Cutting Methodologies Applied to Nuclear Decommissioning

WORKSHOP PROCEEDINGS

KP-JRC-022

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Foreword

In 2021, the European Commission (EC) adopted a new proposal for a Council Regulation[1] establishing a dedicated financial programme for decommissioning nuclear facilities and managing radioactive waste. This instrument covers the co-funding of the decommissioning programmes of Bulgaria, Slovakia and the decommissioning of the Joint Research Centre (JRC). A separate Council Regulation[2] was adopted for the decommissioning programme of Lithuania.

The EC JRC is mandated to foster the spread of decommissioning knowledge across all the European Union Member States and facilitate knowledge sharing arising from implementing the above-mentioned decommissioning programmes, funded by the Nuclear Decommissioning Assistance Programme (NDAP).

The decommissioning operators from the NDAP (NDAP Operators) implemented and tested a knowledge management methodology in 2021 through Project ENER/D2/2020-273. Using this methodology, the NDAP Operators can develop knowledge products that are currently available to share with other European stakeholders. In addition, this methodology is being implemented by the JRC Nuclear Decommissioning and Waste Management Directorate (NDWMD), which has become a knowledge generator extracting the knowledge from the ongoing decommissioning activities across the JRC´s four different sites (Geel, Ispra, Karlsruhe and Petten).

The JRC´s NDWMD aims to become a Centre of Excellence in nuclear decommissioning knowledge management and to develop a decommissioning knowledge platform which allows exchanging information building on EU best practices through executing the multi-annual financial framework (2021 – 2027) strategy. The operational phase of the project started in 2024 with the objectives to: develop ties and exchanges among EU stakeholders, document explicit knowledge and make it available through multi-lateral knowledge transfers on decommissioning and waste management governance issues, managerial best practices, technological challenges, and decommissioning processes at both operational and organisational level, as well as to develop potential EU synergies.

This is a knowledge product prepared by the JRC for the Nuclear Decommissioning and Waste Management Directorate (NDWMD) – Directorate J of the Joint Research Centre.

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Performed by	Guillem Sanchis Ramírez		
Revised by	Pierfederico Briani, Mikolaj M. Semba		
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Approved by	Andrea Piagentini		

[1] Council Regulation (Euratom) 2021/100 of 25 January 2021 establishing a dedicated financial program for the decommissioning of nuclear facilities and the management of radioactive waste, and repealing Regulation (Euratom) No 1368/2013

[2] Council Regulation (EU) 2021/101 of 25 January 2021 establishing the nuclear decommissioning assistance programme of the Ignalina NPP in Lithuania and repealing Regulation (EU) No 1369/2013

PRODUCT DESCRIPTION

The following document summarises the workshop on cutting methodologies applied to Nuclear Decommissioning, which took place at the European Commission's Joint Research Centre (JRC) in Ispra, Italy, on March 24th and 25th, 2026.

ABSTRACT

This KP consists of the proceedings of the workshop on cutting methodologies. The first part summarises the presentations given by the various nuclear decommissioning operators and companies regarding specific cutting solutions as they applied to their particular facilities and under their particular regulatory frameworks, physical constraints, and available resources. The second part of the document synthesises the working groups sessions which were held on the second day of the workshop and in which the participants split in three groups to discuss the specific selection criteria employed within their organisations in relation to the technical, contractual, and safety aspects of cutting applied to nuclear decommissioning. The slides using in the aforementioned presentations are included as an annex at the end of the document.

OBJECTIVE

To record, convey and explain the information shared, and the insights gathered, during the course of the workshop.

APPROACH

This document was developed by gathering the slides, as well as the summaries provided by the speakers, of the presentations delivered at the workshop. The notes gathered by the coordinators of the working groups in the course of the discussions were also used to gather the insights obtained.

RESULTS, FINDINGS AND INSIGHTS

The workshop results highlight that successful implementation of cutting methodologies relies on the early integration of safety, technical optimisation, and project constraints. Safety was consistently identified as the primary selection criterion, with strong interdependencies between safety, cost, and schedule performance.

Key successful practices include the use of remotely operated systems to reduce exposure, optimisation of cutting strategies to minimise secondary waste, and early testing of technologies to validate feasibility under site-specific conditions. The importance of aligning technology selection with execution capabilities and maintaining close coordination between design and safety teams was emphasised.

The findings also show that project performance benefits from simple, robust solutions and from integrating waste management strategies into the cutting approach. Case studies demonstrated improvements in efficiency and safety through iterative learning and reuse of experience across similar projects.

Areas for further improvement include better dissemination of knowledge to field personnel, enhanced material characterisation to reduce technical risks, and more flexible methodologies that can adapt to unforeseen conditions. Additionally, contractual and organisational aspects were identified as critical enablers for successful implementation.

TARGET USERS

This KP is a valuable contribution to entities involved in nuclear decommissioning, including operators, engineering companies, technical support organisations, and regulators.

APPLICATION, VALUE AND USE

The information contained herein offers insights into the selection, design, and implementation of cutting methodologies for nuclear decommissioning, supporting improved technical decision-making, enhanced safety performance, and optimisation of project execution.

KEYWORDS

Decommissioning, management of materials, waste management, cutting methodologies, segmentation, nuclear dismantling, safety, remote handling.

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1. PREFACE

The following document summarises the workshop on cutting methodologies applied to Nuclear Decommissioning, which took place at the European Commission's Joint Research Centre (JRC) in Ispra, Italy, on March 24th and 25th, 2026.

The event brought together experts and practitioners from across the nuclear decommissioning community to exchange experience, compare approaches and identify priorities for future knowledge development, with particular emphasis on decision-making in complex project environments. Participants represented a broad range of roles, including operators, technical support organisations, engineering companies and international bodies, reflecting a wide spectrum of project contexts and regulatory environments.

From the outset, discussions were characterised by a high level of openness and collaboration. Participants shared concrete project examples and discussed, in a candid manner, the practical constraints that influence cutting strategy selection in real-world applications. These included access limitations, radiological conditions, infrastructure constraints, safety requirements and regulatory considerations.

The first day of the workshop combined a series of short technical presentations with facilitated discussion. This format enabled both the structured presentation of experience and peer-to-peer exchange, allowing lessons learned from different organisational and national contexts to be compared.

The second day was dedicated to structured working group activities. Participants were divided into three working groups—Technical, Safety and Contractual—to foster productive discussions and consolidate key outcomes. Each group identified selection criteria and key conclusions relevant to its topic area, documented additional observations and challenges, and proposed topics for future knowledge products.

Beyond the specific technical outputs, the workshop contributed to strengthening professional networks and reinforcing a shared commitment to continued collaboration within the nuclear decommissioning community. Participants expressed clear interest in translating workshop outcomes into concrete knowledge products, including structured lessons learned, knowledge harvesting initiatives and practical guidance to support decision-making across projects.

The workshop brought together organisations from across Europe and beyond, including Spain, Denmark, Lithuania, Italy, Belgium, Bulgaria, Germany, Norway, Sweden and France. Participating organisations included Equipos Nucleares S.A., S.M.E. (ENSA), Dansk Dekommissionering / Danish Decommissioning, Altra, Sogin, Belgoprocess, SERAW, IDOM Nuclear Services, KTE Kerntechnische Entsorgung Karlsruhe, Norsk nukleær dekommisjonering, Vattenfall, GDES | Grupo Dominguis Energy Services, Cyclife, Graphitech Nuclear, Westinghouse Electric Company and the International Atomic Energy Agency (IAEA). IDOM Nuclear Services also supported the organisation of the workshop under the Framework Contract "Services in the Area of Nuclear Decommissioning Knowledge Management" with the JRC.

The JRC thanks all participants for their active engagement and constructive contributions. These proceedings capture the main technical inputs and consolidated outcomes of the workshop and represent an important step in strengthening knowledge sharing and collaboration within the nuclear decommissioning community.

2. TECHNICAL PRESENTATIONS

Segmentation of ESSOR activated material

Raffaele Bencardino

JRC.J –Nuclear Decommissioning and Waste Management

Presentation Summary

The presentation addressed the challenges of segmenting highly activated components from the ESSOR reactor at the JRC Ispra site. The presentation outlined the rationale for a bespoke cutting machine, detailed its design drivers and showed how the equipment will be integrated with transfer casks, cutting units and container-handling subsystems.

The key points covered include:

- **Scope of the waste**: 64 activated components, totalling 7.2 t, with dimensions up to 8.9 m in length and diameters ranging from 5 mm to 233 mm. Materials include steel, Al-Mg, Zircaloy, Zr-Nb, heavy concrete and lead, with contact dose rates reaching 2 500 mSv/h and surface contamination up to 1 250 Bq (^{60}Co).
- **Segmentation requirements**: Approximately 1500 individual cuts are expected, necessitating a flexible and robust remotely-operated cutting system that can handle heterogeneous geometries while minimising secondary waste production.
- **Machine design**: The cutting machine concept comprises:
    - a **transfer cask** for safe transport of components from the storage location to the cutting cell;
    - a **cutting unit** equipped with a hydraulic shear weighing 38 t, having max shearing force of 20 MN (2000 t) and able to perform radiometric measurements to dispose the cut segments into containers of different shielding levels;
    - **container handling** modules for the immediate packaging of cut sections into shielded containers and automatic transport to the designated storage area.
- **Operational workflow**: The process flow from component retrieval, containment, cutting, to final packaging was illustrated in a digital gallery, highlighting the integration of remote handling, radiological monitoring and quality assurance.
- **Opportunities and challenges**: Optimising the cutting strategy can significantly reduce the volume of secondary waste, but technical challenges remain in managing high-dose fields, maintaining cutting precision on thick components, and ensuring reliable remote operation.

The presentation concluded that the proposed cutting machine, built around the identified design drivers and subsystems, offers a feasible solution to safely segment ESSOR activated material while supporting the broader decommissioning and waste-management objectives of the JRC decommissioning and waste management programme.

Nuclear safety strategy and implementation – ESSOR cutting machine

Yannick Pons

YPEX Nuclear

Presentation Summary

The focus of this presentation was on showing how the development and choice of cutting technology require a strong management of safety analyses and choices.

In the case of the technology choice within the decommissioning process of the ESSOR experimental reactor at JRC Ispra, the strategy is based on a mix of, on the one hand, a deterministic approach to define the basic design, and the consideration of *HAZOP* Level 3 hazards, to check and verify robustness of the design, on the other hand. The choice was to focus on the six main hazards during the basic design development process.

In addition, the deterministic approach is constituted by an interactive process to guide the choice and in order to consider potential second order effects.

In conclusion, strict coordination between design team and safety teams, with use of proven tools, is essential.

Latina NPP Boiler Dismantling: Cutting Machine Design

Fabrizio Massicci

Mechanical Design Unit

SOGIN SpA

Presentation Summary

This presentation described the preliminary design of a bespoke cutting machine developed for the dismantling of the steam generators of the Latina Nuclear Power Plant within the constraints of the existing reactor building. The project objective is the safe, controlled and efficient sectioning of six vertically installed steam generators, each approximately 24 m high and weighing about 600 t, while maintaining strict control of loads, vibrations, radiological exposure and interfaces with permanent plant structures.

The dismantling strategy is based on dividing each steam generator into cylindrical segments along the original construction welds. This configuration preserves the mechanical integrity and load paths of internal tube bundles and their support structures, ensuring that they remain attached to the shell sections being handled. As a result, the risk of internal component detachment is avoided, handling operations are simplified, and radiological safety is improved during lifting, transfer and waste conditioning phases.

Diamond wire cutting was selected as the most suitable technology for thick-walled, large-diameter steel vessels with complex internal geometries. The presence of hollow shells, thin-walled internal components and sharp stiffness discontinuities required a dedicated mechanical analysis of wire–structure interaction. The analysis addressed the variability of contact surfaces, local stiffness effects and force equilibrium along the wire path, leading to the definition of optimized cutting parameters. These include reduced angles of attack, increased wire tension and the adoption of a high-tension closed-loop wire configuration without mechanical connectors, eliminating the weakest element of conventional wire systems and mitigating wire glazing phenomena.

Dry cutting operations are supported by an integrated vortex-tube-based air-cooling system, which provides effective thermal control of the diamond wire while avoiding the use of liquid coolants and the associated management of potentially contaminated liquids. The mechanical layout was developed to satisfy commissioning constraints, such as limited available space, modular assembly, bolted connections and minimized impact of tool changeovers. The cutting machine interfaces with adapted existing support structures and a newly installed overhead crane, enabling precise vertical positioning and use of the system as a temporary working platform.

The basic design developed by Sogin was subsequently assessed and confirmed by the Contractor, with targeted refinements introduced to further enhance robustness and operational safety. The proposed solution demonstrates the effectiveness of high-precision wire cutting for large-scale nuclear component dismantling under complex structural and operational constraint.

Garigliano: Control Rod Cutting Machine (MTBC) Design for Reactor Internals Dismantling

Bernardo Capriglione

Head of Mechanical Design Unit

SOGIN SpA

Presentation Summary

This presentation introduced the design of a dedicated cutting system developed to safely dismantle reactor vessel internals at the Garigliano Nuclear Plant, with a specific focus on the segmentation of highly radioactive control rods using the MTBC (Control Rod Cutting Machine). The design is driven by four main goals: radiation protection, minimising contamination spread, enabling remote operation, and optimising waste management to support final disposal.

The dismantling strategy is framed within a broader decommissioning scope structured into three phases: (1) upper internals removal, (2) lower internals dismantling, and (3) final vessel and primary circuit dismantling, supported by preparatory activities such as system refurbishment and decontamination.

The MTBC is designed to cut 90 irradiated control rods underwater, maintaining a minimum 5 m water head to provide shielding. Each rod (approximately 3 m long and 68 kg) is segmented into roughly 20 pieces. To reduce the dispersion of radioactive particles, the project selected mechanical shearing as the cutting method; design parameters were validated through finite element analysis (FEM) and experimental testing.

From an engineering perspective, the MTBC adopts a modular architecture—including tilting, translation, and cutting modules—mounted on a base frame to improve maintainability and facilitate remote handling. During operation, rods are positioned and rotated horizontally, fed into the cutting module for segmentation, and the resulting pieces are collected. Actuation is provided by hydraulic systems controlled by a PLC, incorporating redundancy and UPS backup to support safe operation under off normal conditions. Remote work is enabled and supervised through camera and lighting systems, while the overall component design prioritises corrosion resistance, robustness, and ease of decontamination.

Waste management is integrated into the process: the segmented pieces are packaged into shielded containers, configured to meet density and transport constraints for eventual disposal in the National Repository.

In conclusion, the MTBC is presented as a robust, modular, remotely operated solution tailored for high radiation environments, balancing operational efficiency with safety and waste minimisation through the combined use of mechanical cutting, resilient control systems, and optimised packaging.

Ågesta Decommissioning Programme (2020–2025)

Nicklas Tjernlund

Senior Specialist, Demolition & Dismantling (Robotic Demolition Expert)

Lead – Decommissioning Functional Area

HSO – Vattenfall Power Solutions

Presentation Summary

This presentation outlined the decommissioning programme of the Ågesta Nuclear Power Plant, Sweden's first commercial nuclear power plant, with emphasis on objectives, execution, and key lessons learned.

The primary goal was the safe and efficient removal of all activated and contaminated components, including the management and disposal of radioactive waste, completion of free release measurements, and the restoration of the underground cavern and surrounding area for unrestricted use. The programme prioritised radiation protection (ALARA), waste minimisation, and cost-effective execution.

The project ran from 2020 to 2025, with an estimated total cost of ~€60 million, generating approximately 1,800 tonnes of waste. Major achievements included dismantling and removal of large components such as steam generators, the pressurizer, reactor pressure vessel internals, fuel and control rod wells, heavy water systems, storage tanks, and parts of the biological shield.

A key technical highlight was the in-situ segmentation of highly activated control rods, developed due to the absence of suitable off the shelf solutions. This was successfully accomplished by leveraging existing plant structures and using remotely operated, tailor made (yet largely conventional) equipment, substantially reducing both personnel radiation exposure and waste volumes.

Robotics and remote handling were applied where they delivered clear safety advantages—especially in high dose environments—while simpler manual methods were used where appropriate. The programme also demonstrated that waste handling, activity measurements, and regulatory clearance processes can be more critical to overall progress than physical dismantling alone.

Overall, the main lessons are the importance of early waste strategy planning, close collaboration between dismantling staff, waste specialists, and radiophysicists, and maintaining a "keep it simple" design philosophy. The Ågesta project shows that robotics and remote systems can improve safety and cost efficiency in decommissioning when deployed selectively and purposefully.

Latina Steam Generators Cutting Machine

Roberta Gargiulo

International Project Manager

GD Energy Services (GDES)

Presentation Summary

The presentation described the project developed by GD Energy Services for the dismantling of the steam generators at the Latina nuclear power plant, awarded in 2021 to a joint venture led by the company. The main objective of the project was to design and implement an innovative cutting machine capable of improving safety, operational robustness, and efficiency during the in-situ segmentation of the plant's six steam generators.

The presentation outlined the different project phases: removal of auxiliary structures, manufacturing of the main equipment (cutting machine, overhead crane, and ventilation systems), construction of static and dynamic confinement structures, in-situ segmentation, and final demolition activities. Particular attention is given to GDES's design philosophy, which focused on increasing operational safety, reducing personnel exposure to work at height, improving stability during lifting operations, and enhancing flexibility in both tangential and diametral cutting processes.

From a technical perspective, the machine incorporates several innovative solutions, including a hybrid electro-hydraulic configuration, remote-control operation, full rotation around the boiler for multiple cutting modes, automatic stabilization systems, and elimination of the need for personnel access during lifting activities. Although these improvements resulted in increased weight and structural complexity, they significantly enhanced operational reliability and simplified maintenance procedures.

In conclusion, the presentation highlighted how the project represents a major advancement in nuclear decommissioning technologies, demonstrating GDES's ability to combine innovation, safety, and sustainability in highly complex industrial operations.

Post-segmentation of vessels at Barsebäck and Oskarshamn NPP

Roberto Diego Benito

Manager of Special Projects

GD Energy Services (GDES)

Presentation Summary

The presentation addressed the post-segmentation of reactor pressure vessels and their heads at the Barsebäck and Oskarshamn nuclear power plants, within a project led by Uniper Nuclear Services (developing engineering, licensing and equipment supply), with GDES responsible for on-site execution. The objective was to complete the segmentation of large components safely and efficiently, while improving performance through operational feedback and lessons learned.

The scope covered four reactor pressure vessels and associated heads, along with supporting tasks such as installation of a 16-ton bridge crane, assembly of robotic cutting systems, area confinement, and waste conditioning. Each vessel generated around 430 tons of waste packaged in 2-KKC containers.

The segmentation approach was based on robotized oxy-fuel cutting using a six-axis robot mounted on rails and integrated with a rotating table. This configuration allowed adaptation to complex geometries and material thicknesses up to 600 mm, with remote operation to minimize radiological exposure.

A key lesson learned was the critical role of preheating. Fully automated preheating proved unreliable due to positioning and timing limitations, leading to the adoption of a hybrid solution: manual remote-controlled preheating followed by automatic cutting once adequate conditions were confirmed. This significantly improved process stability and cut quality.

In addition, the project highlighted the importance of properly dimensioning the HVAC system, as insufficient duct length led to excessive temperatures at the filtration stage.

Material-specific challenges were also encountered, particularly with an Inconel ring in the vessel flange, which could not be effectively cut using standard oxyfuel techniques. The solution involved integrating a high-pressure zinc oxide abrasive jet into the cutting process, enabling efficient automated segmentation.

Finally, the similarity between reactors allowed strong synergies, including reuse of equipment and transfer of experience, resulting in reduced costs and improved execution efficiency.

In conclusion, the project demonstrated the importance of process optimization and continuous improvement, providing an effective solution for large-scale nuclear decommissioning.

Barsebäck 1 & 2: Reactor Vessel Internals Segmentation Case Study

Per Segerud

Segmentation Engineering Manager

Westinghouse Electric Sweden AB

Presentation Summary

The presentation covers the project's scope of work, organisation, and worksite layout, and includes examples of cutting tools along with photographs illustrating the activities carried out at Barsebäck. The selected method for this project was mechanical cutting, highlighted as a proven technique for underwater segmentation of RVIs (Reactor Vessel Internals) due to its safety, reliability, and ability to maintain good water visibility during operations. An additional operational benefit described is the possibility to keep the on-site team small; the Barsebäck project was executed with a core team of five people.

Waste packaging is emphasised as a critical success factor, since the final packed containers are effectively the deliverable of the project. Container dimensions strongly influence the segmentation strategy by defining how much cutting is required and, therefore, the project duration. Other constraints that may govern the work include dose-rate limits, activity limits, and weight limits.

The main conclusion is that successful segmentation depends on careful planning, strong cooperation between customer and contractor, and the use of flexible tooling capable of adapting to unexpected conditions encountered on site.

GRAPHITECH NUCLEAR: Capabilities and Cutting Technologies for Graphite Reactor Dismantling

Antoine Krawczyk

Mechanical Engineer

Graphitech Nuclear

Presentation Summary

This presentation provided an overview of GRAPHITECH NUCLEAR, covering its background, mission, current projects, key assets, and mid to long term outlook. GRAPHITECH NUCLEAR is a French joint venture (51% EDF, 49% Veolia), founded in 2019 to address the challenges of dismantling the French UNGG (natural uranium graphite gas) fleet and other graphite moderated reactors across the EU.

The company's activities are organised across two main sites: Lyon (headquarters, focused on dismantling and mechanical studies) and Beaumont en Véron (Industrial Demonstrator, dedicated to full scale physical trials and numerical simulations). The core service offering presented includes developing dismantling scenarios aligned with both regulatory and client requirements; designing, selecting, and integrating tooling and equipment to implement those scenarios; conducting real scale mock up trials complemented by simulations to mitigate identified risks; and training operators on remote dismantling and monitoring systems.

From a cutting technology perspective, the presentation reports that GRAPHITECH has tested a wide range of approaches, including mechanical solutions (e.g., large diameter commercial off the shelf disc saws on bespoke deployment units, commercial hydraulic shears, bespoke internal tube cutters, grinders, milling machines, and large jackhammers), thermal cutting (auto primed oxy fuel), and laser cutting (high power source mounted on a 6 axis arm). The Industrial Demonstrator is described as a continuously evolving facility designed to support cross trials on multiple topics in separate cells while maintaining high safety standards for personnel working nearby.

Finally, leveraging the Industrial Demonstrator's status as an IAEA "Collaborating Centre", GRAPHITECH expresses its intention to foster international collaboration on dismantling related topics.

Decommissioning of Reprocessing Plant Karlsruhe and Compact Sodium-Cooled Power Plant

Dr. Marco Klipfel, Oliver Fath

KTE

Presentation Summary

KTE dismantled various nuclear facilities, both remotely and manually. The dismantling projects – the HLLW storage building, the vitrification facility, VEK and the compact sodium-cooled reactor, KNK – were presented.

In the first two projects mentioned, stainless steel and carbon steel were to be dismantled under similar radiological conditions: very high dose rates, no possibility of conditioning liquid radioactive waste, and mostly confined working conditions within the cells. The KNK decommissioning project required the construction of a modular working platform in the reactor shaft to remotely mobilize the contamination of the biological shield using a TOPTEC excavator and an A-1000 power manipulator.

In areas with high radiation exposure, standard tools were generally used, which were modified for remote operation so that a manipulator can grip and operate them safely. Typical tools included reciprocating saws, angle grinders and hydraulic shears. The modifications to the machines allowed for easy replacement of saw blades or cutting discs.

The angle grinder generates flying sparks but has good cutting performance. The reciprocating saw is suitable for massive components and has low cutting performance. Pipes up to DN 50 are also often cut using the hydraulic shears. A TOPTEC 5500E is being used as the manipulator carrier system in the horizontal decommissioning project of the HLLW storage building. The vertical decommissioning of the VEK is carried out using a telescope from HWM.

3. WORKING GROUPS

Technical Working Group: Cutting Techniques for Nuclear Dismantling

Abstract

The technical session addressed the selection and application of cutting techniques for nuclear dismantling, considering safety, cost, schedule constraints, regulatory frameworks, and site-specific physical limitations. Discussions covered mechanical (shearing and diamond wire) as well as thermal cutting, with particular attention to underwater operations, filtration, secondary waste management, and material behaviour under irradiation. Experience from several European projects highlighted the importance of aligning technical decision making with execution capabilities, prioritizing safety and schedule optimisation, and validating solutions through early testing. Organisational coordination and effective knowledge transfer to field personnel were identified as critical success factors.

Session Summary

Participants introduced cutting approaches applied in their respective projects. The role of large institutional actors operating in technically complex and politically sensitive environments was highlighted, together with the challenges of coordinating safety and technical teams within the same project. While regulatory authorities significantly influence initial cutting technology choices, participants agreed that methodologies must remain adaptable to technical realities to avoid cumulative organizational and technical problems.

Detailed discussions focused on underwater mechanical cutting, associated ventilation and filtration systems, water management, and secondary waste handling. Alternative approaches such as thermal cutting and water jet cutting were considered, with applicability shown to depend strongly on geometry, accessibility, radiological conditions, and available infrastructure. Bulgarian participants shared broad experience with both mechanical and thermal cutting, while Westinghouse representatives described the decisive role of component geometry in selecting mechanical techniques for reactor internals in Sweden.

Concerns were raised regarding the cutting of control rods due to increased contamination risks. Previous experience demonstrated that reinforced local filtration systems can effectively prevent dispersion beyond the immediate cutting area. Water management emerged as a recurring challenge, with German participants describing evaporation as a practical solution to regulatory constraints on discharging large volumes of contaminated water.

Material behaviour under irradiation was discussed extensively. Shear cutting limitations were noted, particularly for hardened or embrittled materials that may crack away from the cutting point instead of deforming plastically, potentially leading to blade wear or hydraulic system damage. These effects reinforce the need for early material characterization and testing.

Key case studies illustrated how constraints shape solutions. At the Bohunice site (Slovakia), limited pool space but ample reactor hall space led to the construction of additional pools, enabling technicians to use familiar underwater cutting techniques. In the decommissioning of the experimental reactor ESSOR being carried out at JRC Ispra, an initial diamond wire cutting approach was abandoned due to radiological exposure risks during wire replacement and contractor preference for a shearing solution.

The session emphasized that safety is the overriding selection criterion, with cost and schedule closely linked (faster solutions often being cheaper). Client urgency, regulatory philosophy, and physical constraints all influence technology choice. Participants agreed that simplicity reduces operational risk and that separating technology selection from execution teams is sub optimal.

The session concluded with recommendations to maximize decontamination prior to cutting, anticipate unforeseen events throughout the project lifecycle, carry out thorough preliminary testing, and improve dissemination of technical knowledge products to technicians in the field.

Contractual Aspects Working Group: Procurement and Contracting Challenges in Nuclear Decommissioning

Abstract

The contractual session explored procurement and contracting challenges specific to nuclear decommissioning and dismantling projects. With contributions from both clients and contractors, the discussion addressed liability allocation, intellectual property provisions, payment mechanisms, public procurement constraints, workforce considerations, and market capacity. Particular attention was given to the mismatch between conventional procurement models and the complexity and uncertainty of decommissioning activities. Participants highlighted the need for differentiated contractual approaches, stronger emphasis on technical competence, and risk informed contract design.

Session Summary

The working group included both clients and contractors, though most participants had technical backgrounds rather than formal procurement expertise. Discussions were primarily based on European experience, with some international comparisons.

A key theme was the weighting of selection criteria. For complex activities such as cutting reactor vessels or reactor vessel internals, participants agreed that technical competence should dominate (suggested up to 80% technical vs. 20% financial). However, public procurement rules often prevent this, despite clear appetite from client technical staff. Excessive focus on price was seen as enabling underqualified bidders, leading to delays and execution issues, while overly strict technical criteria may discourage competition.

Contractors highlighted uncapped or poorly defined liability clauses as a major concern, particularly in public contracts. While D&D projects differ from new build, residual risks remain and must be realistically allocated. Financial solvency criteria were also emphasized, given the severe impact of potential contractor bankruptcy on schedules.

Intellectual property provisions were repeatedly identified as problematic. Contractors accepted the obligation to deliver project IP but stressed the difficulty of distinguishing this from proprietary know how. Innovation was considered essential but should be introduced via pilot projects or subcontracting of innovative SMEs, not on critical path activities. Highly activated cutting and segmentation were consistently described as work for experienced major contractors, with little room for experimentation.

Cash flow issues arising from lack of upfront payments or delayed milestones were seen as significant. Hybrid payment models combining fixed price and performance based elements were suggested. Differentiated contracts were recommended for standardized activities (e.g. concrete decontamination) versus high uncertainty tasks (e.g. underwater cutting, activated components).

Contractors supported wider use of negotiated procedures, enabling discussion of contractual risks alongside technical variants. Standardised international contract models for large engineering projects, such as those published by the International Federation of Consulting Engineers (FIDIC), though contractor experience remains limited. Large framework agreements covering diverse reactor technologies were viewed as difficult; case by case approaches were preferred.

Workforce issues also had contractual implications. Language barriers in international projects should be addressed through contractual requirements or training provisions. The limited attractiveness of D&D work compared to new build and office based roles exacerbates skills shortages and should be considered in contract design. Mandatory knowledge transfer clauses, as used in some regions (e.g. UAE), were discussed as a potential tool when clearly defined.

The session concluded that contractual frameworks must better reflect uncertainty, risk, and workforce realities, and that applying risk management principles explicitly to contract design is essential for complex segmentation projects.

Safety Aspects Working Group: Safety Culture, Inherent Safety, and Knowledge Management

Abstract

The safety session addressed cross cutting safety principles in nuclear decommissioning, with emphasis on inherent safety, safety culture, early risk identification, and knowledge management. Discussions highlighted the importance of integrating safety considerations early in project design rather than retrofitting them onto fixed technical solutions. Organizational responsibility, cultural barriers, and long term cost and schedule impacts of insufficient safety culture were examined, alongside the need for structured safety knowledge preservation and sharing.

Session Summary

Participants emphasized that inherent safety must be built into dismantling design and planning from the outset. Safety analysis should shape technical solutions rather than adapt to existing designs. Early definition of boundary conditions was considered essential, particularly as low probability risks can lead to disproportionately severe consequences if underestimated.

A strong safety culture was identified as a foundational requirement, encompassing clear responsibility allocation, acceptance of authority, and organizational commitment. Participants noted that failure to implement safety culture early often results in avoidable cost escalation and schedule slippage when issues emerge later. Apprehension to fully embrace safety culture, as well as blame culture, still persists in some organizations.

Identifying and characterizing safety risks early and iteratively was emphasized. Participants observed that safety solutions are sometimes deferred due to competing technical priorities, a practice seen as counter productive. Iterative safety analysis was recommended throughout the project lifecycle.

Knowledge management featured prominently. Many organizations have undertaken safety related KM initiatives, but numerous efforts have stalled or were never fully realized. Barriers to sharing safety knowledge persist, particularly due to confidentiality and proprietary concerns in private companies. Despite this, there was strong interest in developing a holistic, interconnected EU level community of practice for safety in nuclear decommissioning.

Suggested future knowledge products included repositories of safety lessons learned, knowledge harvesting from senior safety engineers, examples of safety analysis iterations, case studies linking cost and schedule escalation to poor safety culture, and documented examples of how inadequate safety culture was ultimately corrected.

The session concluded that safety must be treated as a core design principle rather than a compliance obligation, supported by strong safety culture, iterative analysis, and effective knowledge sharing across the decommissioning community.

Overall Conclusions

Across the three sessions, participants consistently emphasized that successful nuclear decommissioning requires early integration of safety, technically sound and adaptable solutions, and contractual frameworks aligned with project complexity and uncertainty. Strong coordination between technical, contractual, and safety domains — supported by effective knowledge management — was identified as essential to avoid cost escalation, schedule delays, and repeated lessons learned across projects.

ANNEX 1 - WORKSHOP SLIDES

Segmentation of ESSOR activated material

Cutting Methodologies Applied to Nuclear Decommissioning

Workshop – Ispra, 24-25 March 2026

Raffaele Bencardino – JRC.J – Nuclear Decommissioning and Waste Management

European Commission

Outline

ESSOR reactor building

Activated components requiring segmentation

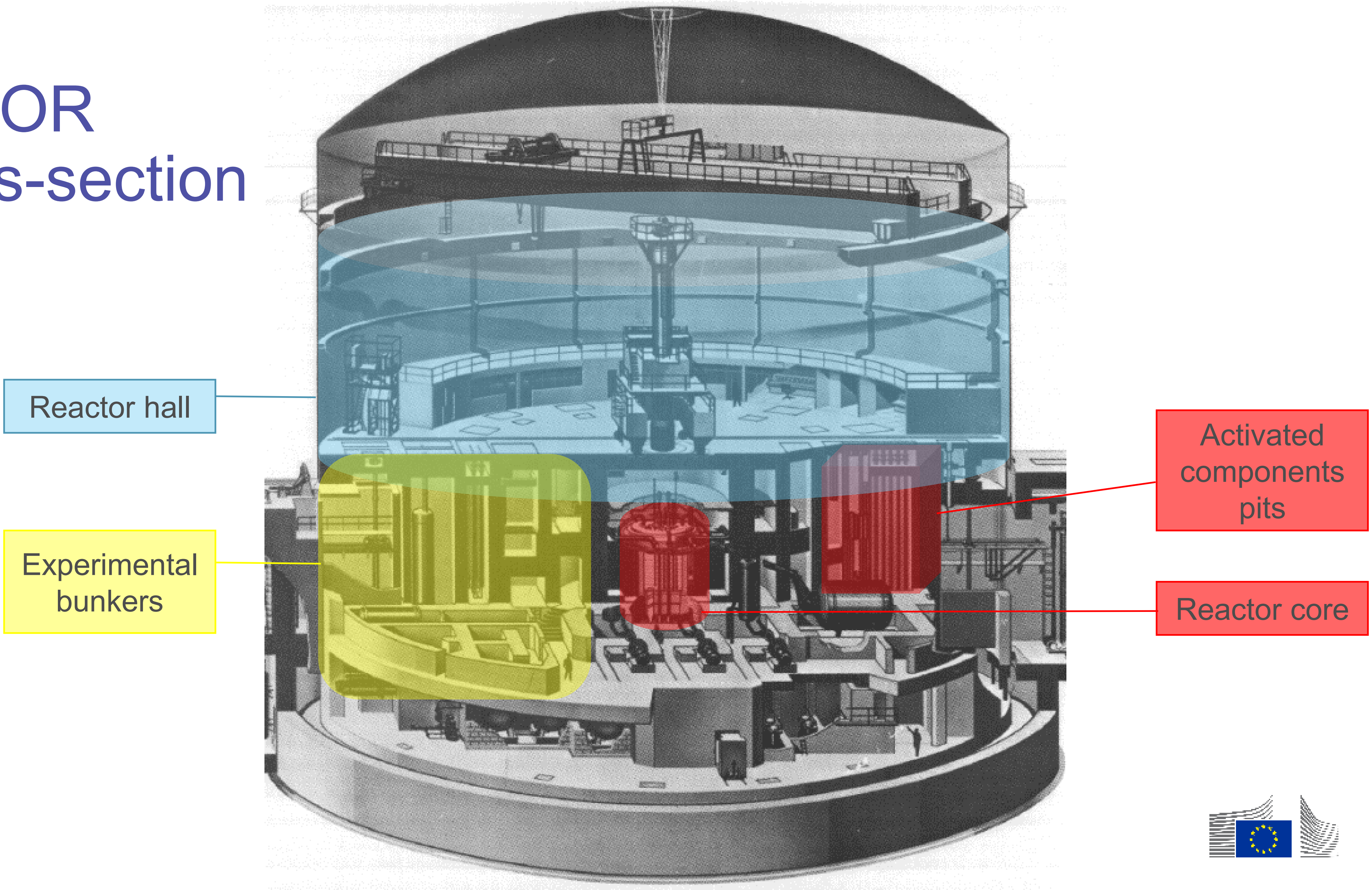
ESSOR cutting machine rationale

- Design drivers
- Subsystems
  - Transfer Cask
  - Cutting Unit
  - Containers Handling

Digital gallery

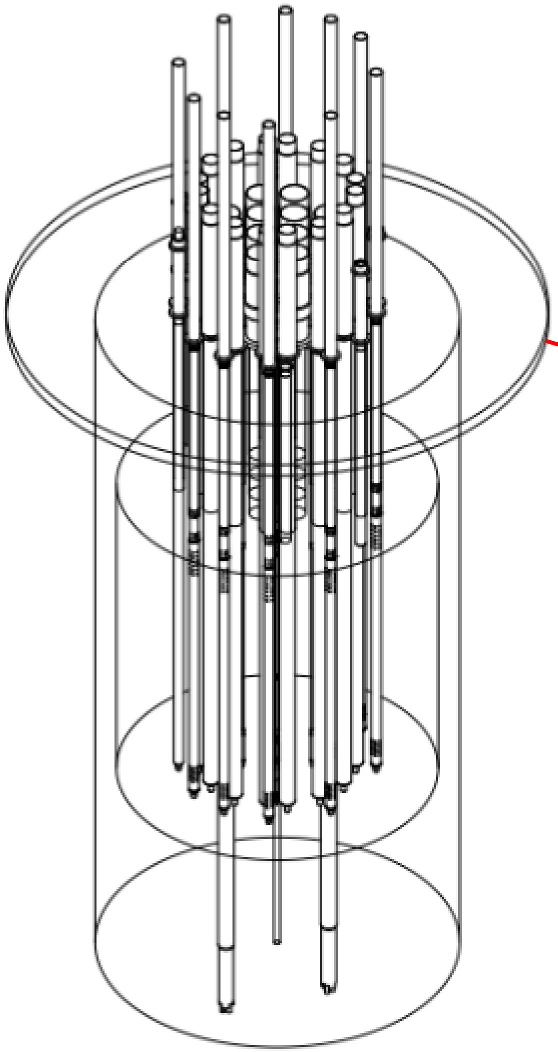
ESSOR reactor building

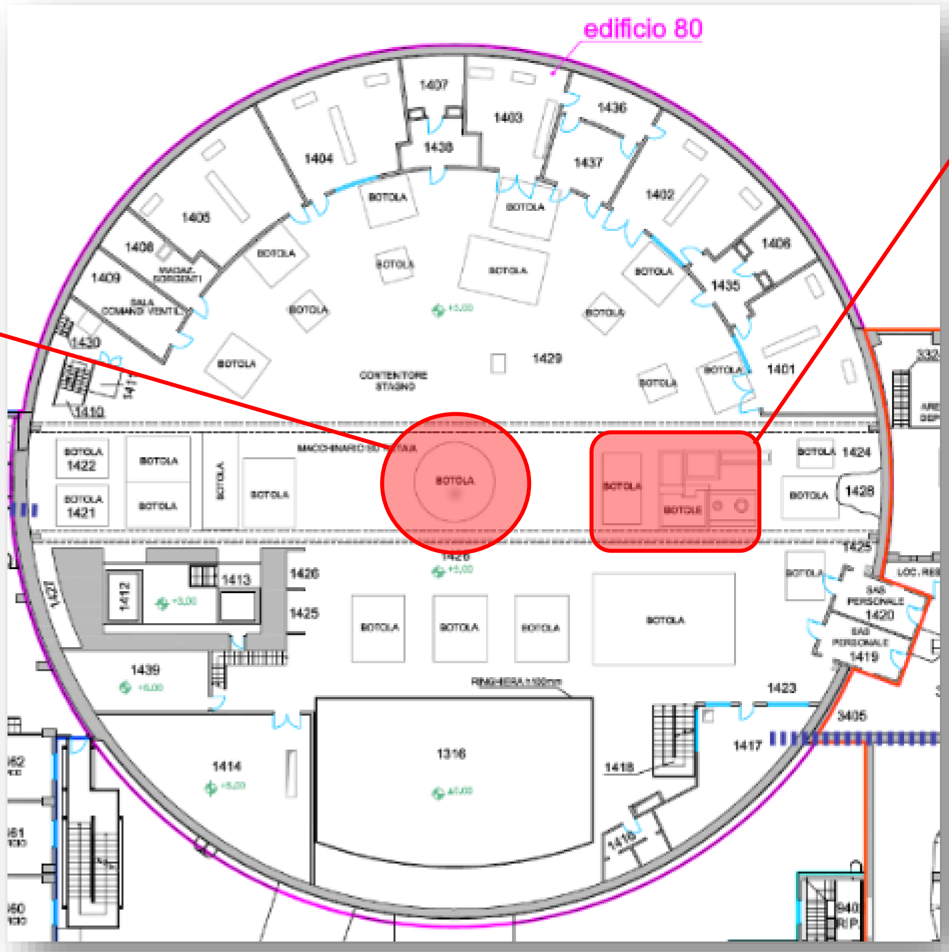
ESSOR cross-section

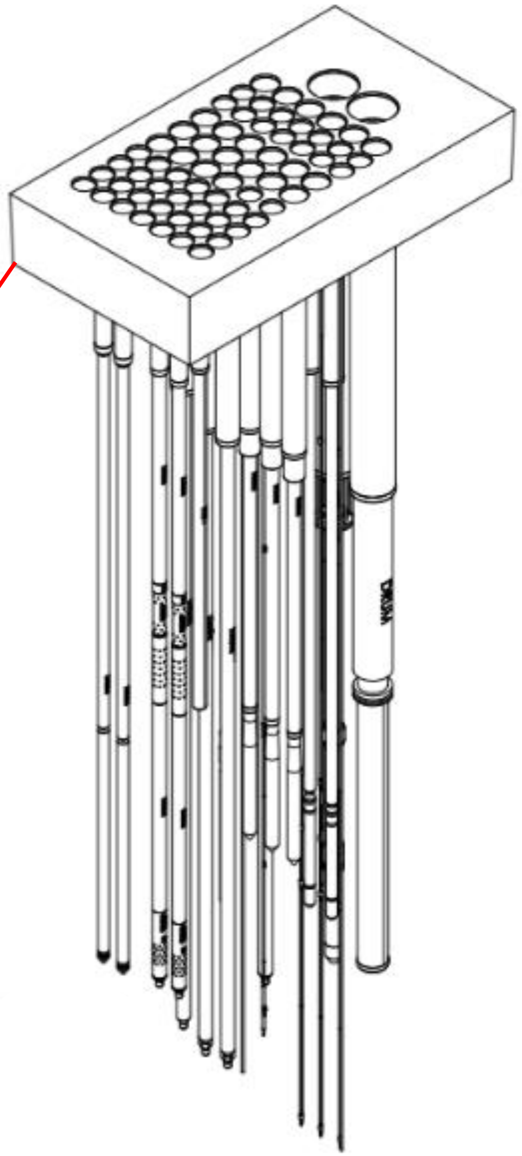


ESSOR – activated components

Experimental channels, Control rods, Dip tubes, Shielding plugs

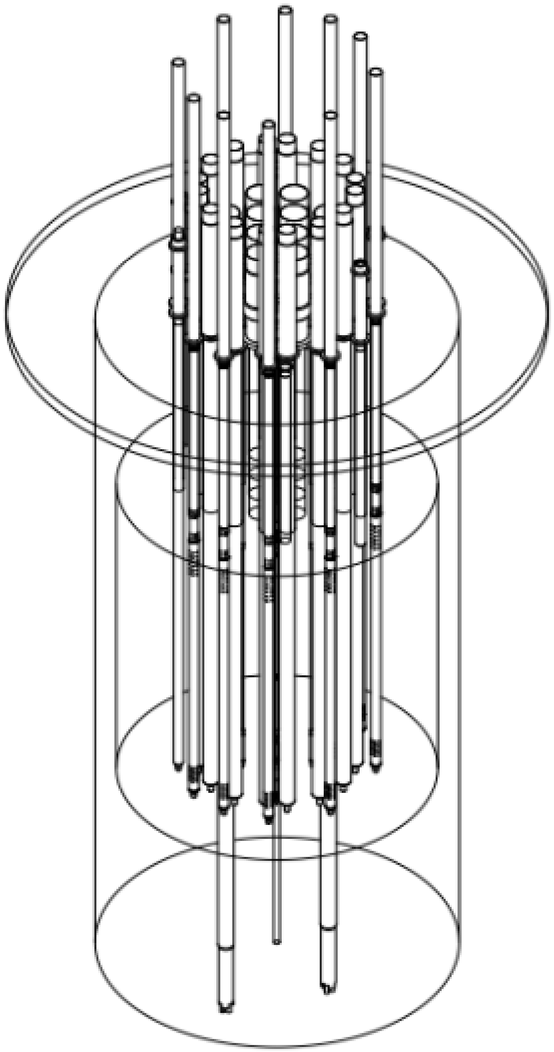






ESSOR – activated components

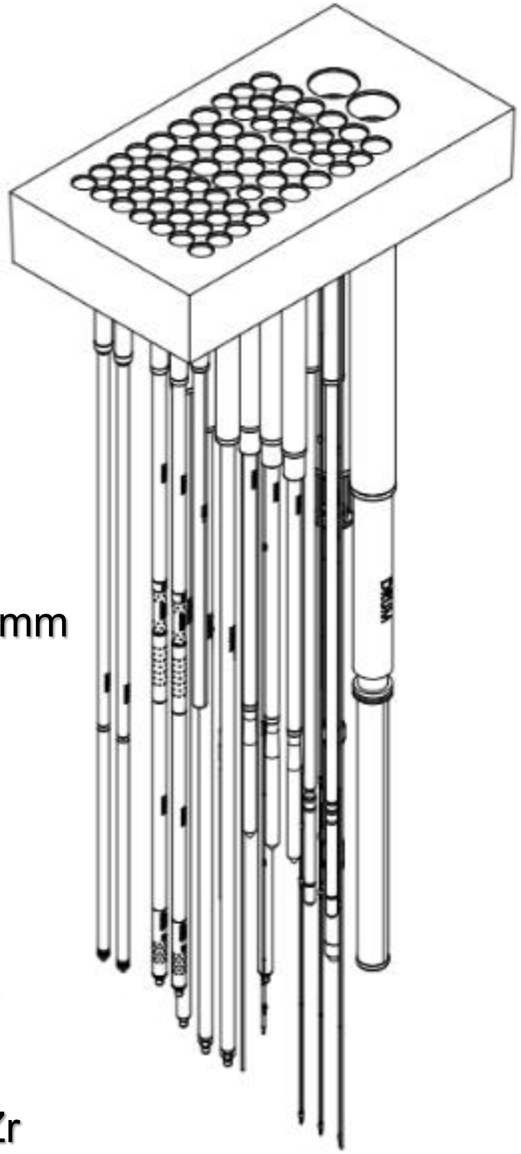
Experimental channels, Control rods, Dip tubes, Shielding plugs



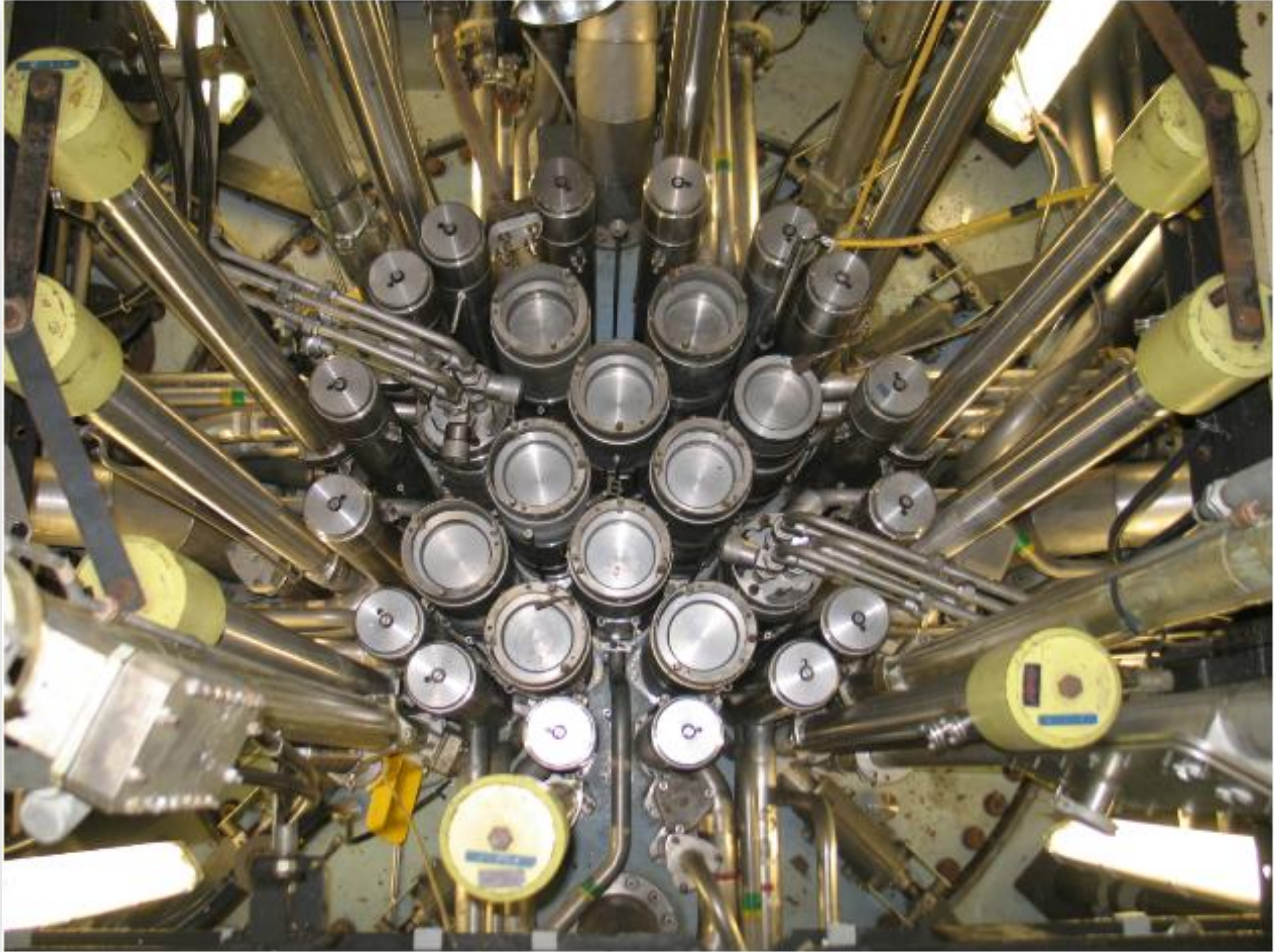
Physical & Radiological Attributes

- Total Inventory: 64 components requiring segmentation
- Mass: Total weight of 7.2 t; component range 1 – 530 kg
- Geometry: Max length 8895 mm; Diameter range 5 – 233 mm
- Operation: ~1500 individual cuts planned
- Materials: Steel, Al-Mg, Zircaloy, Zr-Nb,
  Heavy Concrete (HC), and Lead (Pb) shielding

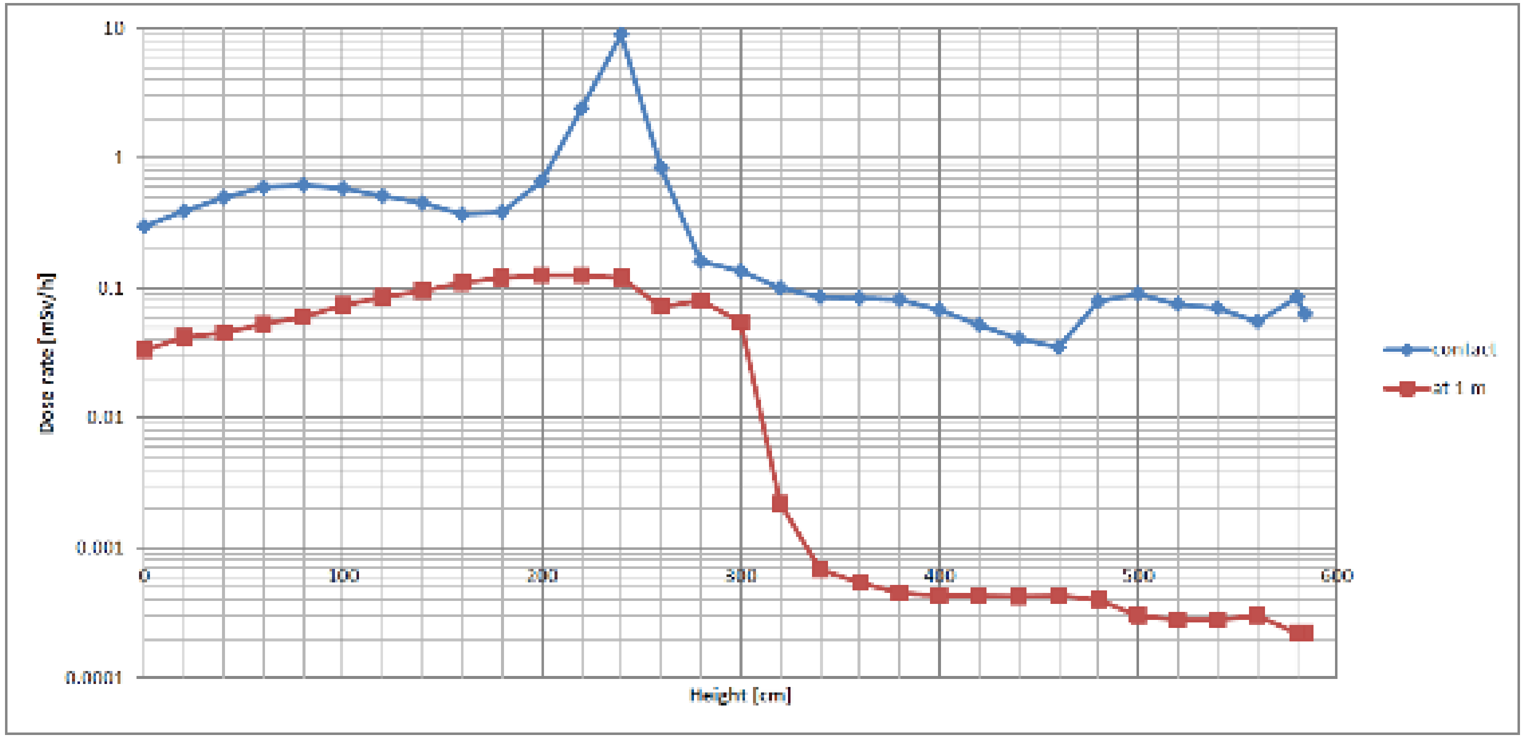
- Activation: Max contact dose rate of 2500 mSv/h
- Surface Contamination: Max 1250 Bq (^{60}Co)
  based on full-length swab analysis
- Dominating nuclides: ^{14}C, ^{55}Fe, ^{60}Co, ^{59}Ni, ^{63}Ni, ^{121m}Sn, ^{93}Zr



ESSOR Reactor Core



Activated components - heterogeneity



Opportunity and Challenge to optimise the waste produced

Transfer of activated components to cutting area

ESSOR Cutting Machine – Rationale

Cutting Methodology selection

Core process

Multi-criteria decision analysis (MCDA)

Most influencing local drivers

- Reliability: Leveraging Industrial Competence
- Sustainability: Liquid Effluents Management impact on Decommmissioning Programme

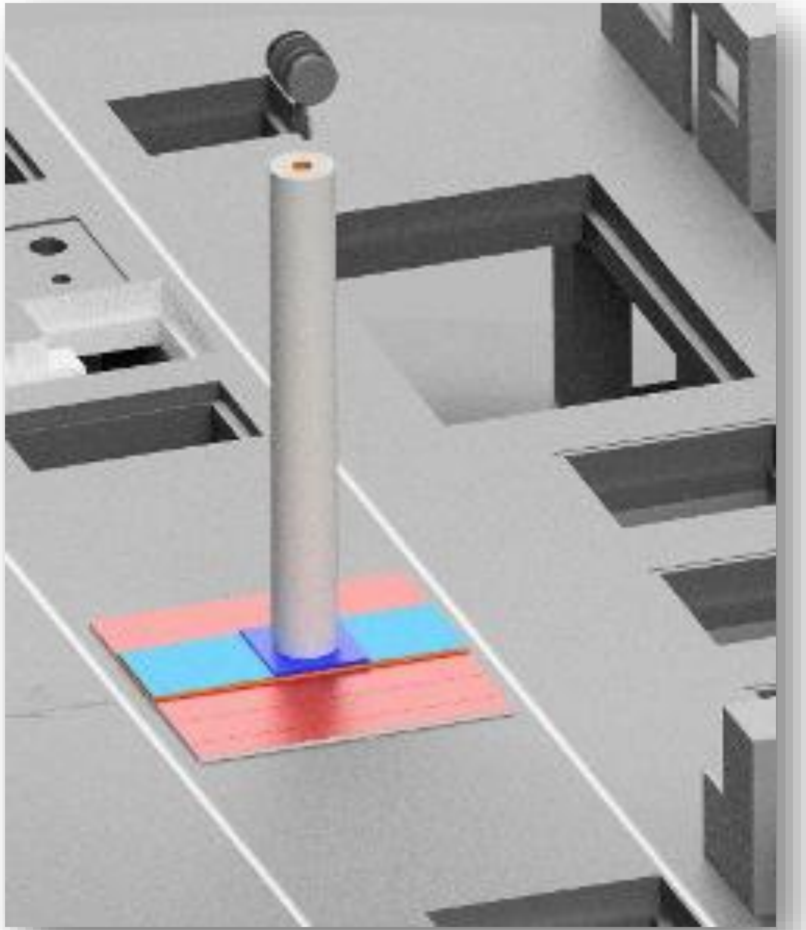
Cutting Machine subsystems

- Transfer Cask
- Cutting Unit: Hydraulic Shear
- Containers Handling

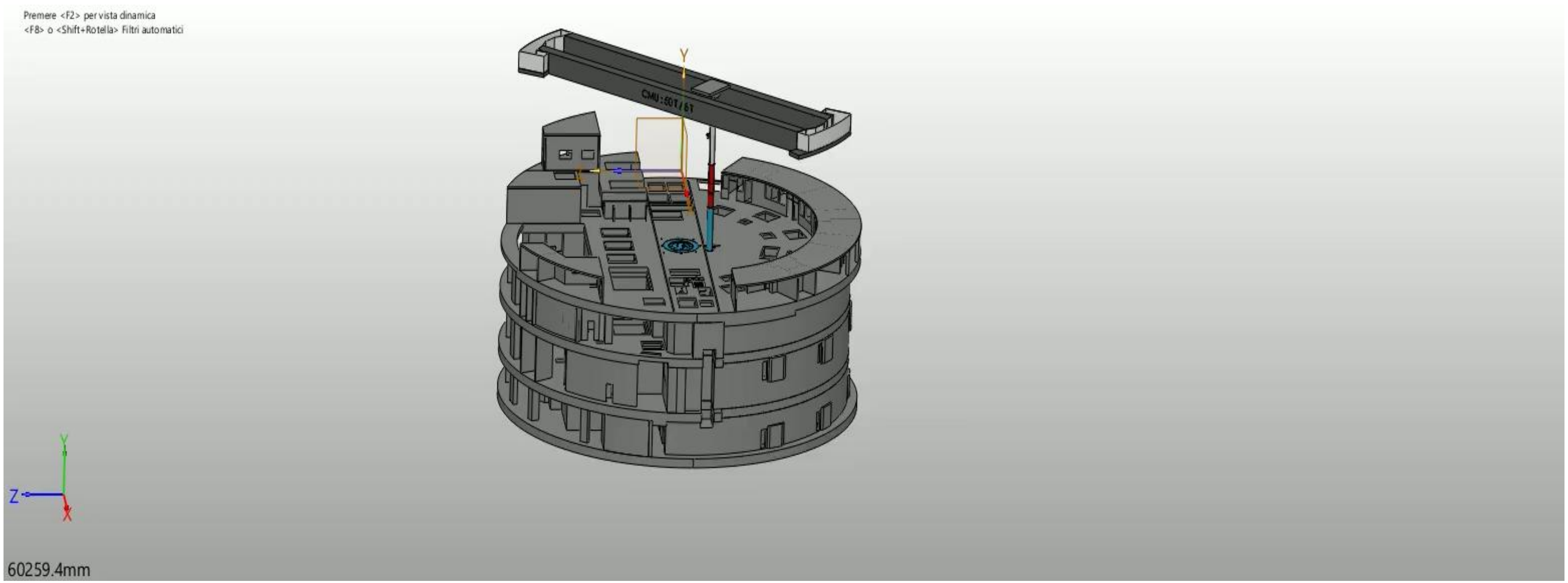
Subsystem 1 – Transfer Cask

Size: 15Φ0.9 m

Weight: 14 t



Transfer cask operation

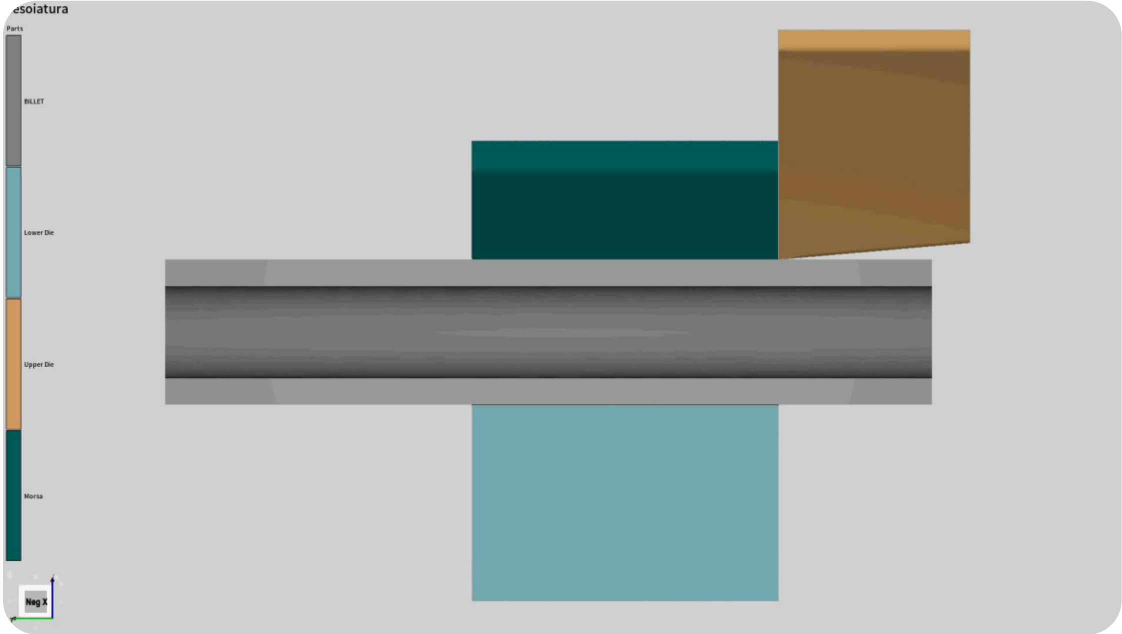


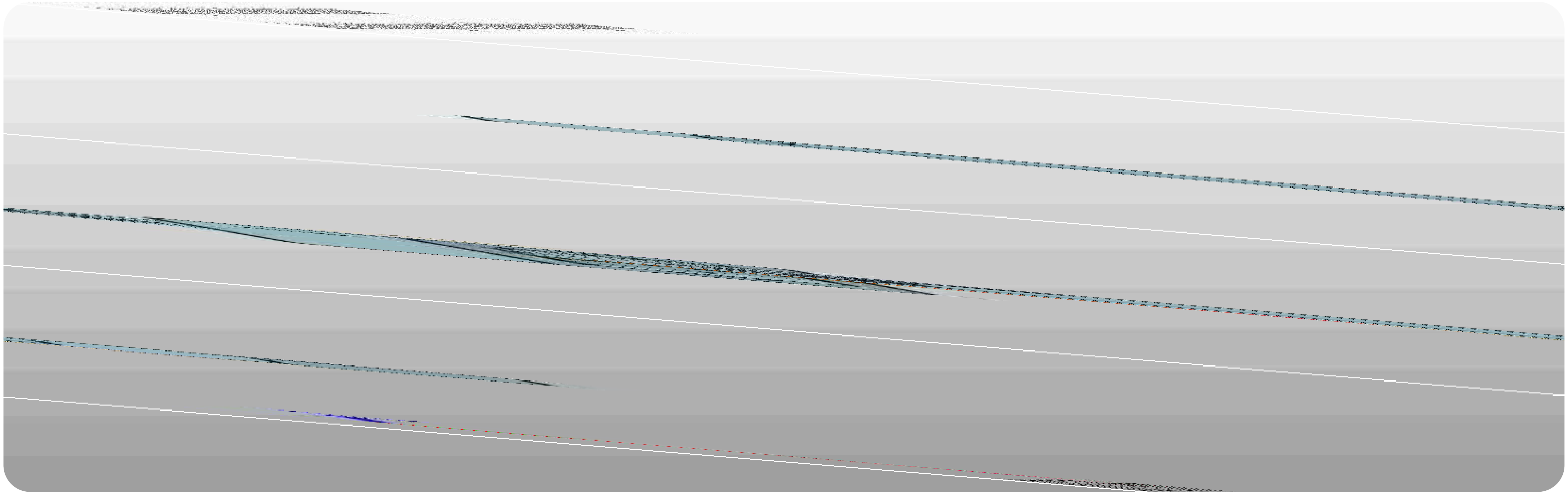
Subsystem 2 – Cutting Unit
Hydraulic Shear

Size: 5.4 x 3.4 x 1.9 m

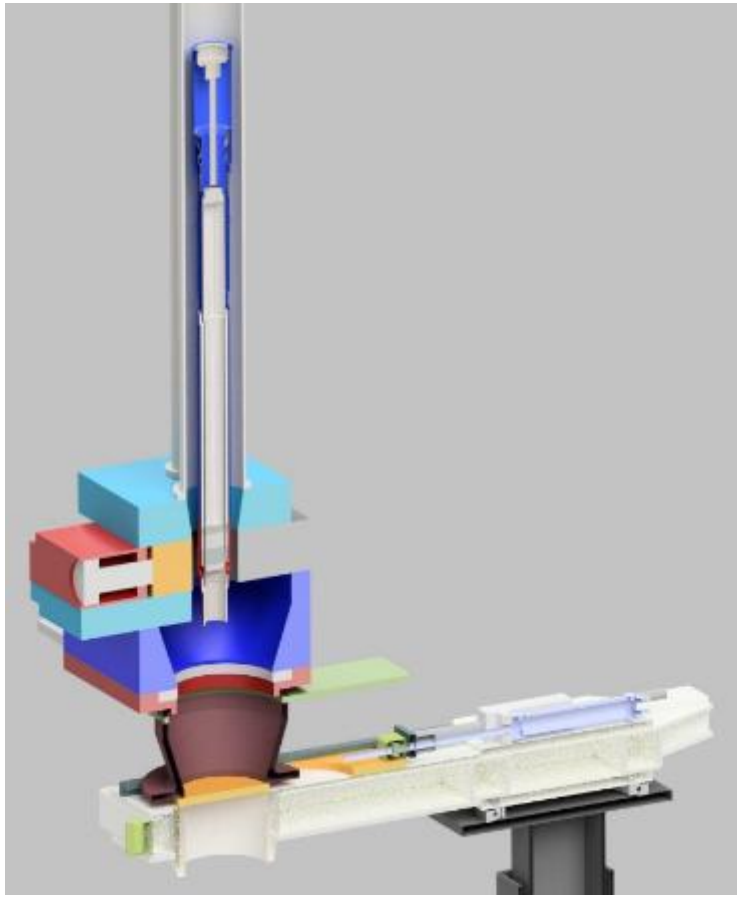
Weight: 38 t

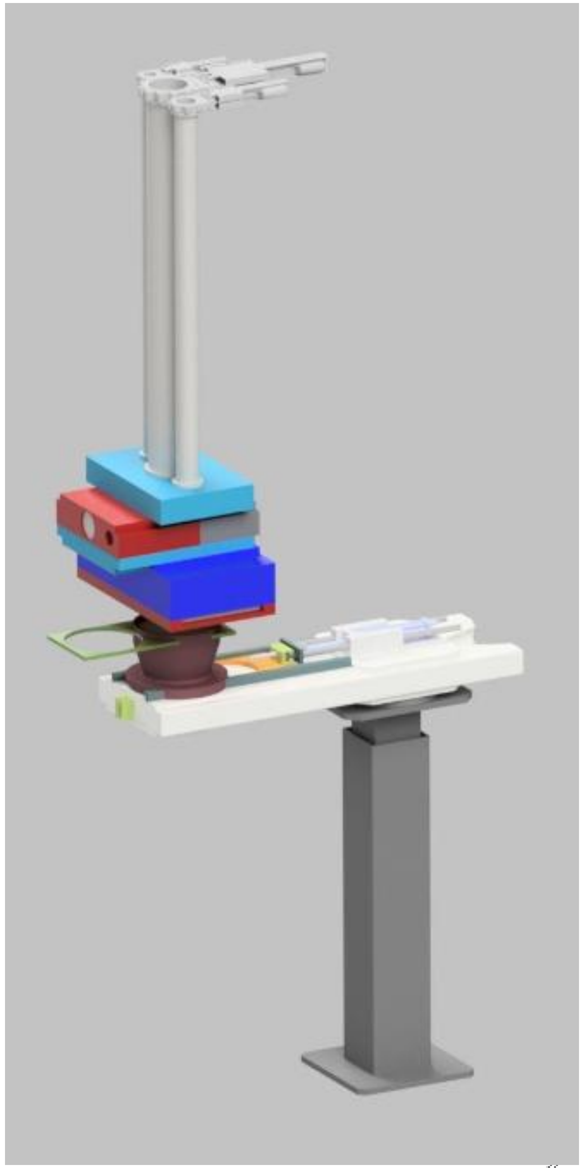
Max shearing Force: ~20 MN = 2000 t



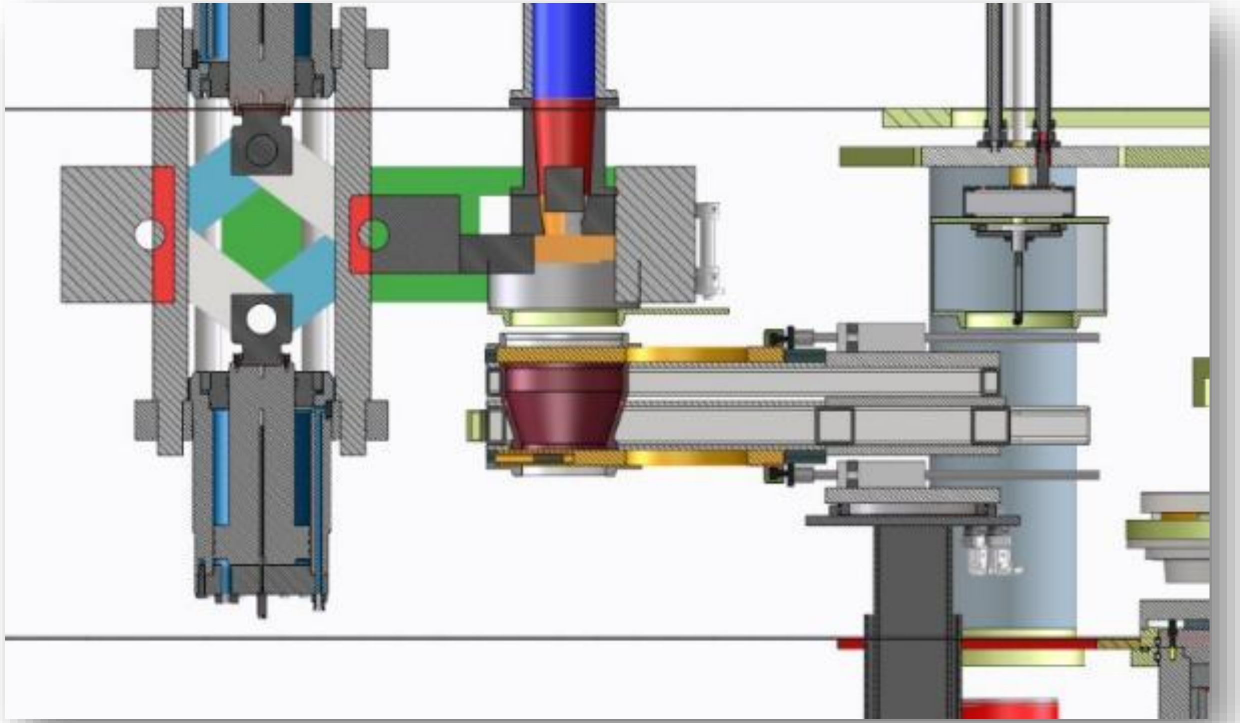


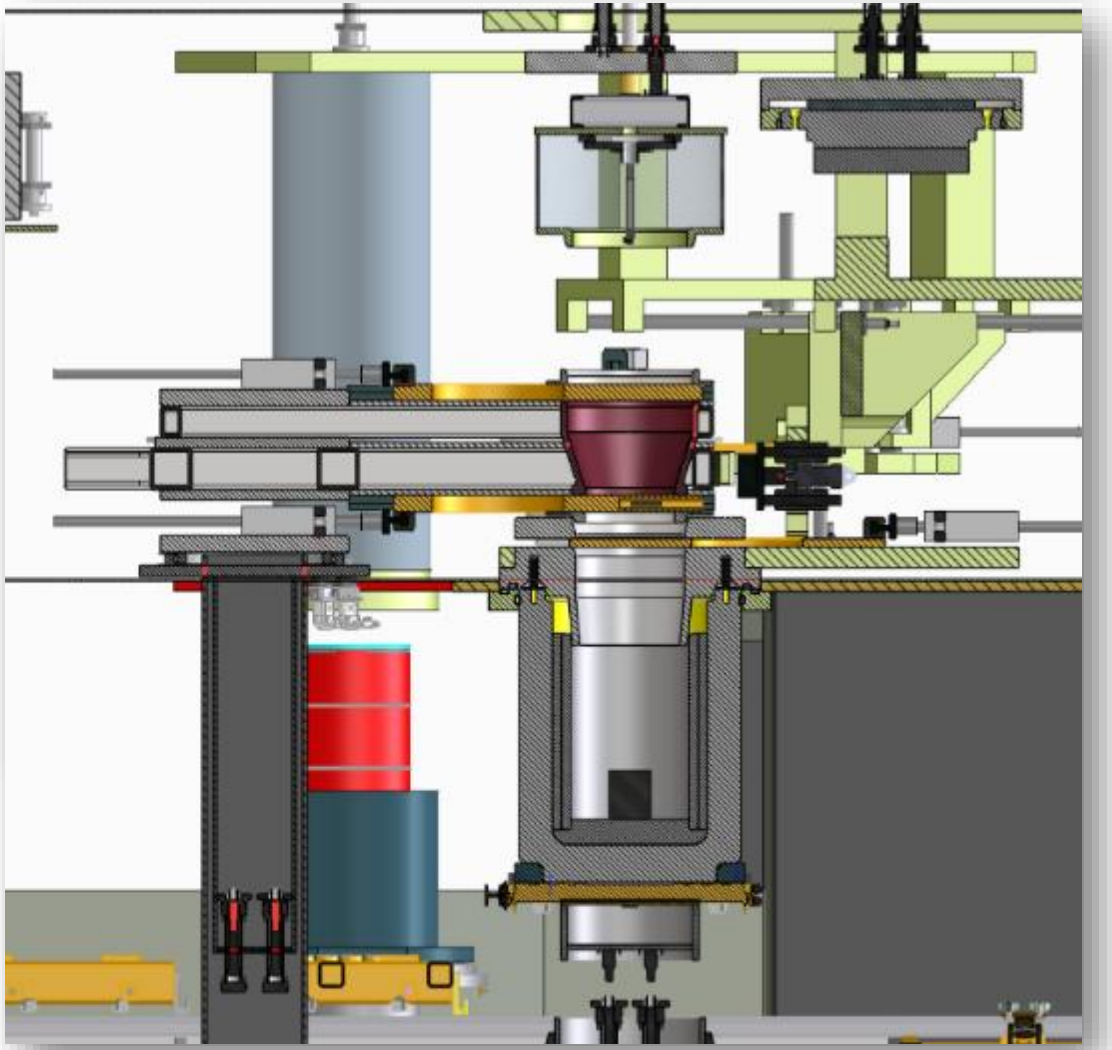
Hopper systems



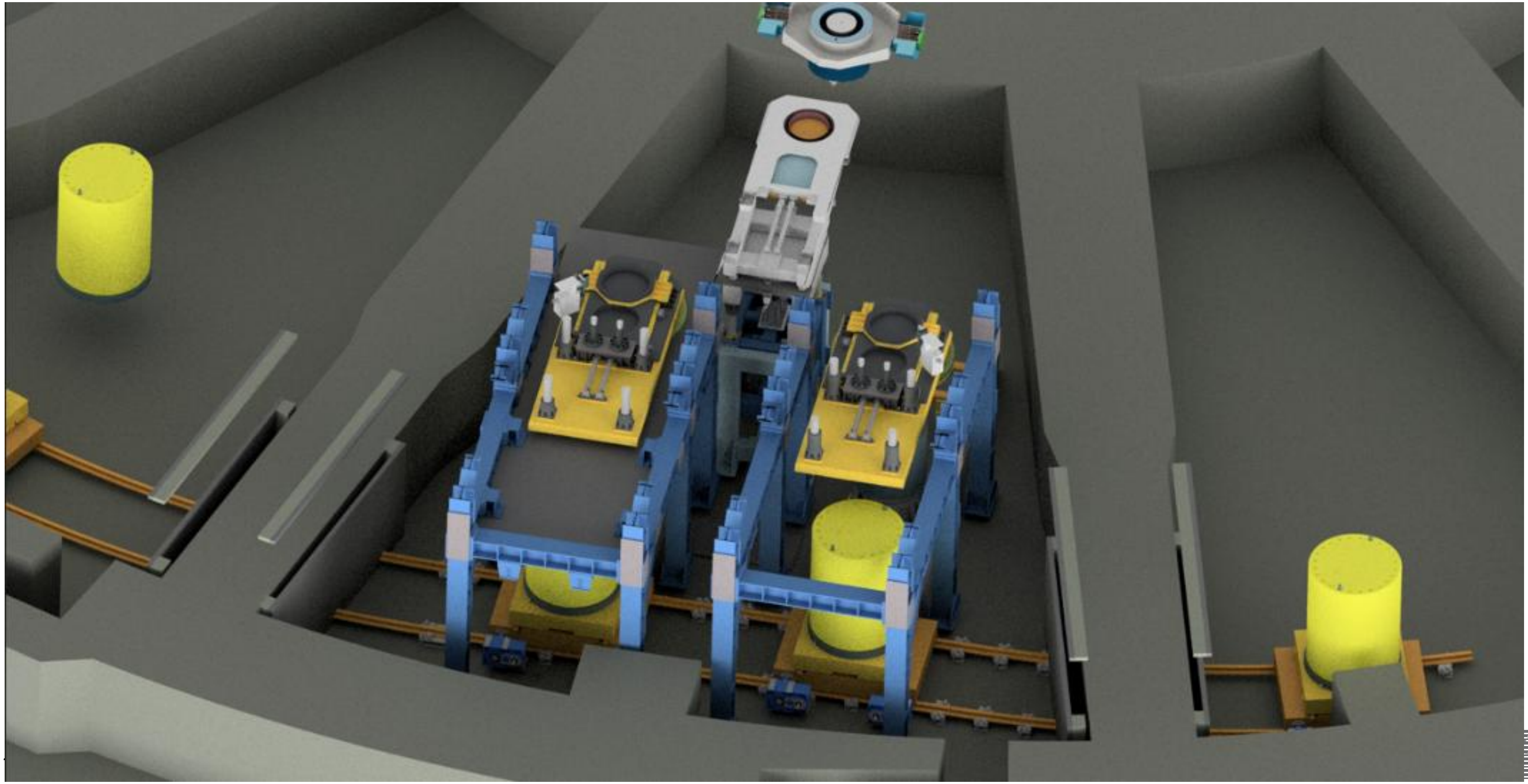


Cutting – transport – packaging

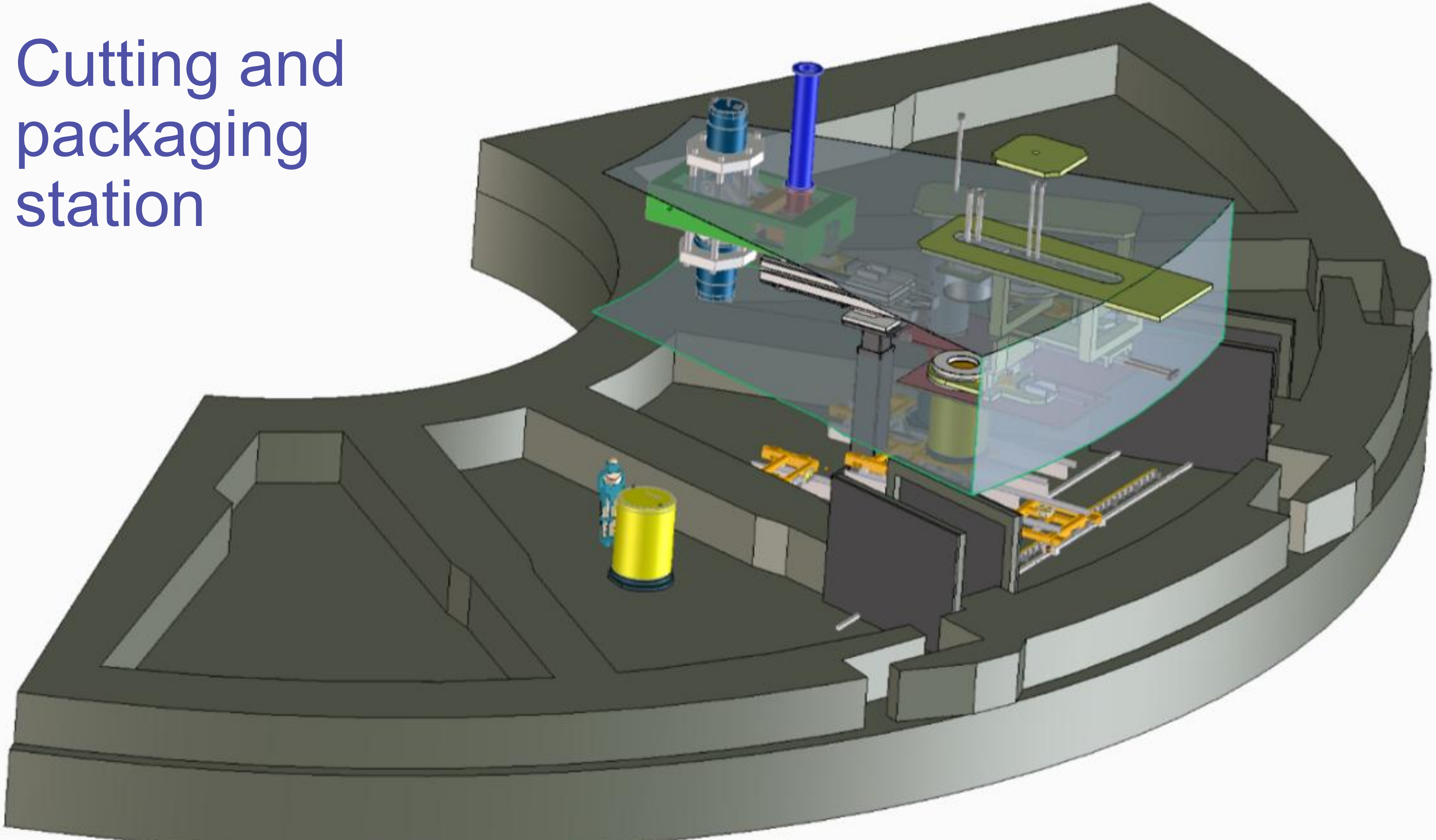




Subsystem 3 – Containers Handling



Cutting and packaging station



Conclusions

The Challenge: A Complex Inventory

- Mass & Scale
- Radiological Peak
- Nuclide Complexity – Scaling Factors

The Solution: Remote Segmentation

- Cutting, handling, characterization and waste management – single automated workflow
- Flexible Design – based on the local driving constraints
- Complex engineering: Integrated kinematics and interlocks to meet
- Nuclear Safety by design – subject of next presentation
- Scale of Effort: A simple cutting concept (shearing) supported by the design of ~13,000 individual components

The Roadmap

- Completed 1-year Design phase
- Transitioning into 1-year Production & Testing
- Start of On-Site Operations expected Q2 2027

Thank you

Cutting Methodologies Applied to Nuclear Decommissioning

24 – 25 March 2026

Nuclear safety strategy and Implementation

ESSOR cutting machine

Yannick PONS

YPEX NUCLEAR

OUTLINE

Before basic design

1. Project Strategy and choices
2. Nuclear Safety strategy
3. Problem identification
4. Safety Compliance Matrix

During basic design

5. Safety analysis implementation
6. Application and example
7. Next steps
8. Summary and conclusion

Project Strategy and choices

Selection of the cutting technology – main drivers

- Nuclear safety
- Conventional safety
- Waste management / volumes of resulting waste
- Easiness of operation / familiarity / resources required
- Costs / easiness of manufacture
- …

Table 4: Parameters and quality assessment of technologies

Parameter/ Technology	Reciprocating saw	Cutting shear	Circular saw	Diamond wire
Reliability	6,8	8,4	6,2	5,8
Safety	7	8,4	6	5,4
Costs	7,6	5,4	8	5,4
Performance	5	8,6	5,6	6,6
Complexity, applicability	7,2	7,2	8	6,2
Operational skills	6,6	7,6	7,2	5,6
Data availability	4,8	7,6	7,2	6,6

Safety strategy considerations

Objective

Safety analysis and strategy must be developed:

- To guarantee no impact on personnel and on environment
- Consistently with the INE decommissioning safety plan
- To meet regulator's expectations

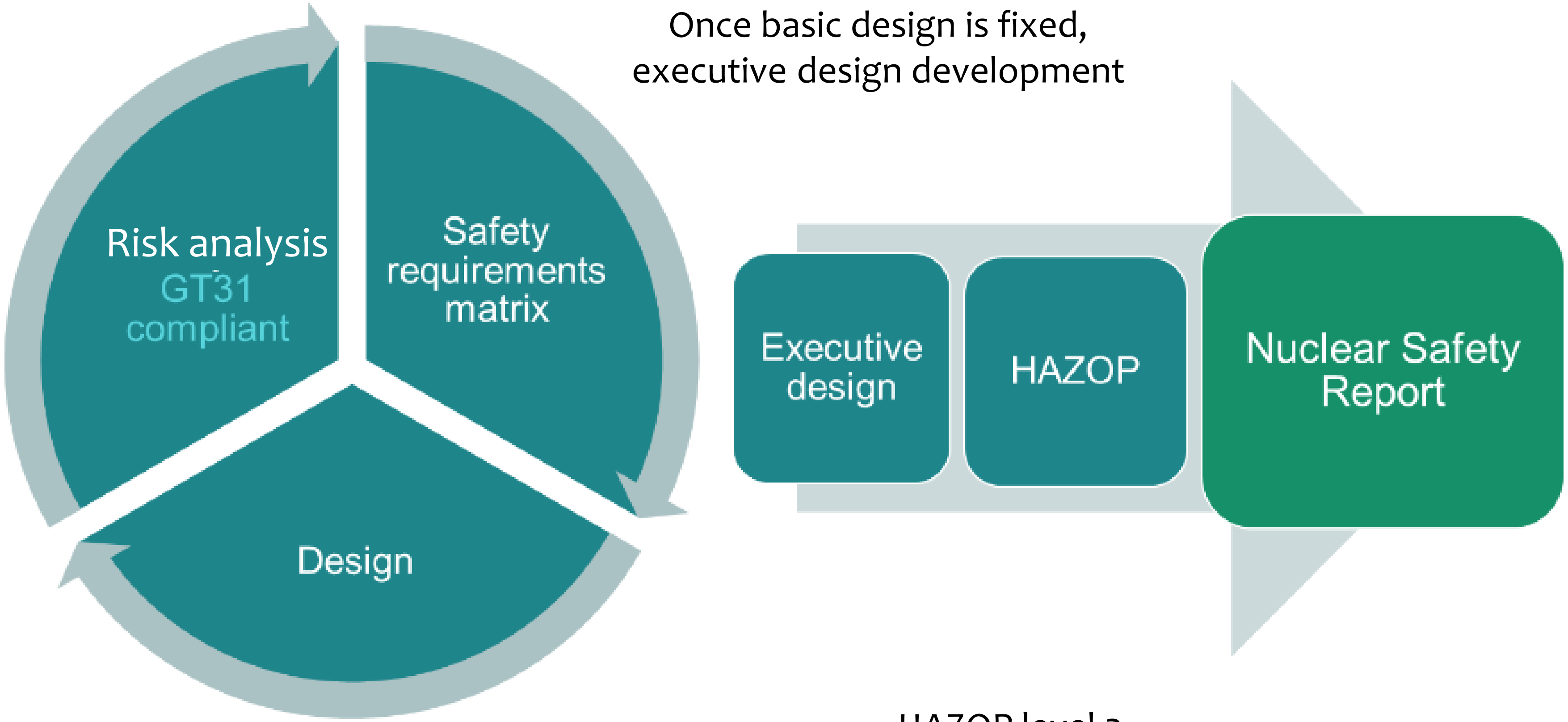
Strategy

Design from scratch

- Deterministic Nuclear safety analysis
  - ❑ Risk Identification
  - ❑ Prevention Measure
  - ❑ Detection measure
  - ❑ Mitigation measure
- Choice since the beginning of the shear concept to mitigate pyrophoricity risk
- From this choice, functional brainstorming for the first basic design
- Iterative Risk analyses and basic design reviews
- HAZOP level 3 – executive design phase

Nuclear Safety strategy

Once basic design is fixed,
executive design development



HAZOP level 3

Iterative deterministic analysis
to guide the design

to check and verify the
robustness of the design

Working analysis and documents

Problem identification

Hazard selection

- Every hazard listed in **Guida tecnica 31** was considered

Guida tecnica 31: italian regulatory body guide for Radioprotection and Safety criteria for dismantling nuclear facility.

- **Project vs. Programme:** Project analysis complements ESSOR Reactor safety hazards
- Focus on the **six hazards** most impactful on the design
- All the remaining hazard will be considered at the HAZOP level 3 stage
- Rationale: accelerate the basic design development

Nuclear safety analyses

Most impactful Hazards from GT31:

- Pyrophoricity zircaloy
- Contamination
- Irradiation
- Internal fire
- Handling
- Earthquake

Main hazards impacting the design

- High Dose rate: up to 5 Sv
- Surfaces contamination
- Cutting zircaloy components: pyrophoricity risk
- Heavy and long components to handle

Shear cutting: first criterium to decrease pyrophoricity hazard

Cutting in specific existing bunker to manage contamination and irradiation

Risk analysis by subsystem

1. Transfer Cask
2. Cutting Unit
3. Container Handling

Safety Compliance Matrix

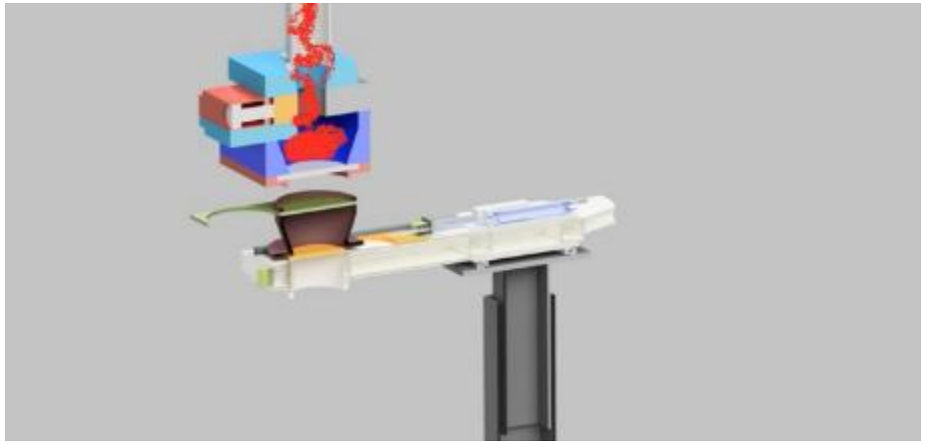
Safety Compliance Matrix

Maps preventive, detection, and mitigation requirements to ensure correct implementation during design iterations

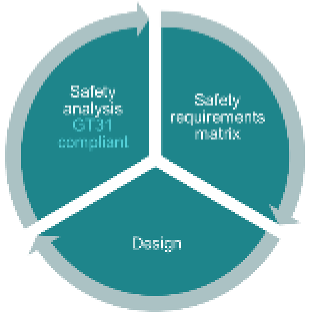
Hazard	Risk identification	Preventive measures	Surveillance measures	Mitigation measures
Activated Material	Contamination dispersion during cutting operation	Confinement system implementation	Monitoring contamination outside of confinement	Second confinement system
Contaminated Material				

Safety analysis implementation – Example

Safety requirement concept

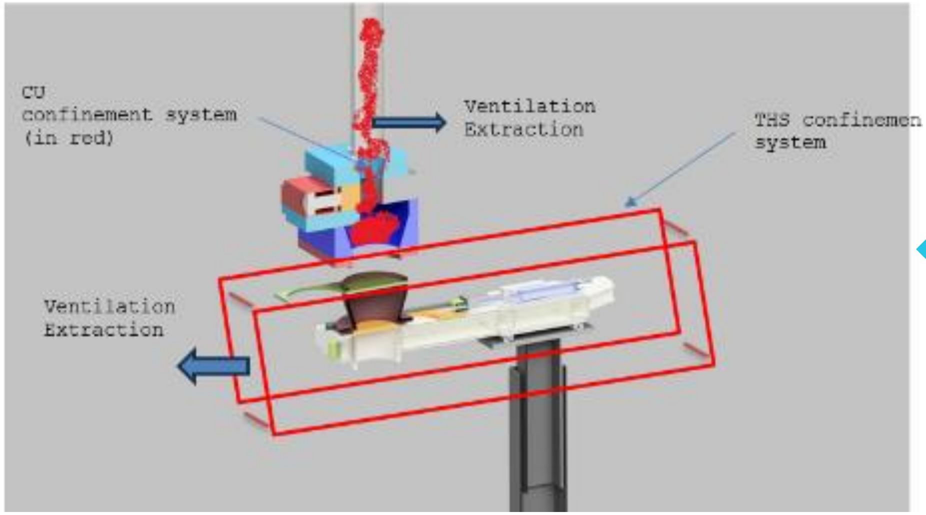


Safety goal: no contamination inside bunker in normal situation

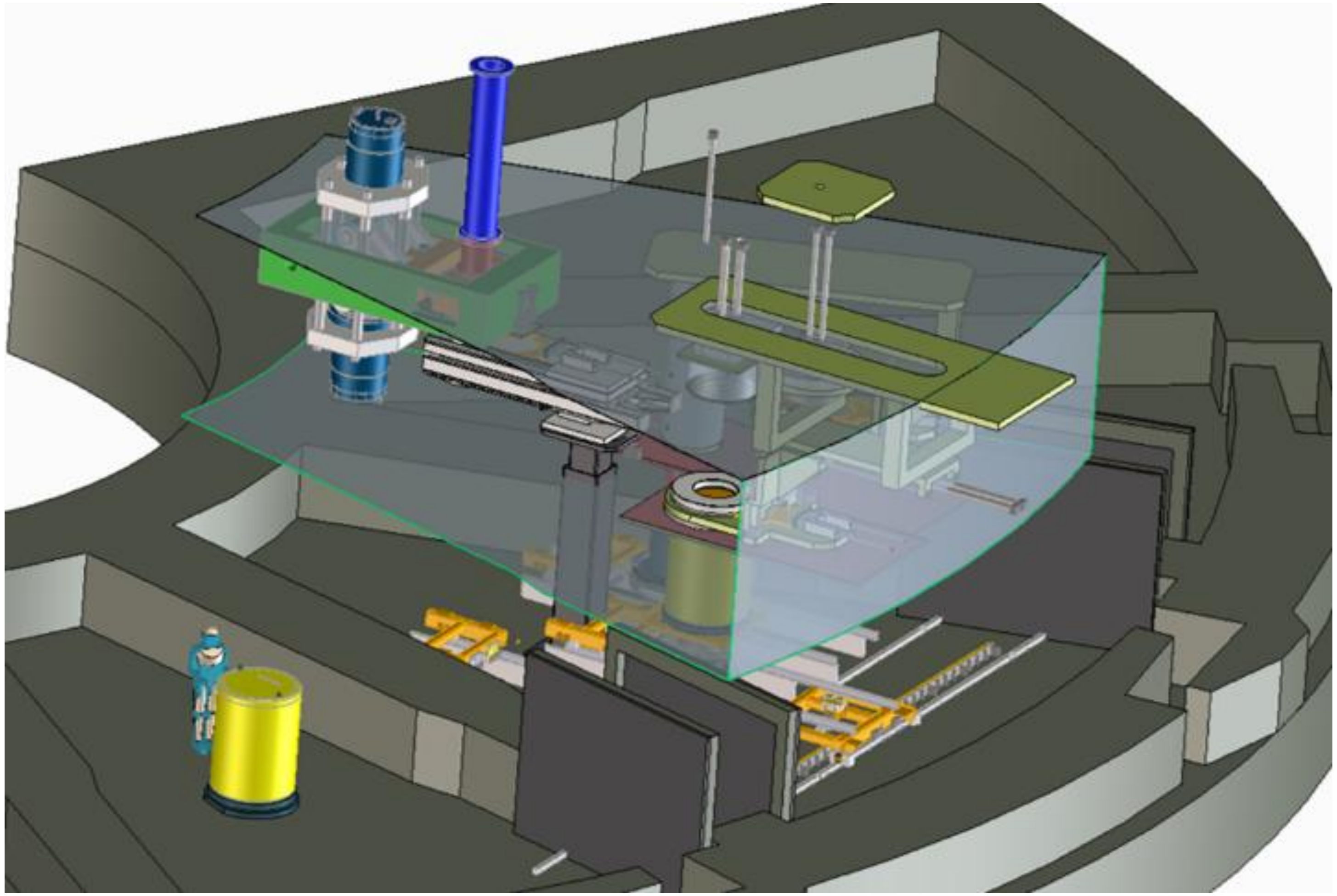


Situation	1st system of confinement	2nd system of confinement
Introduction of the component inside CU system	walls and ventilation of the cutting system	walls of the casemate + ventilation of the casemate
Component during cutting	walls and ventilation of the cutting system	
Cut piece inside hopper during transfer	walls and ventilation of the hopper confinement system	
Cut piece during drop into container	walls and ventilation of the hopper confinement system + container	

Safety requirement implementation



Safety analysis implementation – Example



Impact of the safety requirement implementation:

management of contamination at the container docking interface by a specific docking system

Next steps

- Once the basic design is fixed, the design team completes the Executive design
- The Safety team analyses any modification introduced at the Exec design level, in terms of:
  - Technology choice
  - Material choice
  - Specific technologic issues
- The Safety team validates the changes or requires further modifications
- When no further modifications are required, a final Safety Report is emitted, presenting:
  - HAZOP lev. 3 analysis,
  - Evaluation of Accidental scenarios
  - Evaluation of dose to the operators and the population

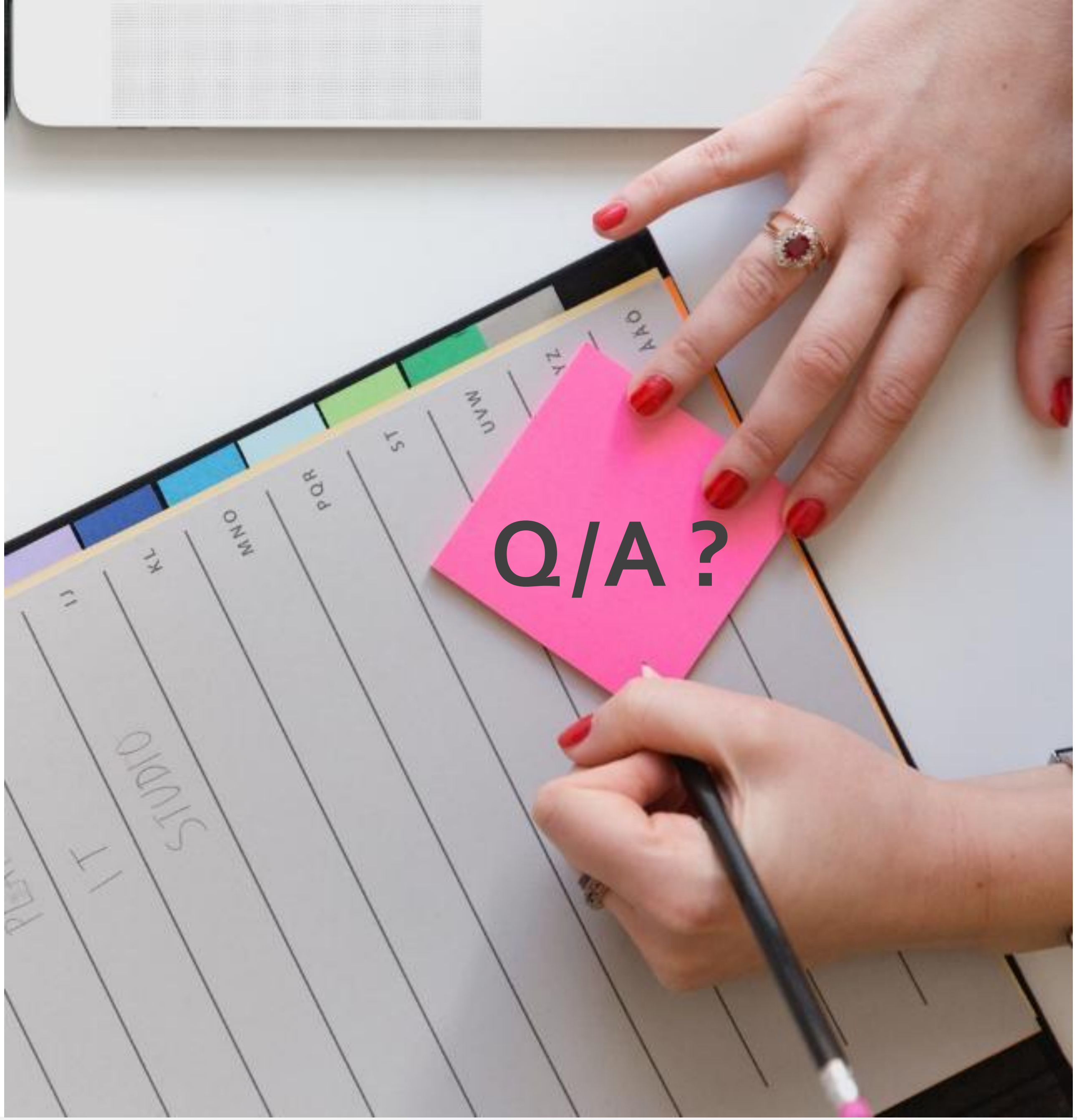
Conclusions – key takeways

Clear safety strategy since the beginning

- Deterministic safety analysis to fix the design
- HAZOP to check robustness of design
- Strict coordination between design team and safety team
- Use of proven tools
- Challenges and opportunities of iterative design review based on safety analysis

Thank you for your attention

Yannick PONS
+ 33 6 85 48 26 38
Yannick.pons@ypex-nuclear.fr
Ypex Nuclear



Q/A ?

Latina NPP – Boiler dismantling Cutting machine design

Fabrizio Massicci
Mechanical Design Unit
E-mail massicci@sogin.it

Event Use and design of cutting machines for nuclear decommissioning and waste management - ISPRA JRC

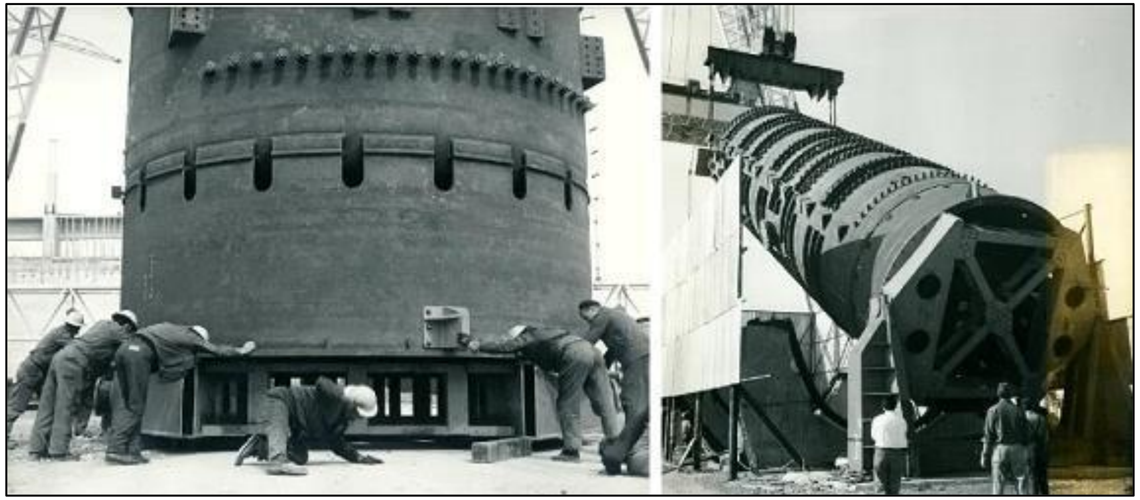
Date 24 March 2026

SOGIN

Content

Steam Generators overview

Vertically mounted vessels arranged in two parallel rows, composed of three elements located along each side of the Reactor Building



Total weight for a GdV **595 tons**
Height **24 m**
Diameter: **5.7 m**
Shell thickness: **55 mm**
Material: **mild steel**

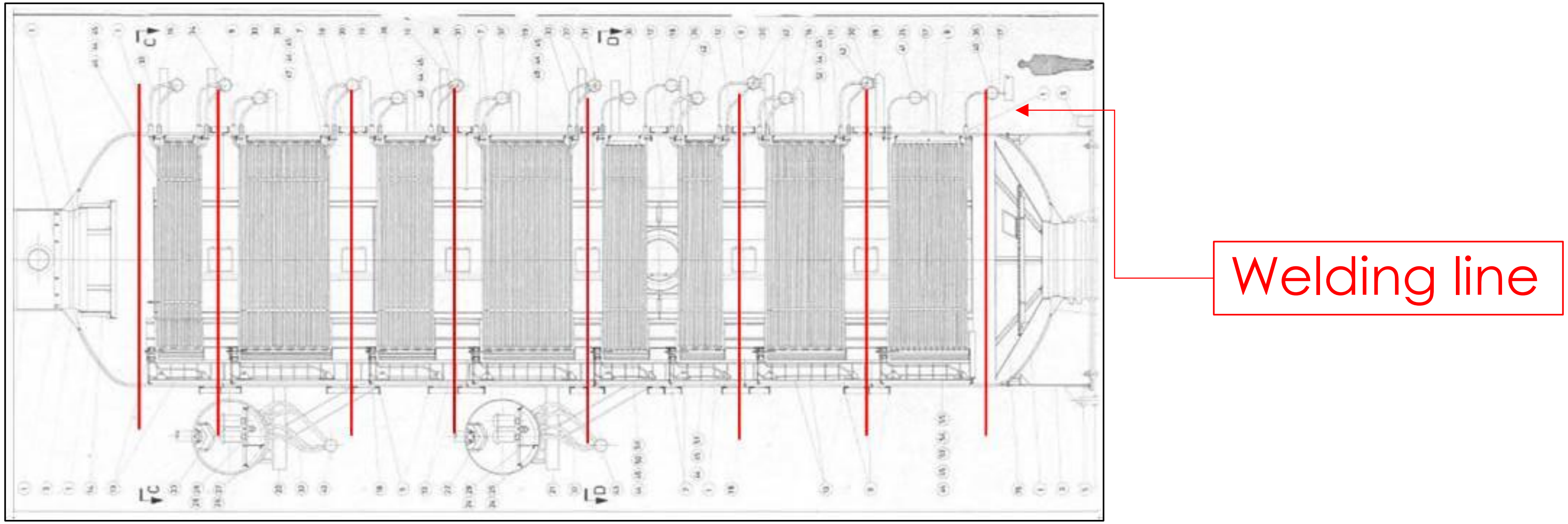
Steam Generators overview

Each steam generator is made up of:

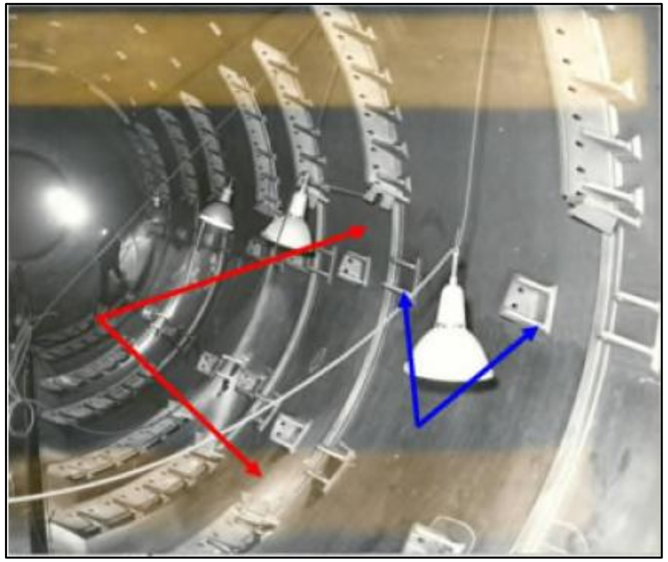
- N.7 cylindrical shells;
- N.2 upper and lower heads

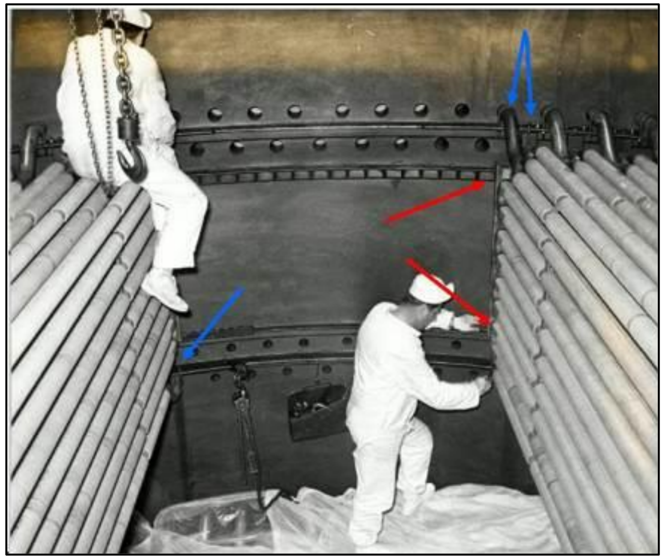
A tube bank is located inside each shell, only for the 5th shell 2 tube banks

Overall: 8 tube banks, respectively 2 super-heaters, 4 evaporators, 2 economizers



Support structures for tube bundles





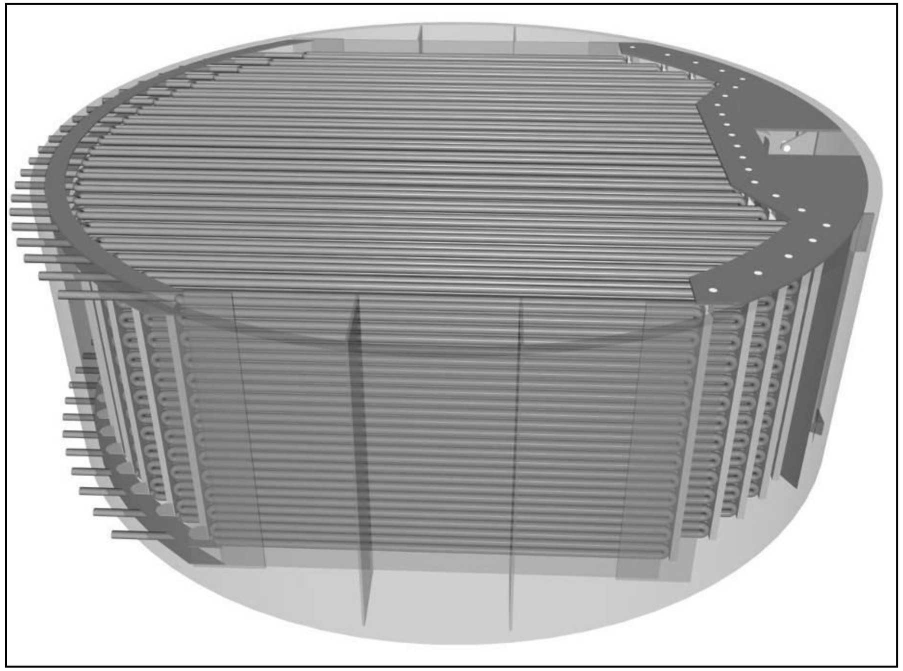
Support shelves

Perforated plates

Stiffening profiles

L-shaped profiles

Tube bundle - 3D Model

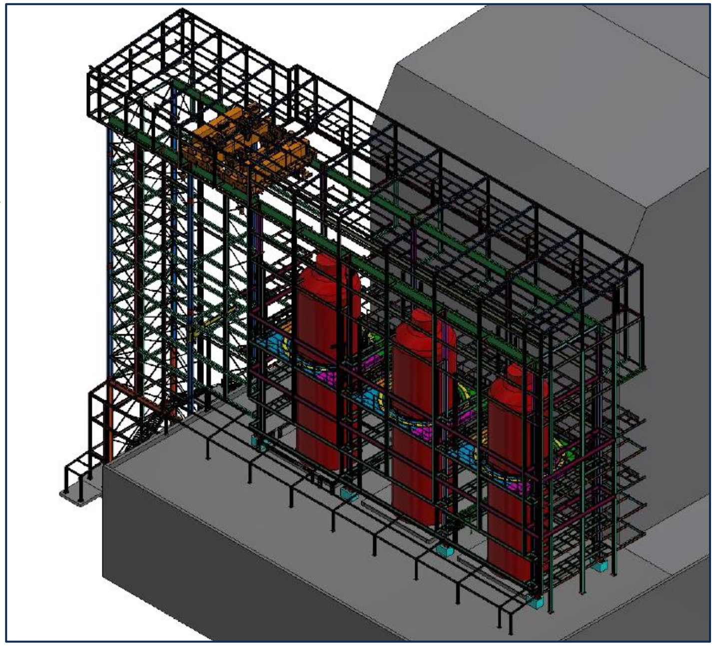


Sogin dismantling strategy

Sectioning each GdV into cylindrical segments including individual tube banks

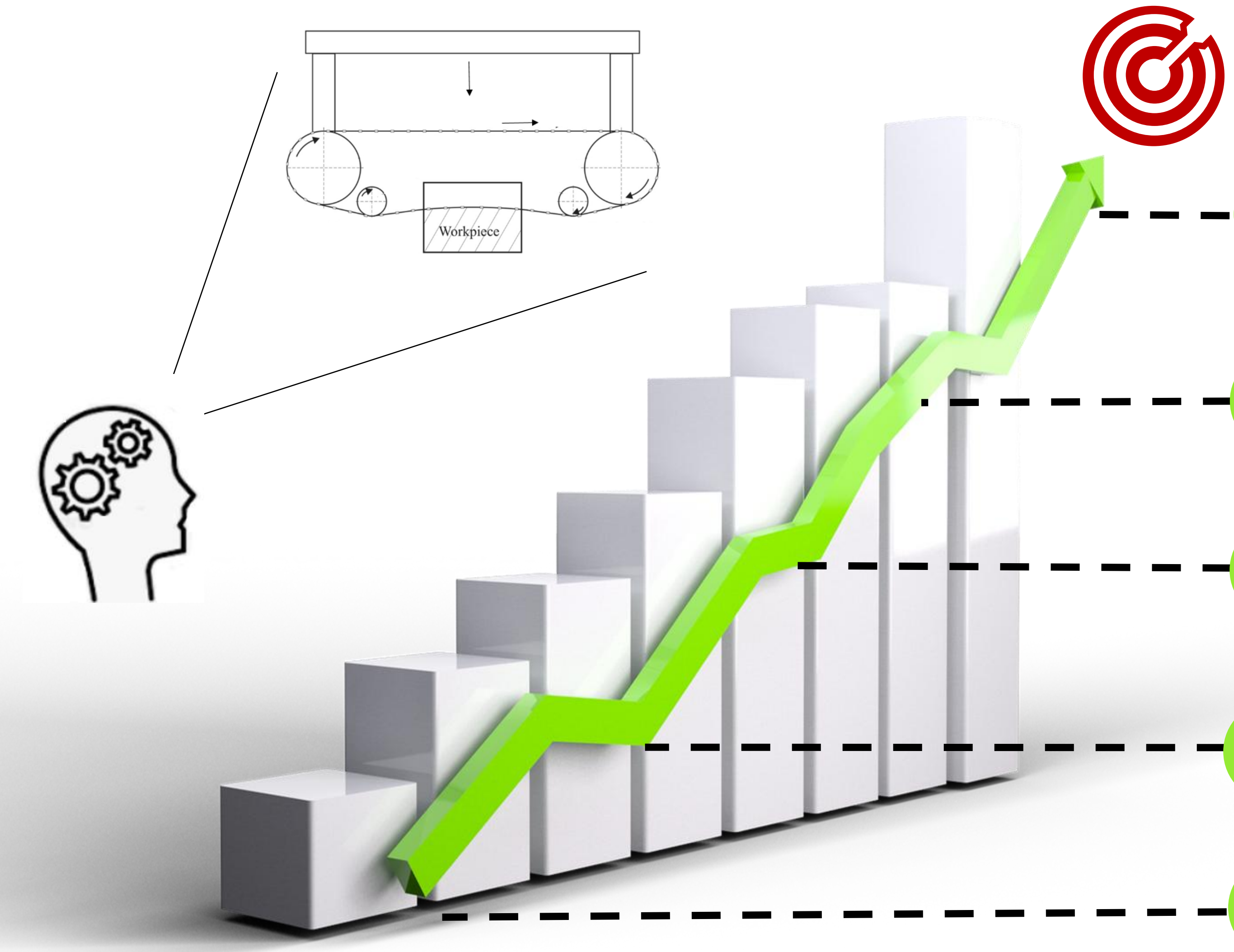
Vertically mounted vessels arranged in two parallel rows

Adaptation of the existing steel structure for the steam generators and installation of an overhead crane on the top of the structure



The crane is first jacked up then rolled inside the building. Then it supports the part of the shell to be cut.

Machine design and functional requirements



5. MINIMIZE CUTTING TOOL CHANGEOVERS
4. SERVE AS A WALKING PLATFORM ONCE FIXED TO THE BOILER SERVICE STRUCTURE
3. DESIGN COMPATIBLE WITH COMMISSIONING PHASE REQUIREMENTS
2. CUTTING OPERATIONS AT CONSTRUCTION WELDS
1. CUTTING THICK-WALLED STEEL COMPONENTS WITH LARGE CURVATURE

Cutting technology selection: wire sawing

SOGIN

Friction force on bead

$$F_F = \frac{\sqrt{3} \cdot V \cdot I}{v_s \cdot L_{wp} \cdot n_L} [N]$$

Weight of the wire per bead

$$F_G \cong \frac{m_L \cdot g}{n_L} [N]$$

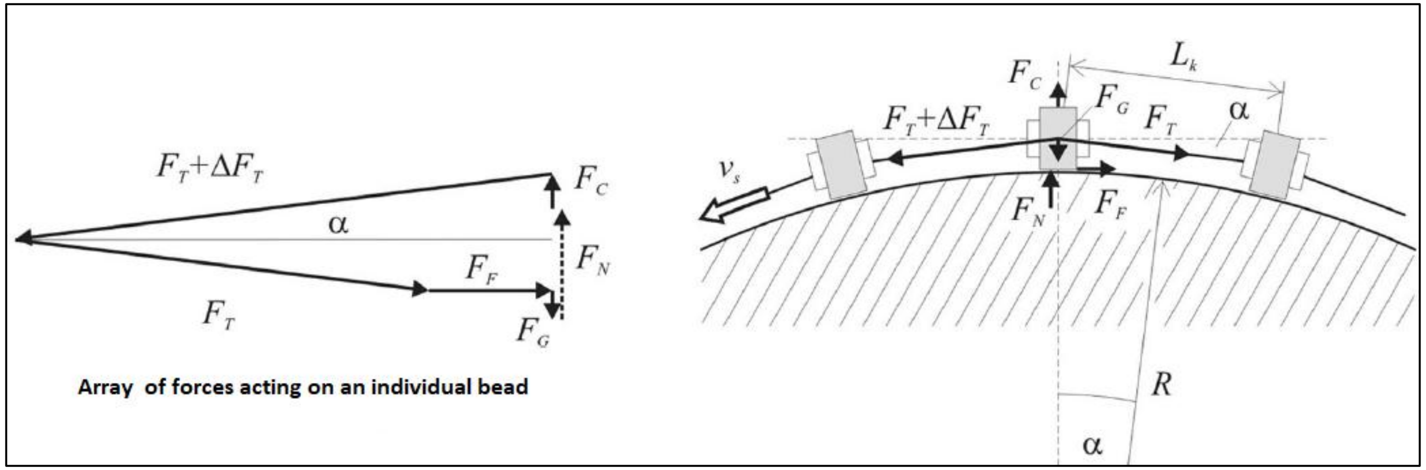
Centrifugal force on bead

$$F_C \cong \frac{m_L v_s^2}{n_L \cdot L_{wp}} [N]$$

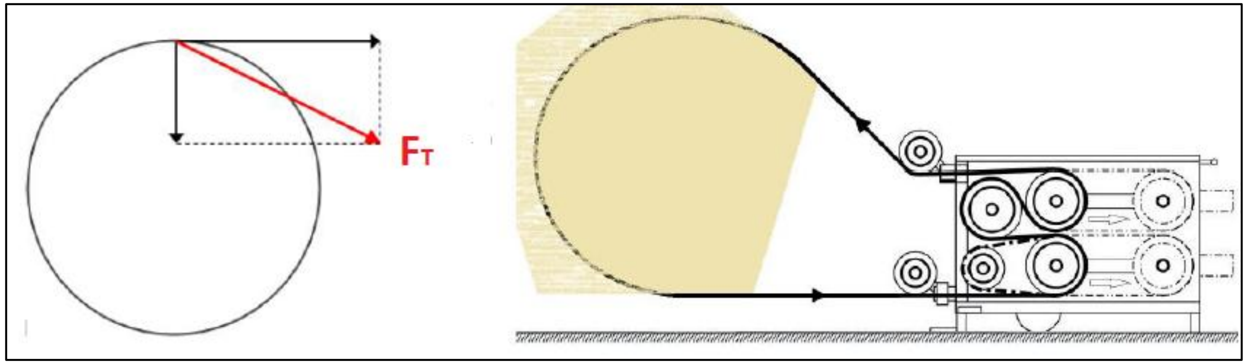
Normal force on bead

$$F_N \cong (2 \cdot F_T + \Delta F_T) \cdot \frac{1}{2 \cdot R \cdot n_L} + F_G - F_C [N]$$

$$\Delta T = F_T + F_F \cdot L_{wp} \cdot n_L [N]$$



Force vector acting on wire **(Standard machine)**



$$F_T \approx 100 - 150[daN]$$

Force analysis in wire cutting

A standard wire cutting operation is characterized by:

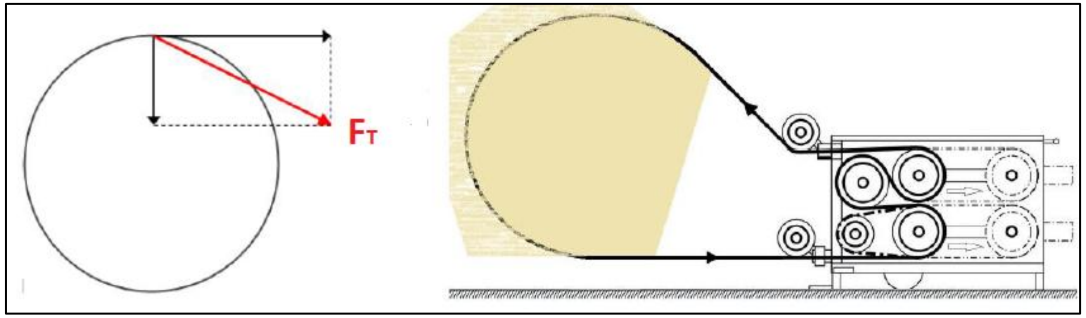
- *Large contact surfaces;*
- *Relatively steep 'angle of attack' at the entrance and exit of the wire.*

Nevertheless, cutting a complex metal structure with a large curvature radius and/or plates oriented perpendicularly to the cut direction leads to issues.
The solution for the reduction of the contact surface is increasing the angle of attack (red vector rotates up).
As a consequence, the vertical component of the vector, which is responsible for the cutting force, reduces eventually resulting in the polishing of the wire (*wire glazing*).

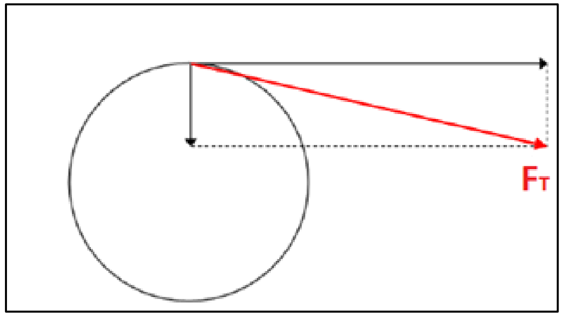
Forces analysis in wire cutting

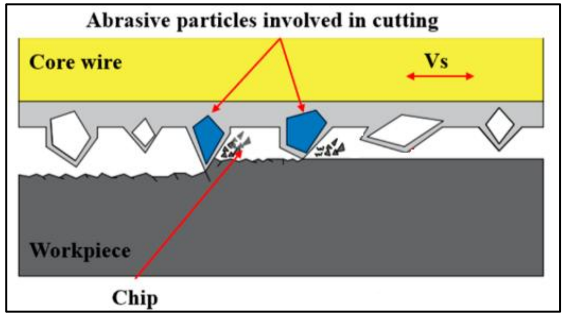
Therefore the solution is to increase the wire tension up to 500-800 kg which leads to the use of a closed loop wire arrangement (no connector):
the weakest link during diamond wire cutting is the connector. This connector is used to joint the two ends of the wire.
A connector can withstand up to 300 kg of pulling force. The addressed solution is usually a ***diamond wire that can be operated at high tension*** using guiding pulleys.

Force vector on wire **Standard machine**



Force vector on wire **Bespoke machine**





Calculation on wire and cutting parameters

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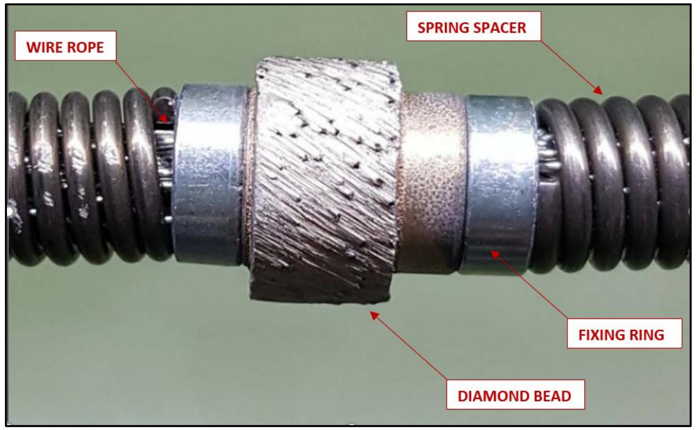
PRELIMINARY CUTTING DATA – MATERIAL: MILD STEEL					
LOAD TRANSFERRED TO MACHINE FRAME	DRY CUT V.BRAZED WIRE 44 BEADS/m	TYPICAL VALUES	15 cm²/min AT THE END OF THE CUT	REQUIRED LENGTH TO FINISH ONE CUT	OPERATIONAL WORKING AREA
WIRE TENSION [daN]	WIRE LIFE [cm²/m]	WIRE SPEED [m/s]	CUTTING RATE [cm² /min]	WIRE LENGTH [m]	CUTTING GAP [m]
500-800	180	max 20	~ 20	59	6X6



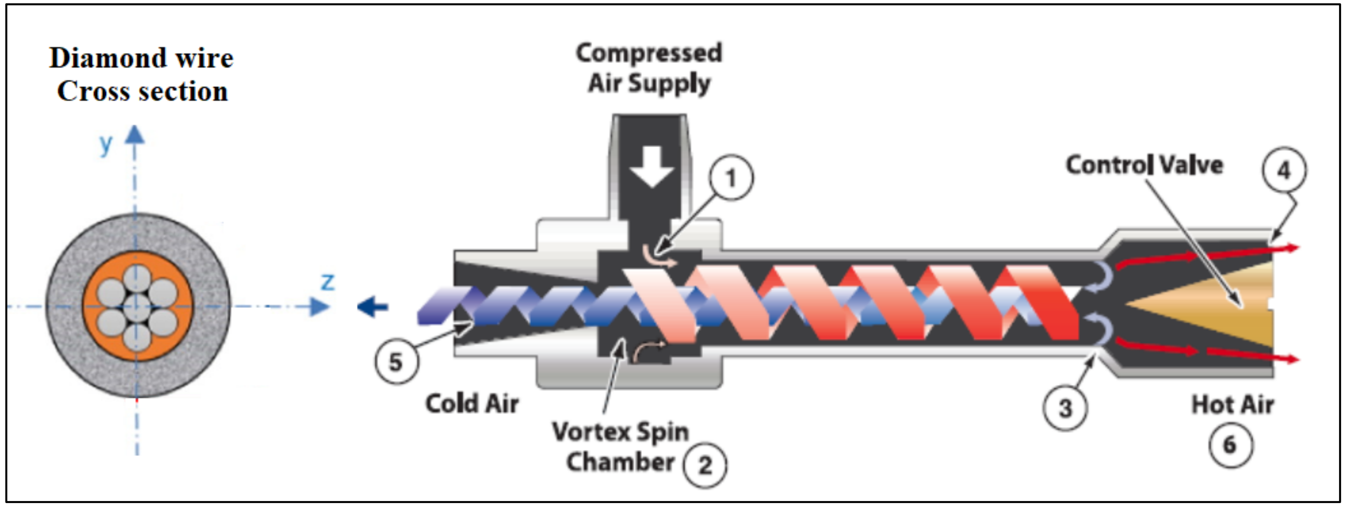
$$A\,[cm^2] = \pi \cdot \frac{(D_{ext}^2 - D_{int}^2)}{4} = 9750\ cm^2$$

$$Wire\ Length\,[m] = \frac{A\,[cm^2]}{Wire\ life\left[\frac{cm^2}{m}\right]} \approx 54\ m$$

Machine is equipped with a closed loop wire of 59 m (10% safety margin)

Cooling system

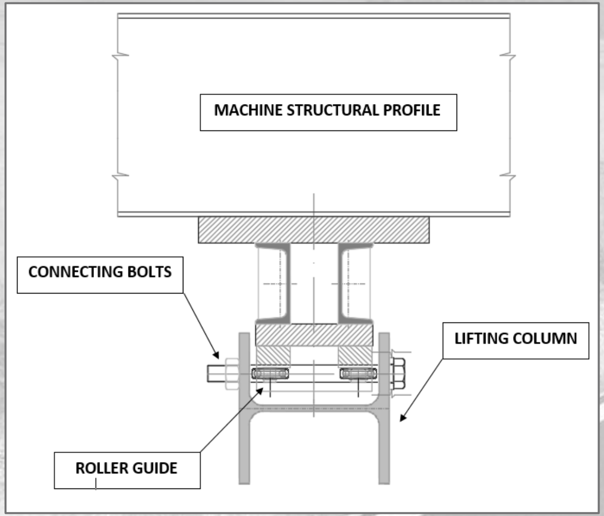
Wire cooling system should be of the dry type; therefore, a vortex tube system should be integrated in the machine.
This device, when supplied with filtered compressed air at 7 barg and 21°C, converts the air into two streams. Colder, low-pressure stream is discharged through an orifice near the centerline towards the wire and warmer, low-pressure stream is released in the opposite direction. Air consumption is about 311 l/min.



Cutting operations at construction welds

3 -ANCHORING SOLUTION

GUIDES SLIDE BETWEEN FLANGES OF COLUMN PROFILES. MANUAL FASTENING

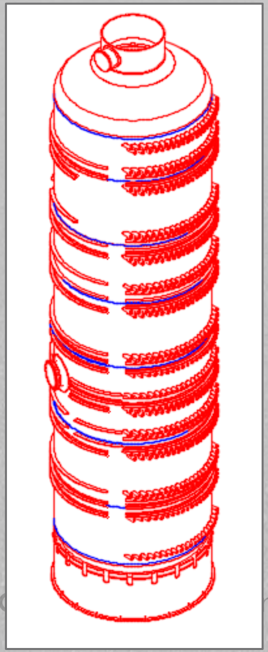


2 - LIFTING SOLUTION

WIRE MACHINE LIFTED AND LOWERED AT A DETERMINED HEIGHT BY MEANS OF NEW LIFTING COLUMNS

1 – CONSTRUCTION WELDS

TUBE BANKS BETWEEN TWO SHELL CONSTRUCTION WELDS IN SEQUENCE

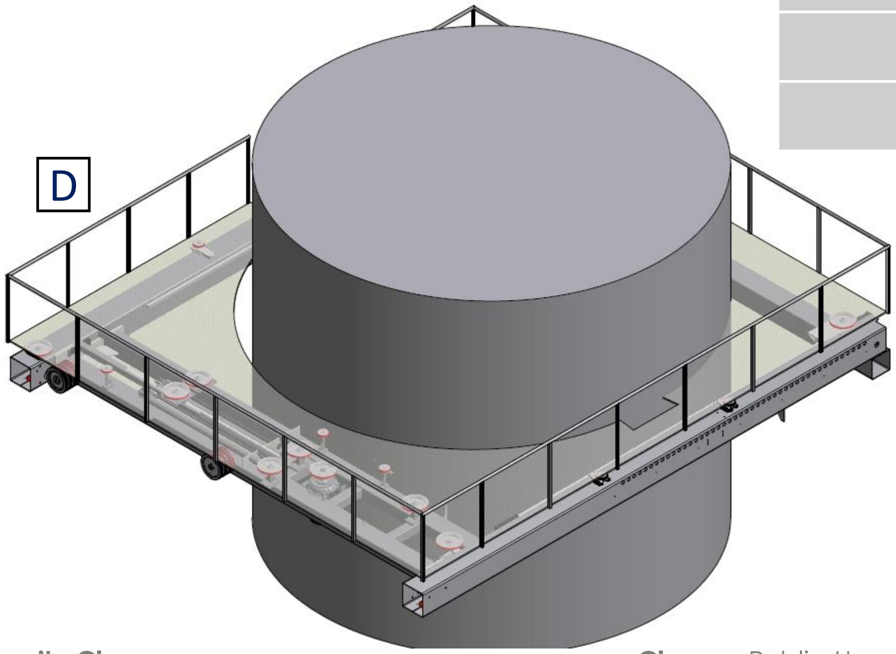


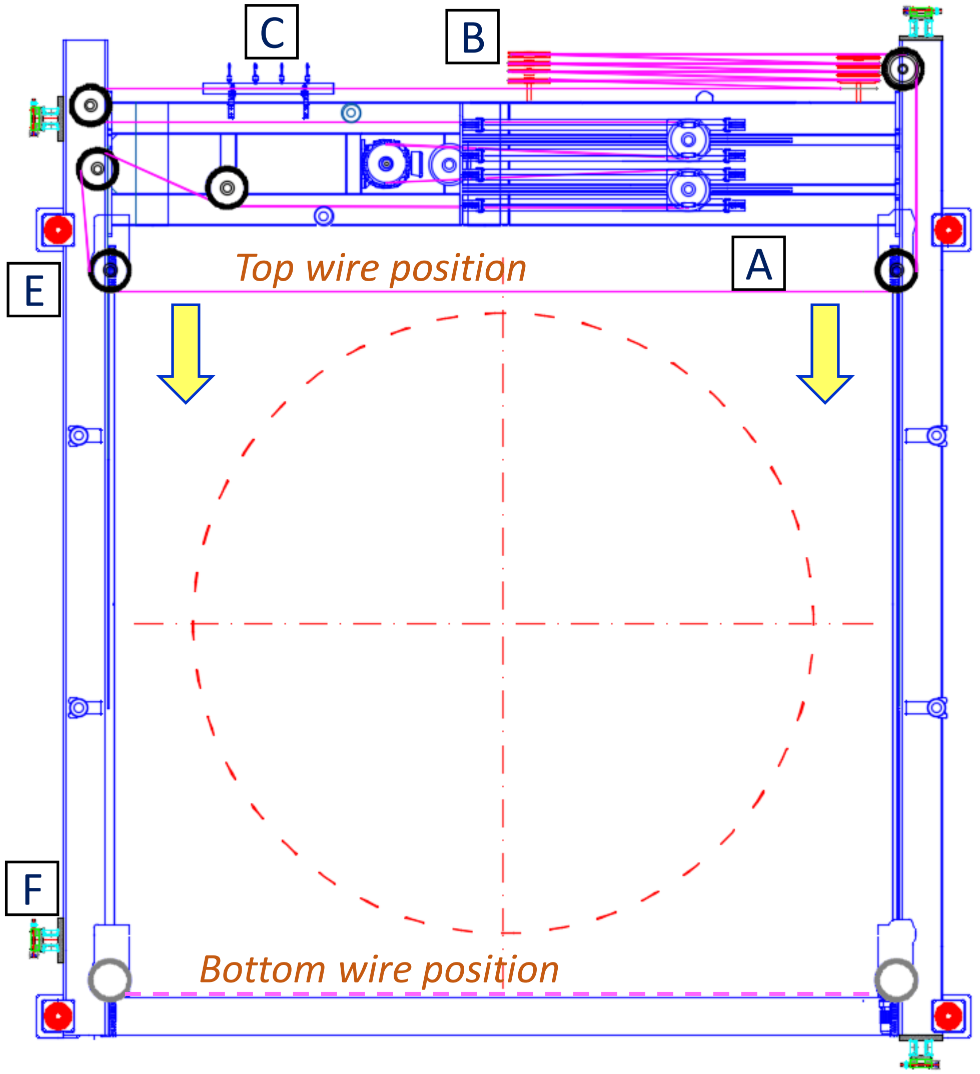
Cutting machine layout: basic design

SOGIN

- A Closed loop wire arrangement
- B Wire garage
- C Wire cooling system
- D Walking platform
- E Lifting point
- F Anchoring support

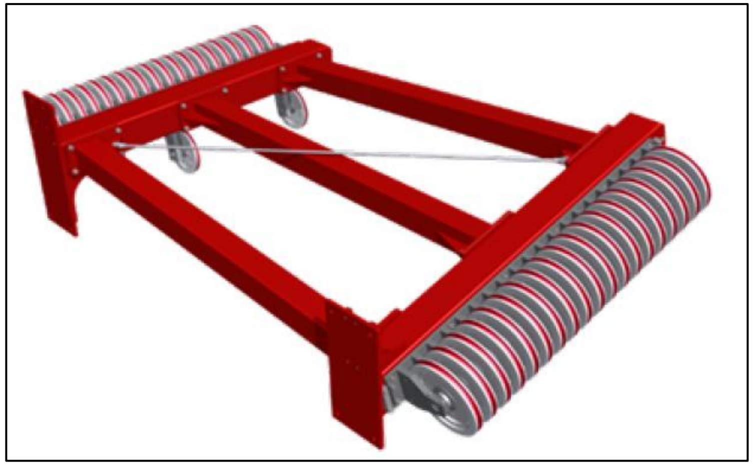
DATA
Overall dimensions
8080 x 9140 [mm]
Estimated weight
8000 [kg]
Rated Power
37 [kW]



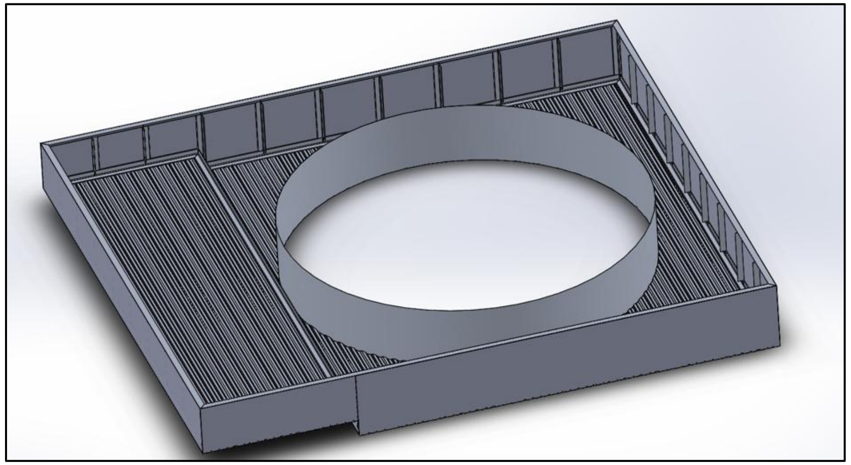


Technical details

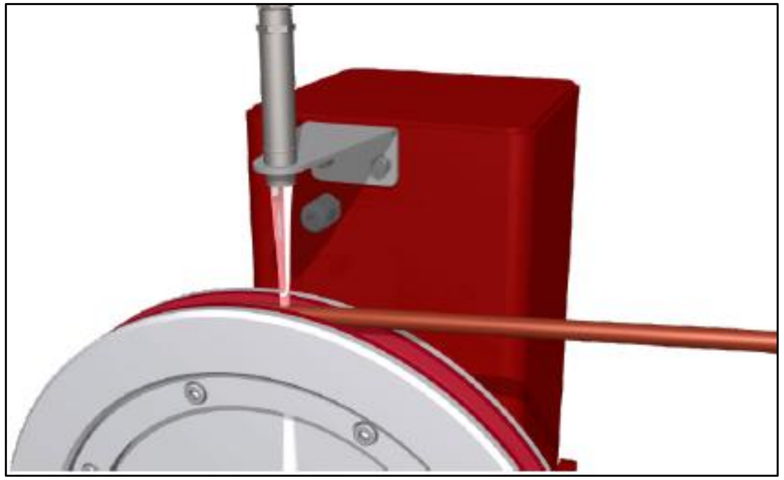
Wire storage – capacity18m



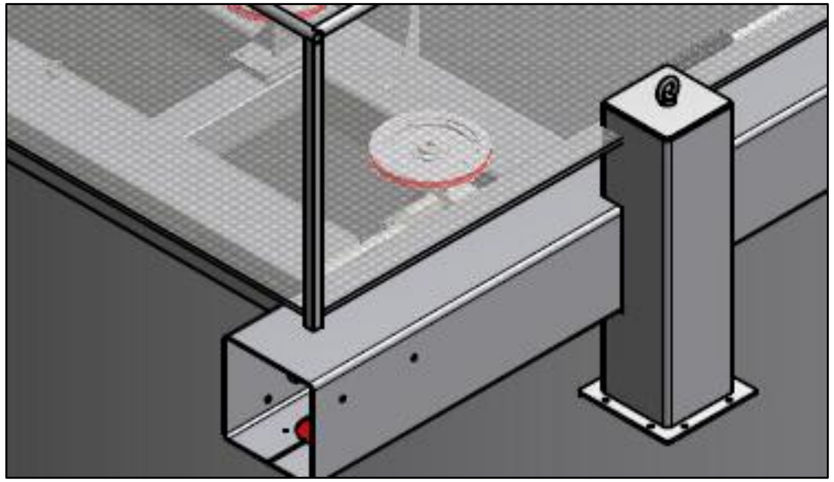
Chip capturing case EN-AW1050A



Infrared (IR)Pyrometer sensor

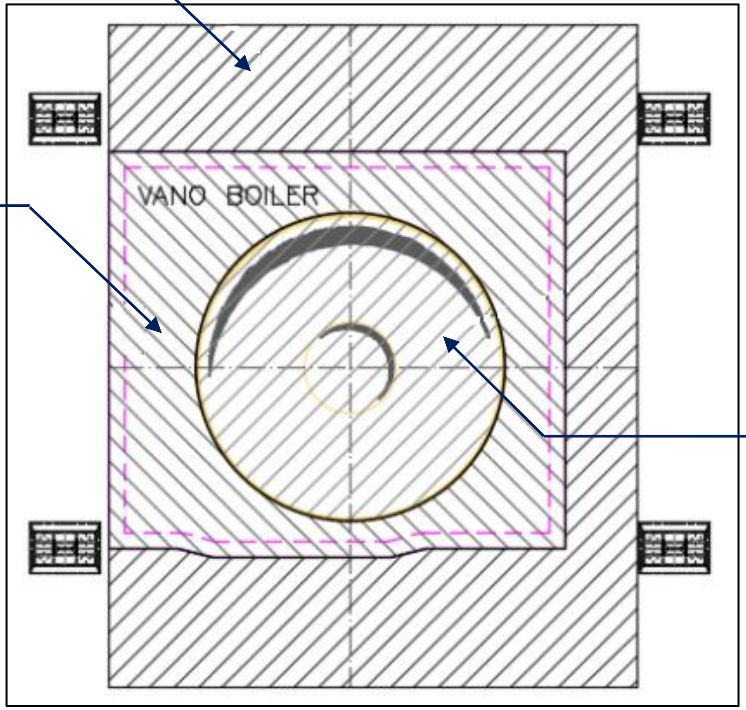


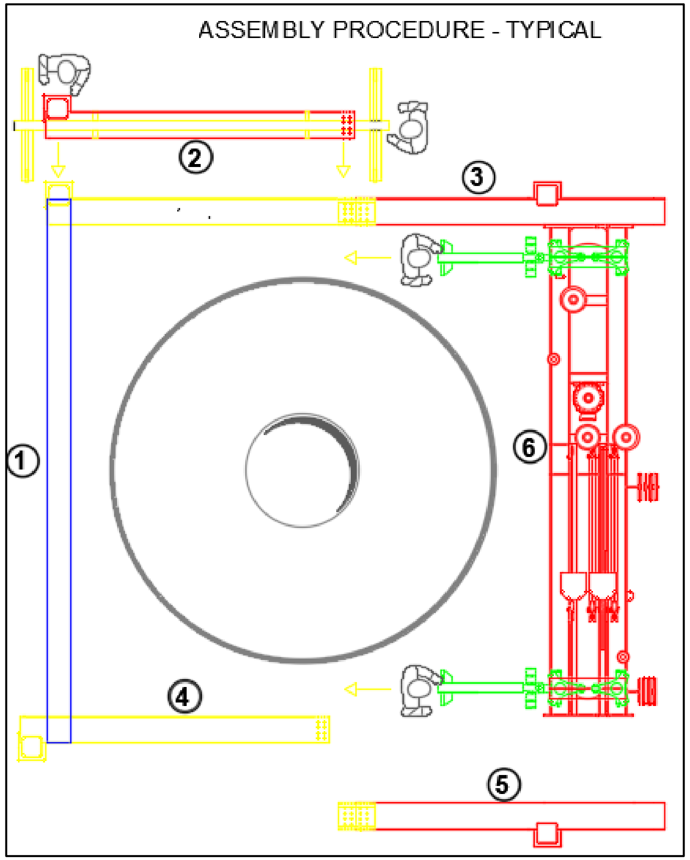
Lifting point 3200 kg



Commissioning phase

Machine base frame should be easily removable; therefore, where applicable, section connections should be bolted. For assembling phase, temporary working plane are required at the height of +18.50m.





Conclusion

The dismantling of the Latina NPP Boilers is a complex activity.
Main challenges lay in:

- Selection of the cutting technology that best fits with the design requirements
- Detailed clash analysis to prevent any interference with the existing structures and buildings;
- Identification and design of the cutting machine, lifting equipment and their mutual interfaces.

The basic design developed by Sogin for the dismantling strategy and technology selection has been assessed and confirmed by the selected Contractor with the introduction of some specific modifications aimed at improving the overall safety of the dismantling activities.

SOGIN

We protect the present
We guarantee the future

Garigliano Nuclear Plant internals dismantling plan
Cutting machine design

Bernardo Capriglione - Head of Mechanical Design Unit

ISPRA JRC – March 24-25/2026

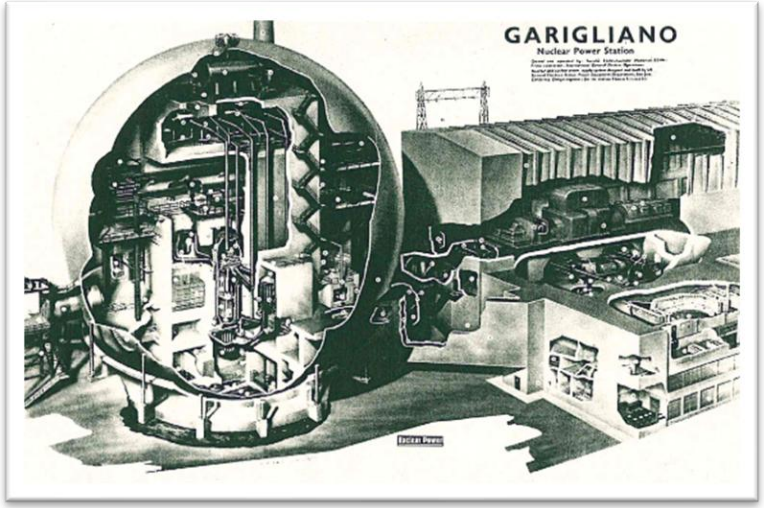
Content

- Project overview: Garigliano vessel and internals dismantling
- Definition of the project
- MTBC
- Control rods
- MTBC functional requirements
- Cutting mode selection
- Loading plan
- Global system architecture
- Machine architecture
- Machine components
- Auxiliary components
- MTBC in action

Project overview: Garigliano vessel and internals dismantling

The dismantling of the vessel and its internal components is one of the most complex activities in the decommissioning process at the Garigliano Nuclear Plant. It is due to:

- the high level of contamination and activation of the components to be removed, requiring most of the operations to be carried out remotely;
- various constraints imposed by the locations where these operations will be carried out.

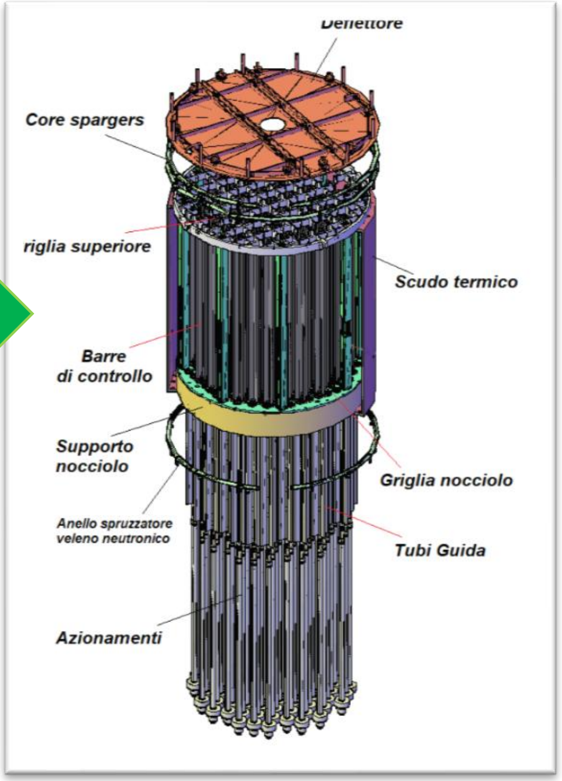


Definition of the project

The Garigliano vessel and internals dismantling project is divided into three phases:

- Phase 1: preparatory activities and upper internals dismantling (above turning vane);
- **Phase 2: Lower internals dismantling;**
- Phase 3: Vessel and primary circuit components dismantling.

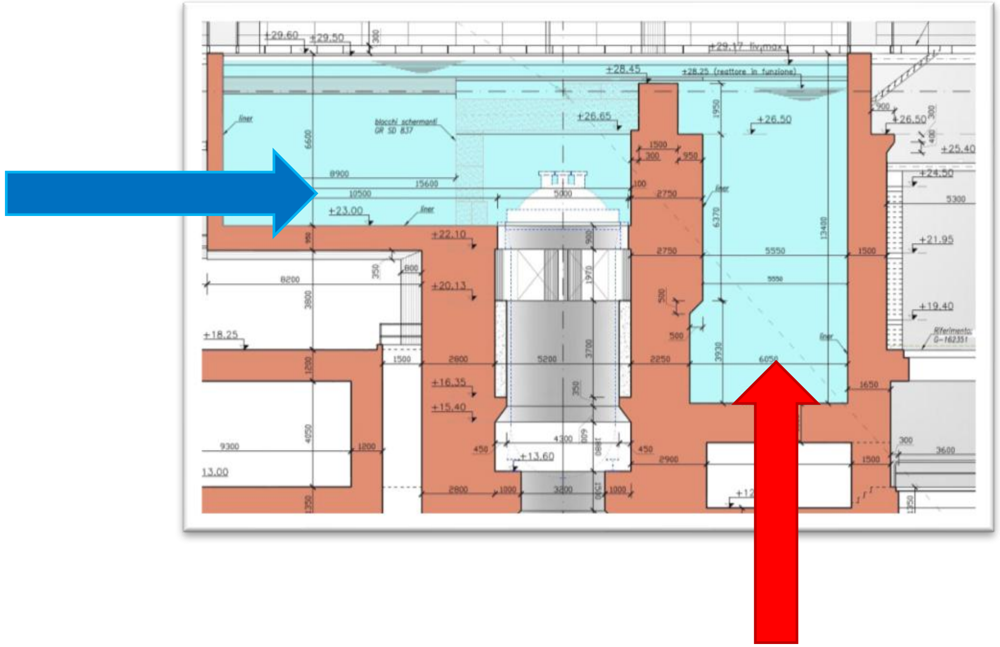
Among the preparatory activities, there was the checking of the tightness of the reactor channel and spent fuel pond liner, the refurbishment of the circuit for the filling of the channel, the pond and the vessel, the emptying of the reactor channel in which a lot of different and contaminated materials had been piled after plant's closure.



MTBC

The MTBC (Macchina di Taglio Barre di Controllo, Control Rod Cutting Machine) is designed to cut irradiated control rods underwater, ensuring radiation shielding, contamination confinement and operator safety.

Cutting plane involves cutting of control rods extracted from the vessel, under a water head inside the reactor channel (L34). The cut will be horizontal, as the low head of the reactor channel would not allow full immersion.

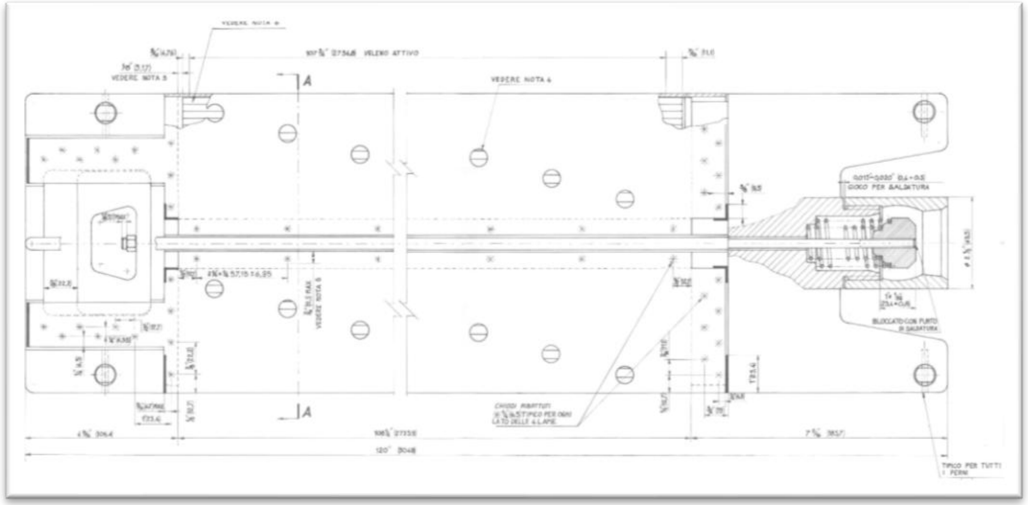


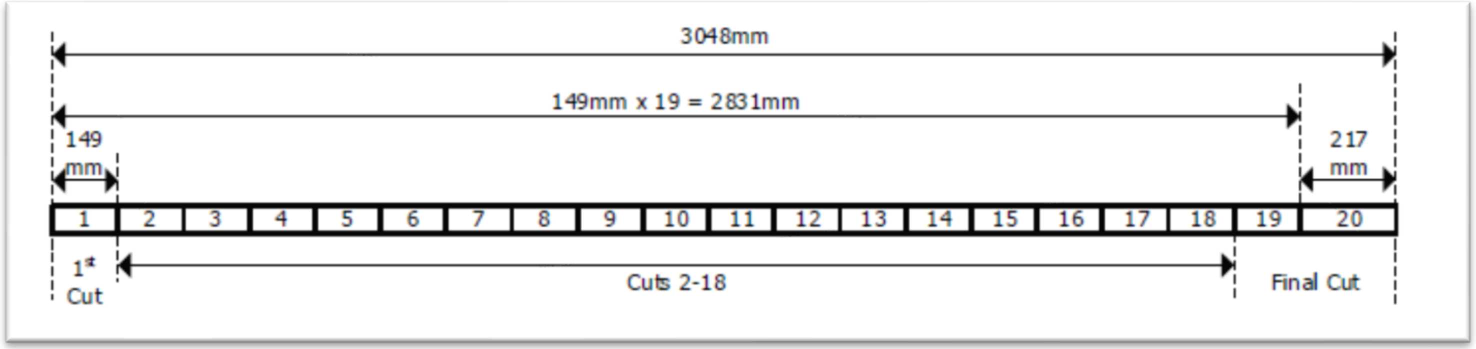
The rods cannot be cut vertically in the fuel pool because it should be kept empty and considered a sort of emergency tank to be used in case of need.

Control rods

The MTBC is designed to cut 90 cruciform control rods. Each rod is 3048 mm long and weighs approximately 68 kg in total (structure + neutron absorber).

The control rods are responsible for almost all of the remaining activity in the plant, especially regarding 60Co, which reaches 0.58 MBq/g in AISI and 222 MBq/g in stellite spheres.

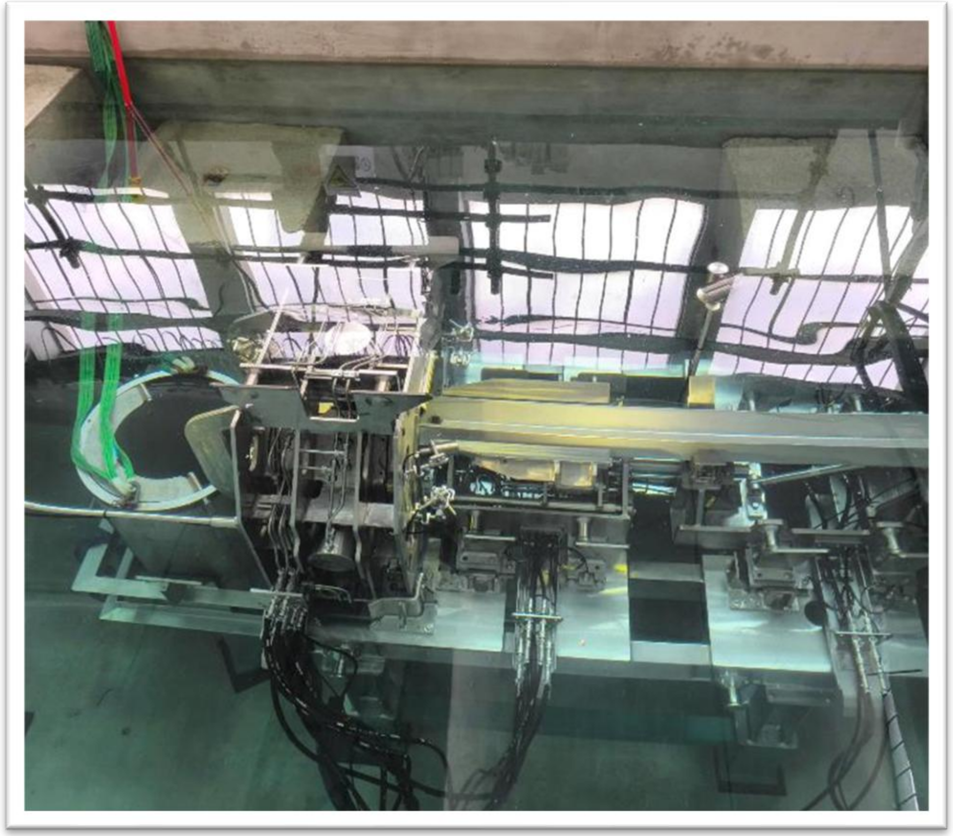




According to cutting plan, the entire rod will be divided in 20 sections of approximately 150 mm.

MTBC functional requirements

- Operability under a water head of at least 5 m;
- High robustness and efficiency of all electrical and mechanical components;
- Resistance to wear and corrosion;
- Easy access to all components requiring routine and extraordinary maintenance;
- Ease of decontamination;
- Modular design with possibility of removing each individual module.



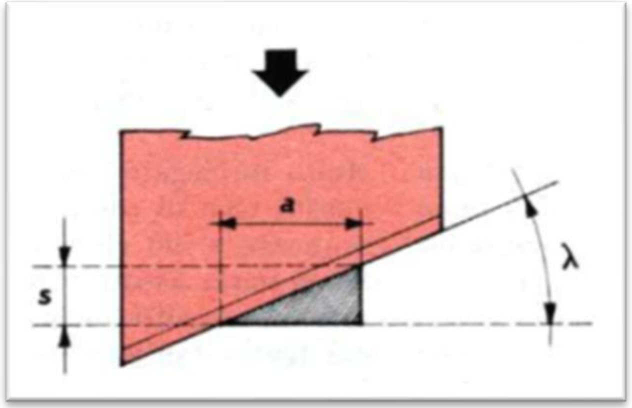
Cutting mode selection

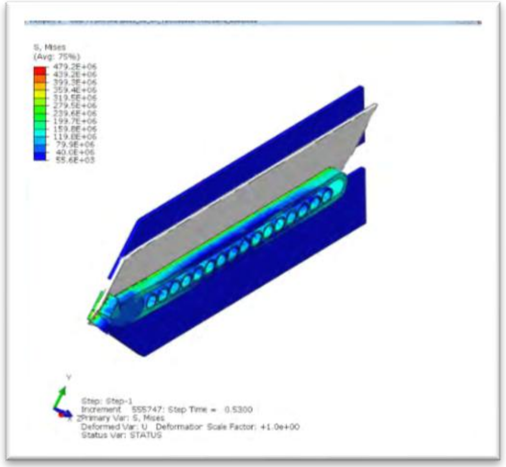
In order to minimize waste dispersion at the bottom of the reactor channel, the optimal method is usually mechanical cutting using shears.

The cutting parameters have been defined through a combination of theoretical formulae and FEM analysis, and experimental tests on dummy rods.

Shearing Force$= \tau \dfrac{s^2}{2 \tan \lambda}$

Johnson-Cook's damage elastoplastic model



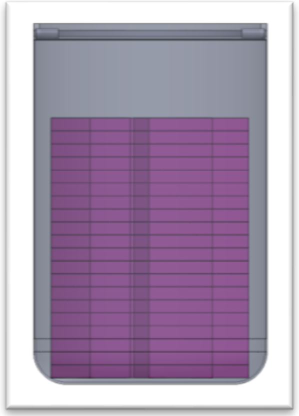


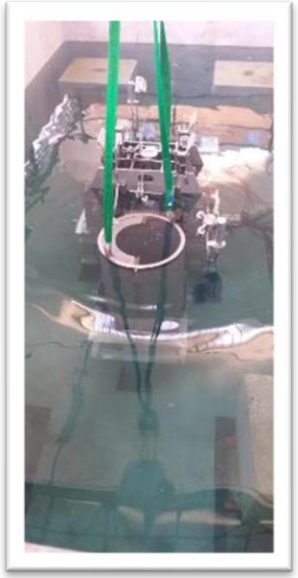
Loading plan

The cut segments will be loaded into special containers according to a cutting and loading plan, to ensure an apparent density of at least 1 g/cm³.

An assessment was conducted on the waste volumes and the number of containers required for adequate storage, as well as their shielding to accommodate their future transport to the National Repository.

The upper structural parts of the control rods, including the stellite rollers, will be packaged in three CSC containers with an additional 60 mm lead shield, while the lower structural parts and the rod body will be packaged in one CP 5.2 container.





Global system architecture

The machine and its auxiliaries, can be divided into seven subassemblies:

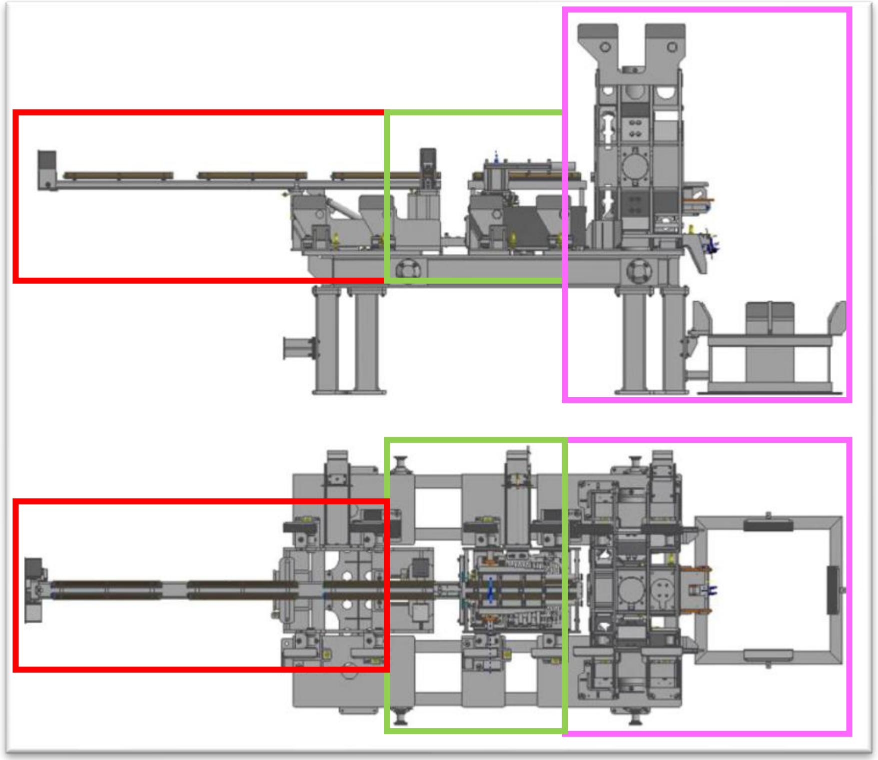
- Cutting machine, installed at a height of 23.50 m, on the work surface structure and operating below water level.
- Hydraulic power unit, installed at the operator's level, 29.90 m, above the water level.
- Control panel/electrical panel (single cabinet), installed at the operator's level, 29.90 m, above the water level.
- Hydraulic piping (rigid), electrical piping, and signal piping (rigid), installed at the operator's level, 29.90 m above the water level.
- Hydraulic piping (flexible), electrical piping, and signal piping (flexible) connecting the cutting machine to the rigid sections of piping.
- Video system: submerged lamps and cameras, installed on the machine, at a height of 29.90 m.
- Lifting beams, used for installing and recovering the cutting machine and for removing and installing individual modules in the event of extraordinary maintenance.

Machine architecture

MTBC consists of a base frame and three main functional modules:

- Tilting module (vertical to horizontal positioning),
- Translation module (linear feeding of the rod),
- Cutting module

All modules are aligned by precision centering pins on a rigid welded base. The division into modules is necessary to facilitate maintenance in the event of a breakdown. Each module is independent and equipped with appropriate pinions to allow for individual lifting.

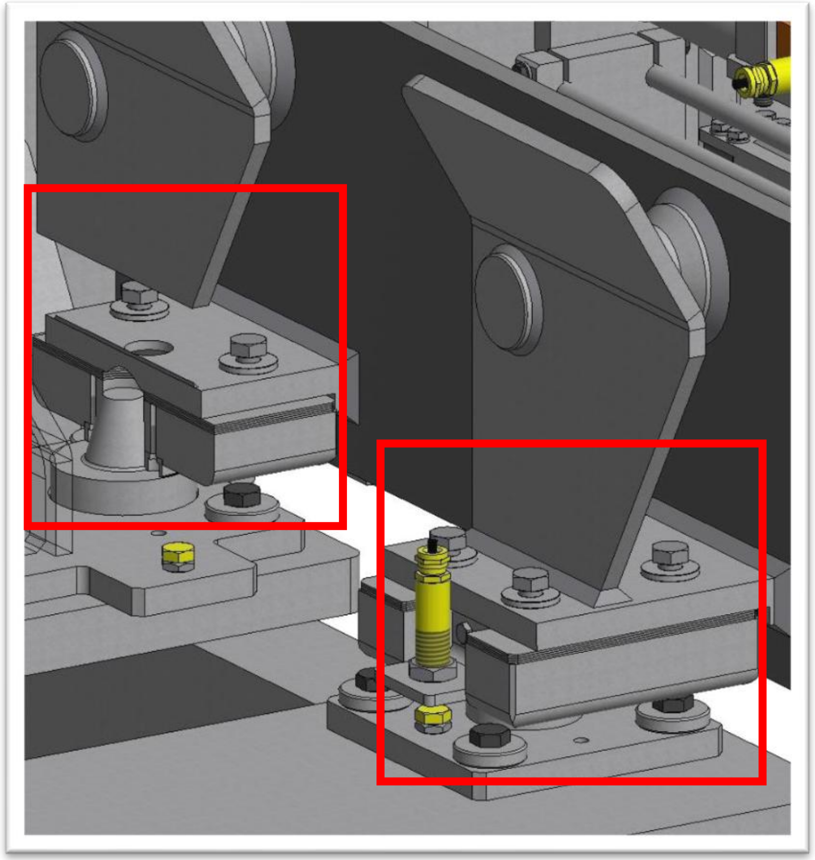


Machine components – Base Frame

The Base Frame supports all the machine components beneath the water head and allows for the relative positioning of the modules as well as the collection basket.

The figure illustrates the pin-and-plate centering system on the base with inclined guide profiles. The module support structures are equipped by perforated plates that facilitate coupling with the centering pins, to ensure correct positioning and precise horizontal alignment.

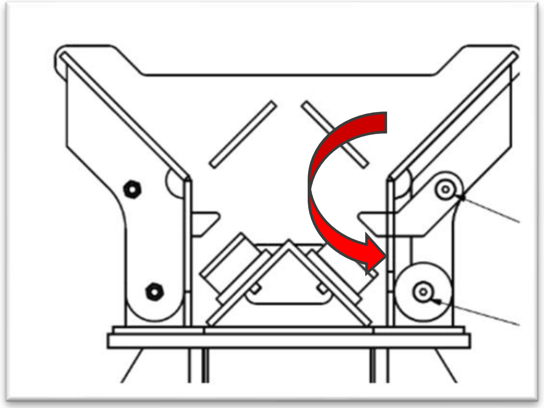
The inclined profiles assist with vertical placement, and the weight distribution and center of mass arrangement guarantee stability during operation and transport.

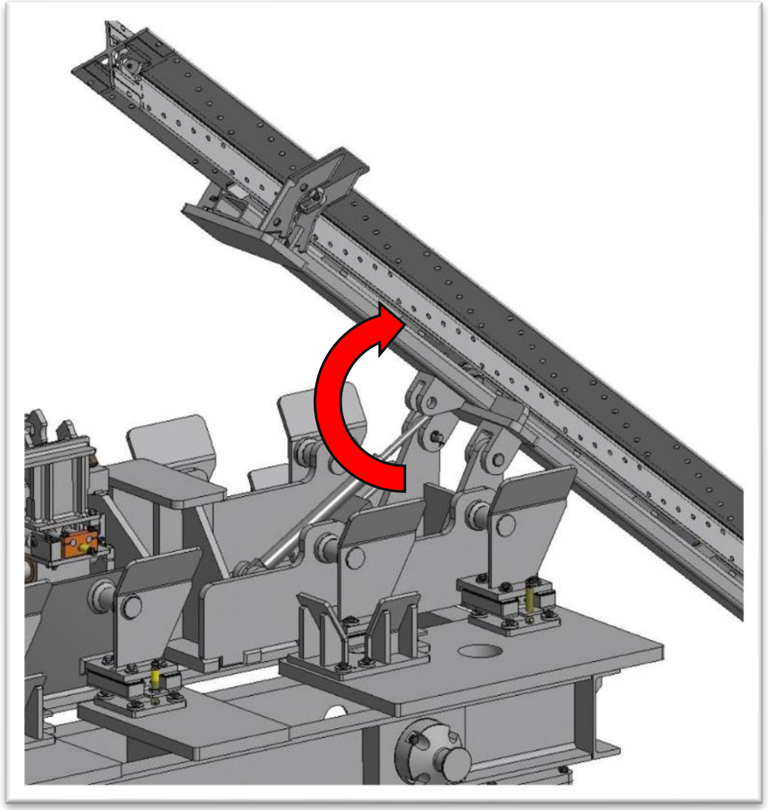


Machine components - Tilting Module

The Tilting Module rotates the control rod from the vertical to the horizontal position. It consists of an AISI 316L steel profile with welded wings to accommodate the control rod on three sides.

Two spring-loaded brackets prevent the rod from extending from the open side. Once the rod is positioned at the bottom of the profile, the hydraulic cylinder actuates, rotating the rod 90° to position it horizontally in front of the translation module.



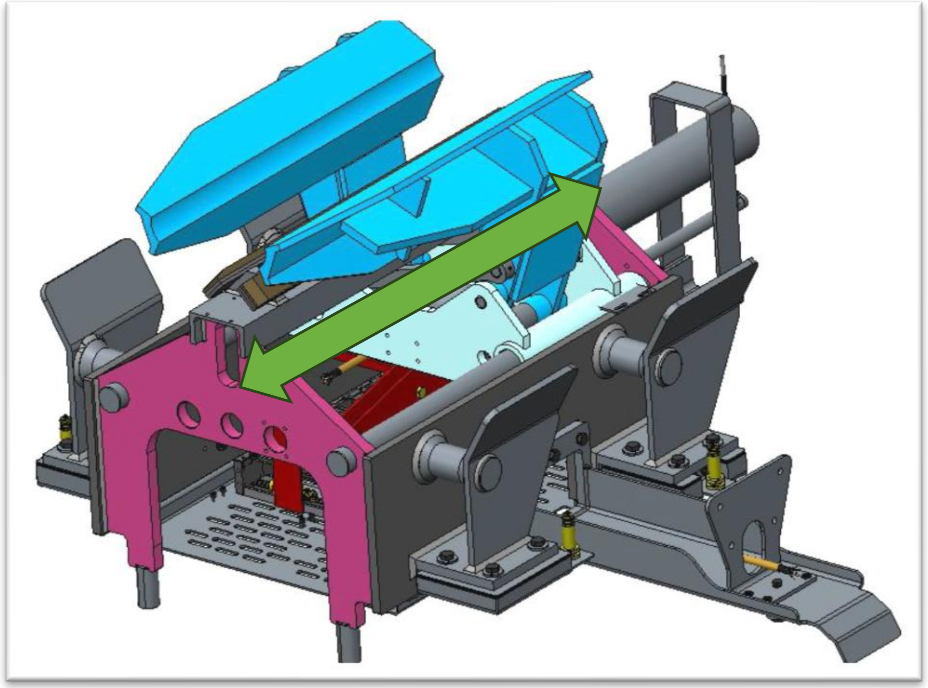


Machine components – Translation Module

The Translation Module has two hydraulically actuated grippers that clamp the control rod.

Mounted on linear guides, the module is moved by longitudinal hydraulic cylinders, transferring the rod from the tilting module to the cutting module.

The grippers engage during forward travel and release on return. The cylinder stroke (up to 350 mm) is controlled by a proportional valve and monitored by an LVDT transducer.

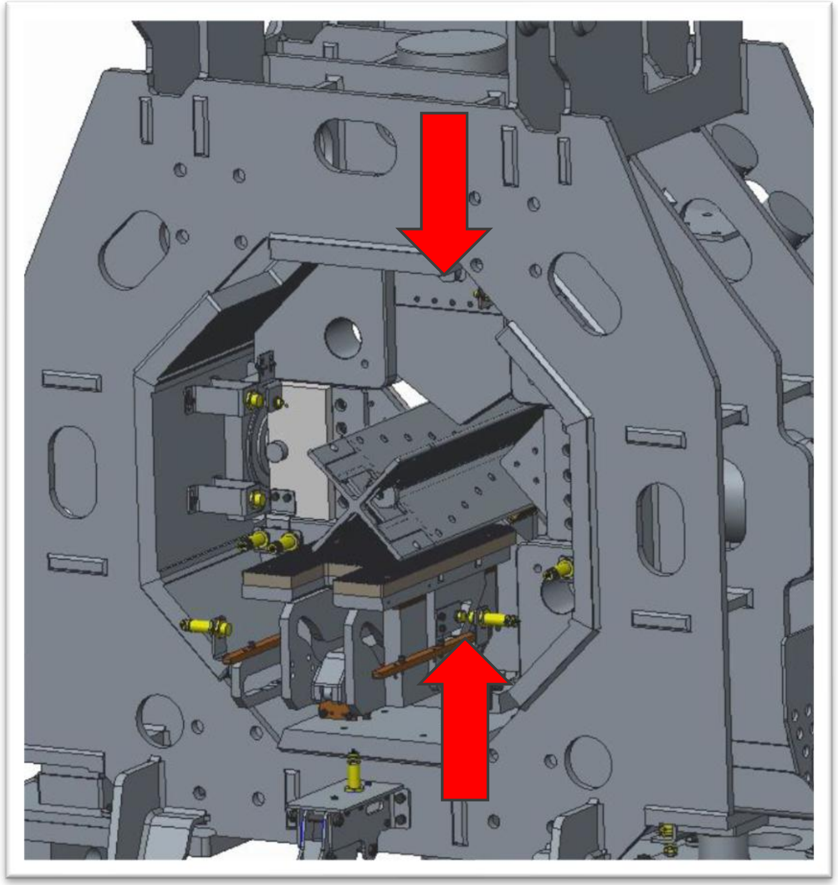


Machine components – Cutting Module

The Cutting Module performs the clamping, cutting and unloading operations.

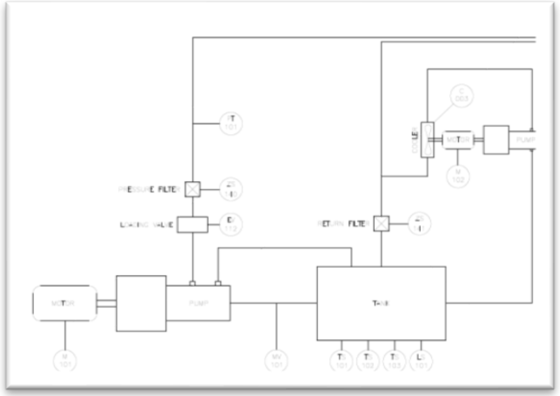
It is arranged to minimize component bending and promote shear failure.

Two hydraulic cylinders operate the blades. First, the upper cylinder cuts the upper flanges past the rod centerline. Then, the lower cylinder completes the cut through the lower flanges and the rod core.



Auxiliary components - Hydraulic and control systems

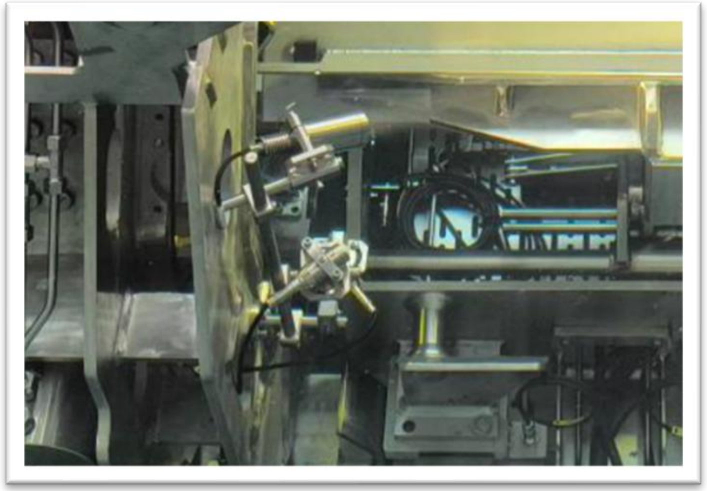
All actuators are supplied by a remote hydraulic power unit (11 KW, 260 bar) through rigid and flexible stainless-steel piping.



Motion, forces, interlocks and safety are managed by a PLC-based control system with redundant CPU, supported by an uninterruptible power supply (UPS) for safe shutdown.

Auxiliary components - Vision and Remote Handling

Submerged fixed and PTZ (Pan, Tilt, Zoom) cameras with integrated lighting provide continuous visual monitoring of cutting, translation, and tilting operations.



Dedicated lifting beams enable remote installation, module replacement and maintenance in contaminated environments.

MTBC in action

This video shows the MTBC in action, moving the control rod towards the cutting module, cutting the segment, and unloading it into the basket.

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THANKS FOR THE ATTENTION

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GENERAL INFORMATION

Multidisciplinary Group working in Energy and Industry in the following areas:

SERVICES

- OPERATION & MAINTENANCE
- DECOMMISSIONING
- SURFACE TREATMENT
- CIRCULAR ECONOMY
- EFFICIENCY & SELF-CONSUMPTION
- T. DIGITAL&BUSINESS 4.0

SECTOR

- NUCLEAR
- WIND
- PHOTOVOLTAIC
- OIL & GAS
- HYDROELECTRIC
- AUTOMOBILE
- AERONAUTICAL
- AGRIFOOD

GDES develops its services around values and axes Key strategies for business development and growth:

VALUES

- ENERGY
- INNOVATION
- PERSONS
- EXCELLENCE
- SUSTAINABILITY

STRATEGIC AXES

- CULTURE FOR SECURITY
- INNOVATION AND TECHNOLOGY
- ENVIRONMENTAL SUSTAINABILITY
- INTERNATIONALIZATION

KEY DATA

GDES

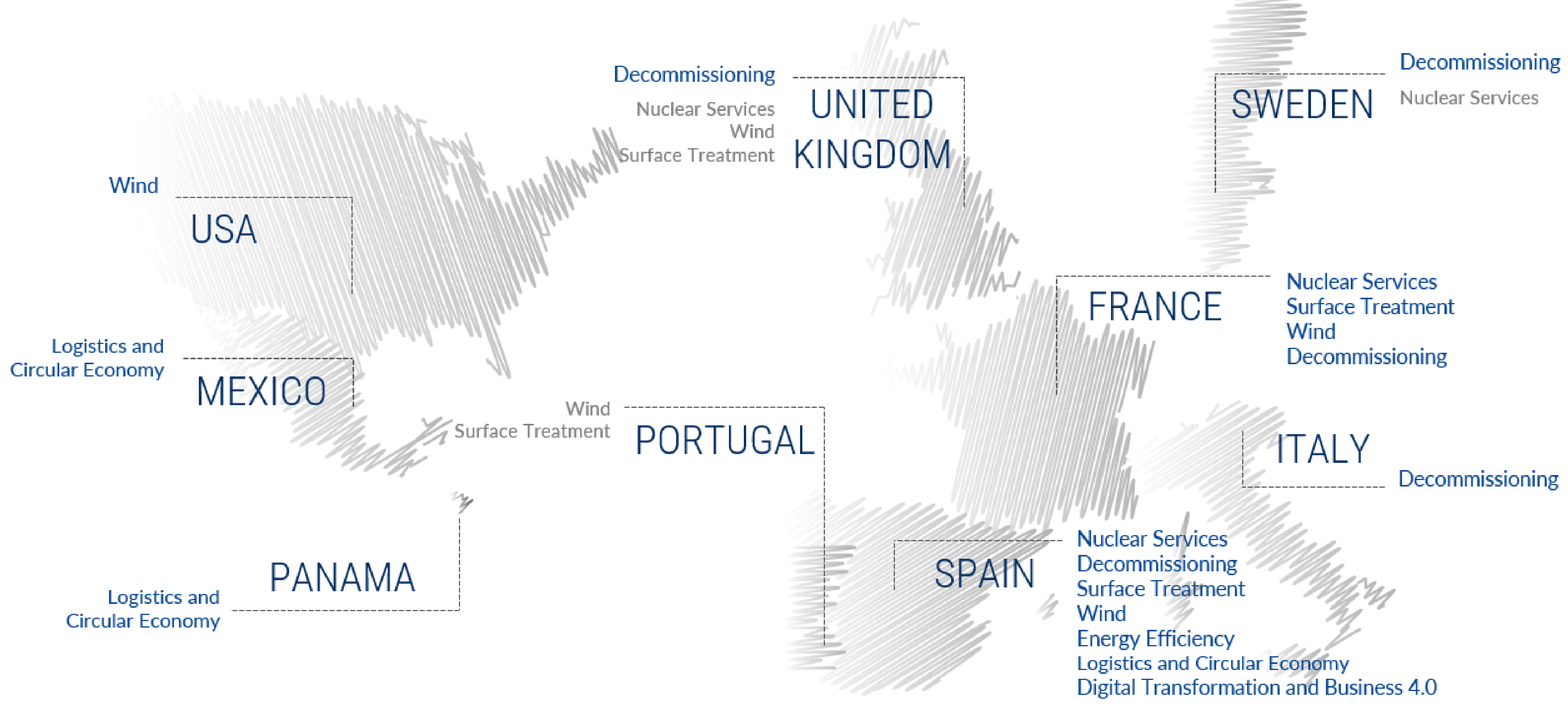
Beginning of activity: 1919
Company Foundation: 1932

Energy & Industry

Employees: 1,100

SERVICES PER COUNTRY

INTERNATIONAL PRESENCE



March 2025

Latina Steam Generators Cutting Machine

GDES

A TRUSTED PARTNER

Contents

Project overview

In 2021 GDES was awarded, as leader of a JV made of 5 companies, the contract to dismantle the 6 steam generators of Latina plant

Project phases

1. REMOVAL OF AUXILIARY STRUCTURES

2. MANUFACTURING (CUTTING MACHINE, OVERHEAD CRANE, VENTILATION SYSTEM, ETC.)

3. **CONSTRUCTION OF 2 X CONFINEMENT (STATIC & DYNAMIC) STRUCTURES**

4. IN-SITU SEGMENTATION

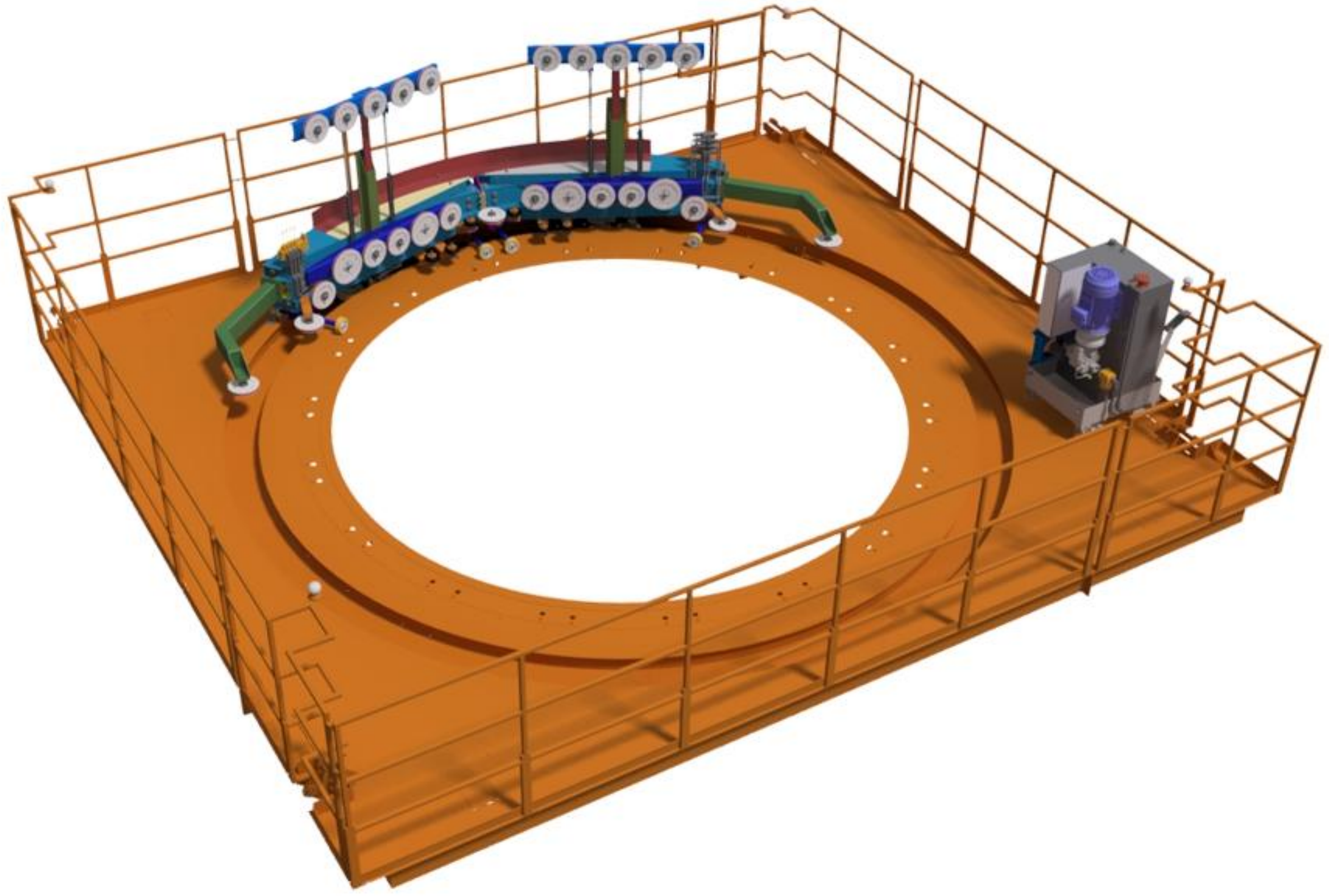
5. FINAL DEMOLITIONS

GDES Design Philosophy

From Basic Concept to Operational Implementation

The implemented cutting machine for Latina introduced a different design philosophy:

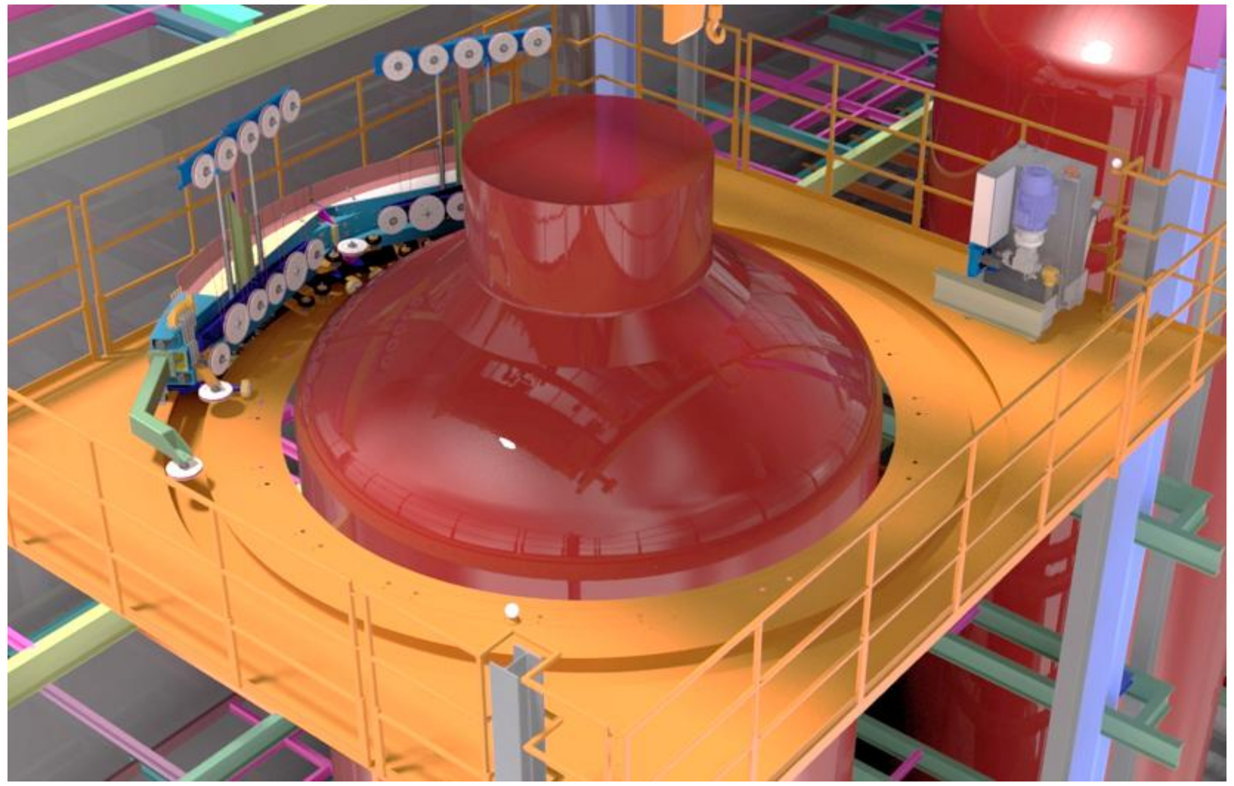
- Increased focus on operational safety
- Reduction of personnel exposure at height
- Improved stability during lifting and anchoring phases
- Enhanced operational flexibility (tangential and diametral cutting)
- Easier maintenance and regulation



The objective was not to modify the cutting principle, but to improve operational robustness and safety under real site conditions.

GDES Engineering Analysis

- Machine positioned **above** the platform
    - Allows easier maintenance and operational regulation without the need of placing the platform at ground level
- Full Machine **rotation** around the boiler allowing Tangential cut
- **Platform secured** with mechanical blocks to the crane hoists
- Remote control station
- **Hybrid electro-hydraulic** configuration
    - Electric motor for movement and power supply
    - Hydraulic power unit for actuation and stabilization
    - Hydraulic pins, integrated into the platform, for automatic lifting and stabilization
    - No need for personnel access to the platform during lifting

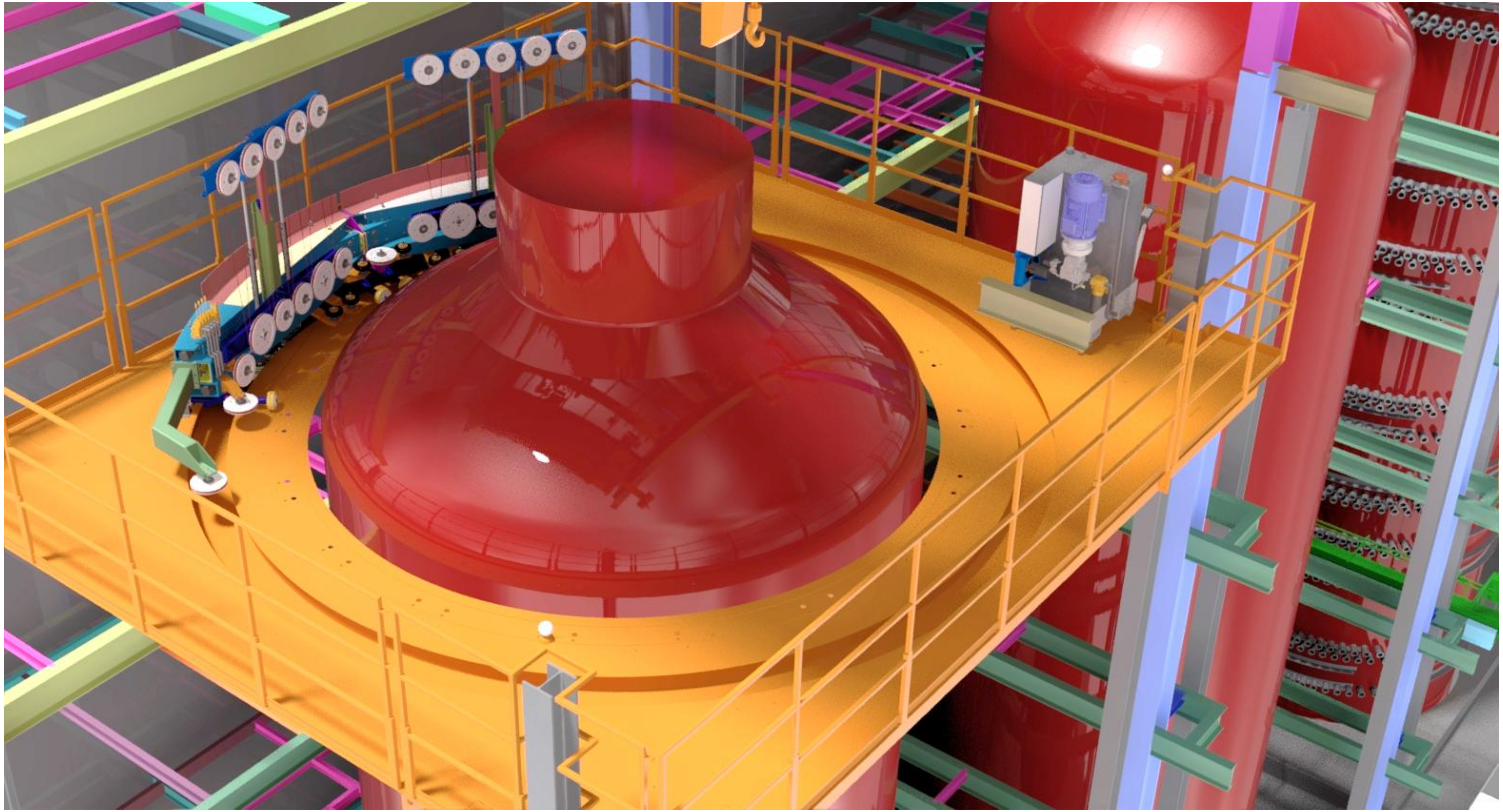


Trade-Off: increased weight (12000kg) and structural complexity

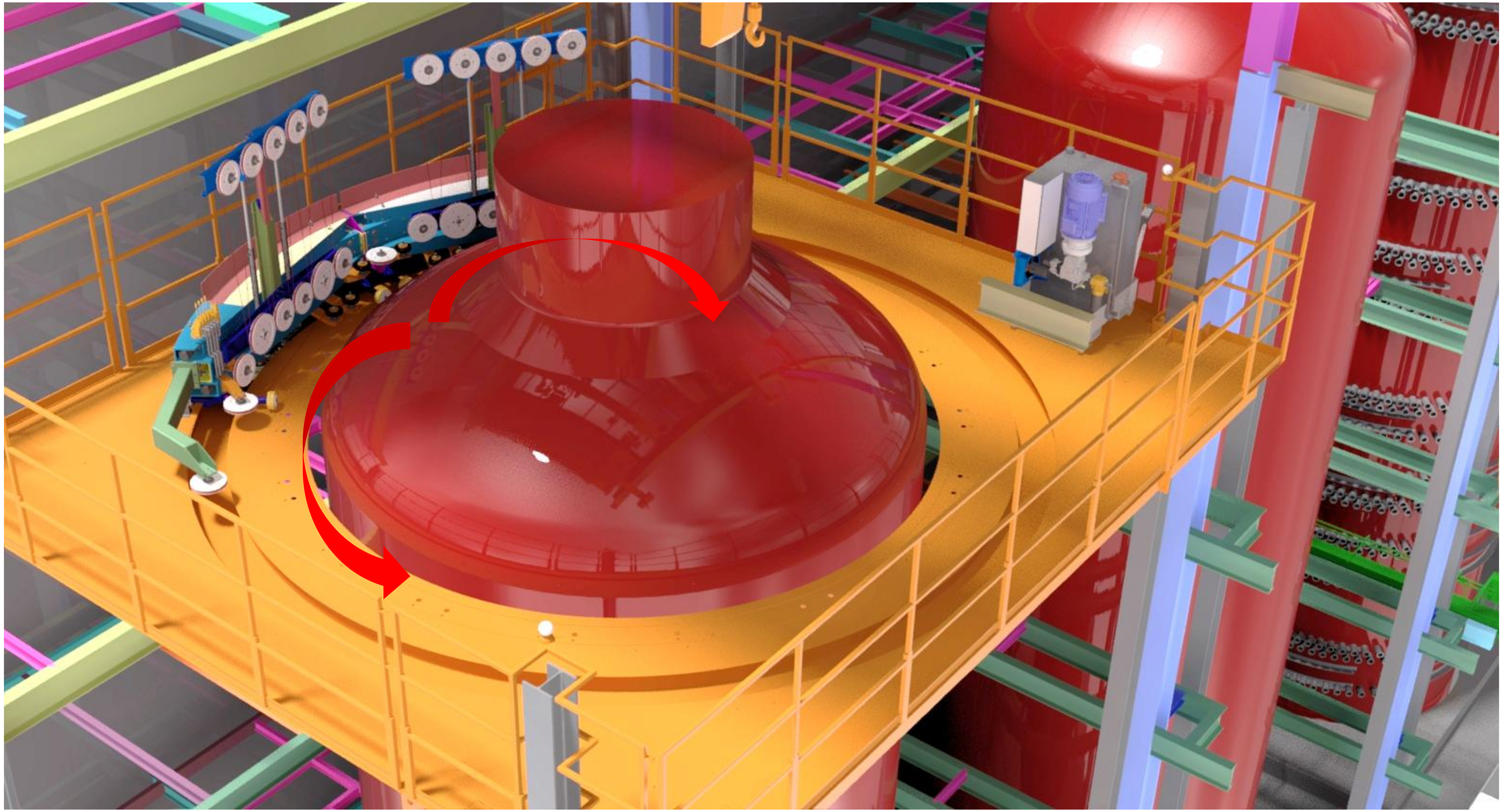
CUTTING SEQUENCE

1. Opening of arms
2. Start of rotation
3. Tangential cut progression
4. Diametral cut
5. Completion of separation

OPENING OF INTERNAL ARMS



OPENING OF INTERNAL ARMS



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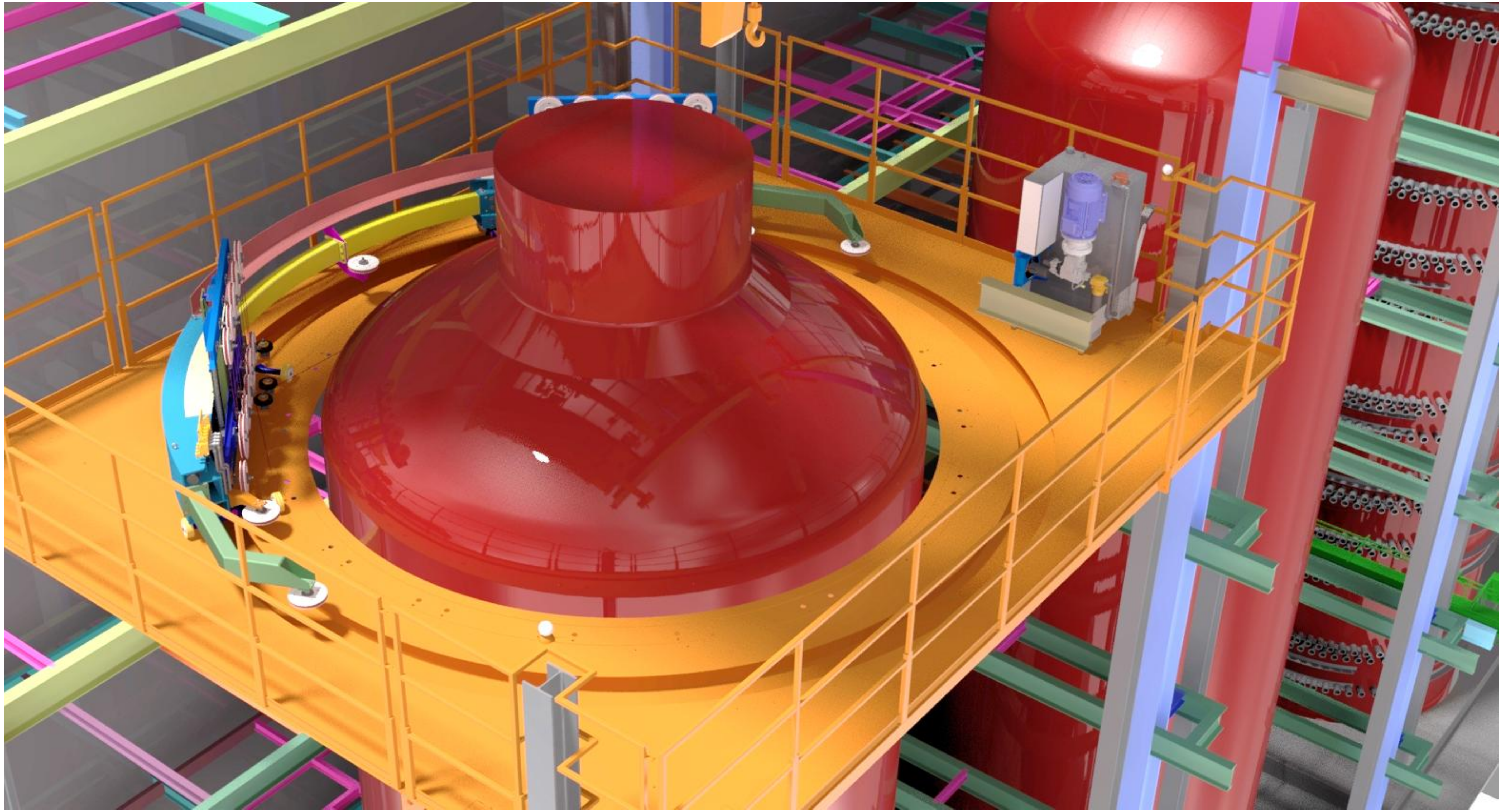
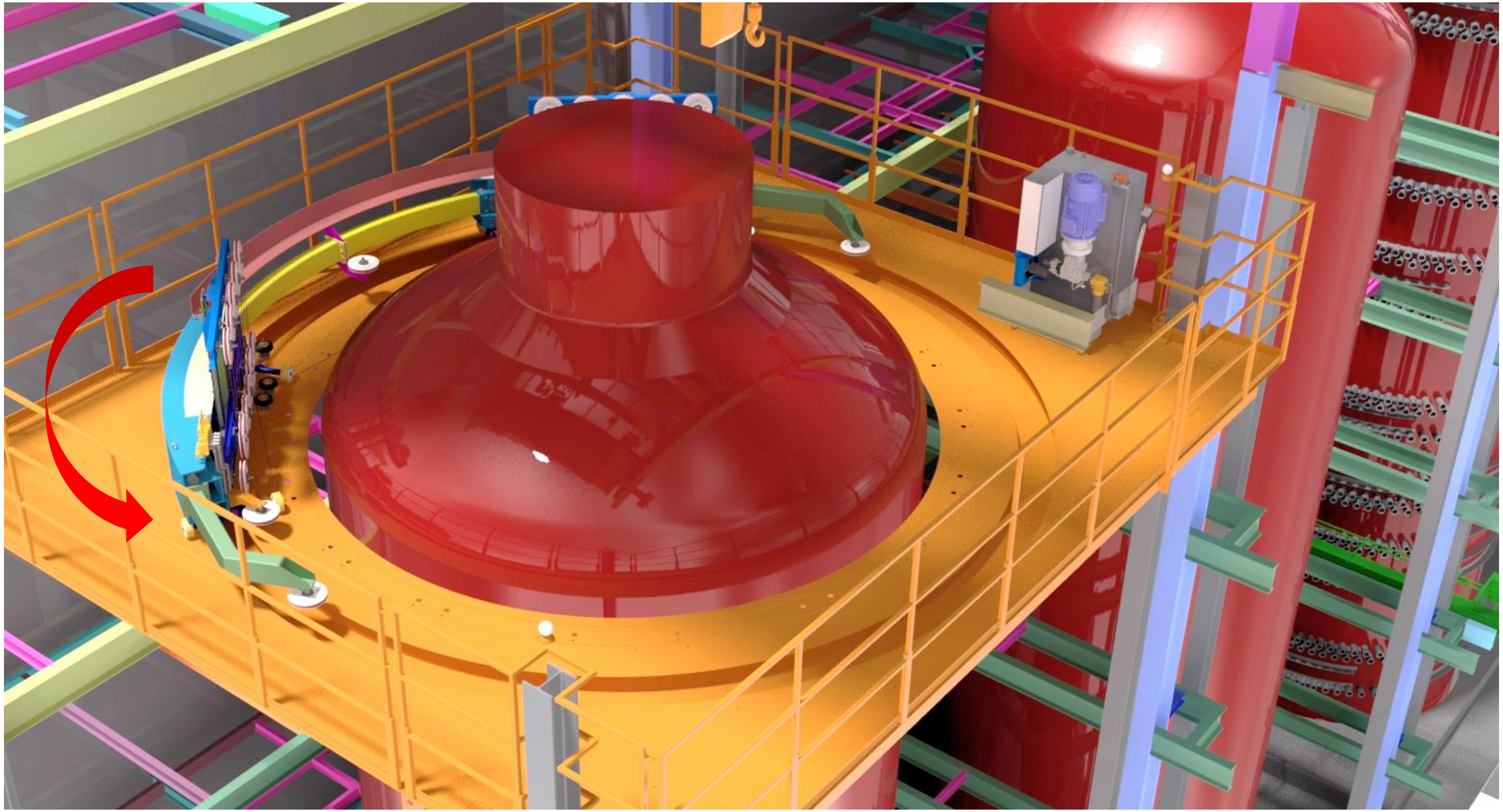
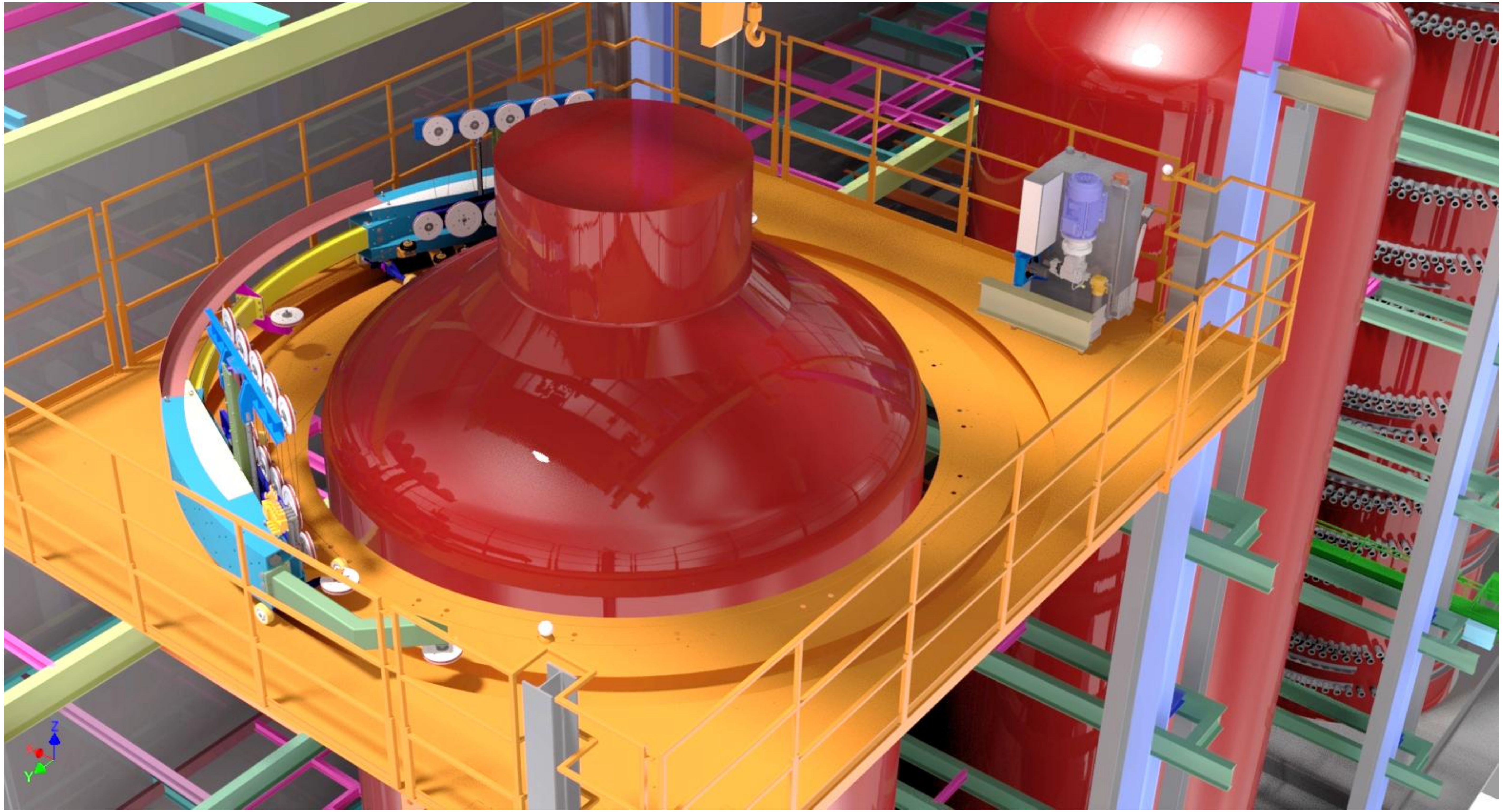


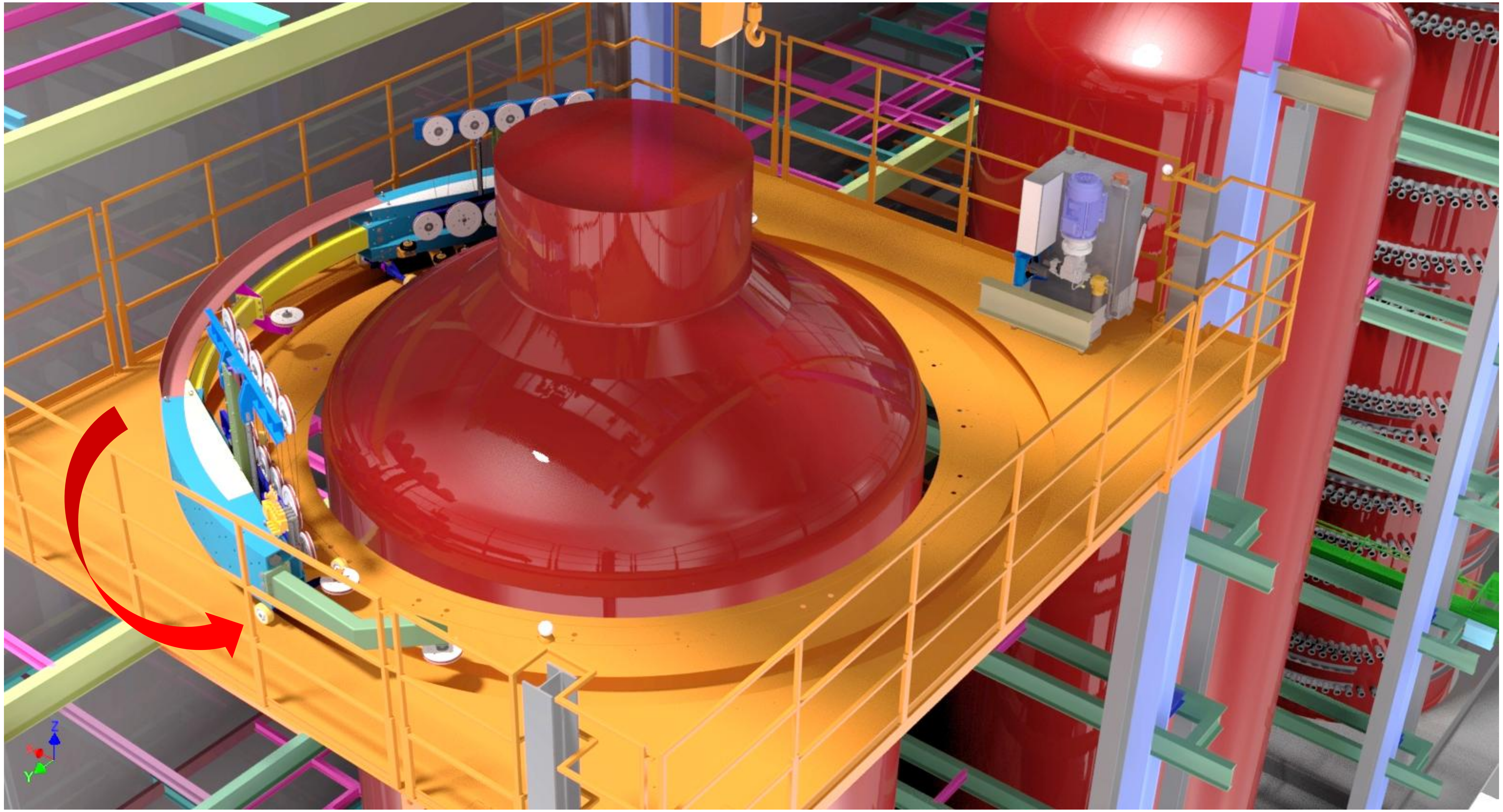
START OF MACHINE ROTATION & CUTTING



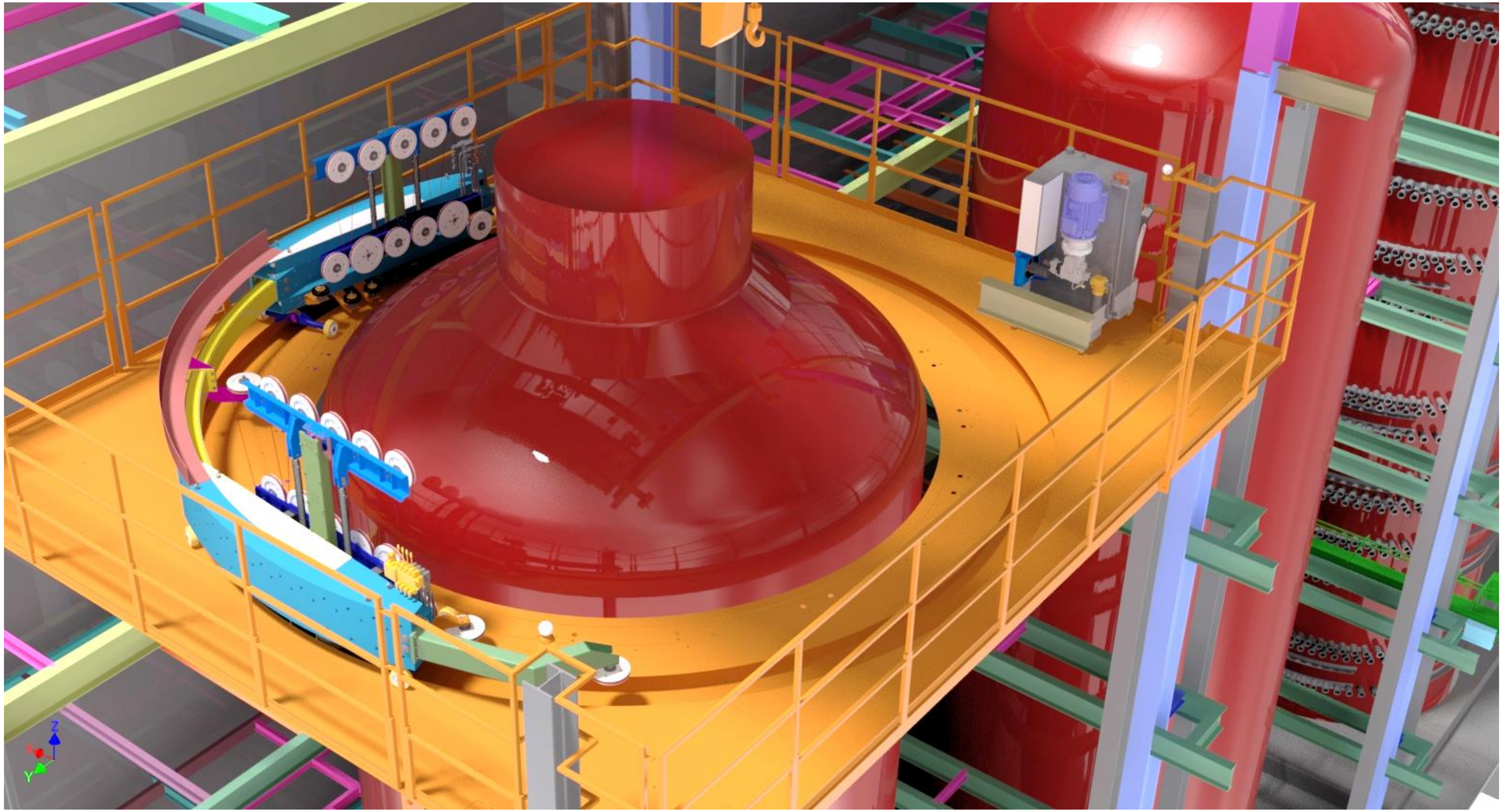
START OF MACHINE ROTATION & CUTTING



CONTINUATION OF CUTTING BY MACHINE ROTATION



CONTINUATION OF CUTTING BY MACHINE ROTATION



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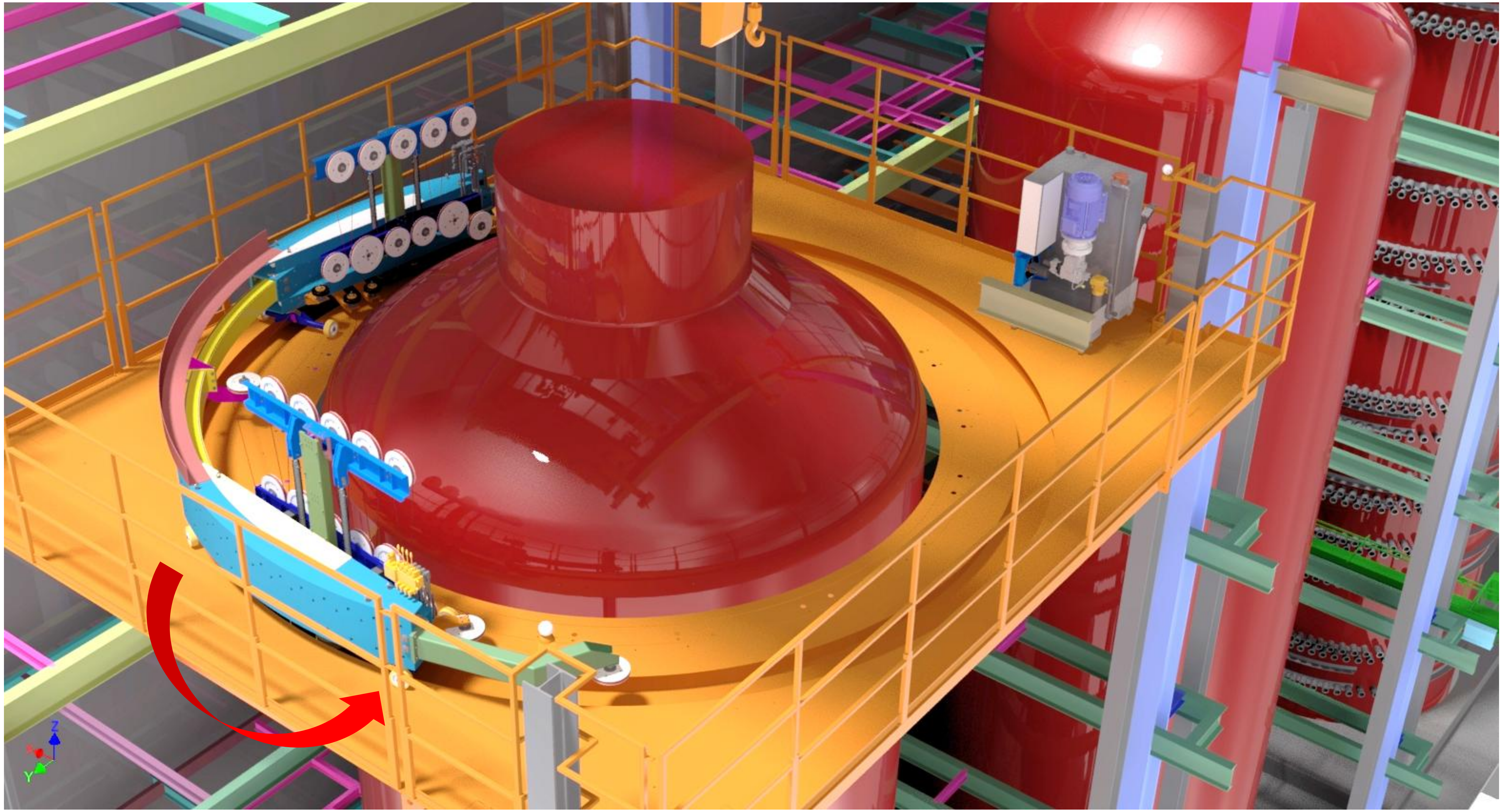

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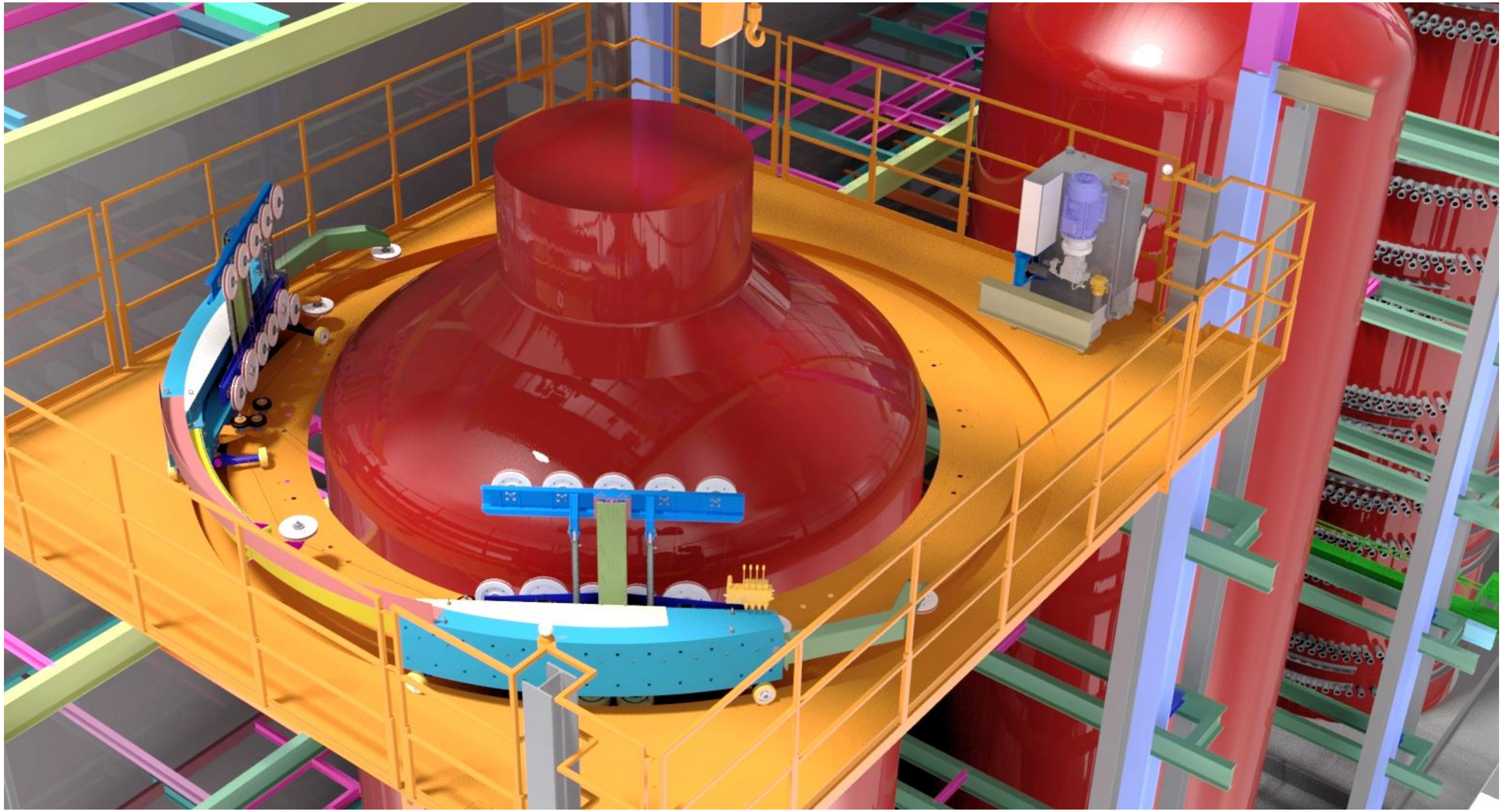

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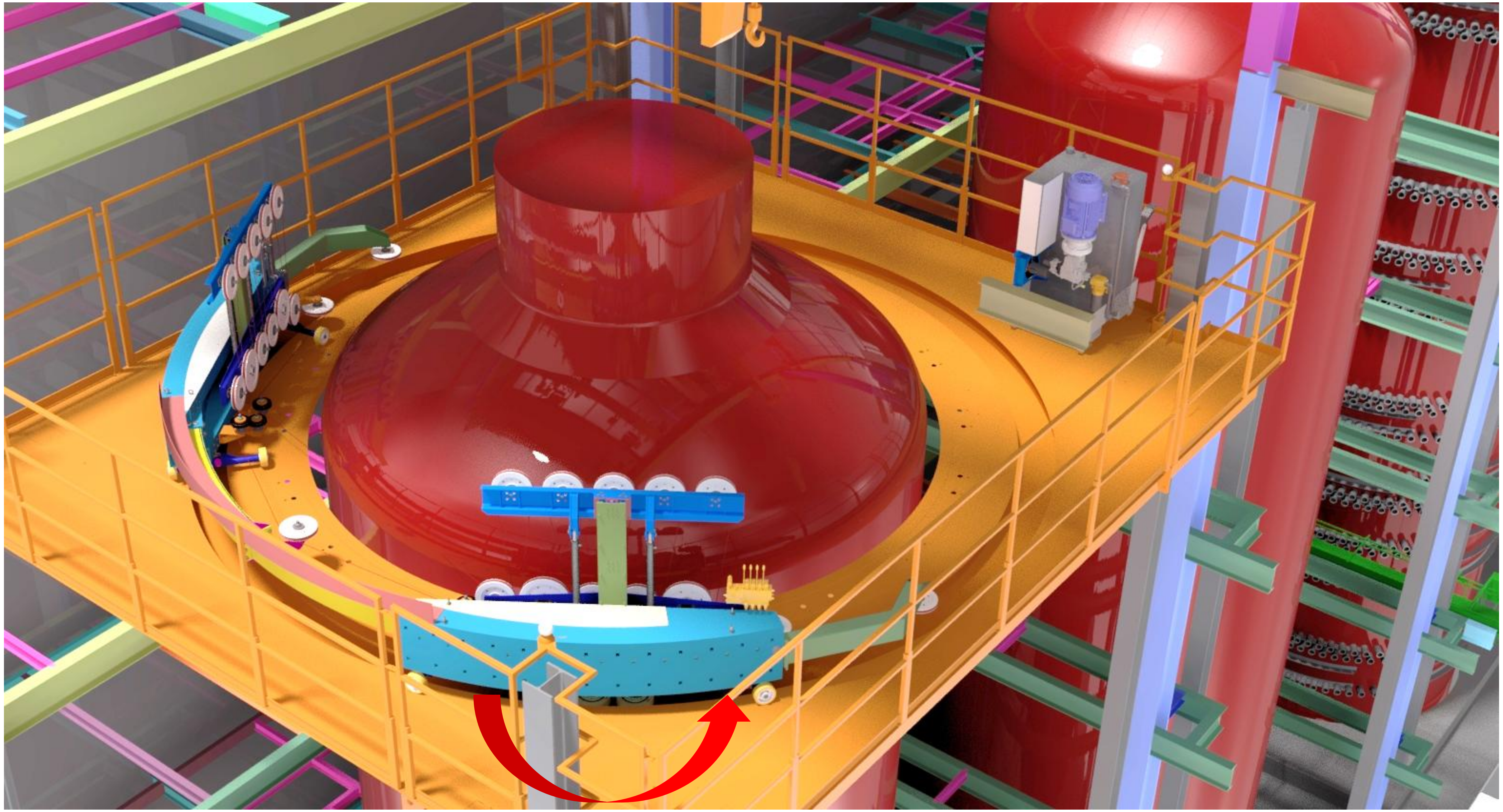

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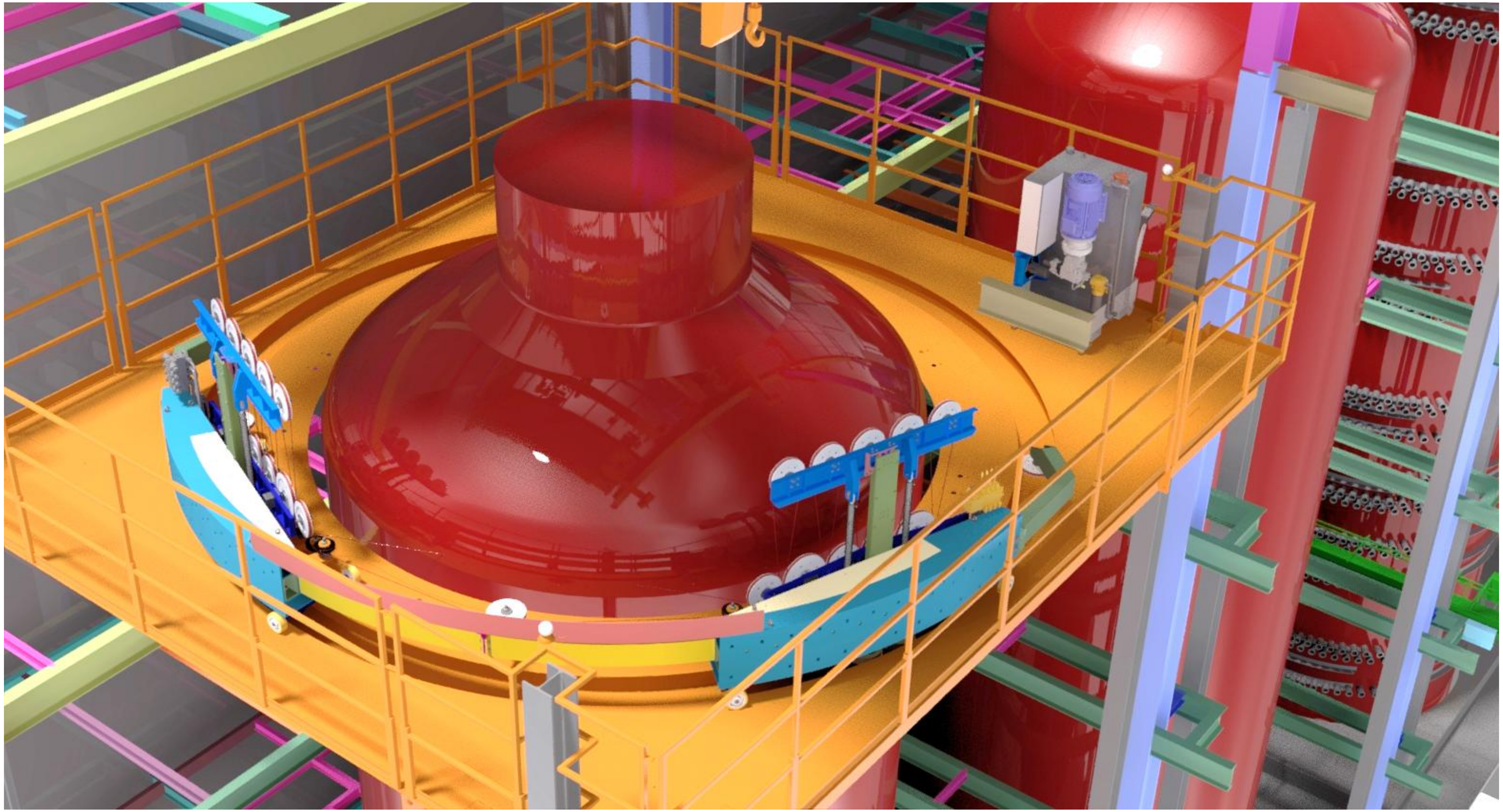

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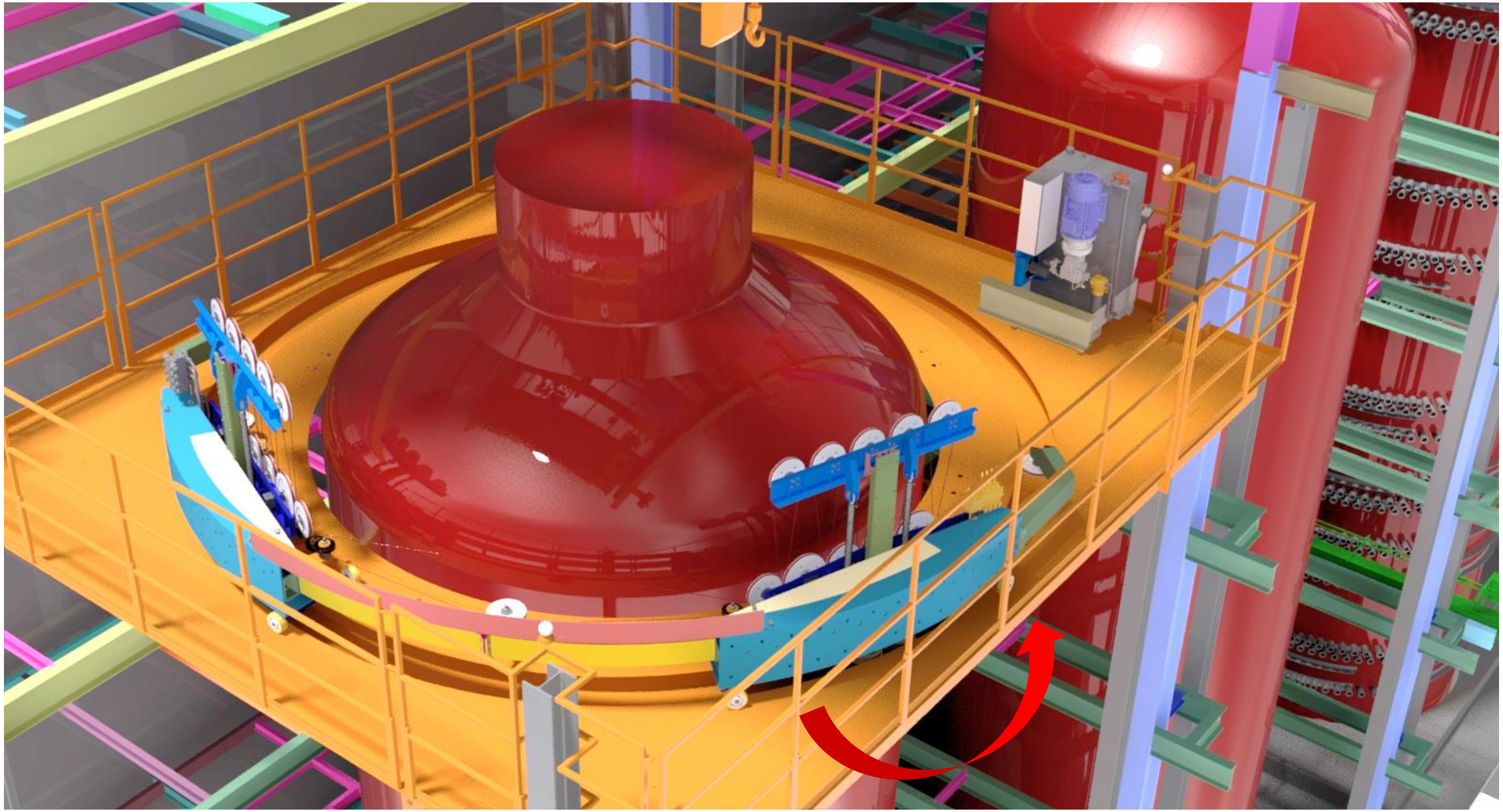

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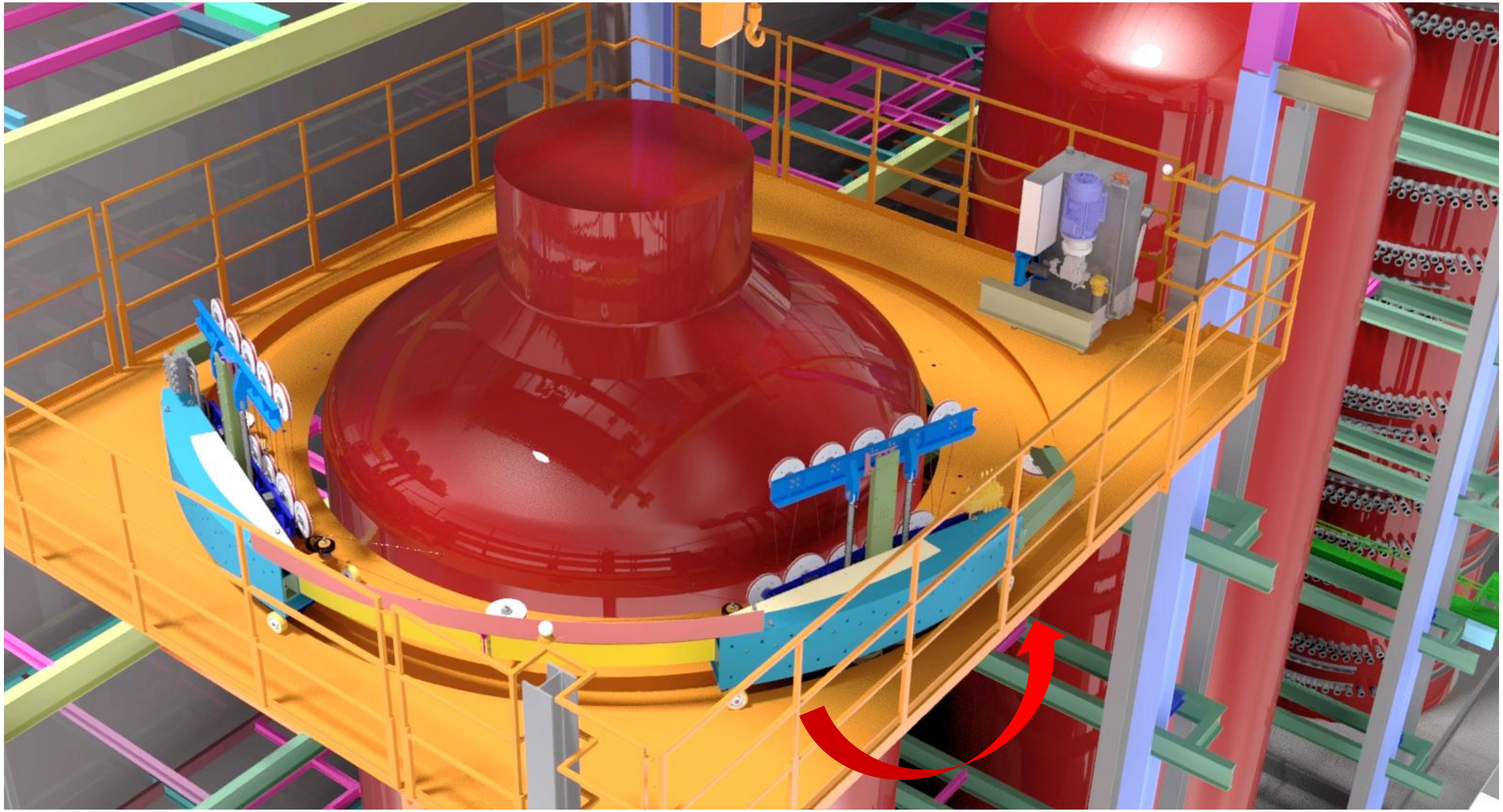

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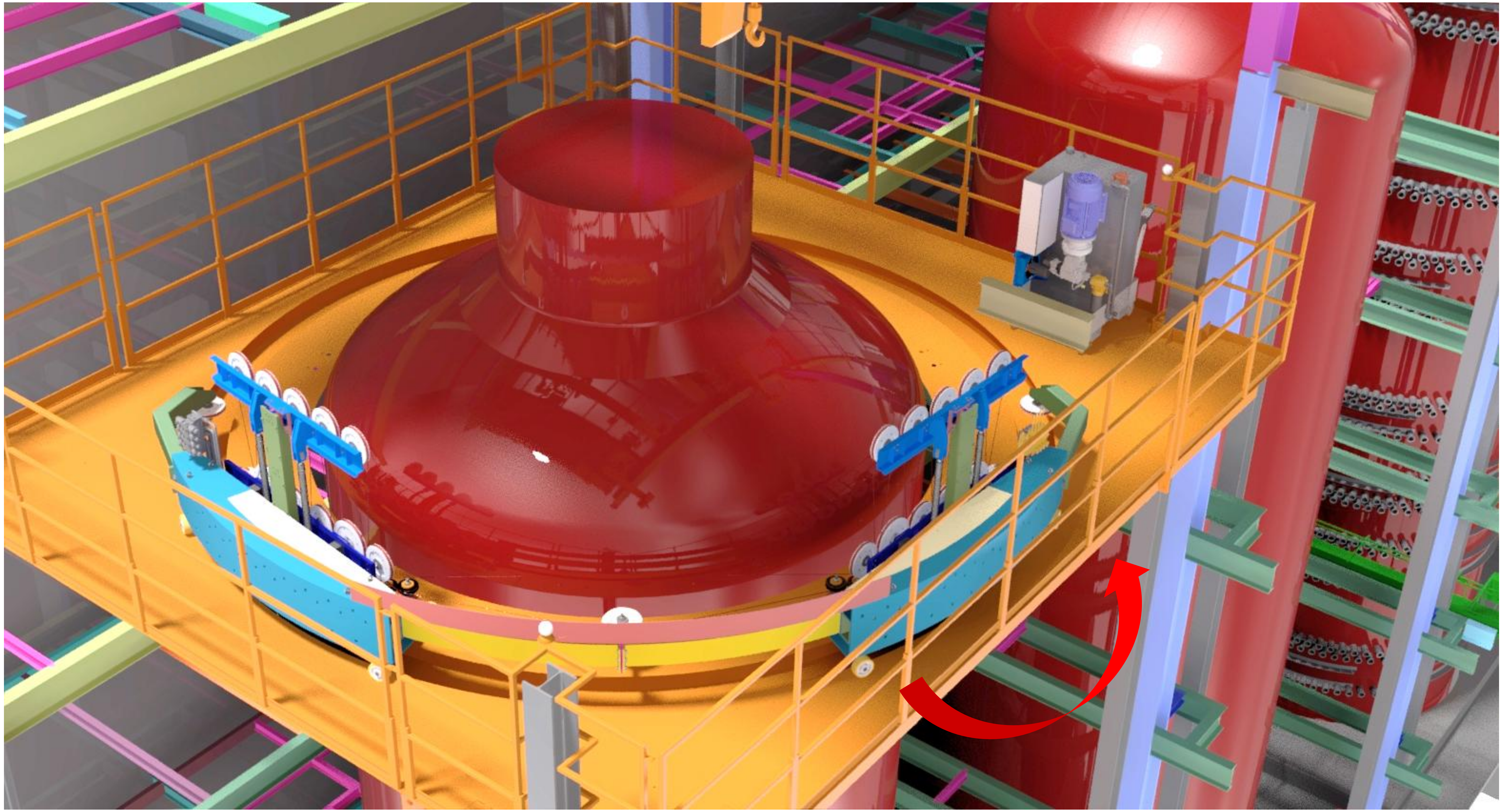
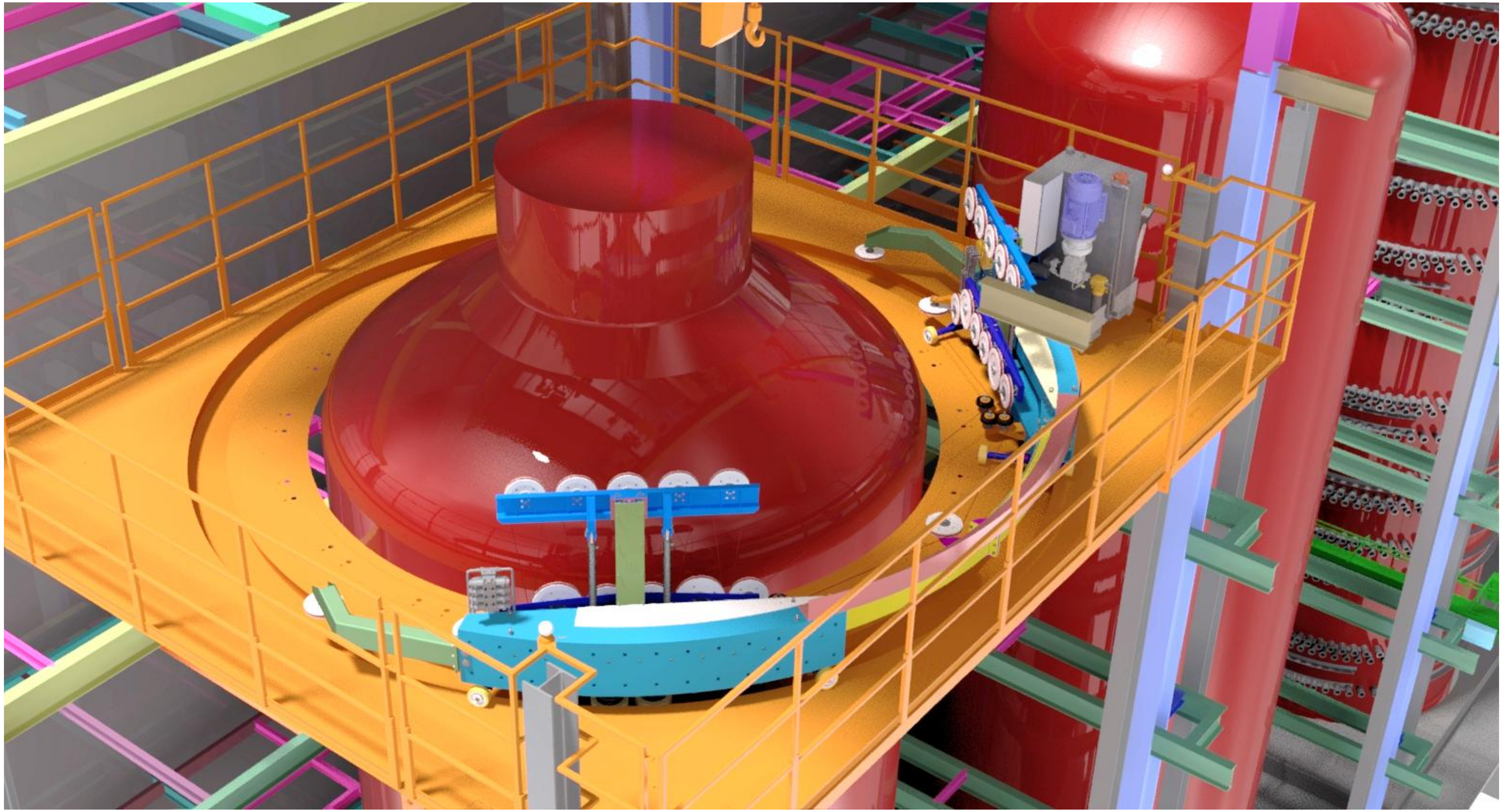
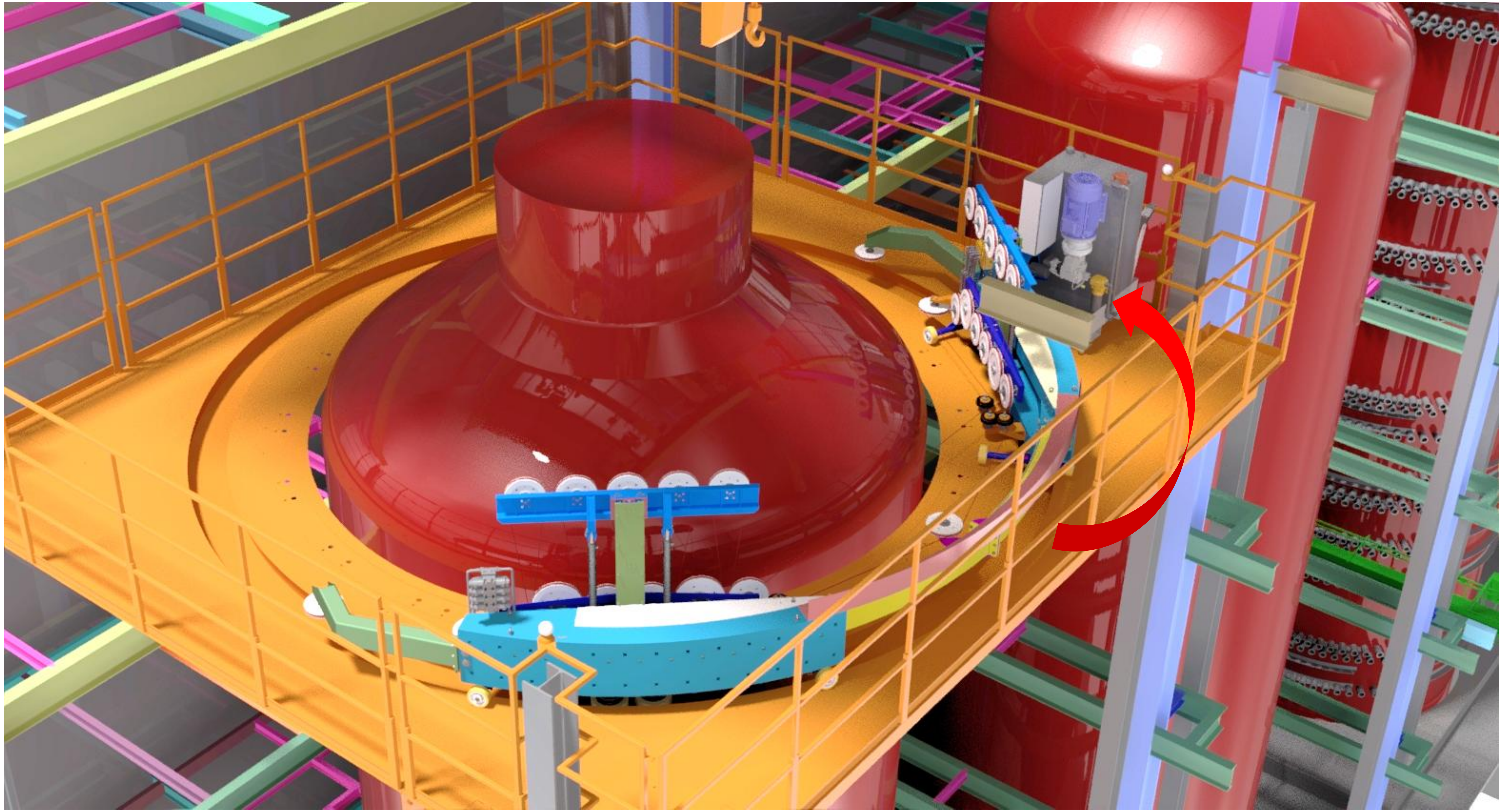


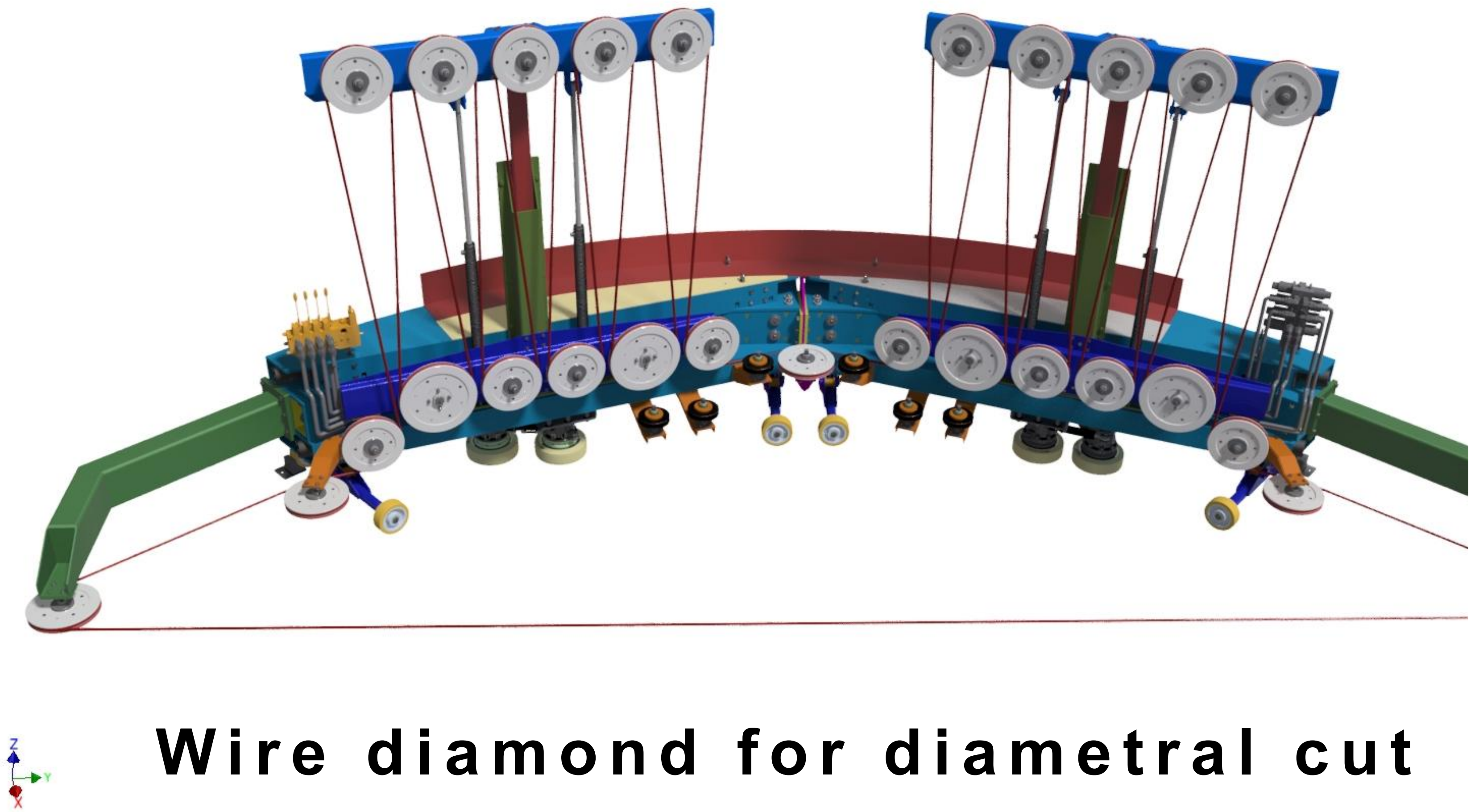
CONTINUATION OF CUTTING BY MACHINE ROTATION



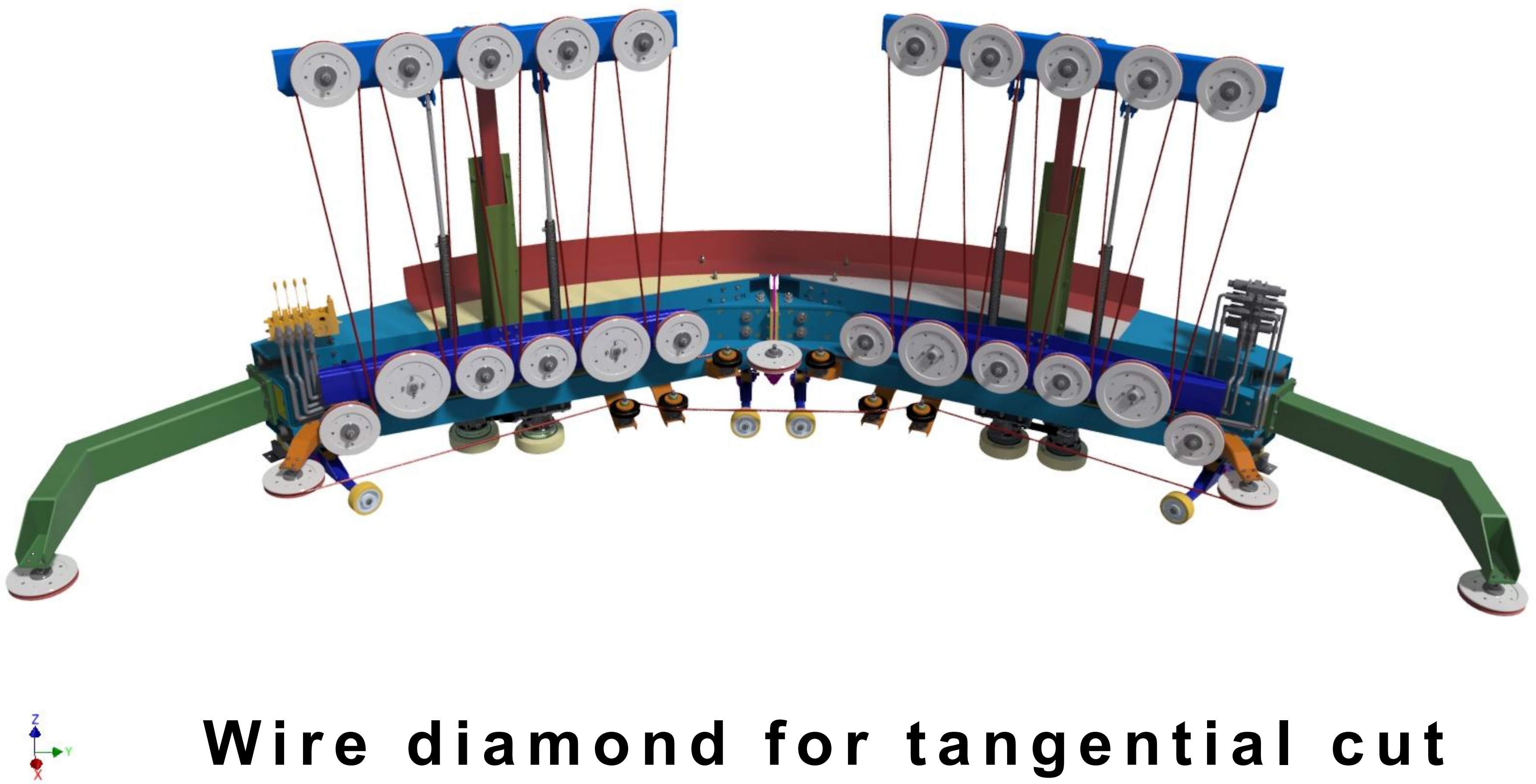
CONTINUE THE ROTATION UNTIL THE END OF THE CUT



Wire diamond configurations

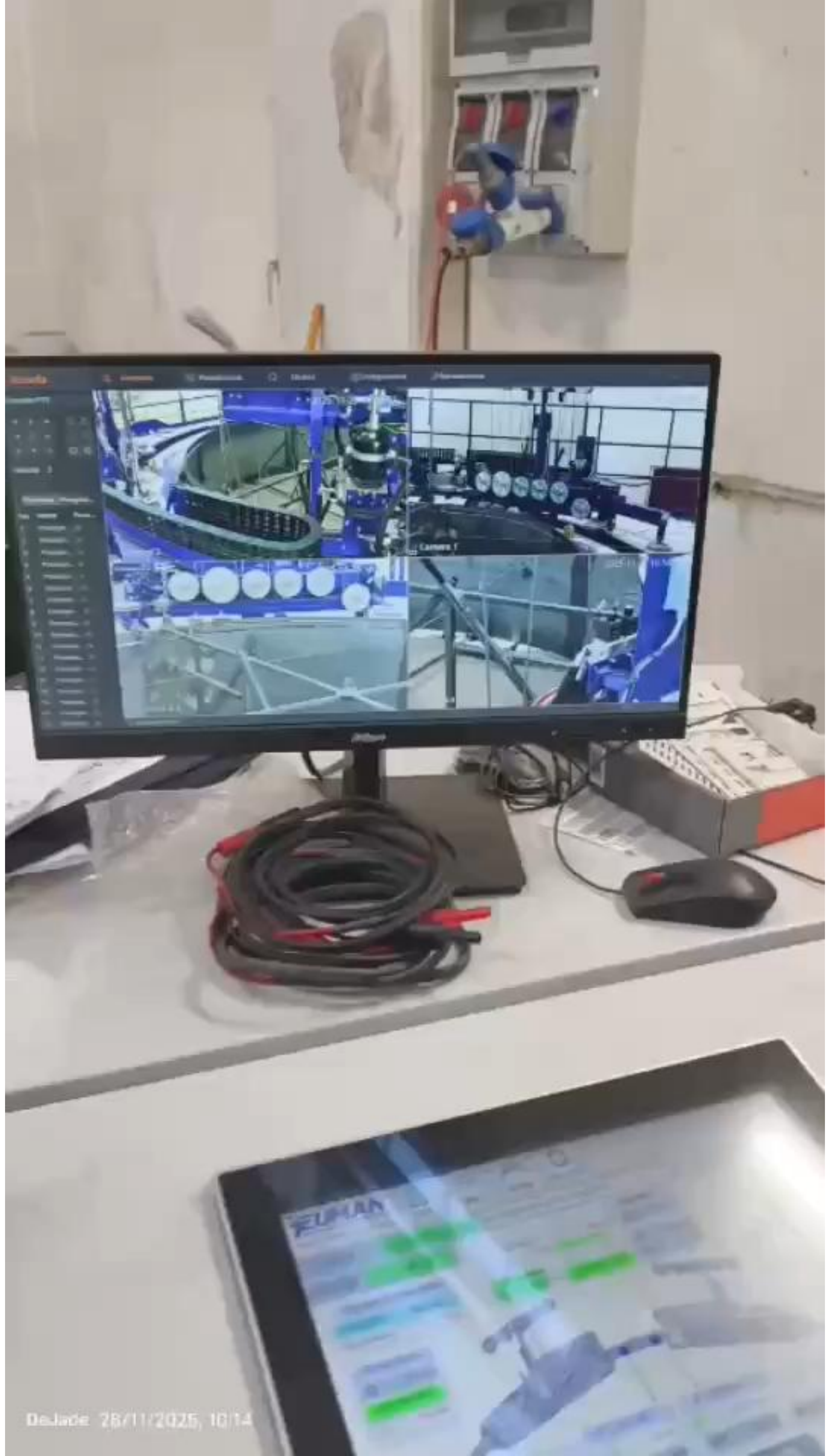


Wire diamond for diametral cut



Wire diamond for tangential cut

FAT



Thank you

March 2025

Post-segmentation of vessels at BARSEBÄCK and OSKARSHAMN NPP (SWEDEN)

uniper

Uniper Nuclear Service

GDES

A TRUSTED PARTNER

Contents

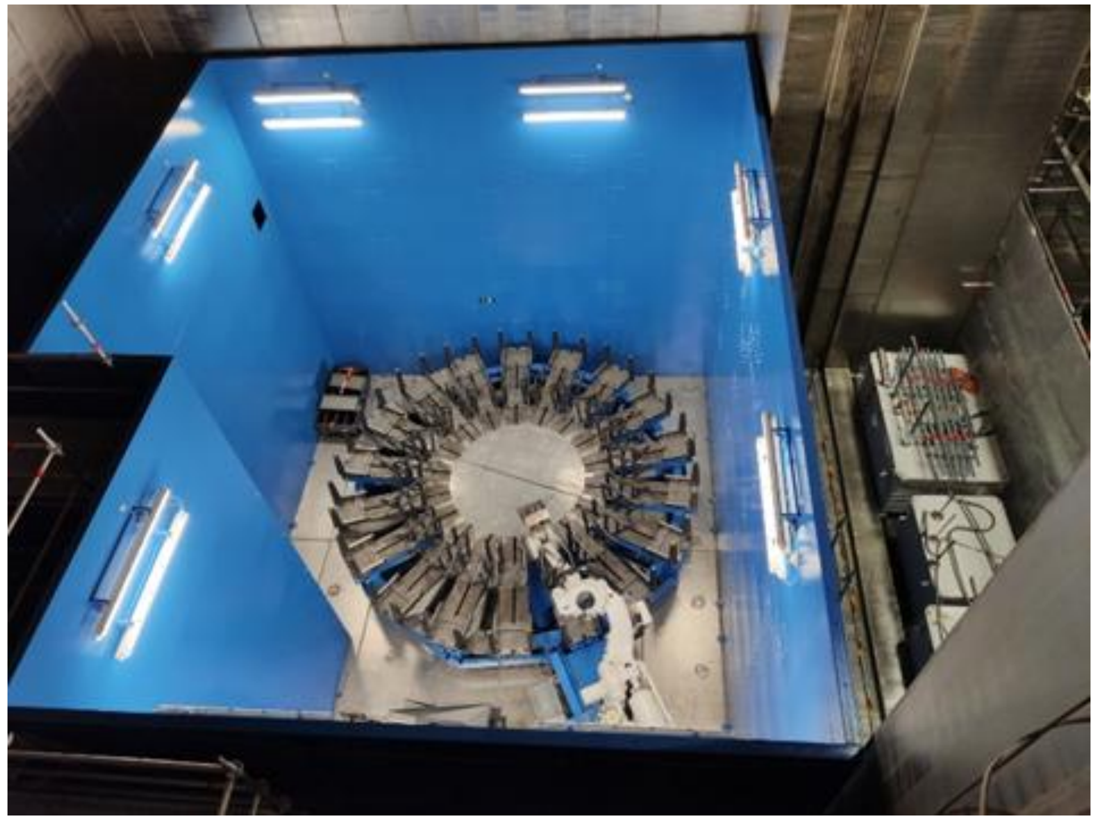
Introduction

RPV Segmentation Project – Sweden
A collaboration between Uniper Nuclear Services and GDES

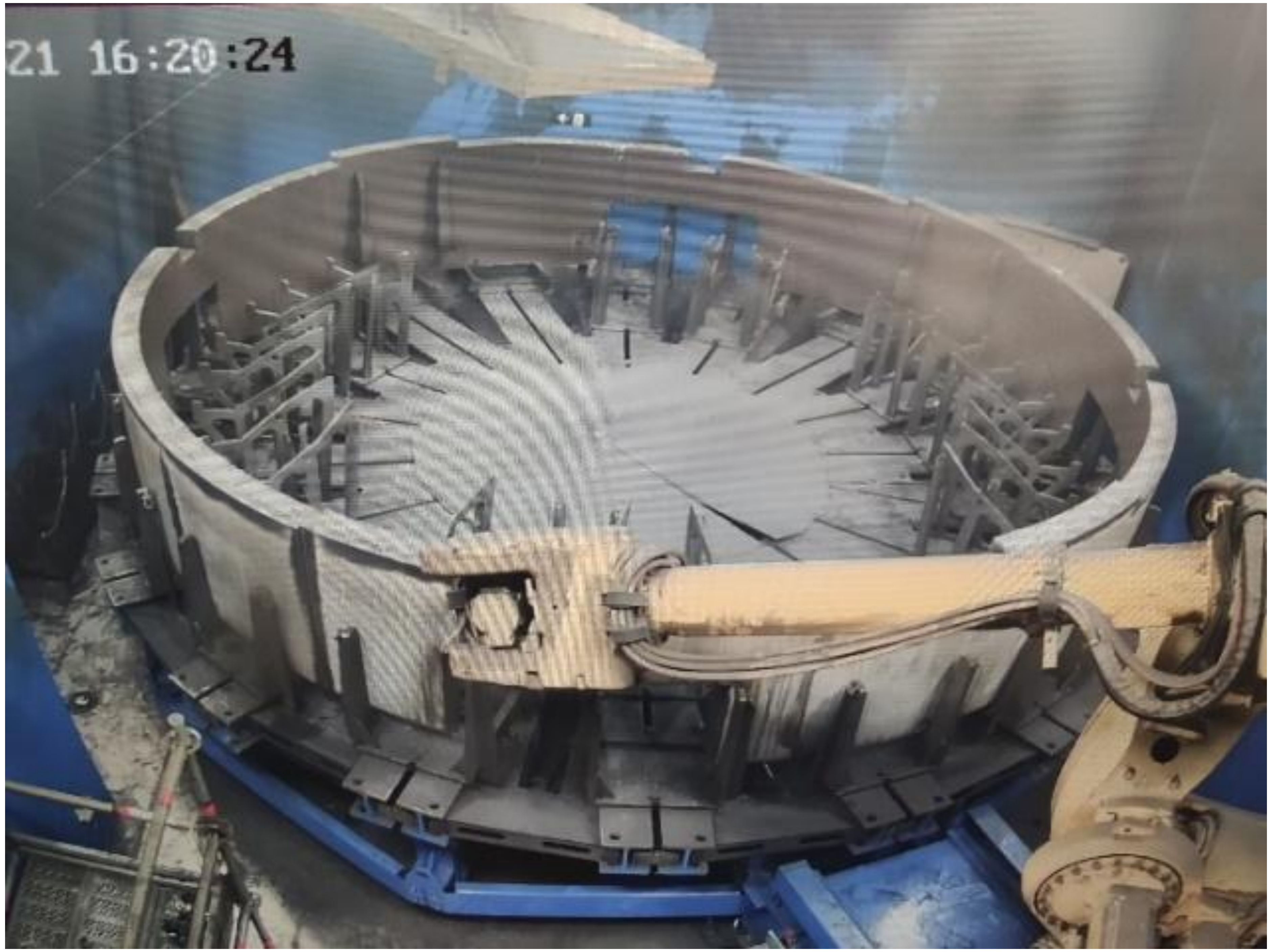
Uniper Nuclear Services acted as:
- Sole project owner and responsible contractor
- Developer of segmentation methods and technical solutions
- Provider of all key equipment and engineering
- Responsible for licensing, safety case, and project delivery

GDES acted as:
- Subcontractor within the Uniper project framework
- Supplier of blue-collar workforce for execution

Note:
- All methodologies, tools, and overall project delivery were led and managed by Uniper Nuclear Services



CASE STUDY

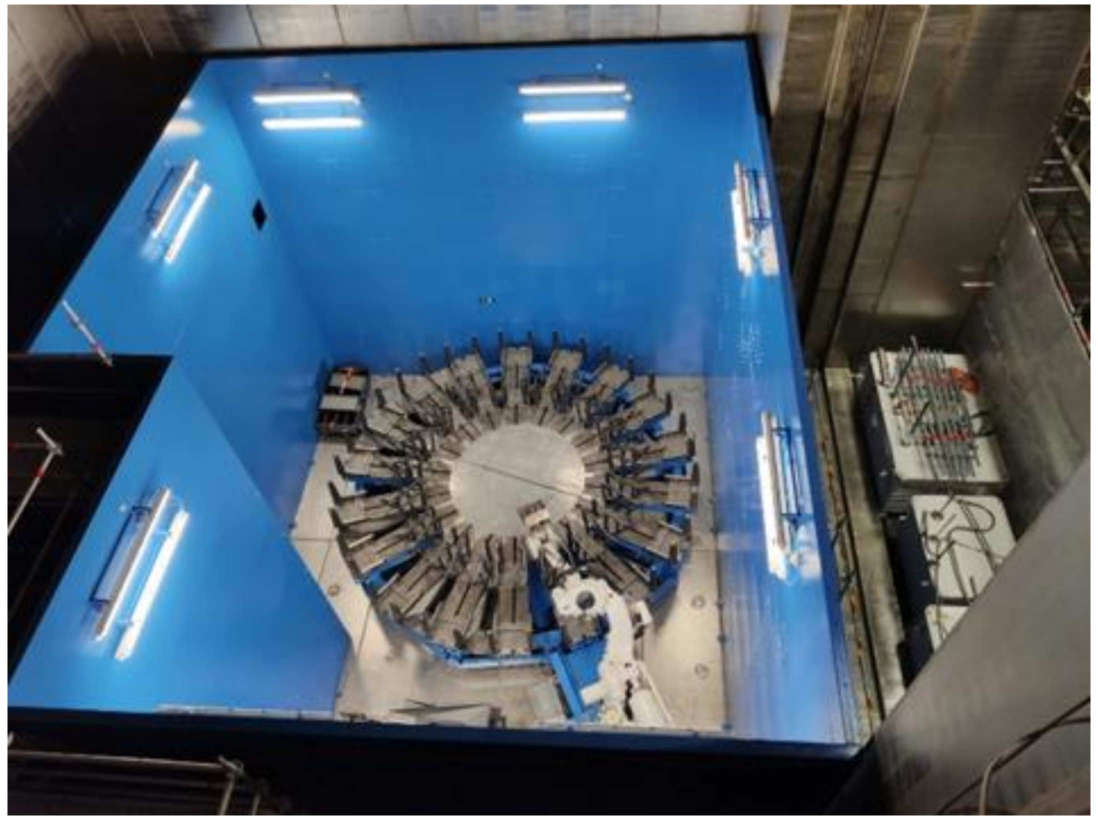


GDES Scope of work

- Barsebäck and Oskarshamn NPP (Sweden) → Post segmentation of:
  - four (4) reactor pressure vessels (RPV)
  - four (4) heads of RPV
- Previous operations:
  - Beams removal and pins cutting of the fuel pool
  - Barsebäck → Decommissioning of auxiliar systems (piping)
  - 16 tons bridge crane installation over the fuel pool
  - Worktable assembly for post segmentation activities, including
    - ✓ Robot used during cutting operations
    - ✓ Confinement of the area.
- Post segmentation with robotized thermal cutting.
- Waste preparation in containers 2-KKC (430 tons per vessel).

Cutting methodology

- Post segmentation of the vessel heads and vessel segments was carried out using thermal cutting (oxy fuel cutting).
    - Cutting pressures depended on the material thickness:
        - ✓ propane 0.3–1.6 bar
        - ✓ oxygen 8.5–11 bar.
- Automated process:
    - 6 axis remotely operated robot on a movement rail, connected to a rotating table
    - Equipped with different torch types to adapt to varying thicknesses (up to 600 mm).
- Cutting operations programmed and executed remotely from a control station located next to the cavity. Cutting speeds → until 4 mm/s.



CASE STUDY

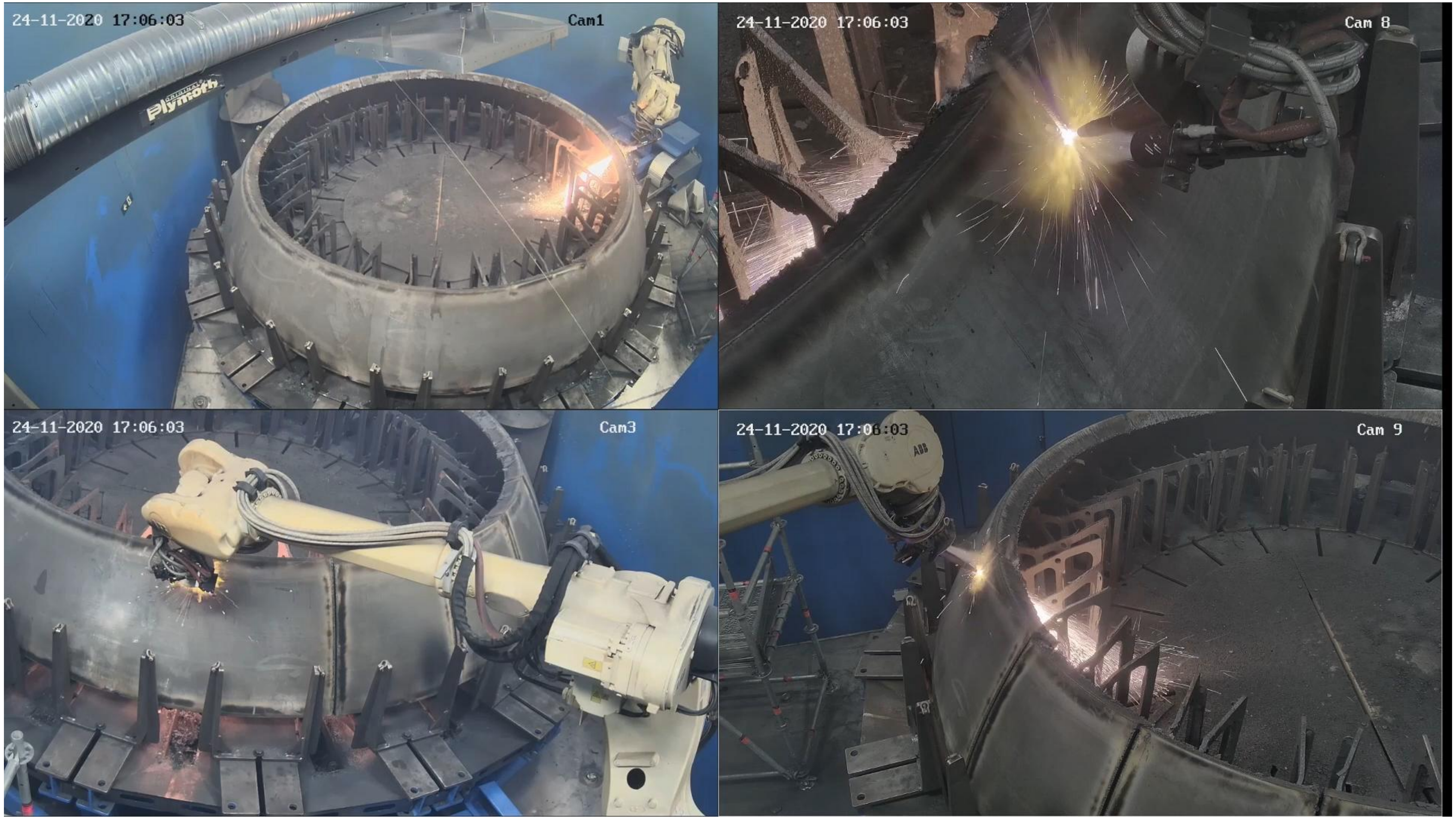
Cutting methodology

Tangencial cutting

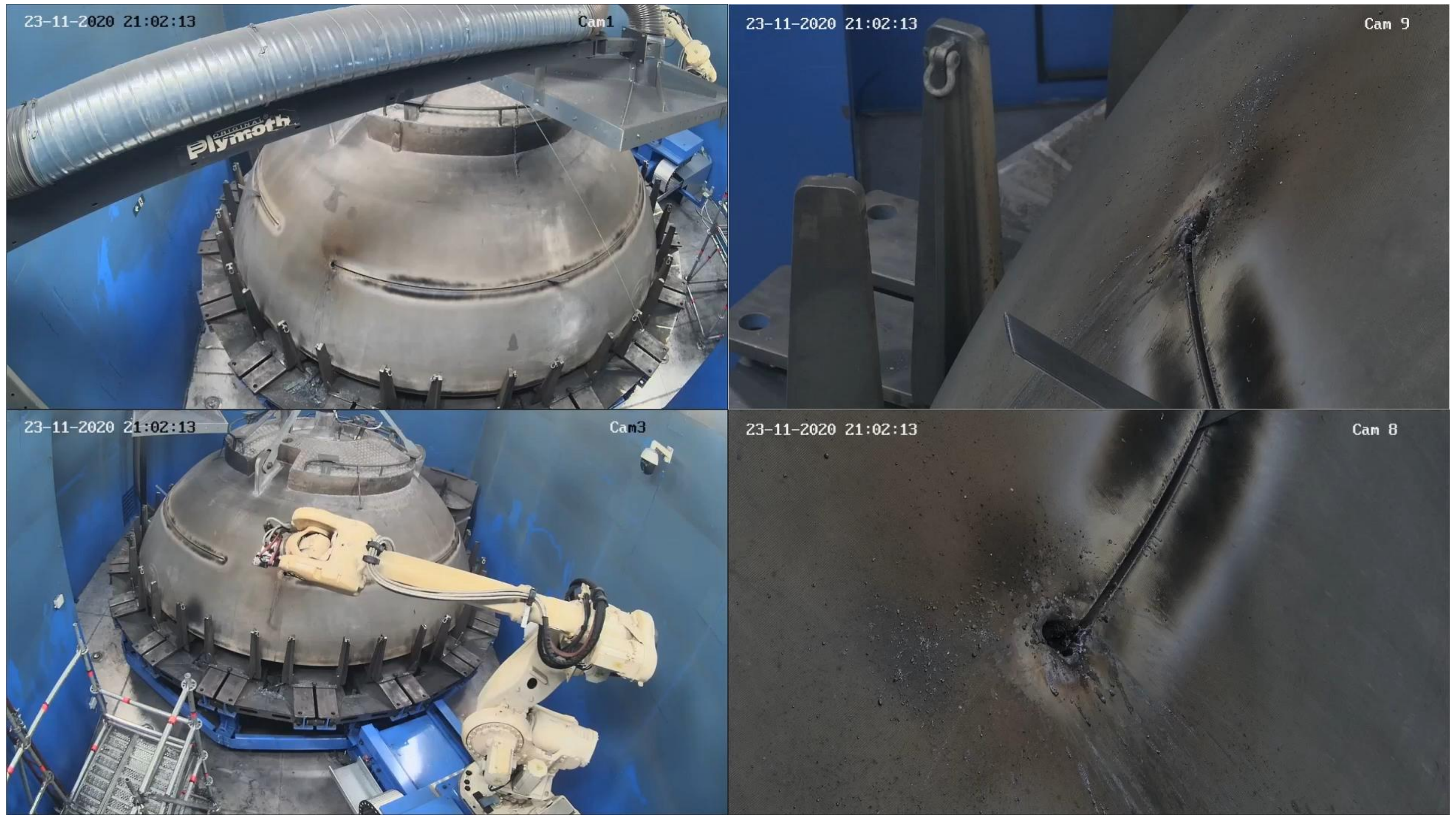
CASE STUDY

Cutting methodology

Cutouts segmentation



Improvement in preheating process

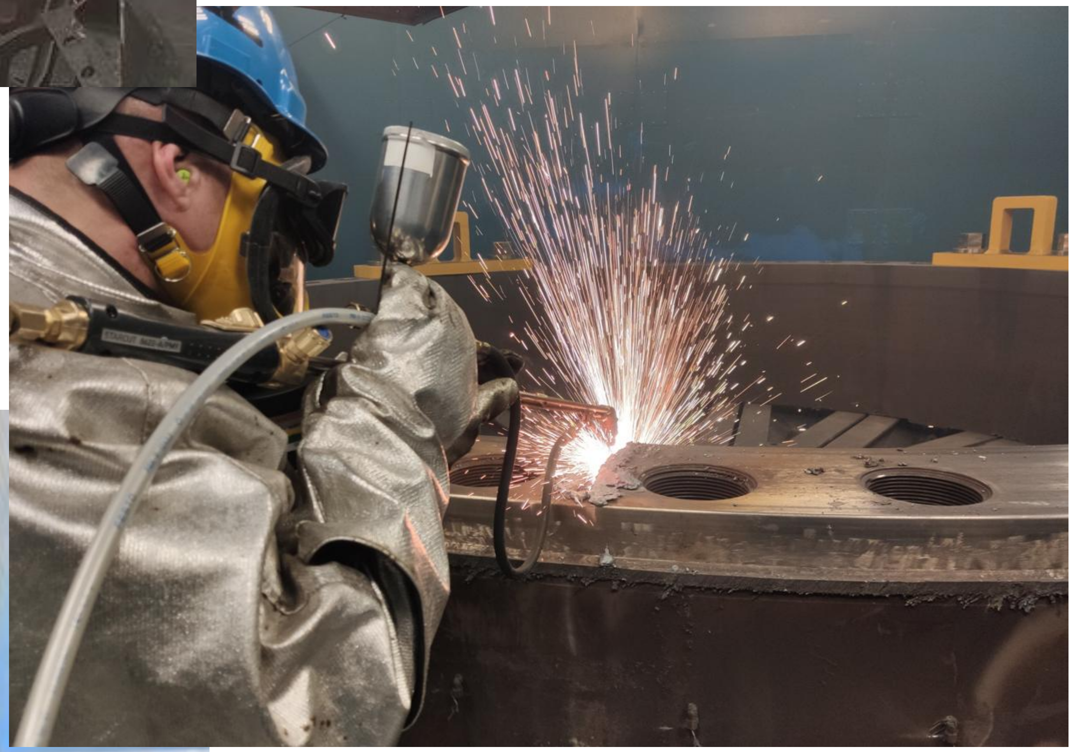


- The entire thermal-cutting segmentation process begins with a preheating phase.
  - Full thickness of the piece must be preheated
  - Accurate positioning of the torch (perpendicular to the part and exactly at the point where the cut is to begin

  Once proper preheating is observed → cutting must start immediately.
- Initial cutting methodology fully automatic, requiring to preset both the position and the preheating time.
- Experience showed that:
  - Setting the position unambiguously is extremely difficult
  - preheating time cannot be reliably parameterized
- Methodology was modified:
  - preheating to be performed manually (via remote control)
  - cutting program launched only once preheating had been correctly completed.

HVAC system

- Air filtered by HVAC system during cutting operations reaches high temperatures.
- In case that the conducts of the system are not long enough, hot temperatures may affect to the filters, as they are not design to work in such challenging conditions
- It is important to consider the elevated temperatures reached at the time of dimensioning the HVAC system. Enough length for the conducts shall be considered for proper cooling when the air arrives to the filters.



Inconel cutting

- The presence of an Inconel ring on the vessel flange prevented proper execution of the flange segmentation using thermal cutting.
- Manual cutting tests were performed
  - Thermal lance
  - Grinder

    → Feasible, but high labor intensive and cost.
- Attachment added to the thermal cutting torch to inject a high-pressure zinc oxide jet into the oxygen–propane mixture. The result was satisfactory.
- Accessory finally integrated into the cutting robot for automatization, allowing the abrasive jet to be activated from the control station.

Synergies in decommissioning strategies

- The similarities among the four Barsebäck and Oskarshamn reactors facilitated the implementation of synergistic dismantling strategies, (methodologies and), enabling:
  - cost reduction
  - continuous improvement in quality
  - execution speed by applying lessons learned on site.
- Equipment was moved from one reactor to the next as each set of tasks was completed.
- Same cutting programs used for post .
- Lessons learned were applied to optimize subsequent cuts.
- Final durations for post segmentation of RPV and head:
  - 5 months in the first reactor
  - Fourth reactor → reduced to 8 months

Thank you

Ein Unternehmen der **EWN** Gruppe

KTE

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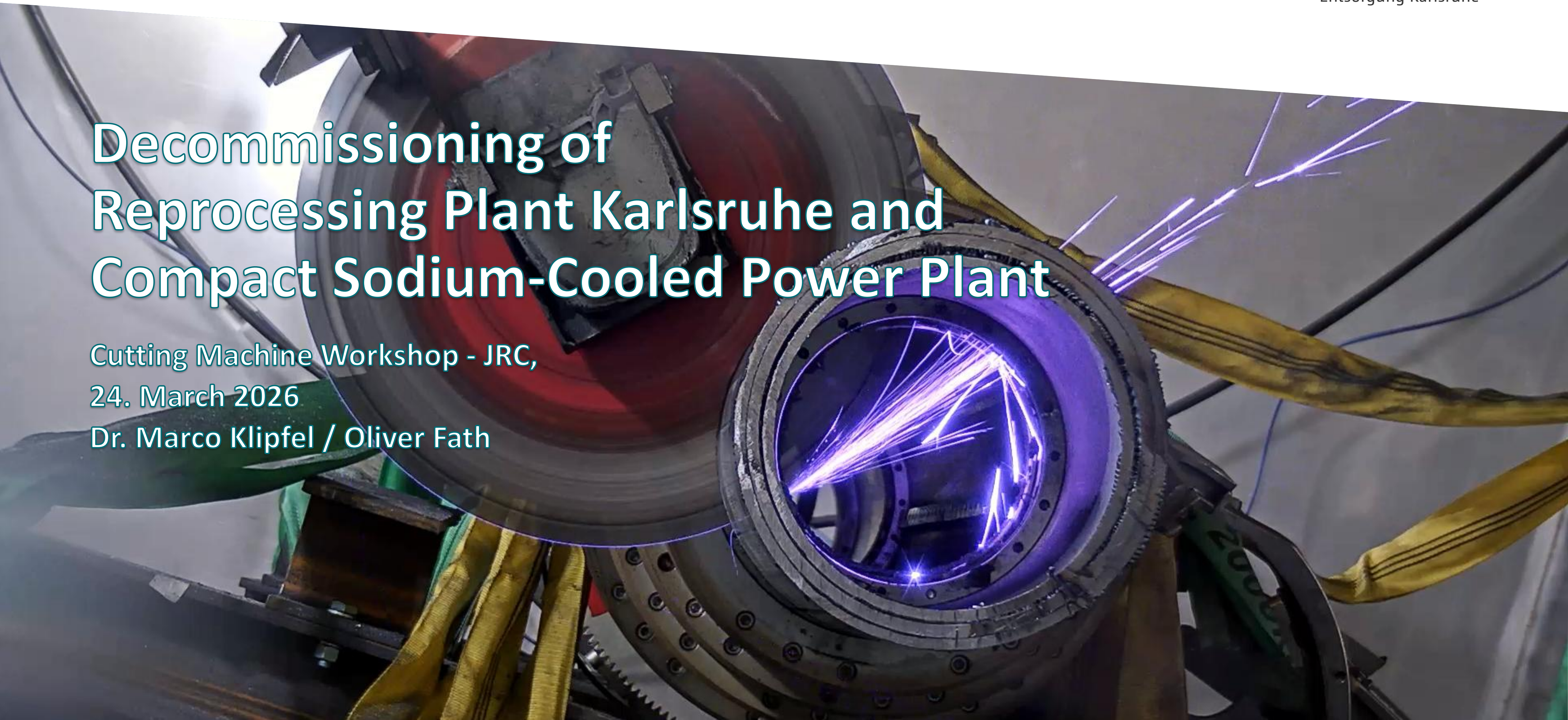


Decommissioning of Reprocessing Plant Karlsruhe and Compact Sodium-Cooled Power Plant

Cutting Machine Workshop - JRC,
24. March 2026

Dr. Marco Klipfel / Oliver Fath

Our D&D Projects And Business Units

KTE

Kerntechnische Entsorgung Karlsruhe

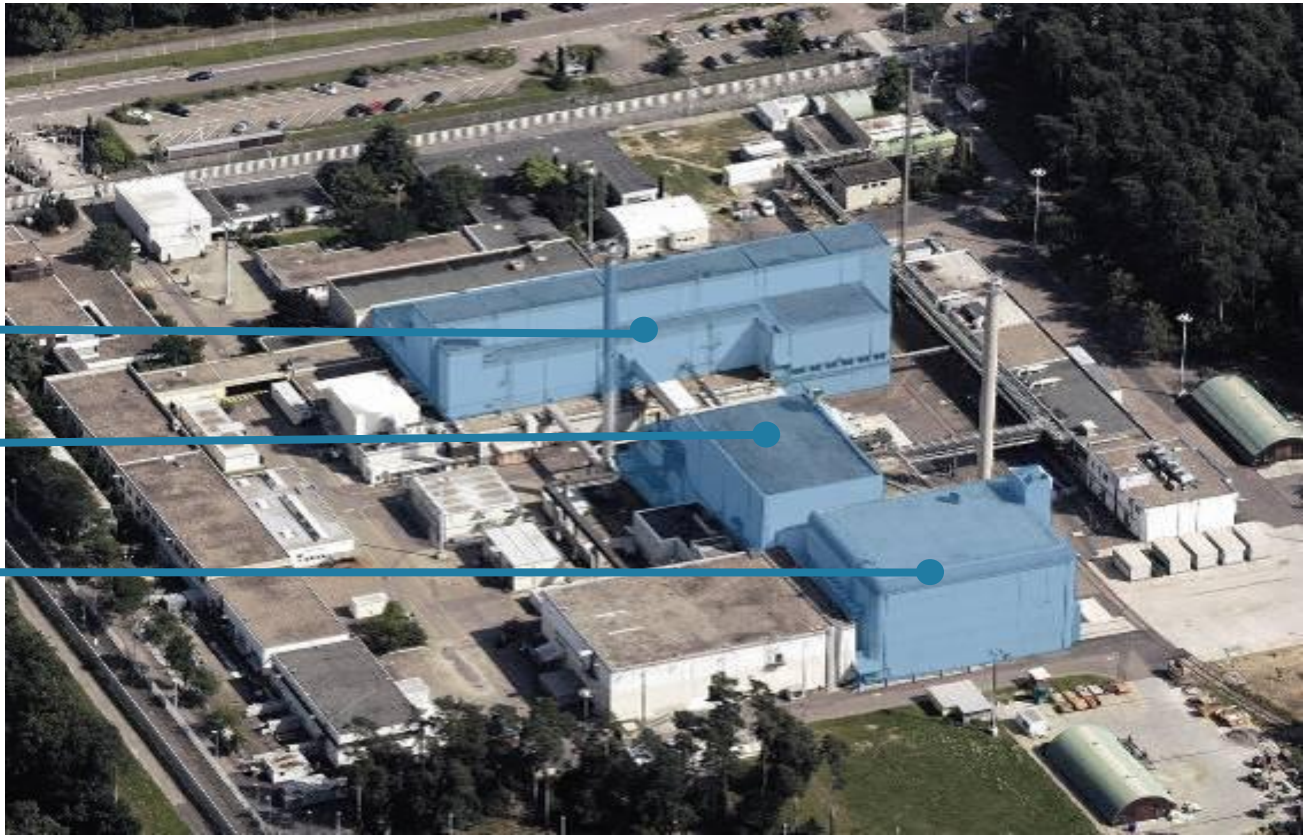
Our D&D Projects
And Business Units

Karlsruhe Reprocessing Plant (WAK)

Reprocessing Plant

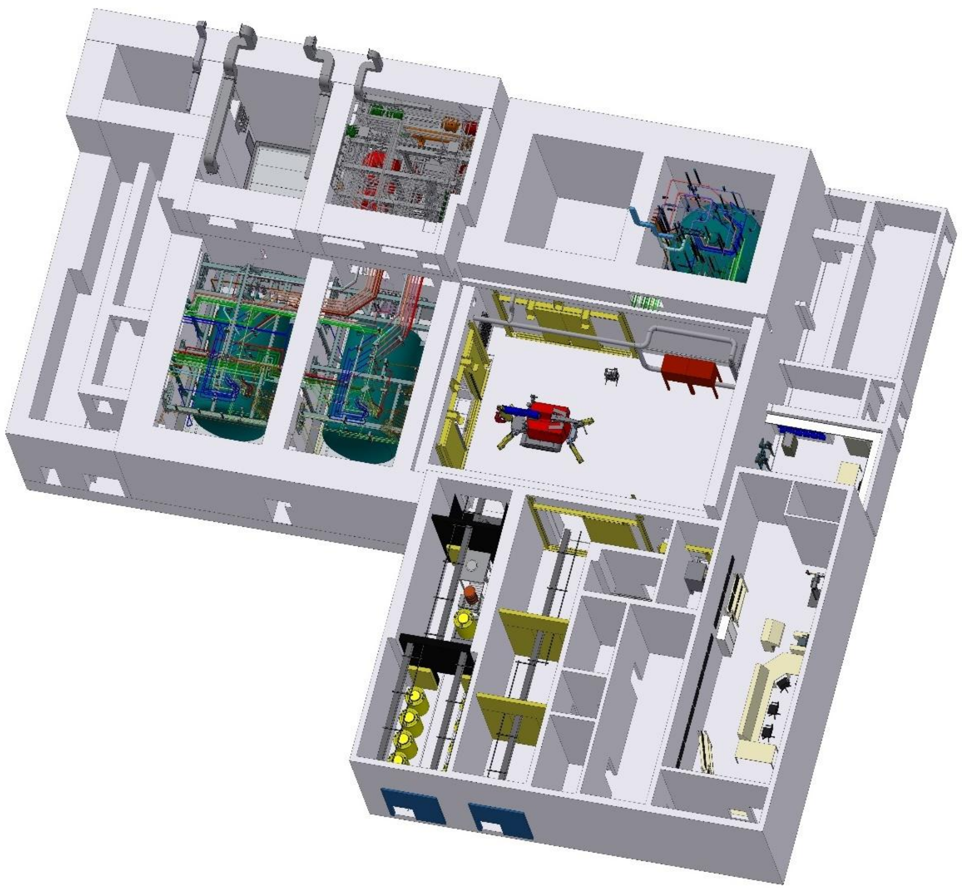
HLLW-Storage Facility

Vitrification Facility VEK

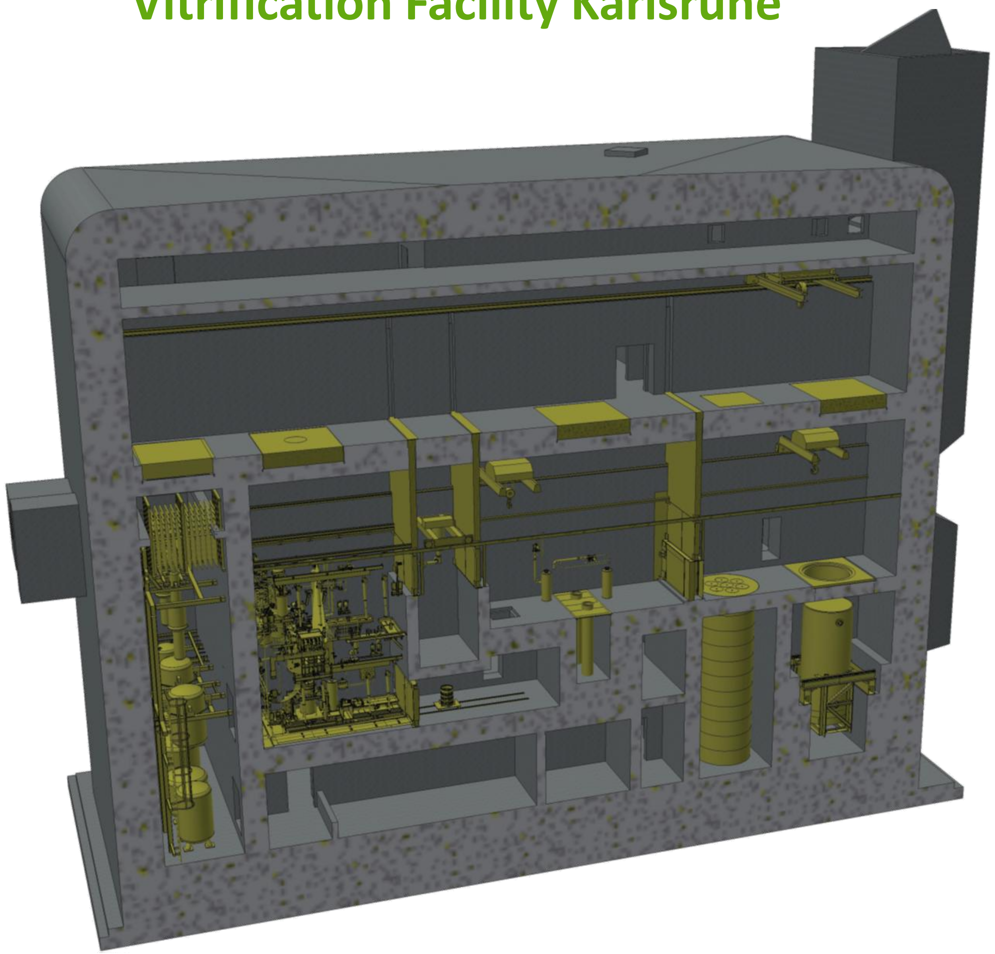


Comparision of D&D Projects

HLLW Storage Building

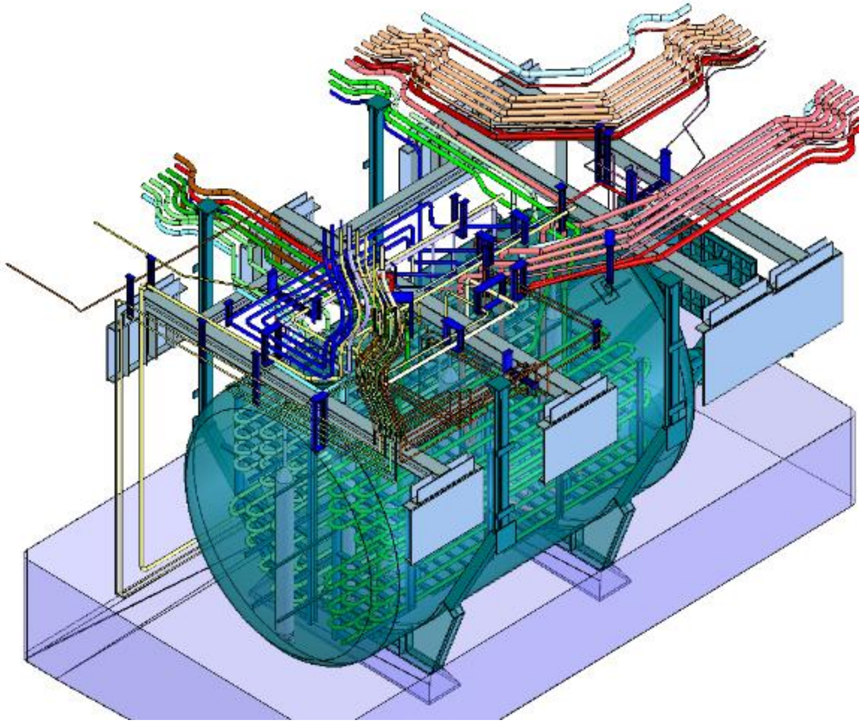


Vitrification Facility Karlsruhe



Comparision of D&D Projects

HLLW Storage Building



Vitrification Facility Karlsruhe

Details of D&D Projects

What we need to dismantle

- Stainless steel
  - Pipes diameter max. 80 mm / thickness 5mm
  - Tanks max. 12 mm
  - I-Beams max. HEM 300
- Carbon steel
  - Massive earthquake protections
  - reinforced steel structures

Technical Constraints

- Limited space in cells and buildings
- NO possibility for liquid MAW treatment
- Dose rates up to **1500 Gy/h** in cells
  - Need for radiation tolerant cutting tools, A&V system, manipulators, etc.
  - Need for recovery concepts of manipulators

Remote Control Machinery for Dismantling

HLLW Storage Building

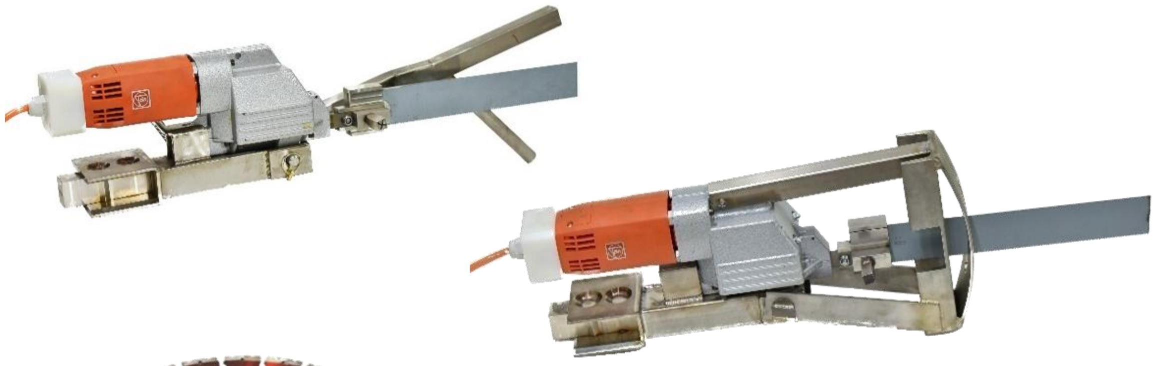
TOPTEC 5500E hydraulic dredger as manipulator carrier system. The manipulator is a **TELBOT, TB 1000** (max . payload 100 kg) used for entire decommissioning work.

Vitrification Facility Karlsruhe

Power manipulator A1000 (max . payload 100 kg & 1 to hook @ telescope) used for entire decommissioning work.

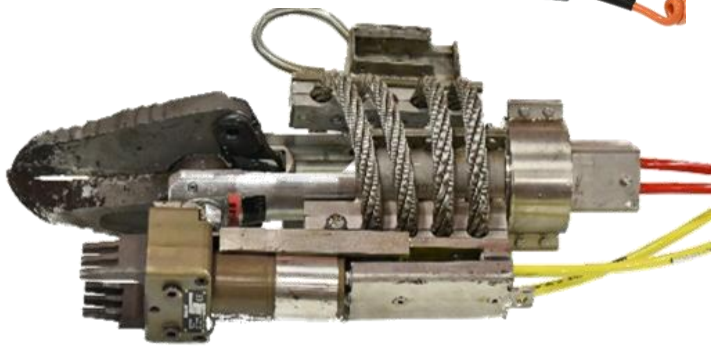
Remote Control Machinery for Dismantling

- **Hacksaw**, ideally suited for cutting **without** sparks
  - Pipework
  - Beams, profiles and metal sheets

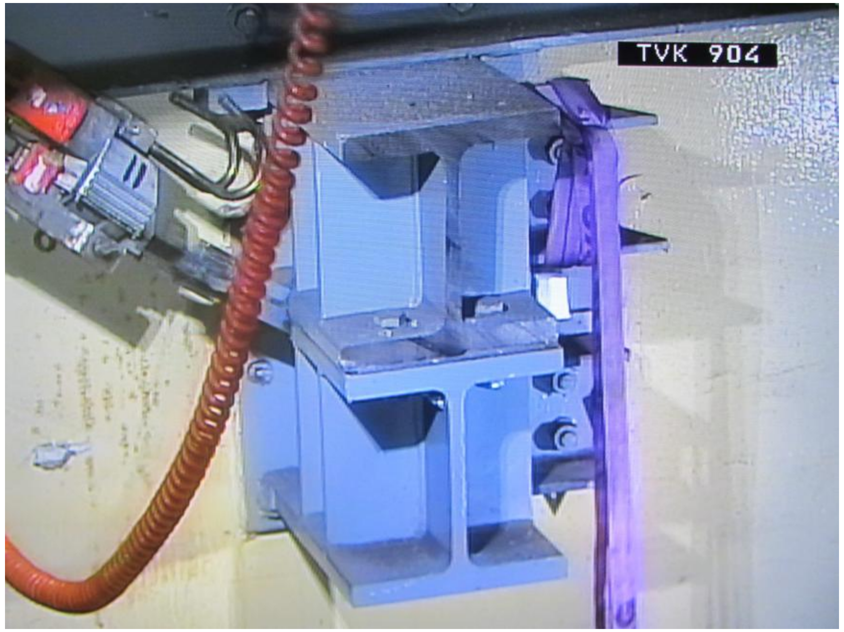


- **Angle grinder** ∅ 350 mm (13.7 in), **high** cutting rate is achieved. Control of sparks is necessary.

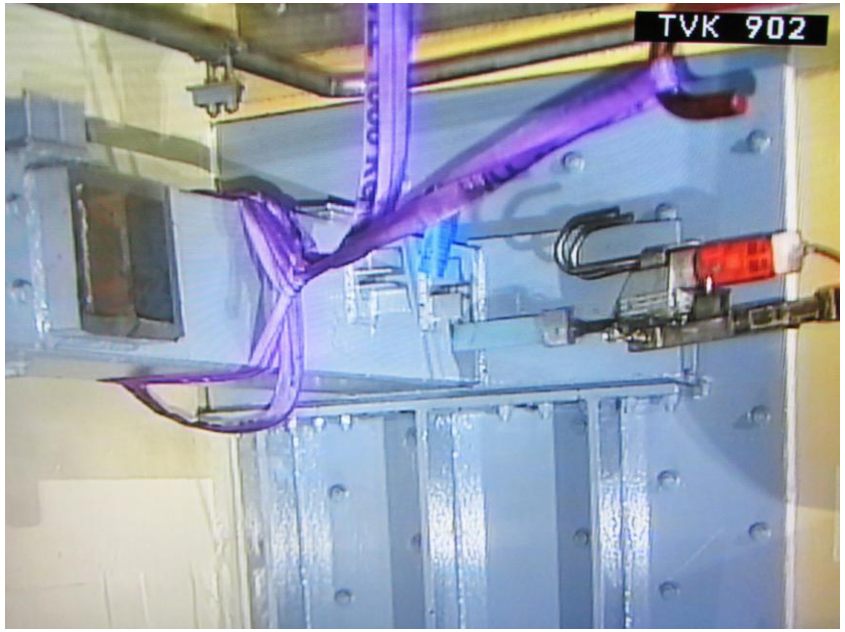
- **Lukas** hydraulic cutter, 700 bar, cutting up to DN 50 **pipes** (60.3 x 4.5 mm) with integrated pipe holder.



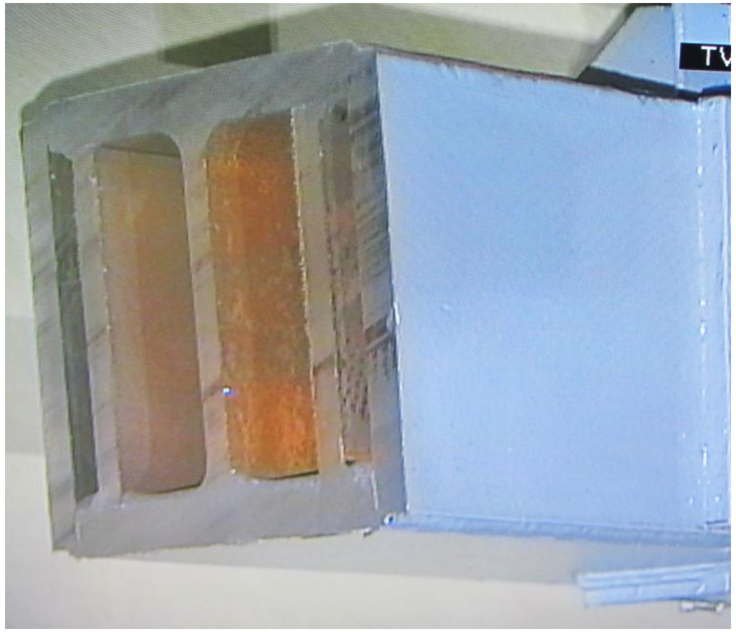
Impressions of Dismantling Work



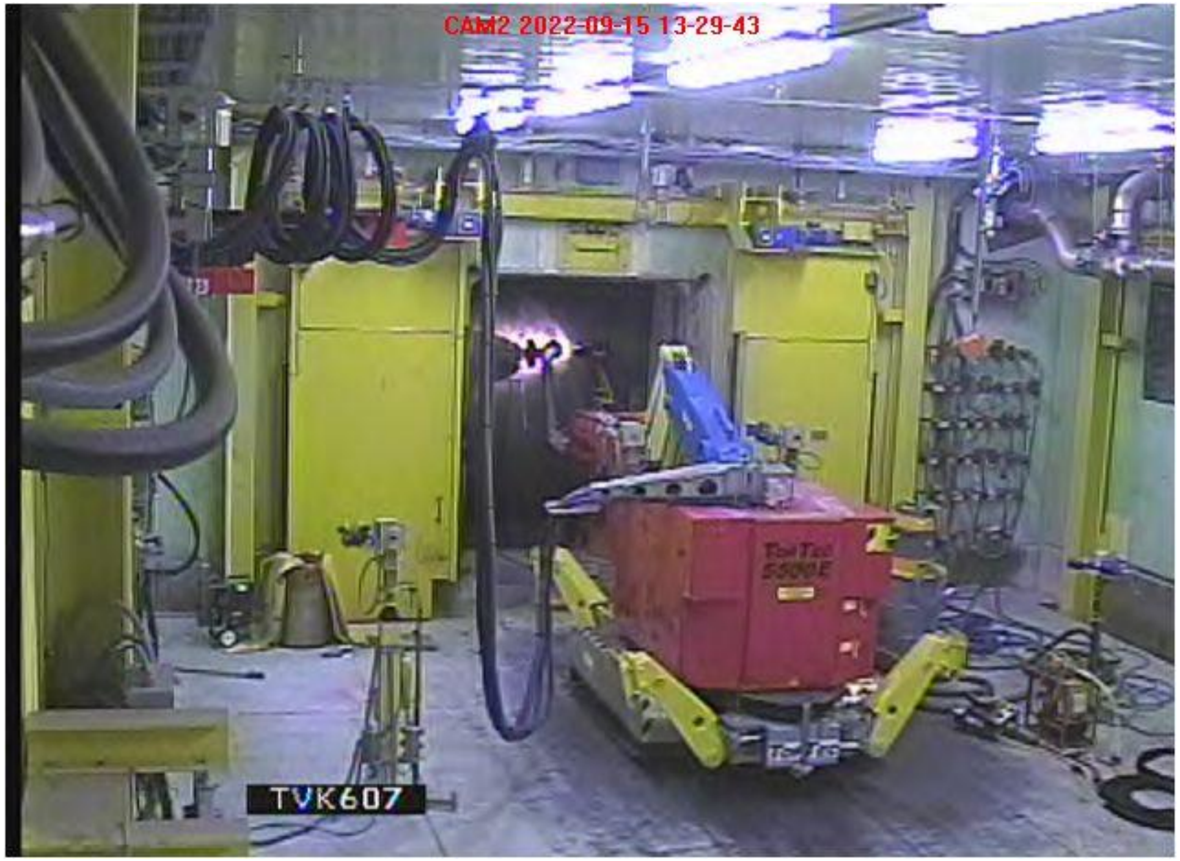
Hacksaw cutting a double I-beam



Hacksaw cutting reinforced steel structure


I-beam HEM 300 4 times reinforced

Impressions of Dismantling Work

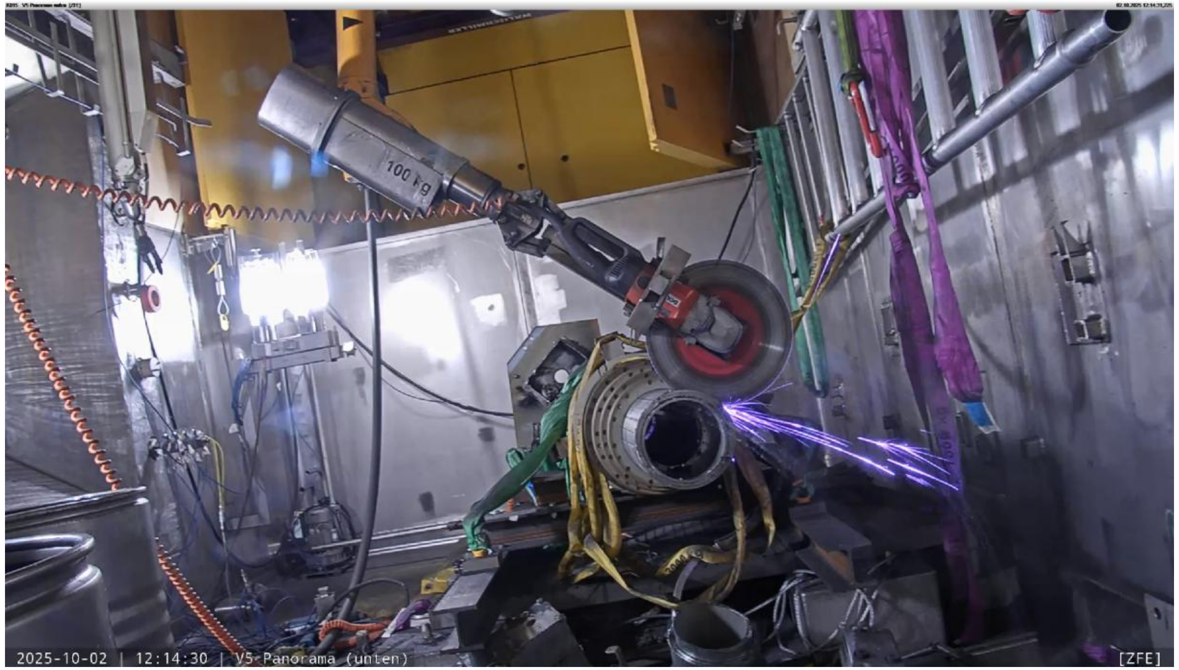


TOPTEC starts cutting the HLLW storage tank

Angle grinder cutting couling pipes inside HLLW tank

Impressions of Dismantling Work

Cutting the manipulator housing



Cutting the telescope

KNK – Dismantling the Biological Shield

Modular Platform System for the Dismantling Tool

- Pluggable modular construction
- Platform for the dismantling tool and the manipulator baseplate
- Capture for falling concrete debris
- Grate to limit the debris sizes
- Integrated, baffle plates to slowdown the drop of concrete debris

Platform top piece with grate

Platform upper segment with grate and debris-funnel

Platform ground section with waste-removal unit

Platform baseplate

KTE

KNK – Dismantling the Biological Shield

Remote operated demolition vehicle with remote rescue equipment

Hydraulic hammer attached to demolition vehicle

KNK – Dismantling the Biological Shield

Power Manipulator attached to “OilQuick” coupler with grinder and 350 mm disc.

Manipulator base plate with manipulator adapter and lifting points for twist look spreader

KNK – Dismantling the Biological Shield

Remote cutting using an angle grinder(Cutting depth: 75 mm)

Picking up the first cut segment with a magnet

KNK – Dismantling the Biological Shield


Excavator in reactor shaft on top of the platform


Excavator at bottom of the reactor shaft

KNK – Dismantling the Biological Shield

Cutting the formwork tank

Cutting the outer edges of the sodium outlet pipes

GRAZIE MILLE PER L'ATTENZIONE!