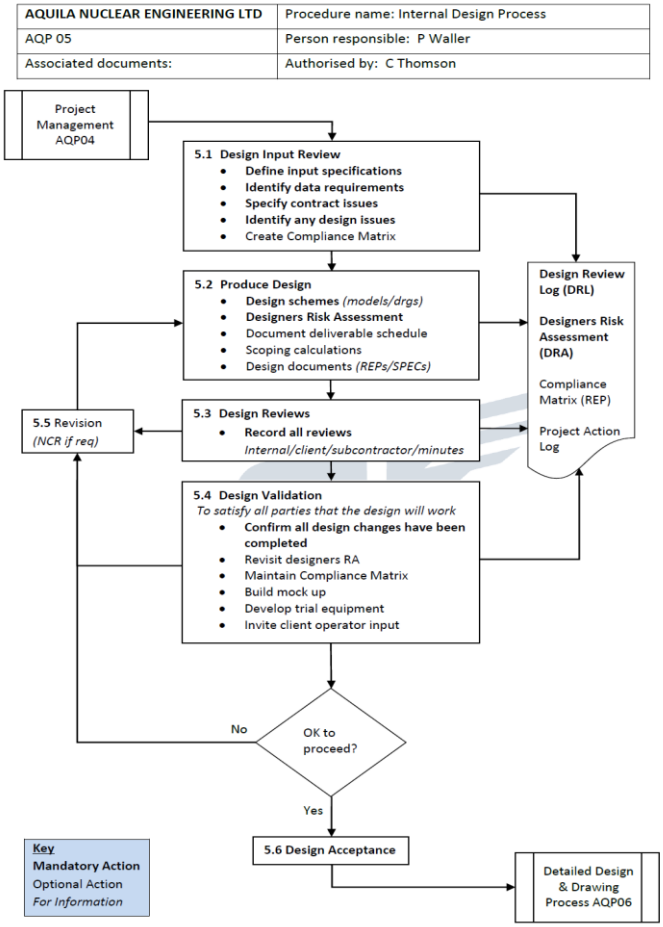


Fig 3. Aquila Quality Procedure AQP 004 Internal Design Process

Initial concept solution options are developed at a high level to be reviewed with the client to identify opportunities and risks. At this stage a cost analysis can be undertaken to underpin the options in support of the client business case. Meetings to be structured with objectives, minutes, and actions.

The chosen solution concept is then developed in a 3D model with supporting calculation to a good level of engineering assurance that the equipment will fulfil the specification requirements. The Concept design is design and risk assessed with the client to ensure alignment with the specification and wider equipment, safety and operational arrangements at the client site. Meetings to be structured with objectives, minutes, and actions.

The design of in-cell equipment is often a compromise between, access, operability, maintenance, etc. With many variables the design process is often iterative, and can be supported by physical mock ups and development. It is important to review all aspect in detail and agree the solutions at this stage as the design principal is effectively set going forward. A design compliance matrix document is generated and maintained throughout the process to verify client and regulatory specifications are addressed.

A Scheme design is developed in a 3D model, this is a fully engineered design which along with calculations, equipment specifications and risk assessment, provides the detail of the design. The Scheme design is reviewed and risk assessed with the client to ensure that items from the concept design review have been addresses in full and that the design is compliant. Meetings to be structured with objectives, minutes, and actions.

Drawings for manufacture are then developed directly from the 3D model, these are presented to the client, reviewed and approved.

This staged approach puts a structure into the process, with identified responsibilities, project program and sign off of the quality plans, hold points provide focus for the output and progress.

Procurement and manufacture

Following sign off for manufacture, the equipment parts lists are released for purchase, manufacture quality, inspection and surveillance, activities are identified within the project quality plans.

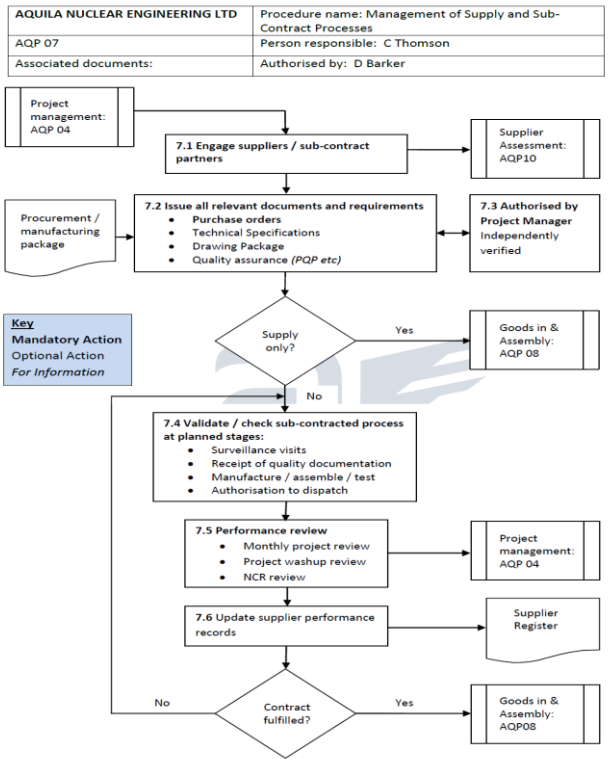


Fig 4. Aquila Quality Procedure AQP 007 Management of supply and subcontractors

It is important to ensure the proprietary item supply and manufacture is undertaken strictly to drawing, given the environment into which the equipment operates, replacement items have to fit first time, setup and datums are maintained.

Manufacture quality plans, weld procedures, NDT, material and component certification are compiled and incorporated into the LTQR's on an ongoing basis.

Assembly, Testing and Training

All equipment is assembled and set to work ensuring fit, form and function are achieved, final equipment validation is achieved by physical testing in line with test schedules at a factory acceptance prior to release for delivery, installation and site acceptance testing. Factory acceptance testing is undertaken with the client and includes, operation, fault scenarios, maintenance, training and knowledge transfer.

4. Hot Cell Categories

Hot Cells fall into two categories

Generic Hot Cells

A Generic Hot Cell provides an envelope of space into which various processes and equipment can be operated on a one off or campaign basis. The Hot Cell facility will define the space envelope, posting arrangements, materials handling, and manipulation, services, and maintenance options, environmental and radiological protection. These form a major part of the basis of design, the in-cell equipment has to be designed to comply with the fixed features of the Hot Cell.

In general the equipment posted in-cell will have drives, sensors and other ancillary equipment on board, there will be a high reliance on remote handling equipment to install, operate, service and maintain the equipment. Equipment has to be simple and robust.



Fig 5. Material Test Cells designed, manufactured and being installed at UKAEA, Culham

Bespoke Hot Cells

A bespoke hot cell allows the process to take precedence without compromise to existing limitations of size, access, environment, etc. The design starts from the user requirement and builds out to throughput, process solutions, operational philosophy, materials flows, access, environmental and radiological protection. All elements can be integrated to provide an optimal solution.



Fig 6. PET production and dispensing cells an integrated process suite

5. Case Studies

5.1 Residual Stress Rigs.

Our client had a requirement to measure the residual stress in an irradiated component during an inspection regime. This is achieved by supporting the component in a fixture and bonding an array of strain gauges set in a pattern at relative locations along the component to allow for inspection activities. It is important to place the strain gauges accurately and make a good bond within a set period to ensure accurate readings are obtained.

The process involves setting the component in a handling fixture to allow for restraint and handling, a jig fixture is placed and secured onto the component to provide set placement points for the strain gauge assemblies. The strain gauge assemblies are bonded onto the component by the application of heat and pressure, the heater/clamp units are connected to the in-cell junction boxes and set aside in readiness for the introduction of the strain gauge assemblies. The strain gauge assemblies are pre-assembled into placement units out of cave, loaded into a handling tray, adhesive applied and posted in-cell.

The strain gauge assemblies set in their placement units are handled directly by the MSM and set onto the jig, the heater/clamp units are set upon the jig and pressure and heat applied. Following application, the strain gauge placement units, heater/clamp units and jig are disassembled by MSM leaving the strain gauges assemblies bonded to the component.

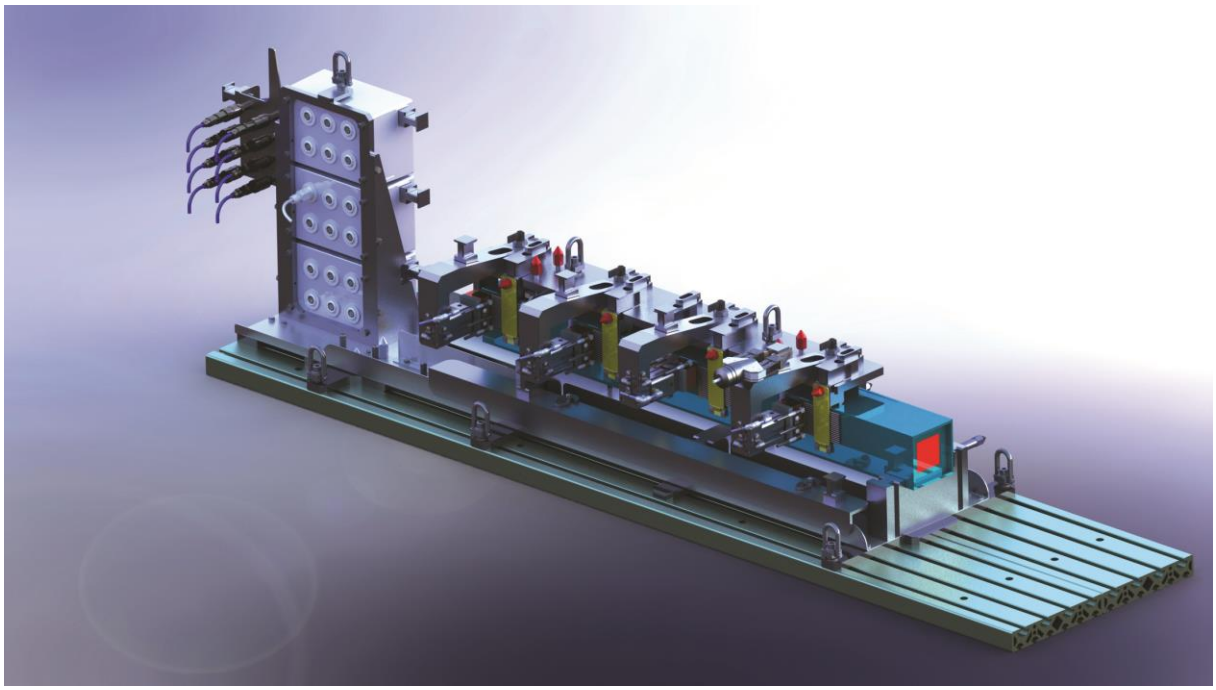


Fig 7. Remotely operated Residual stress rig

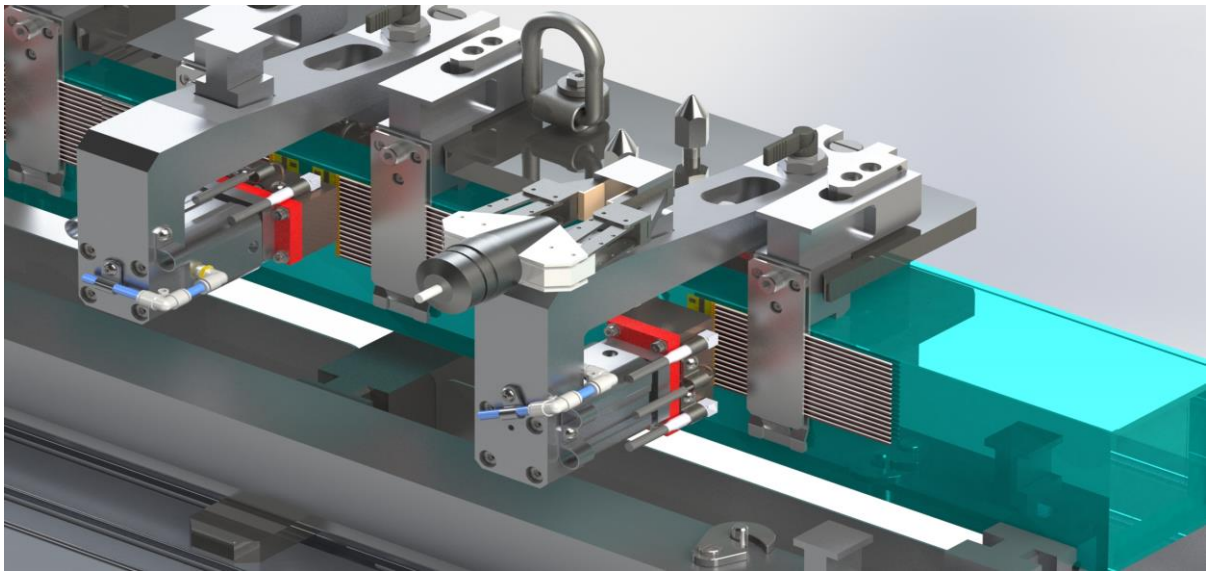


Fig 8. Strain Gauge Assembly, Placement and Heater/Clamp

The equipment has been developed from a functional specification working with the client to ensure we achieve the best opportunity to achieve accurate repeatable placements.

5.2 Remotely Operated Hydraulic Punch

The client has a requirement to remove multiple material samples from irradiated plates, samples have to be removed in accurate patterns about set points, and the equipment is to be fully maintainable in cave via MSM.

A modified hydraulic press has been used to allow samples to be pressed out of a range of sample plates, the modification allows for remote punch and die changing using the MSM. The sample plates are set upon a pair of support arms which are driven in the X & Y axis, direct stepper drive motors are used in combination with linear encoders to provide accurate positioning of the samples under the punch tooling.

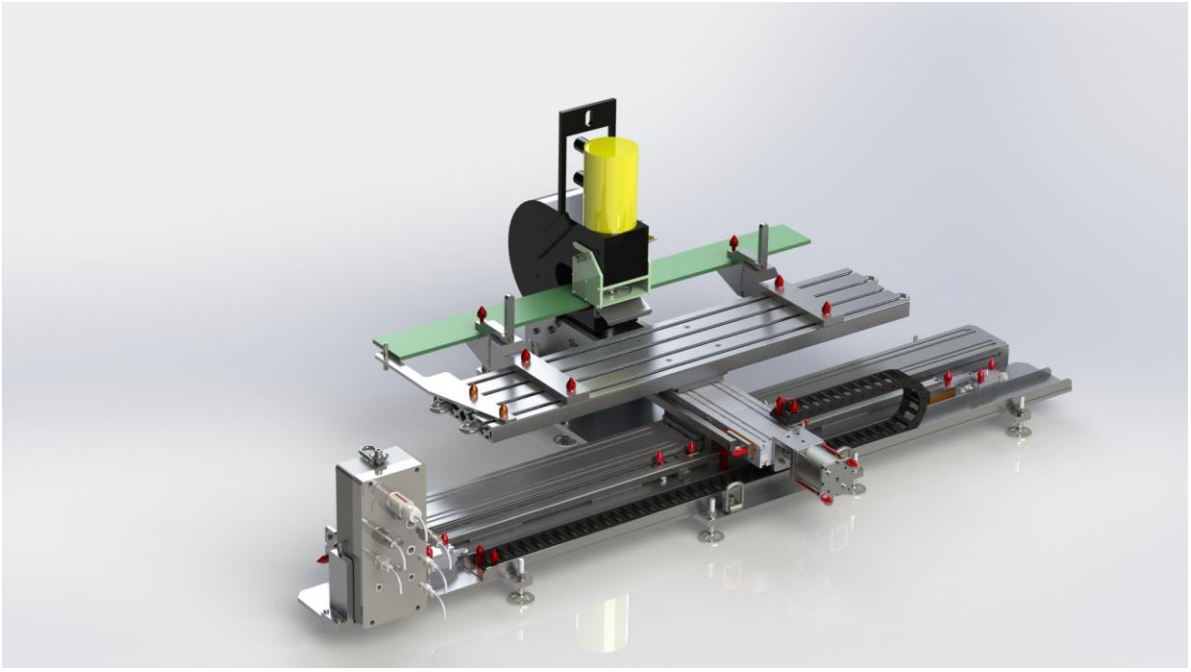


Fig 9. Remotely operated hydraulic punch for preparation of samples

5.3 Gamma Scanner Manipulator

The client has a requirement to manipulate a range of irradiated plates smoothly and accurately in front of a fixed head gamma scanner probe. The equipment to be installed into an existing cave line with restricted access, all assembly and maintenance to be carried out using in cave crane and MSM.

The design challenge was to make the arrangement sufficiently compact to allow for import via a restricted access route, the X axis rails, base and drive units are split to be assembled in-cell via MSM. The Y & Z axis use commercial linear drive units, all drive motors, limit switches, encoders, drives, etc. are replaceable by MSM.

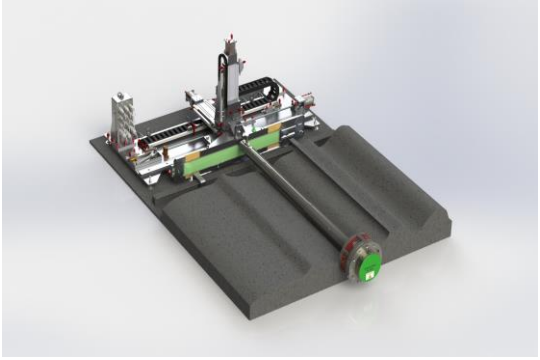


Fig.10 Remotely operated gamma scanner rig in 3D

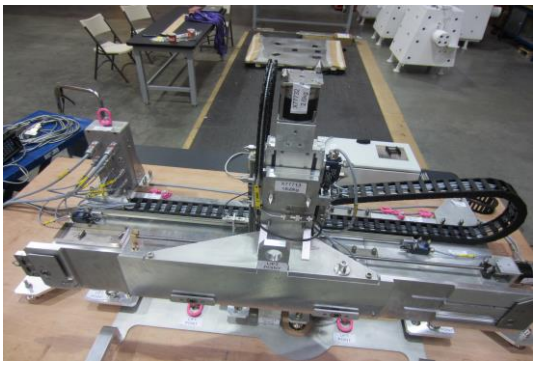


Fig. 11 Remotely operated gamma scanner in workshop

5.4 Analysis and breakdown equipment

The client has a requirement to receive, size reduce and manipulate a range of components and equipment in cave to undertake and range of inspections of irradiated components. The equipment will be installed and setup with man access, all subsequent maintenance activities to be remote via MSM.

The equipment has to locate within an existing cave line with space and load restrictions, development has been carried out in close communication with the client in order to address the various developing design inputs and other equipment design packages. The equipment offers a robust XY gantry table onto which irradiated components are loaded to be reduced in length by way of a reciprocating cut off saw. The X & Y axis are driven by direct drive stepper motors, linear encoders providing accurate position and feedback. A retractable slitting saw head is located at the rear of the equipment, this can be swung into position and has Z axis adjustment to allow for components to be split along their length. Additional fixtures and equipment are sited onto the XY table at various stages to provide manipulation of samples to a fixed probe location providing X,Y & Z articulation, along with component rotation and clamping arrangements.

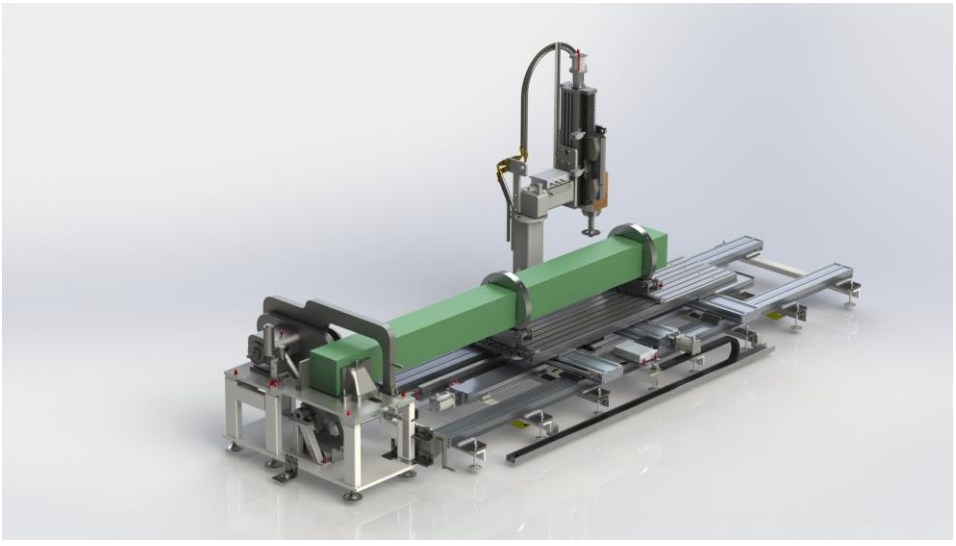


Figure 12. Remotely operated analysis breakdown and size reduction equipment

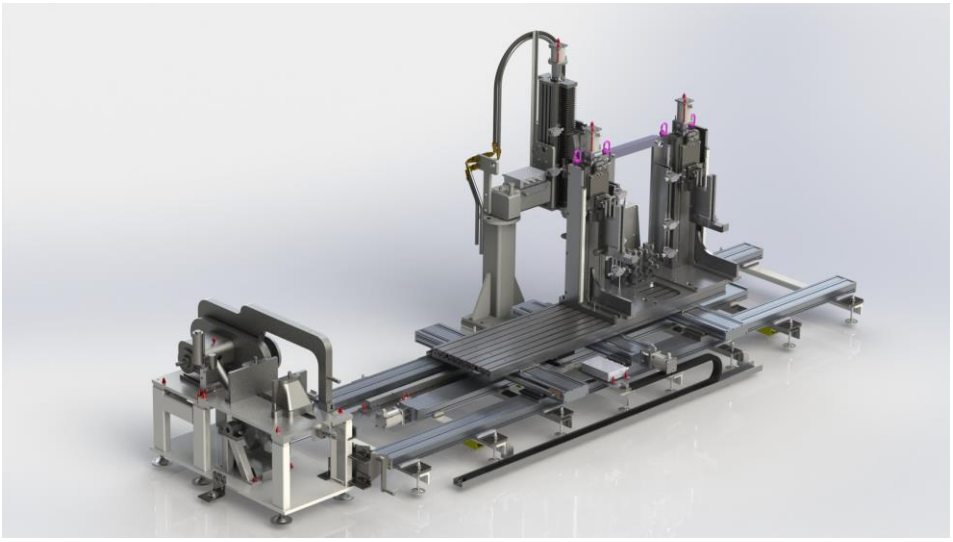


Figure 13. Component manipulation and rotation

6. Summary and Conclusions

At Aquila we have a team of highly experienced engineers with an enviable portfolio of successful projects. Our reputation has been earned by applying a structured approach to each and every new project starting with early engagement followed by staged project management gates. At all stages we work hand in hand with our customer team so that as an integrated team we reach a soft landing during hot commissioning and active operations.