RADCO

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RADCO PROFILE

RADCO
EPRS CENTER (Offshore & Onshore)

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Table of contents

Page

1.0 INTRODUCTION

1.1 COMPANY INTRODUCTION

RADCO (Meh Rad Sanat Khallagh), established in 2017, is a knowledge-based company specializing in engineering and manufacturing advanced equipment for the repair and maintenance of onshore and offshore pipelines. With all required licenses and a strong R&D foundation, RADCO has developed the infrastructure—including a specialized production facility and dedicated testing labs—to design and produce high-tech, strategic EPRS (Emergency Pipeline Repair Systems) products for the oil and gas industry.

Core Competencies:

- Engineering and manufacturing of smart pipeline solutions (e.g. Smart Flange, Smart Clamp)
- Custom equipment for leak repair (split sleeve clamps, elbow clamps, box clamps)
- Reverse engineering and production of advanced oil & gas components
- Detailed and fabrication-level engineering services

By maintaining full control over its manufacturing processes and offering comprehensive supervision for installation, RADCO delivers reliable, cost-effective, and original solutions tailored to each client's needs—reducing both repair costs and downtime.

1.2 ABBREVIATIONS

The following definitions refer to abbreviations used throughout this document:

Parameters	Abbreviations
ASME	American Society of Mechanical Engineers
DNV	Det Norske Veritas
FAT	Factory Acceptance Test
FEA	Finite Element Analysis
FFS	Fitness For Service
ID	Inner Diameter
ITP	Inspection and Test Plan
MRB	Manufacturing Record Book
OD	Outer Diameter
SAW	Submerged Arc-Welded
SI	International System of Units

2.0 EPRS PRODUCT

2.1 SMART FLANGE

Smart Flange is a mechanical end connector engineered for pipeline repair, rerouting, and abandonment applications. Utilizing robust collet grips, it provides a permanent, structural flanged termination by mechanically engaging the pipe. Dual-barrier seals ensure long-term integrity, supported by an integrated test port for annulus seal verification. The single-set design simultaneously actuates both grips and seals, enabling fast and reliable installation.

SMART FLANGE

- Pipeline Spool Piece Repairs
- Pipeline Reroutes
- Pipeline Abandonments
- Riser Repairs
- Structural Repairs

2.2 SMART CLAMP

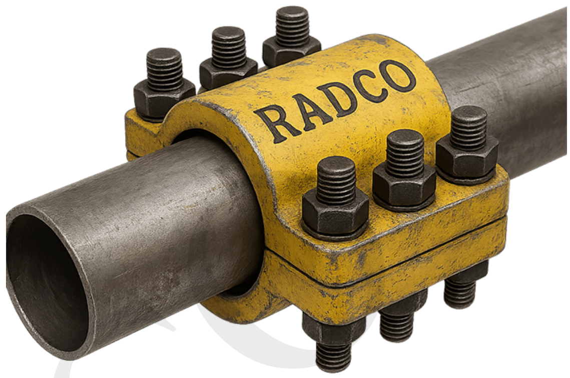
Smart Clamp is a structural, split mechanical fitting engineered for permanent, in-situ repair of pipelines with significant damage, such as cracked girth welds, kinks, or punctures. It restores full mechanical integrity by utilizing retained, energizing gripping mechanisms at both ends, combined with a high-performance elastomeric sealing system effective in both circumferential and longitudinal orientations.

STRUCTURAL SMART CLAMP

- leak repair of crack-like defects.
- Restores pipeline structural integrity.
- Tolerates bending moments and axial forces.

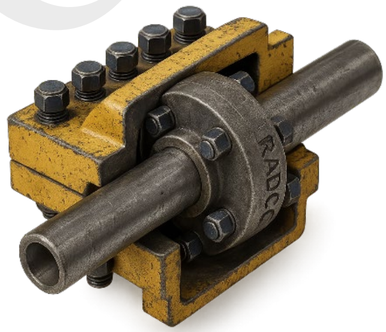
2.3 SPLIT SLEEVE CLAMP (LEAK PREVENTING CLAMP)

RADCO Split Sleeve Clamps are engineered repair fittings for sealing pipeline leaks caused by corrosion or damage, applicable to both onshore and subsea systems. These clamps are quick and safe to install; sealing is achieved simply by fully torquing the clamp, and permanent repair can be ensured by welding. Steel Girder Rings prevent displacement and damage of the packing during installation.



Leak Preventing Clamp

Elbow Clamp



Flange Box Clamp

Flange Ring Clamp

Valve Flange Clamp

2.4 MODULAR SPLIT SLEEVE CLAMP (MSSC)

MSSC is an advanced interlocking clamp system designed to reinforce corroded pipe sections. Its main advantage is modularity—allowing the clamping length to be adjusted onsite, based on the actual extent of corrosion. This eliminates the need for multiple clamp sizes and delivers significant time and cost savings, especially beneficial for large-scale projects with various installation zones. MSSC can also function as a bend limiter in critical subsea pipeline sections.

Key Features:

- Onsite-adjustable modular length for precise fit
- Eliminates need for multiple clamp sizes
- Reduces installation time and costs

2.5 REINFORCEMENT CLAMP

A Reinforcement Clamp is a specialized device engineered to restore structural integrity and provide localized reinforcement to damaged or corroded pipeline sections—often without full system shutdown or pipe replacement. These clamps deliver robust structural support and effective leak containment, making them ideal for both emergency repairs and preventative maintenance.

Key Features:

- Strengthens and reinforces damaged or corroded pipeline areas
- Enables repair without full shutdown or pipe replacement
- Prevents leaks and restores mechanical integrity
- Suitable for both emergency and preventive applications

2.6 WELD ENDS COUPLING

Weld Ends Coupling enables secure, flange-free connection of two pipelines, with no pipe end preparation required. During installation, flow is isolated; after precise alignment and full bolt tightening, the coupling centralizes and grips both pipe ends, establishing a high-integrity seal.

2.7 PIPE CONNECTOR

Pipe Connectors are engineered to provide a robust structural joint between two pipeline ends, eliminating the need for traditional flange-to-flange or flange-to-Smart Flange tie-ins and significantly reducing repair downtime. For installation, both pipe ends are cut and beveled, and the connector is positioned onto one side. The sealing and gripping mechanisms on both ends are simultaneously activated. Dual test ports enable annulus testing after installation to confirm sealing integrity.

Key Features:

- Provides permanent structural connection between two pipe ends
- Eliminates need for conventional flange connections, minimizing downtime

3.0 PRODUCT SPECIFICATION

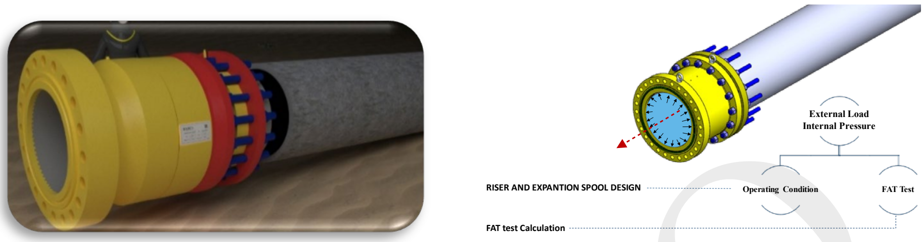
Product Specification	
Item	**Description**
Engineering design	DNV RP F116-F113, DNV GL OS F101, ASME SECVIII
Nominal pipe size (NPS)	4 to 56 in
Pressure Temperature Rating	#150, 300, 600, 900, 1500, 2500
Service	Crude Oil/, Sweet Gas, Sour Gas, Condensate
Design Pressure (barg)	ASME/ANSI B16.5 & B16.47
Test/injection Port	1/2" NPT
Material	A694 F52, F65, ASTM A105, AISI 4140, A216, A516 ...
Material test	Sour service, HIC, SSC, Impact test, Hardness, Mechanical test
Gasket design code	ASME B16.20
Seal Material	HNBR, Viton, NBR
Stud bolts and Nuts	A320 L7, A 193 B7M , A 194 (2HM)
Protection sheet	SS 304L
Coating	Epoxy, Marine Epoxy, …
Cathodic Protection	Anode
Packing	Wooden Pallet
NDT	VT (100%), MT (100%), UT (100%)
Material Test	Tensile Properties
	Impact Properties
	Hardness Survey
	Hydrogen Induced Cracking (HIC)
	Sulfide Stress Cracking (SSC)
Weld overlay	comply with ASME, section IX (Corrosion protection – Weld Metal Overlay)
Certification	BS EN10204 3.1.B

RADCO could offer material or design equivalent with the datasheet or proven by engineering design calculation.

4.0 DESIGN PHILOSOPHY

The design of connectors for subsea pipeline repair requires a multidisciplinary engineering approach, considering structural and operational challenges under extreme environmental and mechanical conditions.

One of the main challenges is ensuring sealing performance and mechanical grip under varying pipeline geometries and external pressures.



Connector on subsea under different load condition

To address these challenges, a nonlinear finite element analysis (FEA) approach was adopted using the Abaqus software. Special emphasis was laid on verifying the sealing performance of elastomeric materials and the grip mechanism of the gripper. The design process was validated through experimental benchmarks and by adhering to established industry standards, particularly the DNV GL RP F113. This report elaborates on the methods, modeling details, and tests performed to achieve a robust and validated connector design.

The connector comprises two essential components requiring nonlinear FEA:

- Sealing System: Utilizing elastomeric materials for pipeline sealing.
- Grip Mechanism: Ensuring structural locking under substantial axial, bending, and internal pipeline forces.

Nonlinear finite element modeling was conducted as part of the design qualification process to evaluate the performance of critical connector components thoroughly. Physical testing and measurement tools were previously built to validate the FEA models and ensure their real-world accuracy

4.1 DETAIL DESIGN

The design of the EPRS products will be in accordance with corresponding codes, standards and Recommended Practices for pipeline repair systems.

General Design Requirements are listed below:

- EPRS products will be designed to an operating pressure in accordance with project specification and ASME B16.5, 16.47.

- EPRS products will be designed to be used on pipe that meets the tolerances listed in API 5L for welded pipe.
- EPRS products will be applicable for standard service such as crude oil, natural gas, hydrocarbons, sour service, water or chemical injection, etc.
- EPRS products shall incorporate sacrificial anodes to provide cathodic protection.
- Dual seals each end would be supplied to enable a pressure verification test to be performed subsea to confirm that a successful installation has been achieved.
- Longer gripper area is considered to tolerate bending moment and axial force.

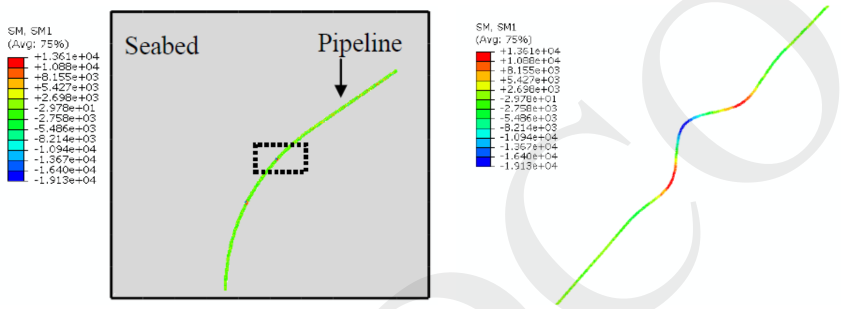
4.2 ADVANCED COMPUTER AIDED DESIGN

The detail design includes an FEA analysis on the system, hand calculations and all detailed engineering drawings. FEA work which is an essential part of the design is run on Abaqus and Ls-Dyna. All detailed engineering drawings are generated using Solidworks and AutoCAD. The following softwares are normally intended to be used for the performance of the WORK; the list is not exhaustive and may evolve during the course of the engineering.

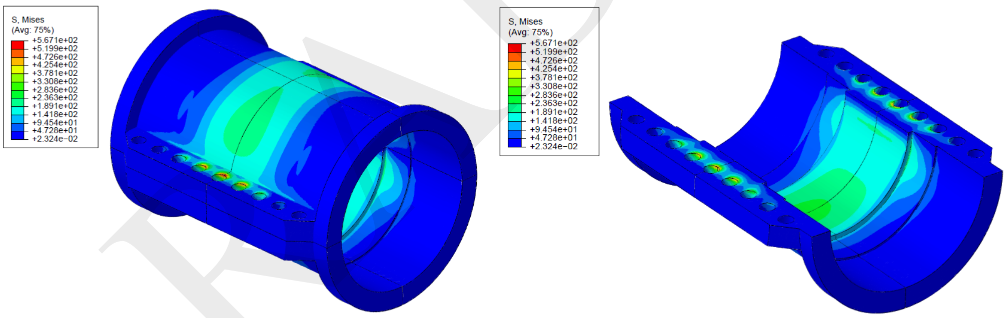
Softwares	
Title	**Description**
SolidWorks	3D modeling
Abaqus	Advance finite element analysis
Key to steels	Material selection
Mathcad	Standard based design
Ls-dyna	Sealing analysis
Bolt right	Bolt tightening calculation

4.3 FINITE ELEMENT MODELING

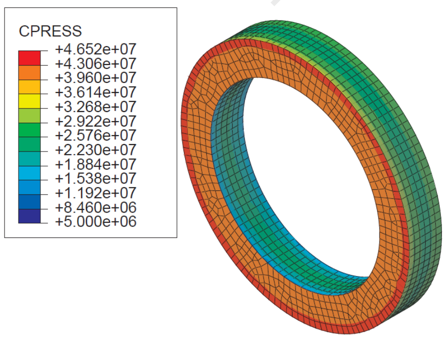
The elastomeric sealing system was designed as per the DNV GL RP F113 standards. Elastomer performance is crucial, as it maintains the sealing of the connector under high external pressures and adverse environmental conditions. The nonlinear behavior of elastomers adds complexity to the analysis, particularly when interfacing with metallic components, such as the pipeline wall. The complexity of elastomer-metal interaction increases when the pipe surface may feature imperfections, such as ovalities, weld seams, scratches, or dents. These surface irregularities introduce additional challenges, making it imperative to conduct a fully three-dimensional analysis to accurately simulate and assess the sealing performance under real-world conditions.



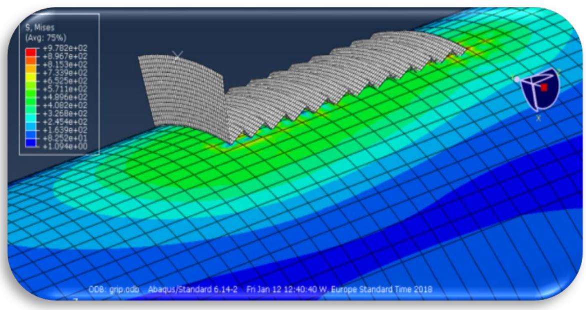
Bending moment distribution along the pipeline route in case of thermal buckling



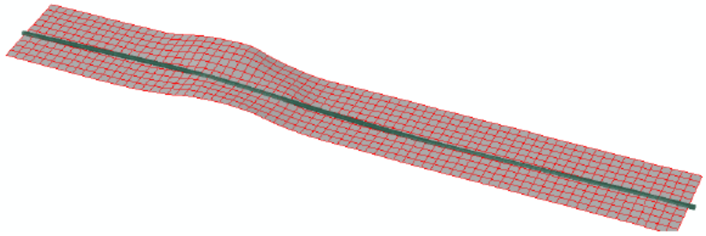
Typical FEA output on smart clamp body under pressure



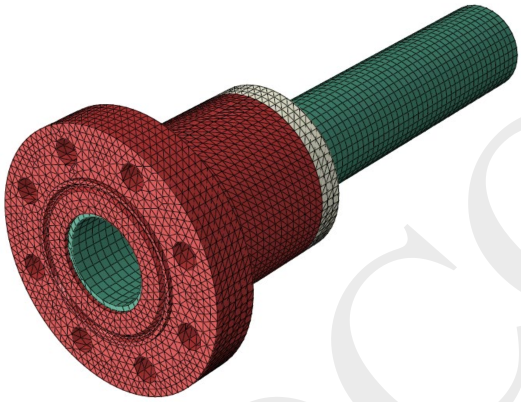
Typical FEA output on seal rings



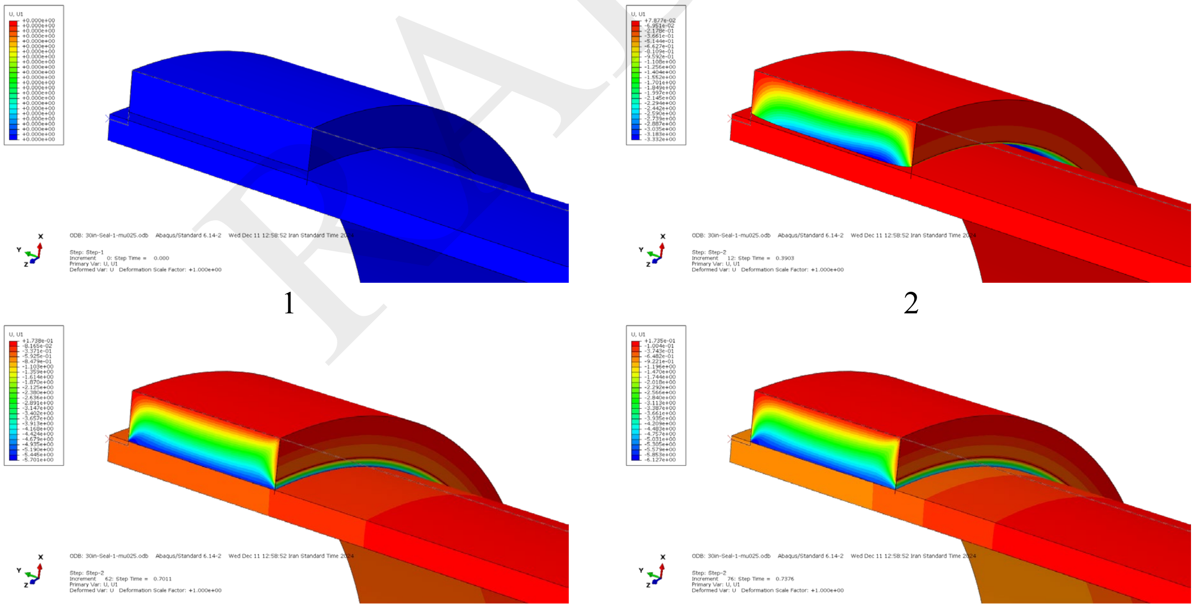
Typical FEA output on gripping



Typical FEA mesh for pipeline laid on 3D seabed



Typical FEA mesh on smart flange



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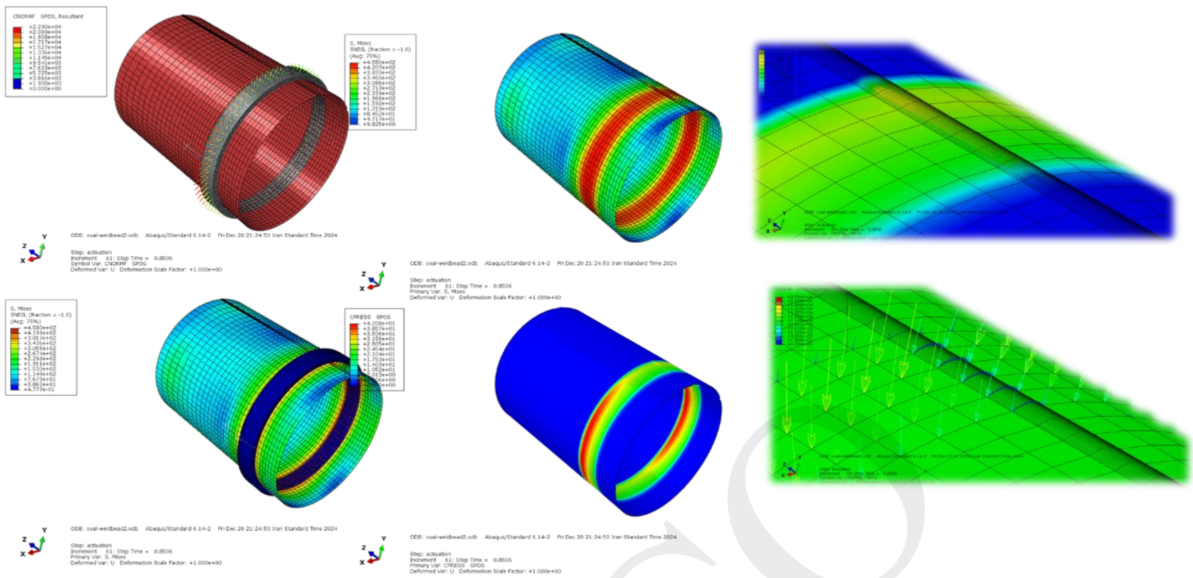
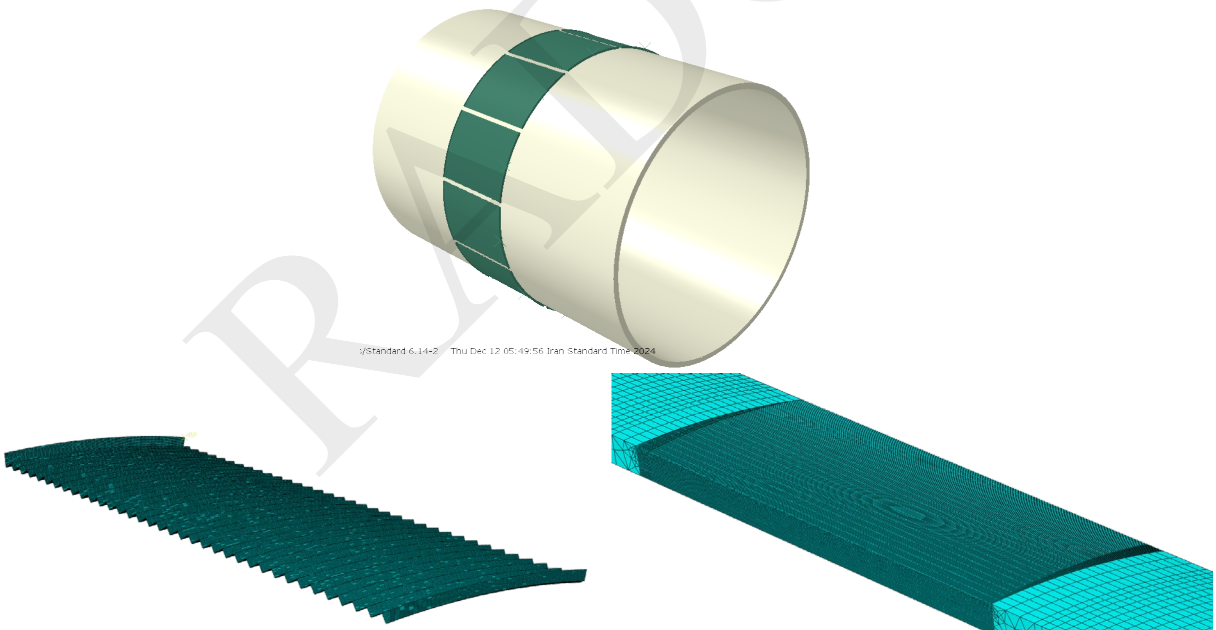
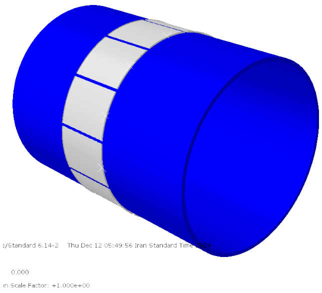
Sealing Activation



Analysis of Sealing Element Behavior in the Presence of Pipeline Defects



3D finite element of pipeline and gripper with special user defined elements



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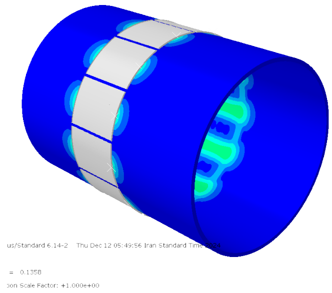

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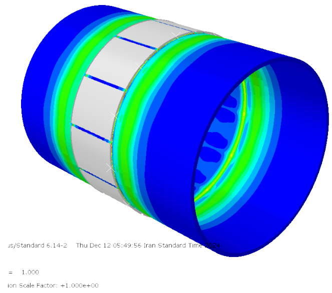

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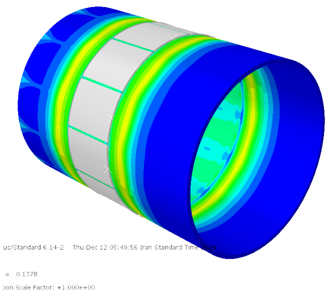

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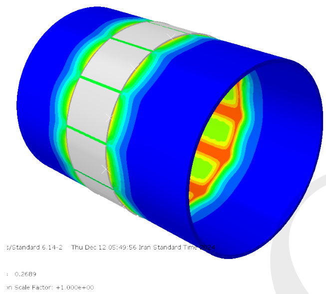

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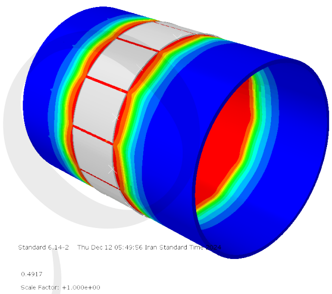

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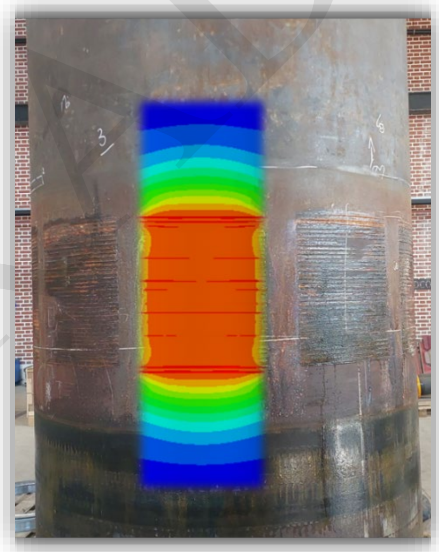
Sequential Stages of Gripper Penetration on the Pipe



Gripper effect on pipeline

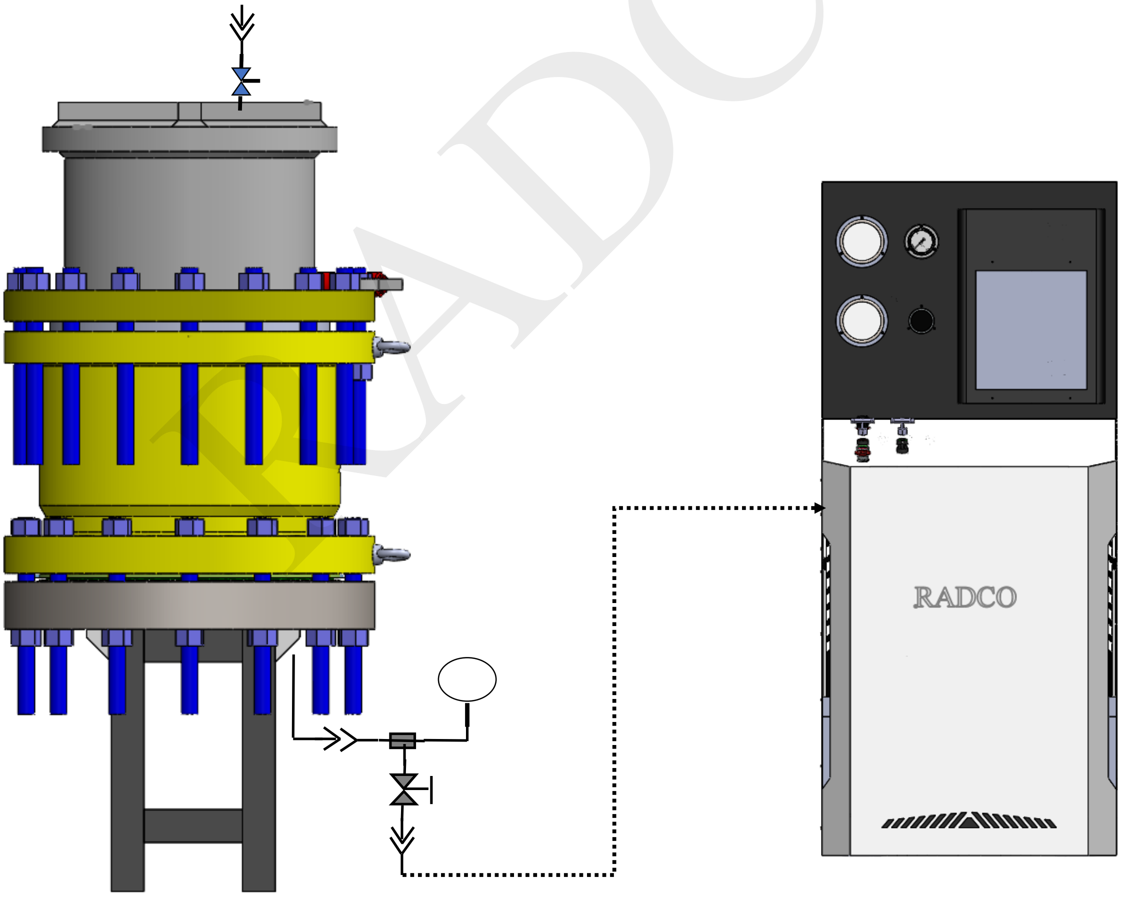
5.0 TESTING AND INSPECTION

Products shall be subjected to a FAT test to demonstrate the intended and required functionality are met. The FAT procedures shall be written in accordance with DNV OS F101 and ASME B31 as applicable. The FAT procedure will be submitted for approval prior to commencing of any tests.

The hydrostatic shall be acceptable if:

- No visible leakage occurs during the specified pressure hold period of the test.
- Pressure shall be considered stabilized when rate of change of pressure is no more than 5% of test pressure per hour.
- Hold periods will start after stabilization has occurred.
- The test pressure shall not drop below the minimum test pressure.

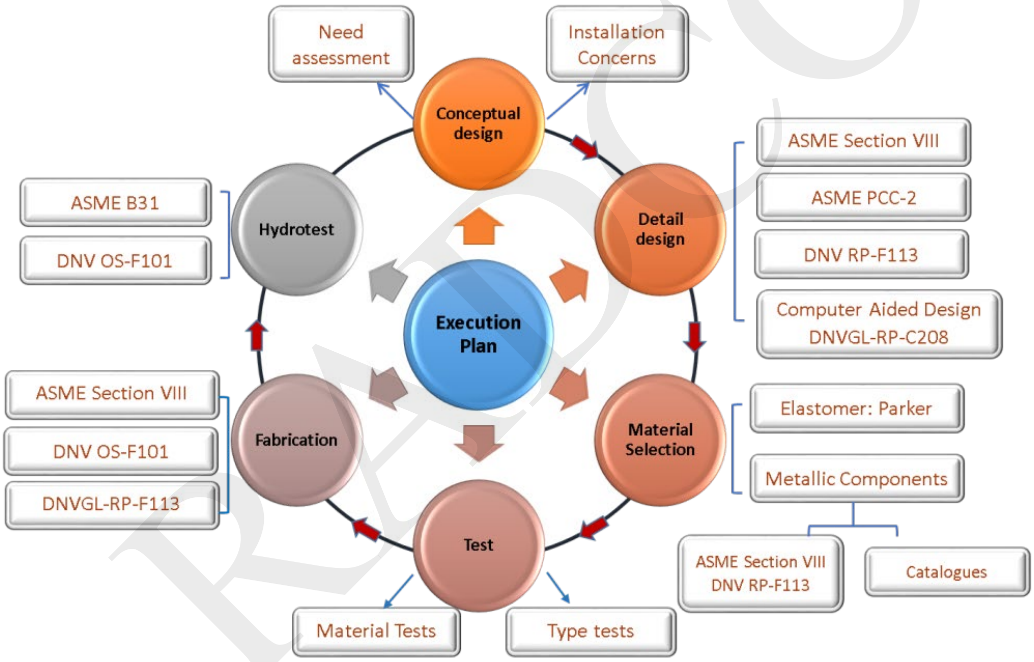
All testing will be performed by competent persons at the main workshop in the presence of the client and third party. The test results and product certification will be presented as part of MRB document, which is expanded upon in the documentation section.



6.0 PROJECT EXECUTION PLAN

6.1 EXECUTION PLAN

RADCO has launched to provide oilfield engineered services and products primarily to the offshore oil and gas industry. RADCO is able to provide the entire package and can offer aftersales supports for the client, upon request. The personnel have extensive experience in the design, production, assembly and testing. Following contract award, a kick-off meeting is arranged at the soonest convenience to all to communicate all the technical aspects of the project. The smart Flange are designed per RADCO designs and analysis, and test procedures. Technical interface meetings are suggested to ensure the designs provide the proper solution and installation is a success. The overall execution plan from the engineering, material selection, manufacturing and test throughout the project is shown in the below flowchart.



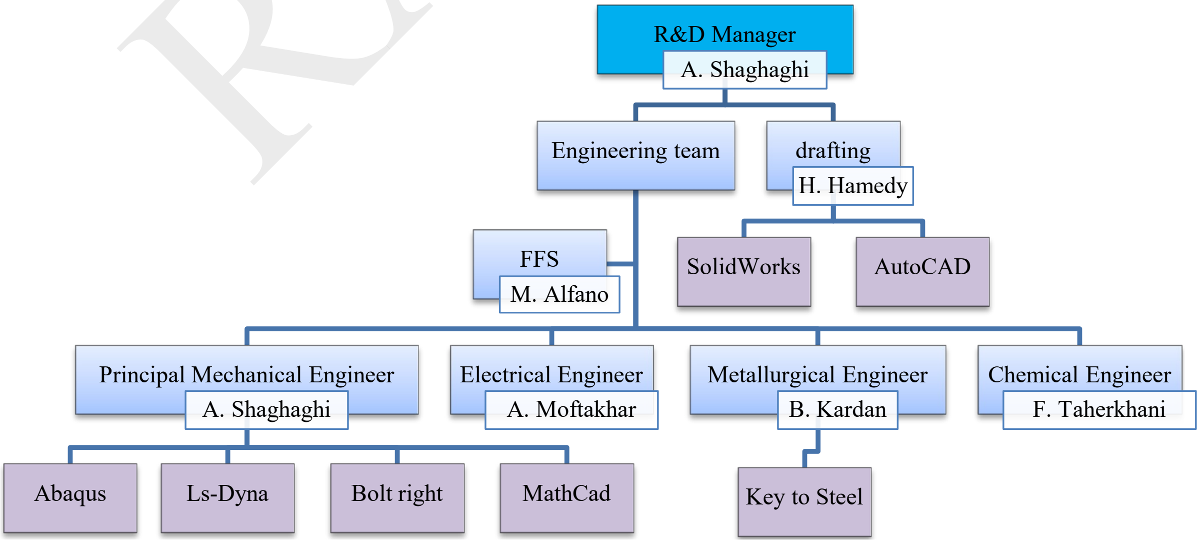
Execution plan

From the execution plan, it is inferred that all the necessary steps from detail design to FAT test are executed based on the verified standards and codes. This helps the EPRS products be tested and trusted in an approved way.

6.2 R&D KEY PERSONNEL

RADCO would engineer and perform qualification testing of the EPRS products in house to a client approved detailed inspection and test plan. To this purpose, comprehensive research and development (R&D) has been considered for EPRS products. A Memorandum of Cooperation has been assigned with the University of Calabria in Italy for future collaboration of test facilities. The Memorandum of Cooperation is shown in Appendix C. The following table and chart show the R&D personnel and corresponding tasks performed throughout the project.

R&D Tasks	
Title	**Tasks**
Mechanical engineer	➢ Conceptual design for typical EPRS products ➢ 3D modelling ➢ Drafting
Senior Principal mechanical engineer	➢ Preforming design and analysis to support research and development ➢ Performing advanced FEA analysis ➢ Detail design and hand calculation
Senior fatigue and fracture engineer	➢ Performing fitness for service analysis ➢ Performing failure analysis ➢ Performing ECA and FFS analysis
Senior Materials and metallurgical engineering	➢ Material selection for metallic parts for subsea use, in sweet and sour service ➢ Material selection for sealing and anti-extrusion plate and rings for high pressure application in sweet and sour services
Electrical engineering	➢ For future development of Smart pigs and …



R&D organization chart

6.3 WORK LOCATION

The design, R&D, build and FAT will be conducted in house at our facility. Our facility includes:

Engineering Office located in Qazvin Science & Technology Park

Project management, R&D, design and document issue are performed in the engineering office. A conference hall and a meeting room are available to arrange for meeting and training workshops.

Conference Hall

Meeting rooms

Manufacturing yard located in CASPIAN Industrial city

Where the manufacturing, Quality control, dimensional check and etc. are performed. For development of high tech EPRS products, a test workshop has been constructed on Caspian Industrial Town. This workshop has been designed particularly for type tests, main tests and FAT tests. According to agreed ITP, this workshop will be equipped with the corresponding typical test utilities. Future high tech EPRS products will be undertaken in this workshop.[1]

Manufacturing yard

1 Before its completion, the before mentioned tasks are performed in the Manufacturing yard.

Basic tests

6.4 MANUFACTURING

All manufacturing is performed by our facility. We are an <u>Original Equipment Manufacturer (OEM)</u> which enables us to maintain our high quality standards and be very commercially competitive. For special circumstances, machining would be outsourced to other manufacturers. Machining is performed by high precise facilities to ensure high tolerances and quality components are produced. All manufactured components are subjected to 100% inspection and this process is recorded on individual inspection forms. Some facilities are listed as:

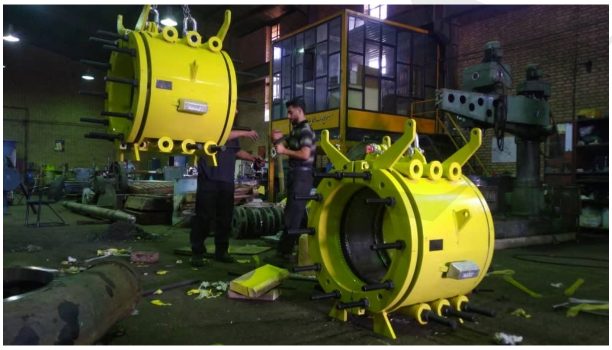
- Heavy duty floor type NC boring
- Heavy duty milling
- Heavy duty lathe machining
- Heavy duty carousel machining
- Casting utilities
- Heavy duty plate rolling machine

Some facilities available in the workshop

Purchasing raw material





Manufacturing process

6.5 PROJECT MEETING

Throughout the development of the project, RADCO will host meetings in the main office as:

- Kick off meeting
- Technical interface meeting

6.6 THROUGH-PROJECT DOCUMENTATION

Upon agreement, the following list outlines typical project specific documents that are generated, reviewed and approved during the course of the project:

- Factory Acceptance Test (FAT) procedure
- Master Document Register (MDR)

6.7 DOCUMENTATION

Documentation will be supplied in accordance with project document requirements. A Manufacturing Record Book (MRB) provides the required documentation as:

- Fully signed Inspection and Test Plan (ITP)
- As built general assembly drawings
- FAT Test Report
- Installation procedure
- Release Note

6.8 COMMITMENT

RADCO is committed to:

- Understanding and anticipating customer requirements and expectation.
- Providing value added services and products using effective and efficient processes.
- Delivering services and products on time.
- Measuring results to quantify successes and identify opportunities for improvement.
- Identifying and eliminating waste in all aspects of executing our work.

7.0 SUPPORT

7.1 ENGINEERING SUPPORT

Upon request, the following engineering activities can be supported by RADCO:

- Failure analysis of defects in the pipeline to find root causes.
- Comprehensive FE analysis of the as built condition of pipeline.
- ECA and FFS analysis.
- On site engineering support for any unpredicted issue during installation.

7.2 SPARES

The identification and extent of spares supplied with the project deliverables can be agreed prior to the project award. A typical set of spare will be listed in the summary.

- Nut and bolt
- Gasket and ring
- Hydro test ring
- WN flange

7.3 AFTERSALES SUPPORT AND MAINTENANCE

The team can provide office based and out-of-hours technical support for all delivered systems with access to a database of both technical data and construction information. On-site commissioning, servicing and repairs can also be carried out for working both on and offshore, upon request.

7.4 CLIENT INSPECTION AND AUDITING

RADCO promotes an open door policy with clients free to visit and inspect both at our facility and key nominated sub-contractors. To ensure we have the appropriate deliverables available for such visits we request a 3-day minimum notice period.

8.0 INDUSTRY STANDARD REFERENCES

The following standards and specifications will be used in the engineering and production of the proposed smart flanges:

- API SPEC 5L, Specification for Line Pipe
- API SPEC 6H, Specification on End Closures, Connectors and Swivels
- ASME B16.5, Pipe Flanges and Flanged Fittings
- ASME B31.4_piping transportation system for liquid hydrocarbons and other liquids
- ASME B31.8_ Gas transmission and distribution piping system
- ASME B31G, Manual for Determining the Remaining Strength of Corroded Pipelines
- ASME Boiler and Pressure Vessel Code, Section IX Welding and Brazing Qualifications
- ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 and 2.
- ASME Boiler Pressure Vessel Code, Section V Nondestructive Examination
- ASME PCC-1,Guidelines for Pressure Boundary Bolted Flange Joint Assembly
- ASME PCC-2,Repair of Pressure Equipment and Piping
- ASME/ANSI B18.2.1, Square and Hex Bolts and Screws Inch Series
- DNV RP B401, Cathodic Protection Design
- DNV RP-F113 pipeline subsea repair
- DNVGL-RP-C208, Determination of structural capacity by non-linear finite element analysis methods
- DNVGL-RP-F113 Pipeline subsea repair - Rules and standards
- DNVGL-ST-F101, Submarine pipeline systems
- DNV-OS-F101, Submarine Pipeline Systems
- MSS SP-44, Steel Pipeline Flanges
- NACE MR0175, Part1 & Part2 (resist sulfide stress cracking)