SUBSEA CONTROLS
DOWN UNDER 2024

SUT
Society for Underwater Technology

Enhancing Local Testing Capabilities for Subsea Control Modules: Adaptation of a Deepwater Hyperbaric Test Facility

An Innovative Industry Collaboration Project by-

JTSI, SICA, Matrix Composites & Engineering and Baker Hughes

Regional Deepwater Test Facility

SUBSEA CONTROLS DOWN UNDER 2024

SUT Society for Underwater Technology

Problem Statement

Subsea Control Modules (SCM) currently have to go to Europe for hyperbaric testing

- Supply Chain Risk – Cost – Lack of Transparency
- Existing local facilities too small or not designed for required pressure testing

Opportunity for a Regional Deepwater Testing Facility

- Upskilling and a subsequent increase in the inspection and repair capability locally and the creation of new jobs and training requirements
- A direct increase in the local content quotas for operators and OEMs
- Increased transparency of failure root cause analysis
- The potential for having a more comprehensive testing and repair facility linked to the Hyperbaric Chamber facility
- Significantly reduce supply chain risk
- Open up regional opportunities

Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA

SUBSEA INNOVATION CLUSTER AUSTRALIA

Matrix COMPOSITES & ENGINEERING

Baker Hughes

Feasibility Study Key Points

- **Initial work was focused on SCM Hyperbaric testing and repair**
  - Significant cost savings per SCM per test~80%
  - Estimate of 8 tests per year
  - A suitable local facility identified for modification
  - Initial modification cost estimated $1.2M
  - A recent study carried out by Subsea UK for the Scottish Enterprise Board and the building of two new chambers in Norway have both indicated increased testing and repair work through having local facilities

SUBSEA CONTROLS DOWN UNDER 2024

Society for Underwater Technology

3 Phased Approach

Phase 1
Hyperbaric Test Facility

Setup a hyperbaric test facility for testing and repair of Subsea Control Modules

- Secure funding
- Design, build and commission the required modifications
- Work with AMC CUF to develop appropriate third party engagement procedures to allow work to be carried out on the facility including IP protection
- Launch new facilities

Phase 2
Additional Facilities

Setup additional facilities for additional testing, repair and forensic work

- Setup clean room and associated testing facilities
- Hydraulic safety systems to allow variable water depth testing.

Phase 3
Expand to APAC Market

Market the new facility to the rest of the APAC region

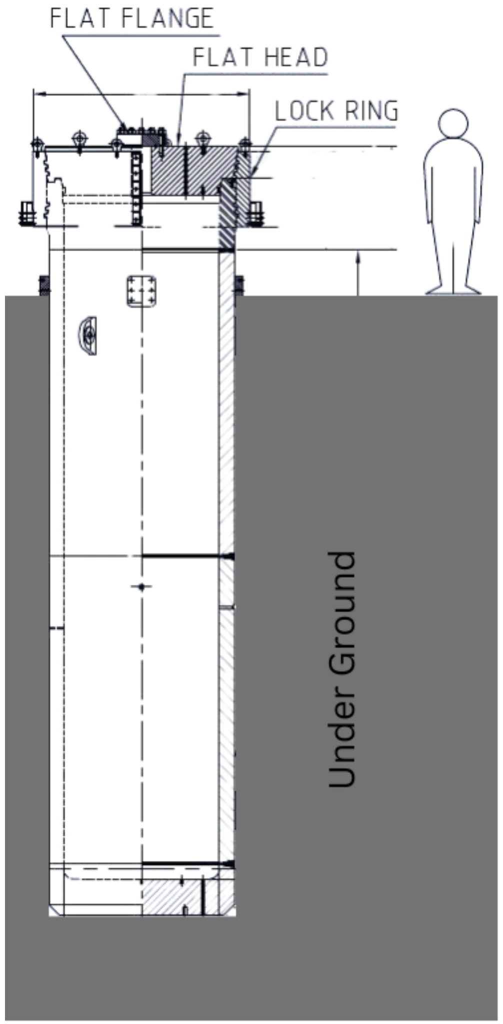
- Develop marketing strategy and material
- Work with Austrade to identify potential clients

Matrix Hyperbaric Test Facility

Existing Capability

- 2 Large Hyperbaric Chambers (HC) designed and built to test riser buoyancy and floatation production modules to API 17L and API 16F standards .
- Design registered and operated per AS1200 regulatory requirements.
- 40 T crane to service 330 m^2 area
- Kraken Chamber was well suited for the new application with low utilization .

Hyperbaric Chamber	Kraken	Meg
Inner Diameter (ID.)	1.52 m ✓	1.6 m
Depth	6.0 m ✓	6.4 m
Pressure rating	340 bar ✓	520 Bar
Avg yearly utilization over past 5 years	< 10% ✓	>75%
Remaining HC Shell design fatigue life	> 90% ✓	
No. of additional Penetrations	2 ✗	



Defining Scope of Work

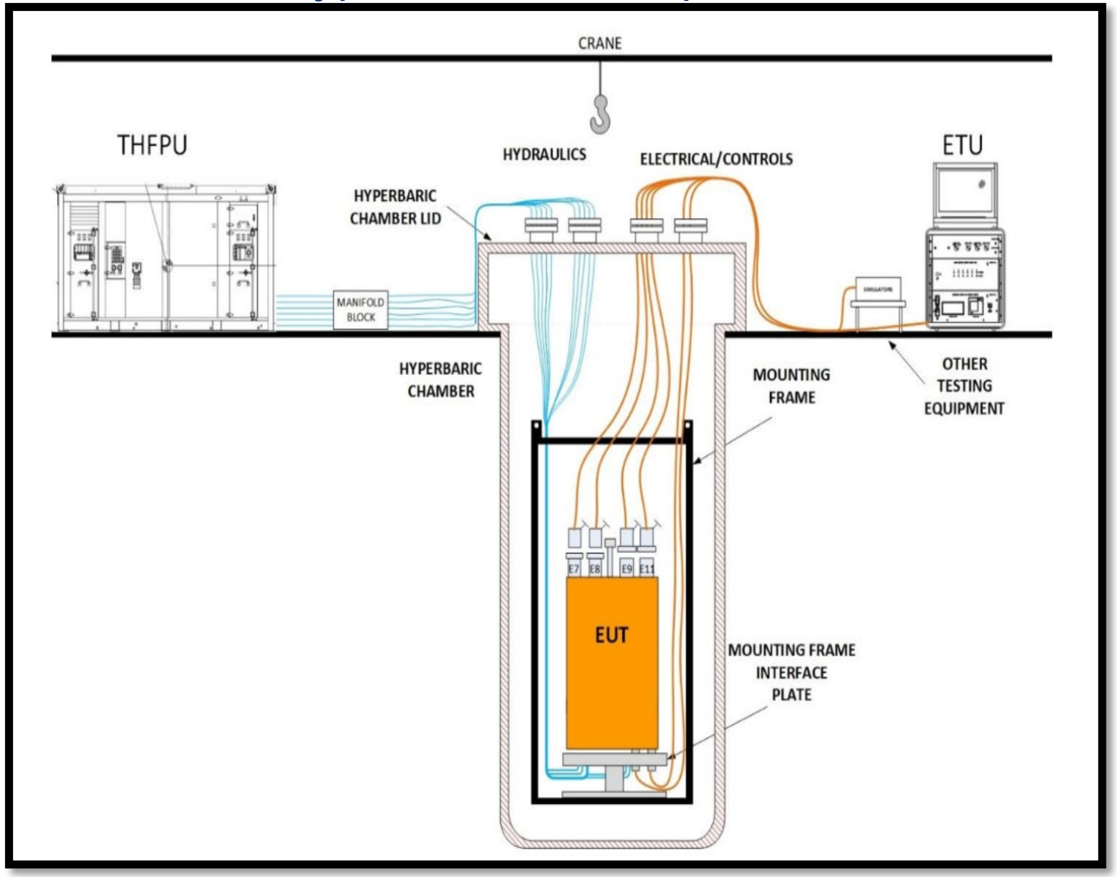
SUBSEA CONTROLS DOWN UNDER 2024

Society for Underwater Technology

API17F 5th Edition specifies the below for a reworked subsea module:

"SCM and other subsea units containing pressure compensation and/or electronic components shall be pressure tested. The test shall include verification of any pressure compensation, hydraulic and electrical function, and frame loss testing of electrical Ethernet….."

Typical Test Set Up



Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA

SUBSEA INNOVATION CLUSTER AUSTRALIA

Matrix COMPOSITES & ENGINEERING

Baker Hughes

Defining Scope of Work

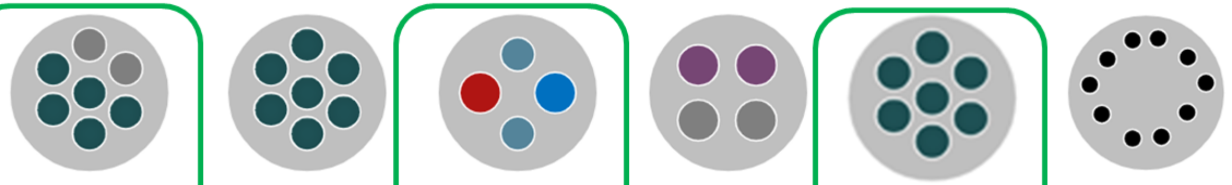
SUBSEA CONTROLS DOWN UNDER 2024

Society for Underwater Technology

For any given BH subsea equipment ,a maximum of 4 flanges would be required to fully function test the equipment which involves

- Up to 15 electrical penetrations
- 10 hydraulic penetrations
- Up to 4 fibre optic penetrations

Baker Hughes UK Test Facility Capabilities



	1	2	3	4	5 *	6
Purpose	Electrical	Electrical	Electrical	Optical	Electrical	Hydraulic
Functions	5 x SCM/PCDM Output 2 x SCM/PCDM Input (SEMStar5 & SEM2k)	7 x PCDM Output	2 x SCM Input (SEMStar5) 1 x HV Input 1 x High Current Input		6 x SCM Output	2 x LP Input 2 x LP Function 1 x LP Return 2 x HP Input 2 x HP Function 1 x HP Return
Connections	5 x HDM306-13P 2 x blank	7 x HDM306-13P	2 x HDM506-13S 2 off 1 x HDM508-4S/HV 1 x HDM508-4S Not used	2 x Seacon 2 x blank	6 x HDM306-13P 7 off	5 x LP 5 x HP
SCM Testing	√		√		√	√
PCDM Testing	√	√	√	√		

Use Flange 2 Design – common part (flange 1)

Use Flange 2 Design – common part (flange 5)

Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA

SUBSEA INNOVATION CLUSTER AUSTRALIA

Matrix COMPOSITES & ENGINEERING

Baker Hughes

SUBSEA CONTROLS
DOWN UNDER 2024

Lid and Flange Design

Society for Underwater Technology

Basis of Design

Wood Group was engaged to design chamber lid and flanges.

Design objective:

Lid design to accommodate maximum number of penetrations possible to meet SCM functional testing, chamber operational (min. 2000 cycles) and safety requirements.

Design Criteria:

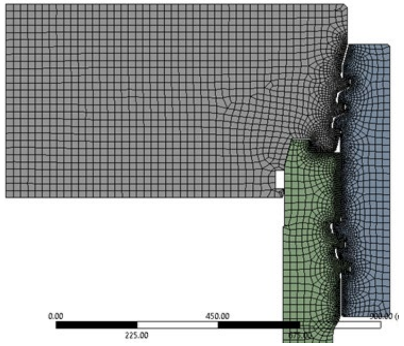
- AS 1210-2010, +A1, +A2 standard as primary design code
- Class of construction: 1H
- FEA analysis to confirm to ASME VIII-2 Part 5 criteria

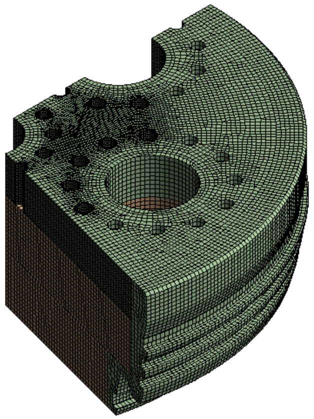
Design Verification:

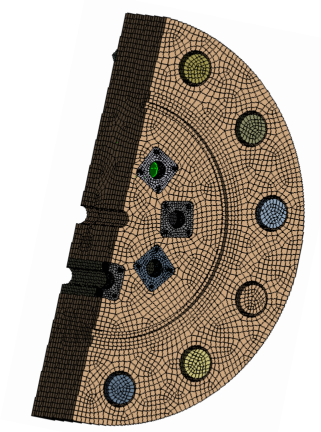
- By independent engineering consultancy other than design company

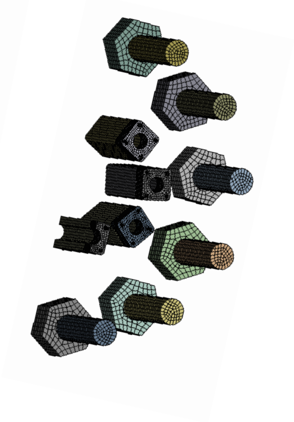
FEA Analysis

- Axi-symmetric model of the chamber, cover and locking ring.
- 3D model included penetrations and bolt holes for cover flanges.
- Multilinear isotropic hardening material was used for this analysis
- The load factor 1.5 was applied to all loading to provide safety margin.









Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA

SUBSEA INNOVATION CLUSTER AUSTRALIA

Matrix COMPOSITES & ENGINEERING

Baker Hughes

SUBSEA CONTROLS DOWN UNDER 2024

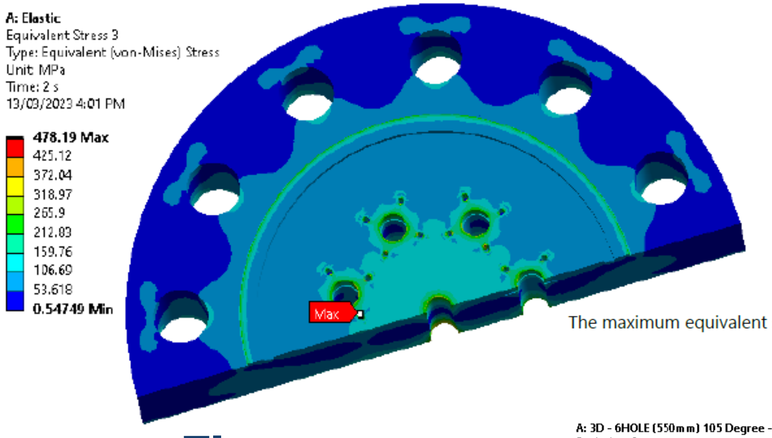
Lid and Flange FEA Analysis

Society for Underwater Technology

FEA Analysis Outcome

- A 550mm-thick forged flat head meets the design requirements.
- Maximum allowable number of pressure cycles are at minimum 3 times and up to 10 times the design requirement – far exceeds the life of chamber lid
- Maximum equivalent stresses on elastic model is 533.94 Mpa occurred at the bolt holes

Figure C- 1 : Equivalent Stress Plot for Elastic Analysis

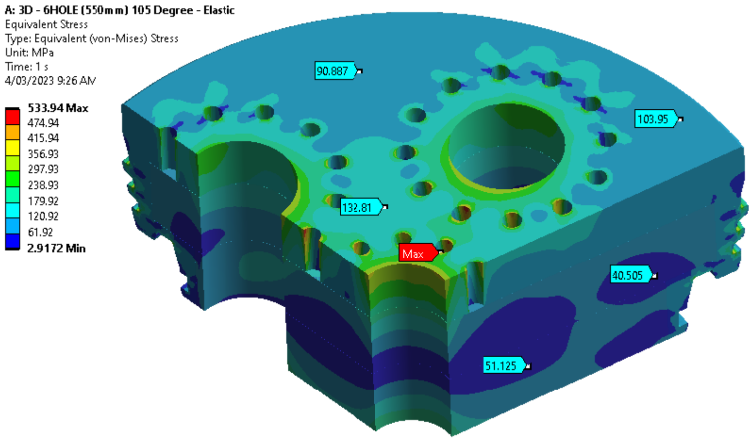


Flange

Chamber LID

The maximum equivalent stress occurred at the bolt, which can be considered the maximum fatigue stress.

Figure C-1: Equivalent Stress Plot for Elastic Analysis

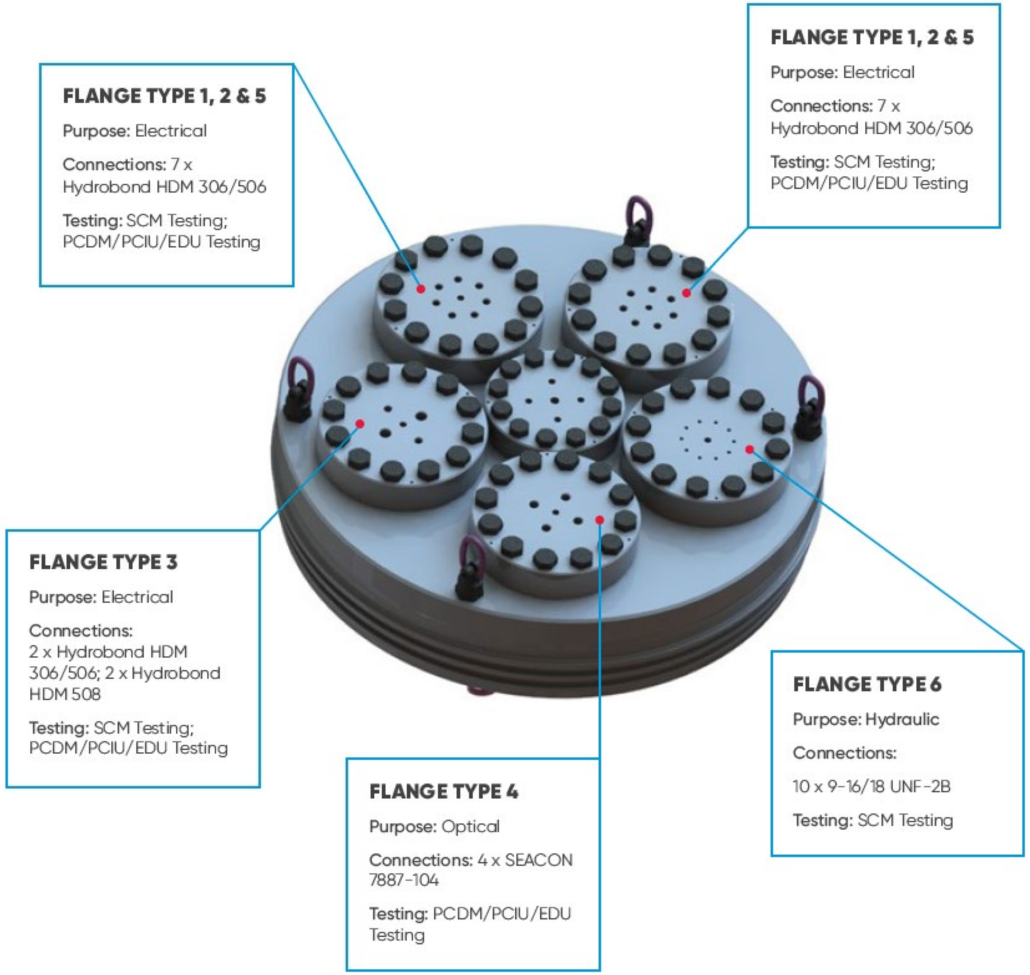


Flnage No.	Max. Stress (MPa)	Max. Fatigue Sress (MPa)	Max. All. No. of Cycle	Design No. of Cycle	Judge
Type 1,2,5	478.19	478.19	16358	2000	Pass
Type 3	441.11	441.11	20547	2000	Pass
Type 4	483.44	483.44	15871	2000	Pass
Type 6	536.13	536.13	11984	2000	Pass
9" Flange	667.54	667.54	6808	2000	Pass

Maximum allowable cycle number is calculated in accordance to Appendix M, AS 1210-2010.

Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA
SUBSEA INNOVATION CLUSTER AUSTRALIA
Matrix COMPOSITES & ENGINEERING
Baker Hughes

Hyperbaric Chamber- Upgraded Capability



Chamber Upgraded Capability

New lid has **5** interchangeable flanges to suit any equipment under test requirements. Additional blank flanges were fabricated to suit bespoke penetration requirements from clients.

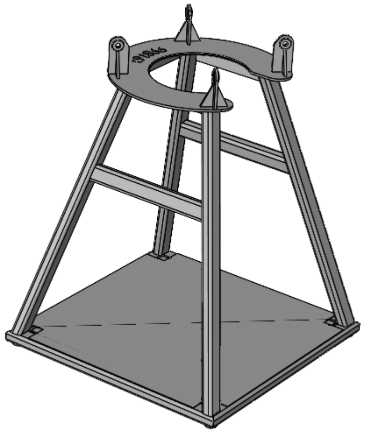
- ❖ Existing 5 flange penetrations has a total of
  - 21 Electrical Penetrations
  - 2 HV Penetrations
  - 10 hydraulic penetrations
  - 4 Fibre optic penetrations
- ❖ That can be configured to test
  - Up to 10 Hydraulic function lines on SCMs
  - Up to 12 Electrical harnesses on SCMs
  - Up to 15 Electrical harnesses on PCDMs
  - Up to 4 FO Harnesses
  - Up to 2 Low Voltage (power, COPS or CAPS)
  - 1 off High Voltage (project dependant)

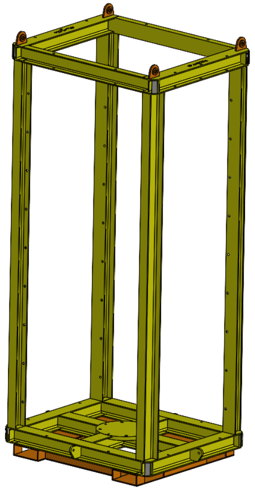
SUBSEA CONTROLS DOWN UNDER 2024

SCM Support and Assembly Frames

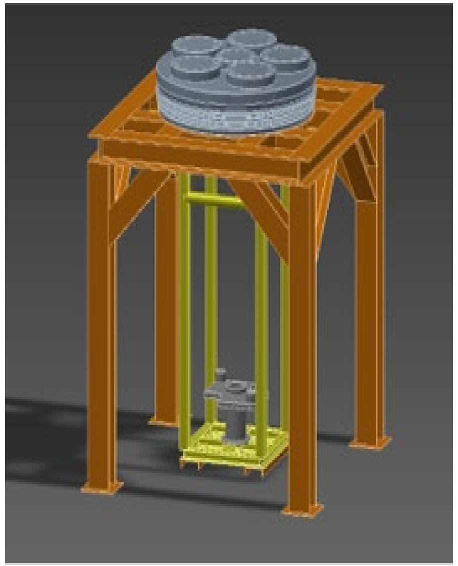
SUT Society for Underwater Technology

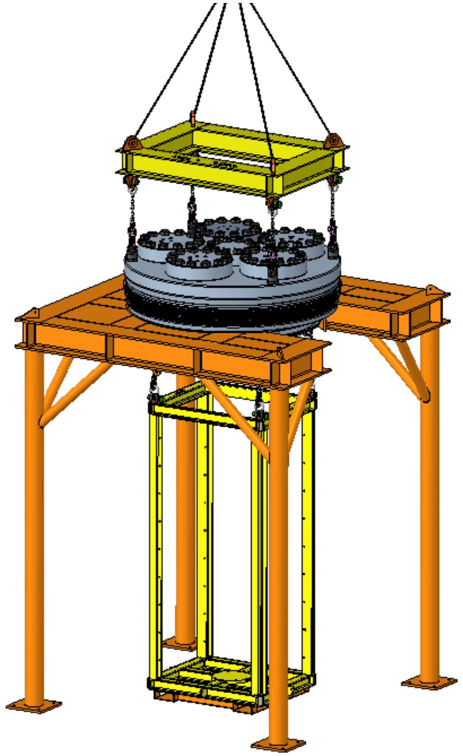
Apart from Lid – project required support structure and lifting frame to enable assembly , lifting and loading of SCM into Hyperbaric chamber

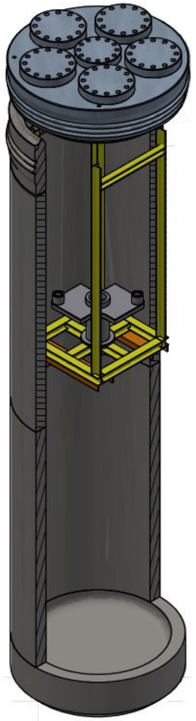




Main support frame







Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA

SUBSEA INNOVATION CLUSTER AUSTRALIA

Matrix COMPOSITES & ENGINEERING

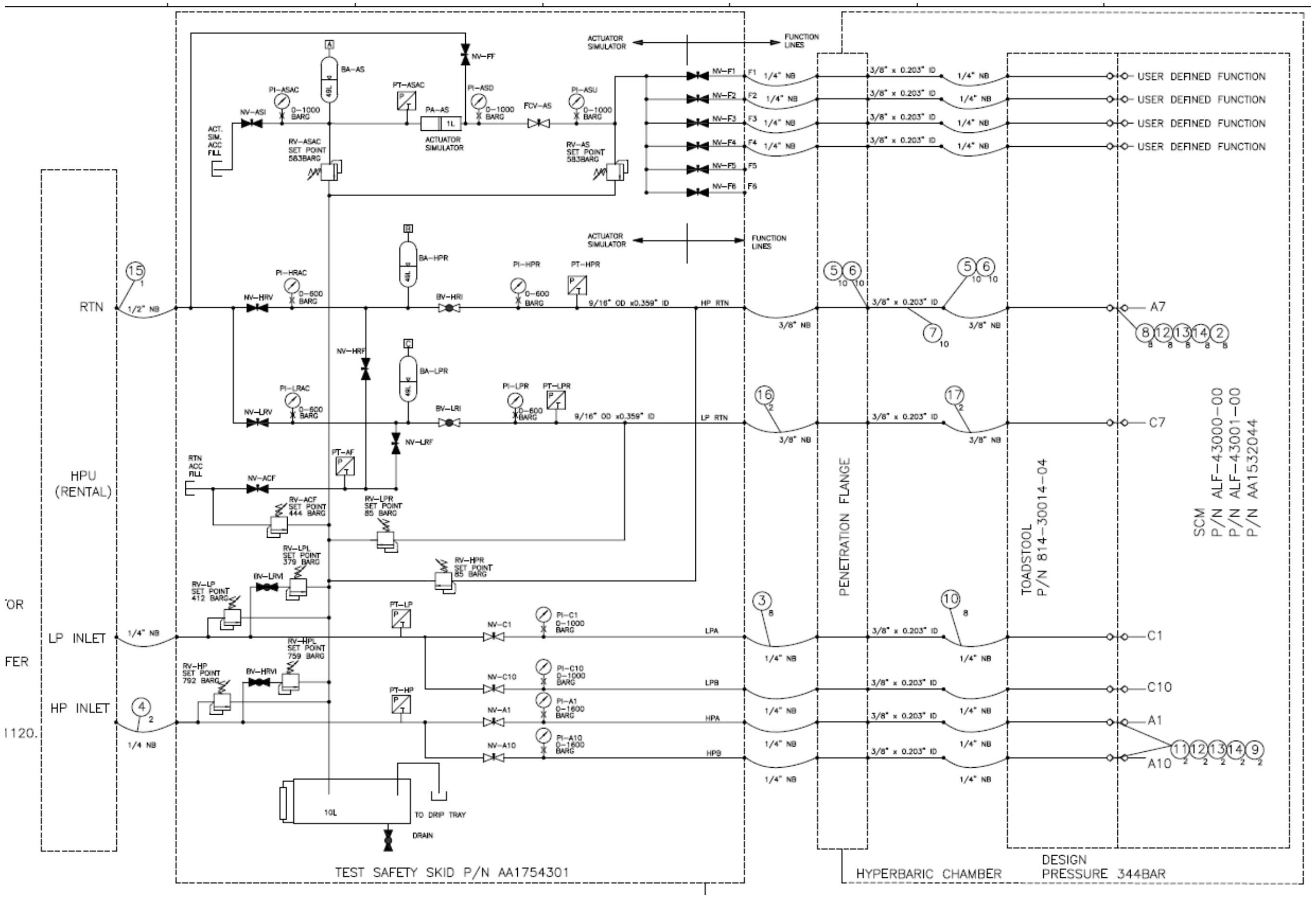
Baker Hughes

SUBSEA CONTROLS DOWN UNDER 2024

Hydraulic and Electrical Scope of Supply

SUT Society for Underwater Technology

Generic Hydraulic Panel to Support all types of Baker Hughes SCMs



Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA

SUBSEA INNOVATION CLUSTER AUSTRALIA

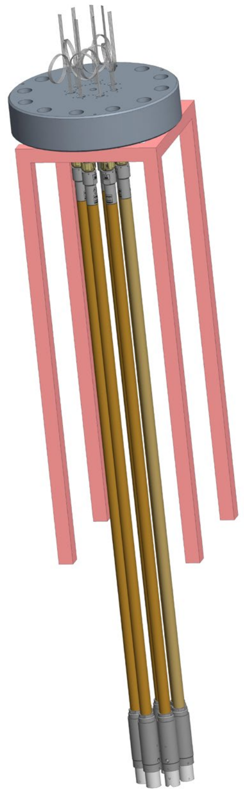
Matrix COMPOSITES & ENGINEERING

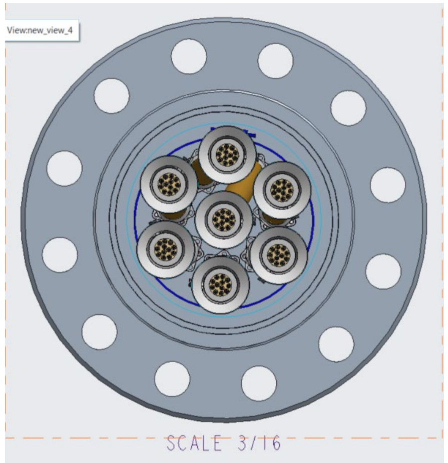
Baker Hughes

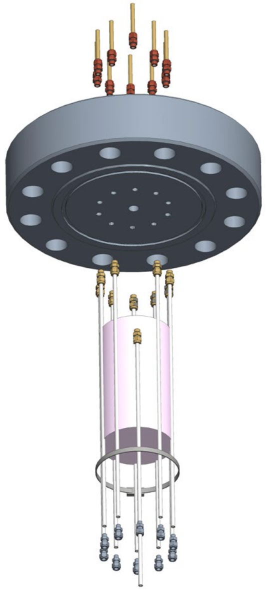
Assembly Process

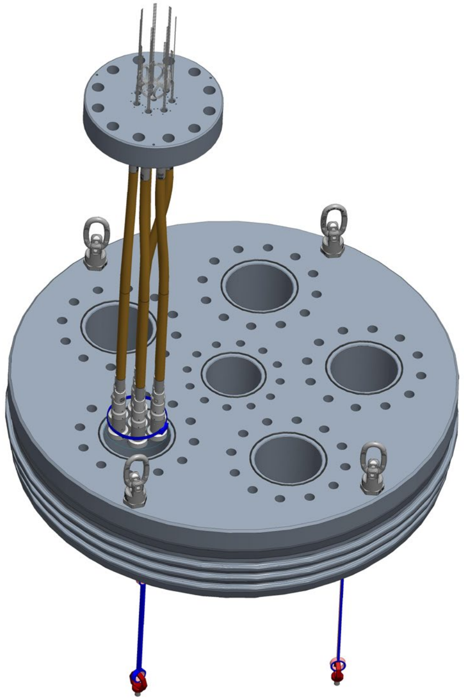
SUBSEA CONTROLS
DOWN UNDER 2024

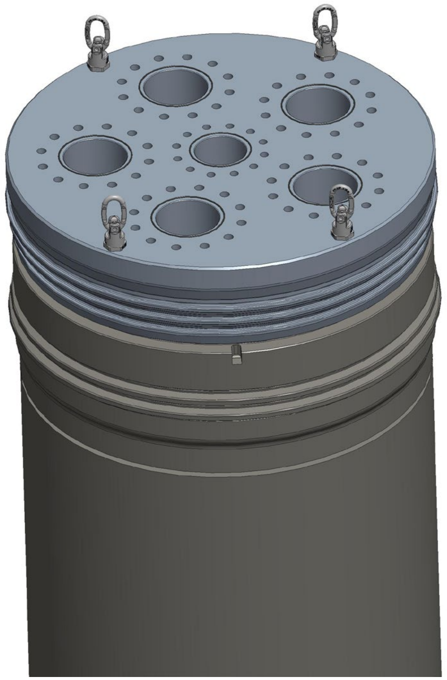
SUT
Society for
Underwater
Technology











GOVERNMENT OF
WESTERN AUSTRALIA
Department of
Jobs, Tourism, Science
and Innovation

SUBSEA INNOVATION CLUSTER
AUSTRALIA

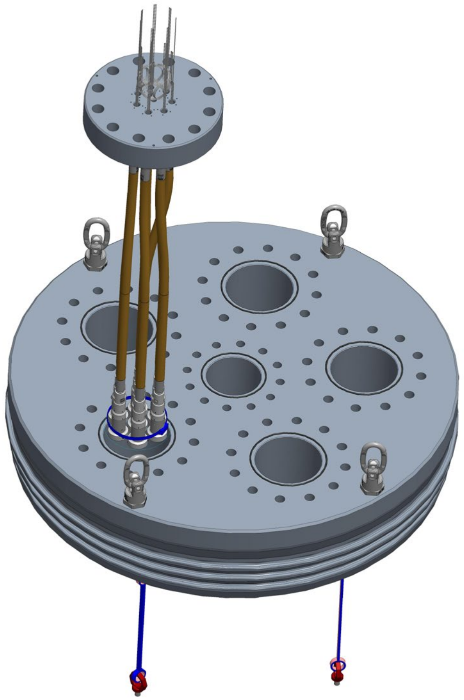
Matrix
COMPOSITES & ENGINEERING

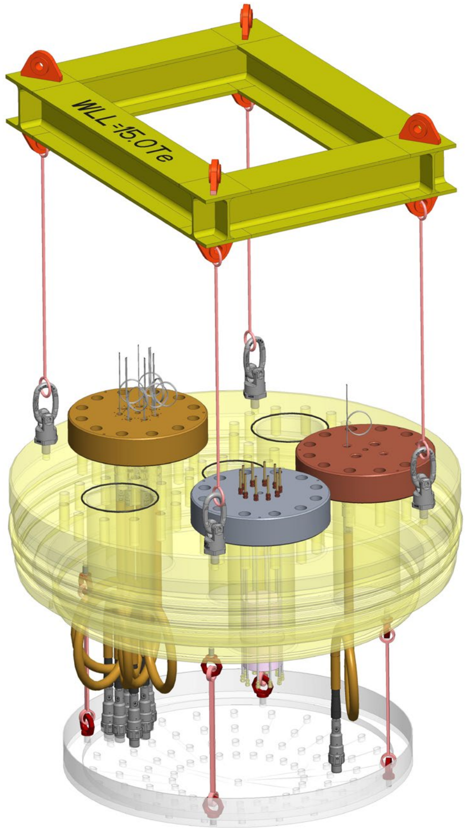
Baker
Hughes

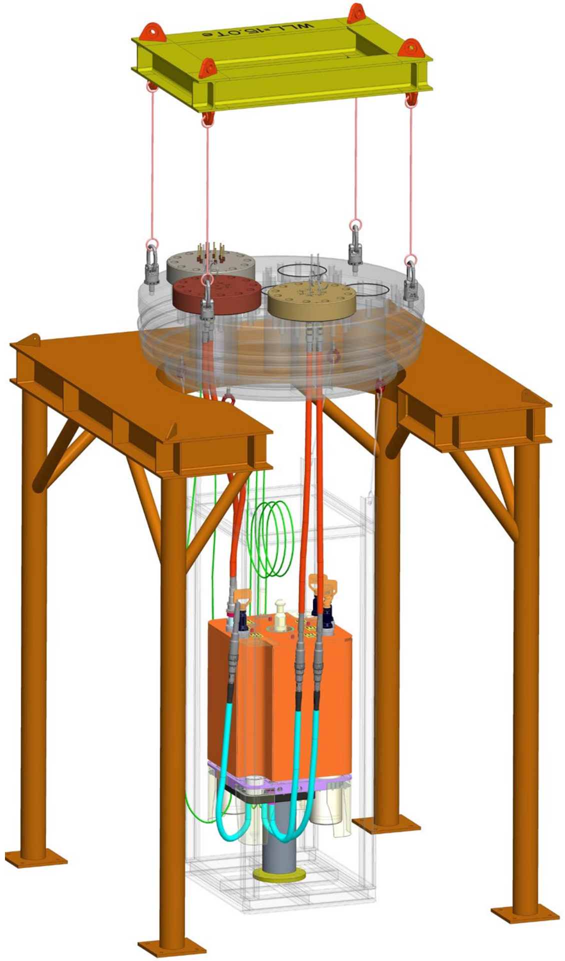
SUBSEA CONTROLS
DOWN UNDER 2024

Assembly Process

SUT
Society for
Underwater
Technology







GOVERNMENT OF
WESTERN AUSTRALIA
Department of
Jobs, Tourism, Science
and Innovation

SUBSEA INNOVATION CLUSTER
AUSTRALIA

Matrix
COMPOSITES & ENGINEERING

Baker
Hughes

Matrix Deepwater Hyperbaric CUF - Chamber Commissioning

SUBSEA CONTROLS DOWN UNDER 2024

Society for Underwater Technology

Hydrostatic testing of Hyperbaric Chamber

- Tested to AS4037 (1999) , AS1210 (2010) standards
  - 1.43 times design pressure (492 bar)

- Upgraded chamber was re-registered with Work Safe WA
- Testing witnessed by 3^{rd} party inspector along with SICA and BH representatives

Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA

SUBSEA INNOVATION CLUSTER AUSTRALIA

Matrix COMPOSITES & ENGINEERING

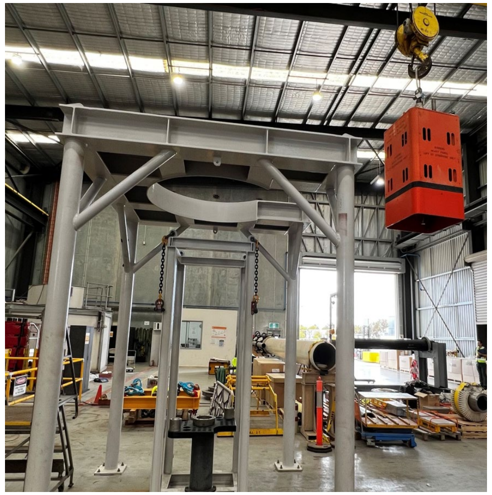
Baker Hughes

SUBSEA CONTROLS
DOWN UNDER 2024

Site Integration Test

SUT
Society for Underwater Technology

Used dummy SCM for the SIT



Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA

SUBSEA INNOVATION CLUSTER AUSTRALIA

Matrix
COMPOSITES & ENGINEERING

Baker Hughes

SUBSEA CONTROLS
DOWN UNDER 2024

Successful SCM Interface Test

SUT
Society for Underwater Technology

Test Objective

Rig-up and test 2 Tonne SCM to 330 bar pressure.

Result

- Successfully pressure tested to 330 bar with zero leaks and consistent temperature.
- Witnessed by both OEM and operator involved.

Impact

- Customer met operator's deployment timeline for their flagship project at a fraction of the cost.
- Derisked delays in shipping via sea and air freight to Europe

Test Date: June 2024

Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA

SUBSEA INNOVATION CLUSTER AUSTRALIA

Matrix COMPOSITES & ENGINEERING

Baker Hughes

Next Step

First function testing of SCM is planned for Nov 2024 in the newly established Matrix Deepwater Hyperbaric Common User Facility!

Questions??

SUBSEA CONTROLS DOWN UNDER 2024

Society for Underwater Technology

Department of Jobs, Tourism, Science and Innovation
GOVERNMENT OF WESTERN AUSTRALIA