Enhancing Offshore Recovery by Enabling Longer, Safer, and Cheaper Subsea Well Tiebacks

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U.S. Department of Energy

National Energy Technology Laboratory

Carbon Management and Natural Gas & Oil Research Project Review Meeting

Virtual Meetings August 2 through August 31, 2021

Presentation Outline

- Project Overview
- Technical Status
- Accomplishments to Date
- Lessons Learned
- Project Summary
- Appendix (additional available information)

Project Overview

Opportunity

U.S. BOEM, BSEE Looking at Ways to Boost Gulf of Mexico Oil and Gas Output

OE Staff • *September 23, 2020*

Per BOEM, about 4 out of 5 deepwater facilities are **producing less than 50%** of their daily oil production capacity, based on a three-year average of daily production rates.

"Through collaboration, BOEM and BSEE identified **contingent resources that exist 30-60 miles away from existing facilities**. This research will identify any difficulties that new technological advances may face, that could potentially hinder production and project economics," the two agencies said.

“BSEE has … examined **extended-reach subsea tieback projects** given the capacity that exists in the region,” said BOEM Acting Director Walter Cruickshank. “Based on that analysis, BSEE could have more tools to minimize stranded resources.”

Project Overview

Goals and Objectives

The **goa**l is to develop and demonstrate new technology that can be utilized to help reduce the cost of subsea well tie-backs and extend their reach to unlock stranded resources.

Offshore, ‘enhanced oil recovery’ can be the difference between economically drilling a subsea well and achieving primary and often secondary (usually water injection) recoveries (50/60%) versus leaving the resources in the ground (0% recovery) due to the high cost of dry tree, platform supported wells.

The **objective** is to design, engineer, construct/fabricate, test, and qualify a full-scale prototype subsea chemical storage and injection system for low dosage rate production chemicals to enhance offshore oil production.

Project Overview

Specific Objectives

Phase 1, 2020-04 through **2021-12 key objectives:**

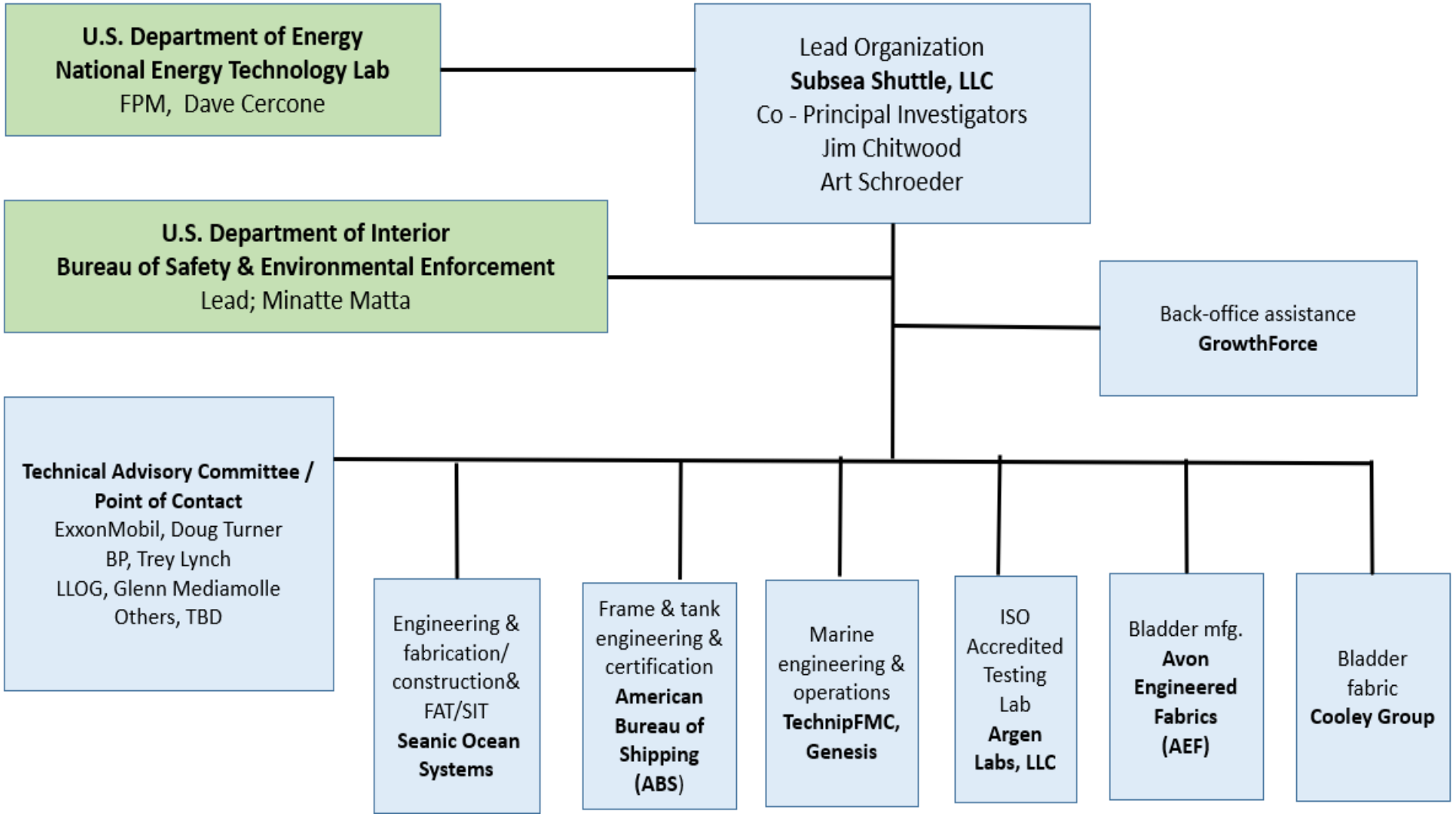
- Design, engineer, procure, fabricate subassemblies
- Integration of subassemblies into a complete prototype Integrated Unit.
- Prototype Integrated Unit tests and qualification activities culminating with a System Integration Test (SIT).
- Identify and contract w/ operator to demo Integrated Unit in an offshore field

Phase II, 2022-01 through **2022-12 key objectives:**

- Planning & coordination of offshore demonstration of the Integrated Unit, including regulatory reviews
- Acquisition & fabrication of all site specific (offshore field demonstration location) components
- Offshore deployment, operation/demonstration, then recovery
- Onshore post-demo Integrated Unit inspection, review and analysis
- Final technical report

Project Overview

Participants



Technical Status

- Engineered fabric; 1000's of uses over decades

- ✓Abrasion resistant
- ✓Tear resistant
- ✓Tremendous tensile strength
- ✓Wet environment properties
- ✓Material – matched to chemical use
- ✓10-year + life expectancy in many applications

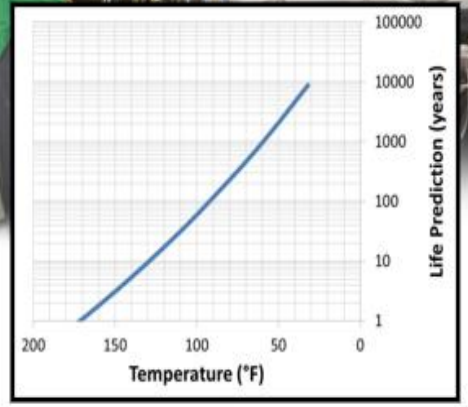
Technical Status

- Production chemicals, testing and 3rd party qualification

- Long-Term Aging Testing
  - Test Temperature(s): Wide range, 3 temperatures
  - Test Duration: 60 days
  - Test Fluids: Various
  - Test Pressure: 4400 psi
  - Testing: Triplicate + samples

Biaxial Tensile Properties – Proprietary me
Uniaxial Tensile Properties - ASTM D412/D
Mass Change, Volume Swell - ASTM D471
Tearing Resistance - ASTM D1004
Permeation Testing -API 17J

Friction/Wear Testing; Fabric on Fabric and Fabric on Tank Wall

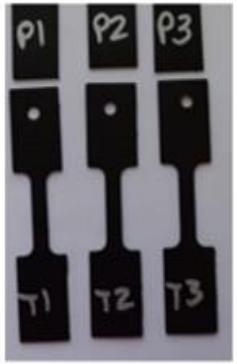


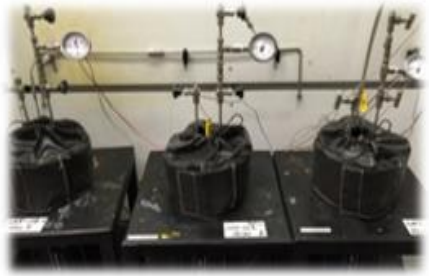
Chemical/fabric qualification:

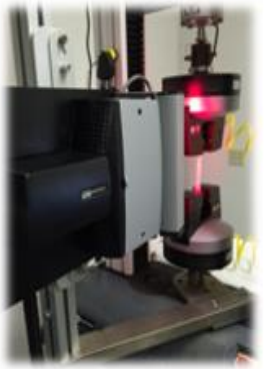
1. MeOH
2. LDHI
3. Scale Inhibitor
4. Corrosion Inhibitor
5. Asphaltene Inhibitor
6. Dispersant
7. Seawater
8. Process developed to qualify additional chemical

Logistics of Testing

Prepare Specimens → Age in Fluid → Test Mechanical & Physical Properties

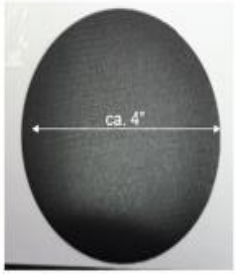






Uniaxial Tensile
Two Orientations
ASTM D1708

Puncture
ASTM D751



Seam (Shear)
Custom Method

Trapezoidal Tear
ASTM D751

Technical Status

- Scale (500 gallons) storage system test and optimization

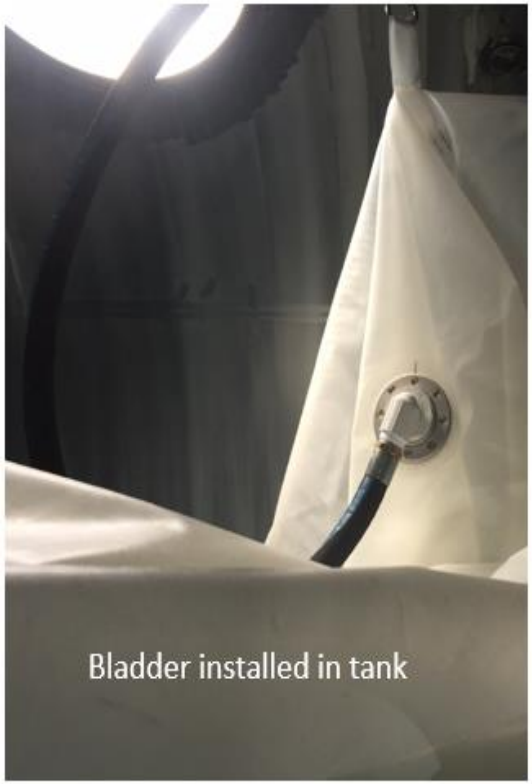
Earlier Phase Testing results

- Bladder behavior was consistent, predictable & repeatable
- Able to achieve very low chemical residuals after pump-down.
- No observed detrimental bladder material behavior.

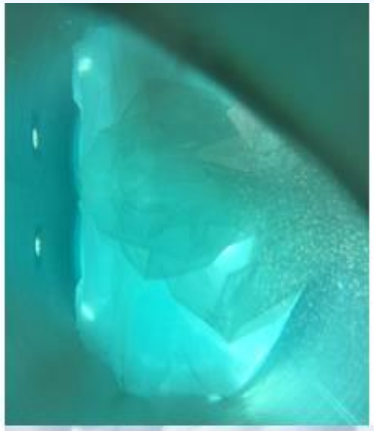
Over 30 SME participants + regulators witnessed model test / demonstration

Technical Status

Full size test tank/bladder performance testing



Test tank; full scale but w/o process module

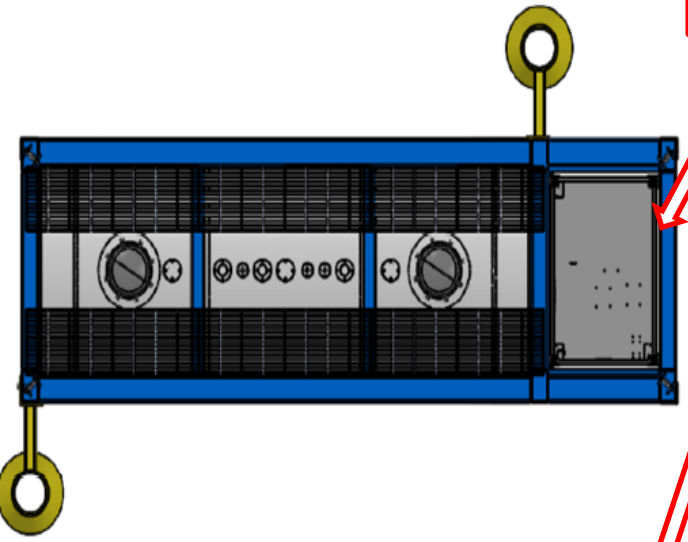


Bladder in tank, filing

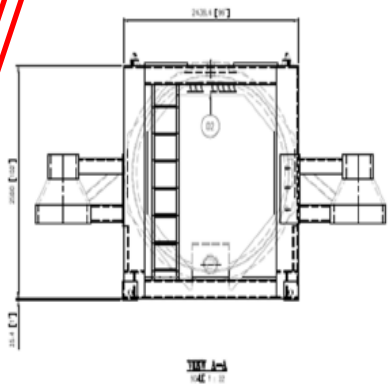
Installing bladder in tank,
Subsequently perfected methodology for installing w/o manned entry

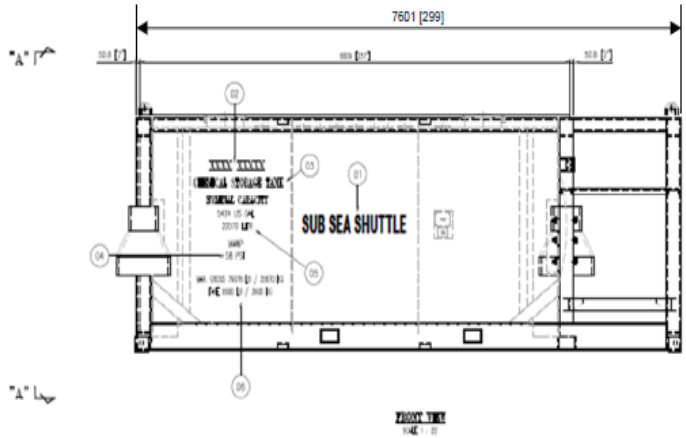
Technical Status

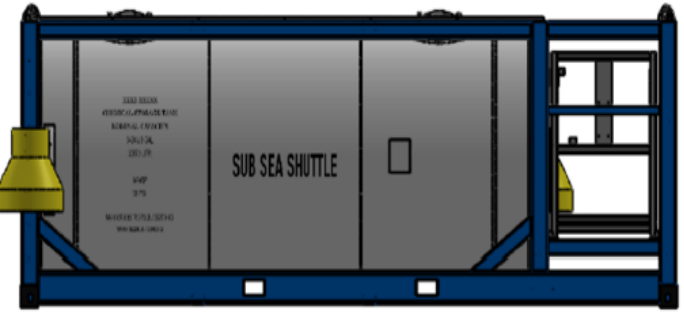
- Prototype frame, process and storage system, under construction

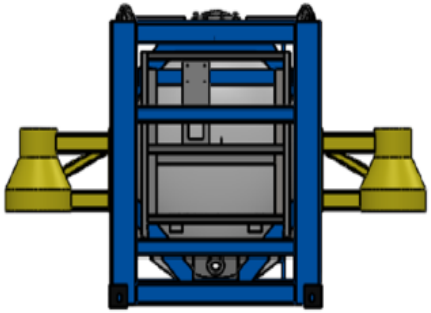


Process module









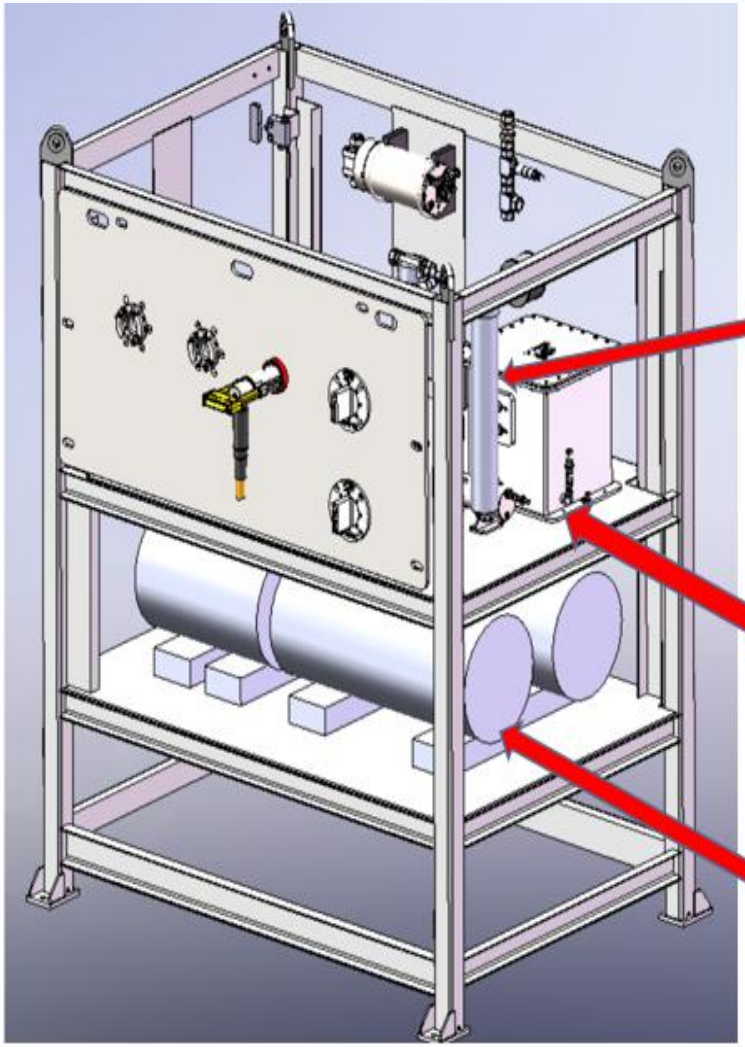
CSIU Details

- Length – 25’ 0”
- Width (structure only) – 8’ 0”
- Width (with guide cones) – 16’ 0”
- Height – 8’ 6”
- Height (with padeyes) – 9’ 0”
- Total Weight (air, empty) – 33.7 kips
- Total Weight (air, full) – 79.1 kips (35.9 mt)

Technical Status

- Process module

Process skid



Injection pump testing

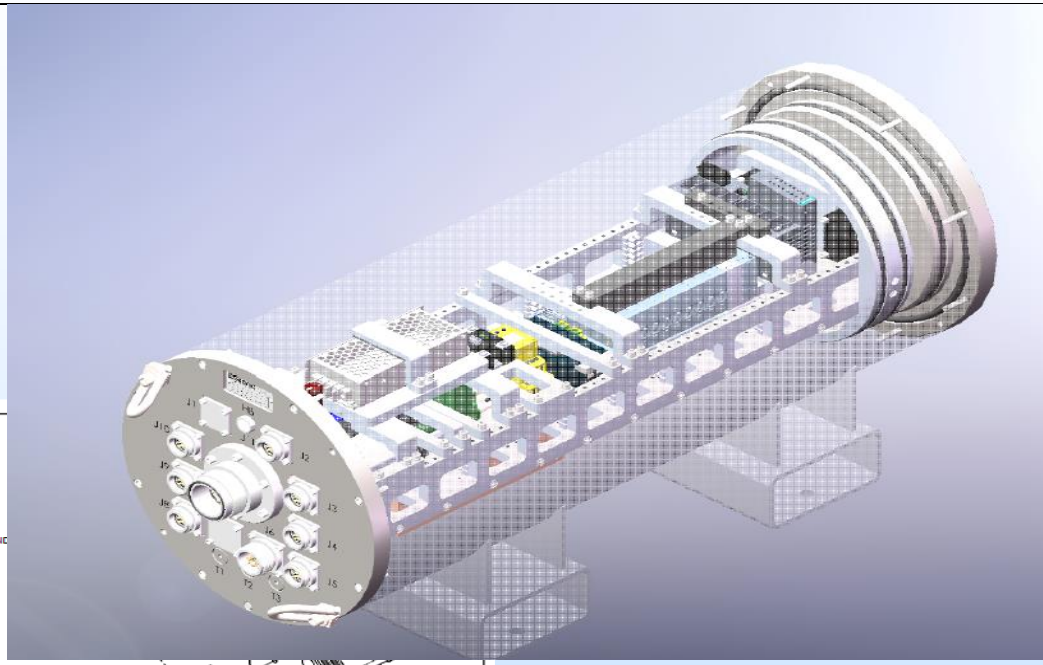
Flow meter

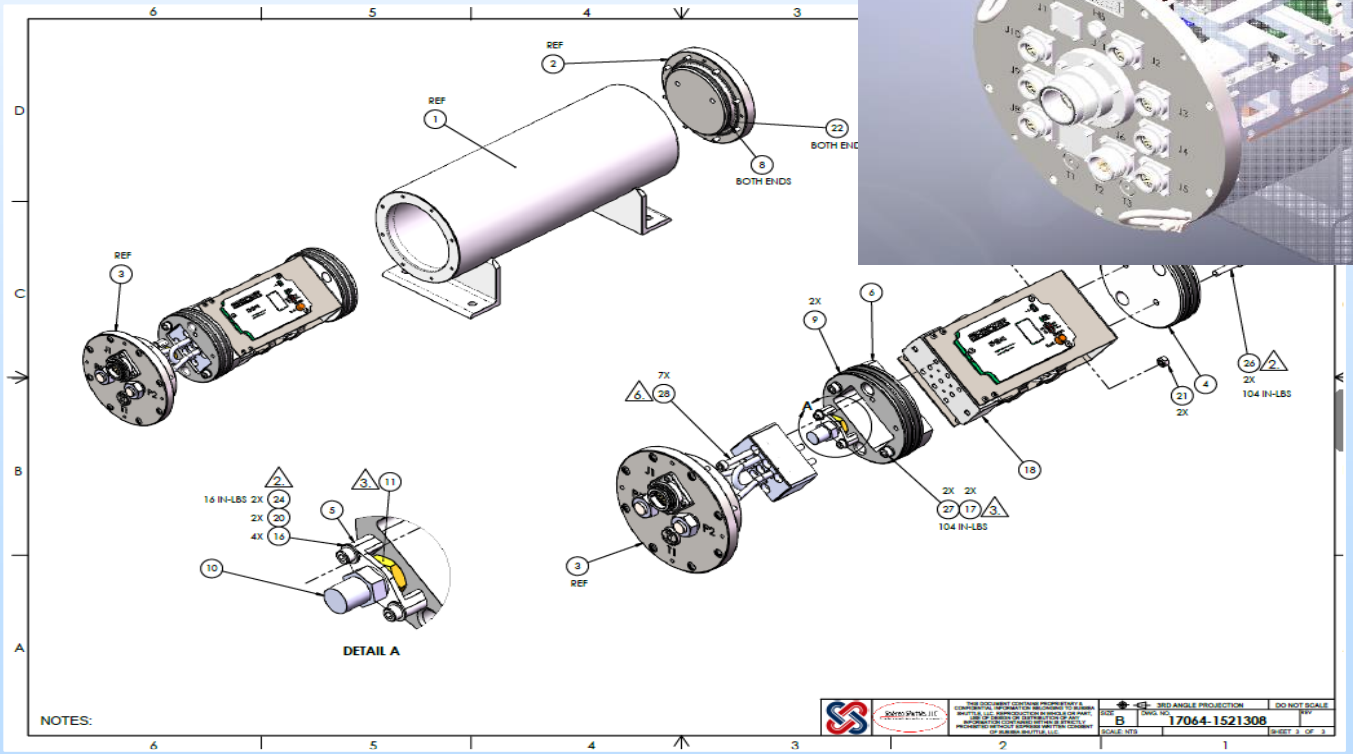
Subsea electronics (1 atmosphere pressure cans)

Technical Status

- **Subsea electronics**

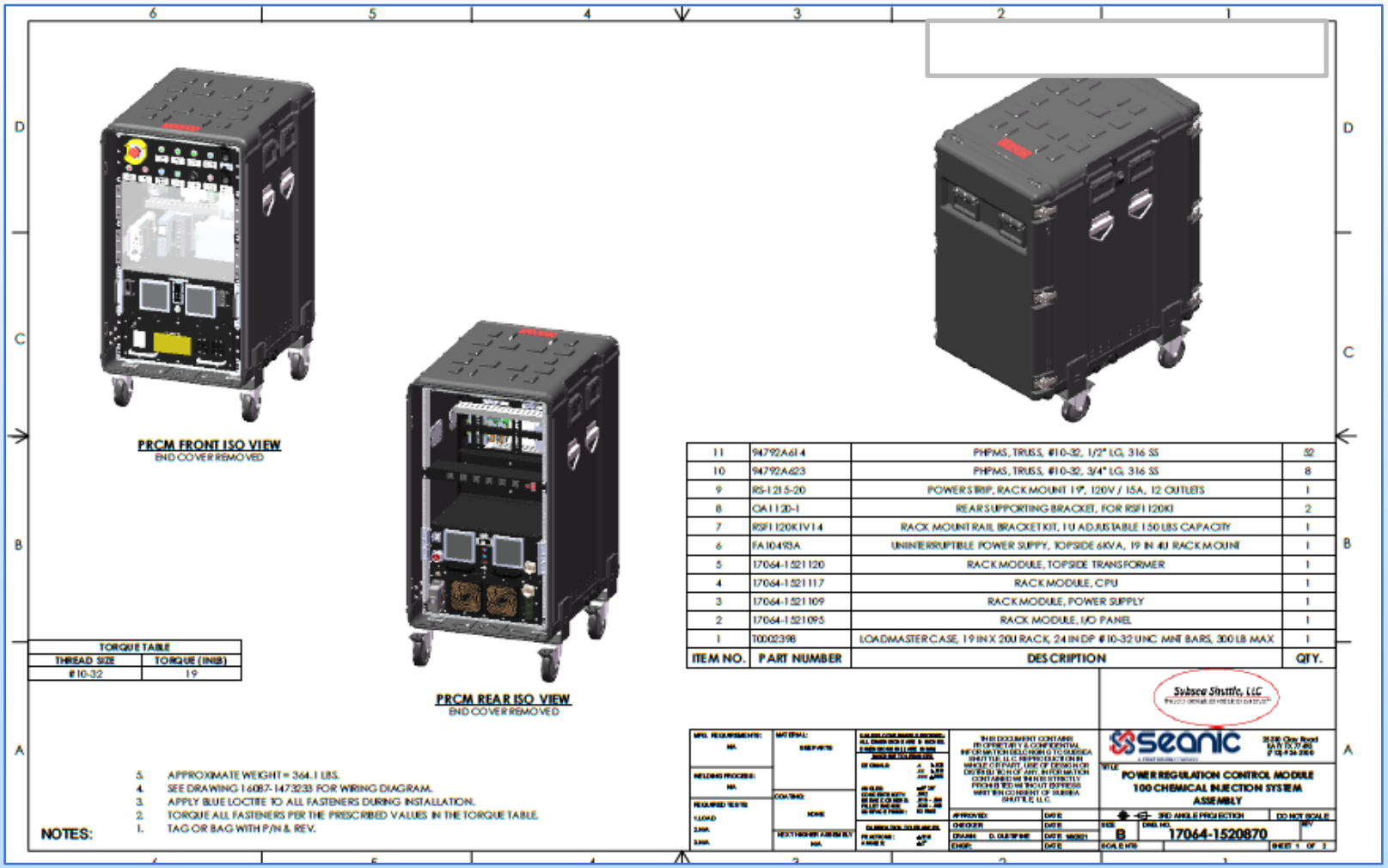
One (1) atmospheric ‘cans’
(pressure vessels) hold electronics





Technical Status

- Top-side (host platform) electronics, PRCM, power regulation and control module



Technical Status

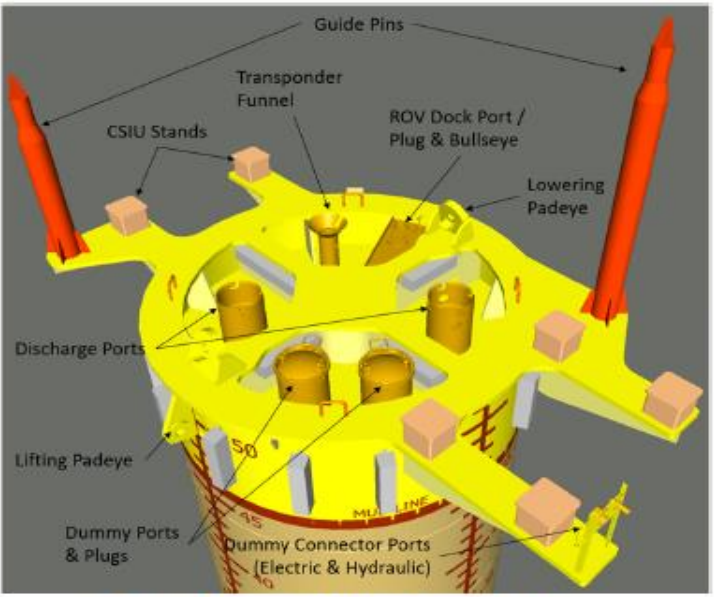
- Phase 1 (onshore) test facilities

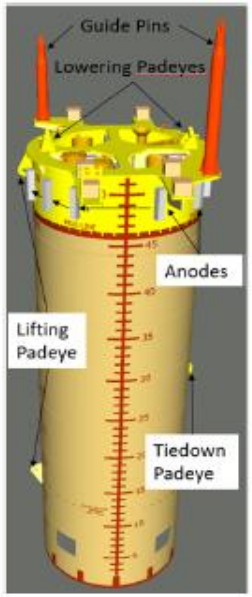
Test Tank Facilities

- 50’ x 50’ x 30’ (deep)
- 560,000 gallons
- 2000 lbs./sf loading
- 10 T overhead crane
- HD video & LED lighting
- Remote monitoring
- ROV operations
- Oil Spill Collection System

Technical Status

- Foundation design



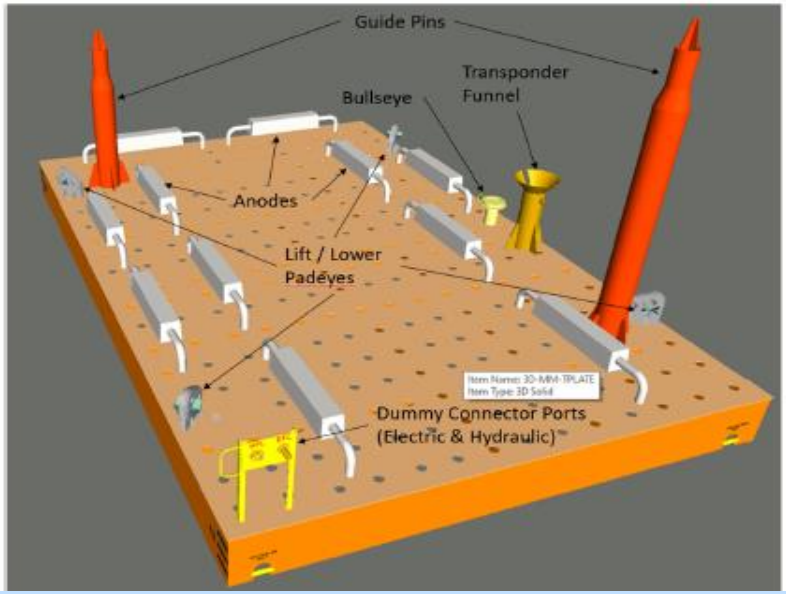


Suction Pile Details

- Pile Outside Diameter – 16’ 0”
- Pile Length – 52’ 0”
- Short Pin Length – 8’ 11”
- Long Pin Length – 12’ 11”
- Pile Steel Weight (air) – 220.4 kips
- Outfitting Weight (air) – 5.1 kips
- Total Weight (air) – 225.5 kips (102.3 mt)

Mudmat Details

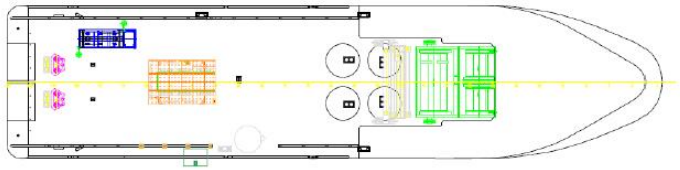
- Length – 29’ 0”
- Width – 19’ 0”
- Short Pin Length – 8’ 11”
- Long Pin Length – 12’ 11”
- Total Weight (air) – 28.5 kips (12.9 mt)



Technical Status

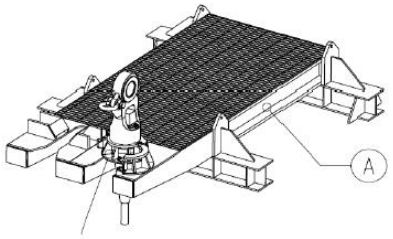
- Offshore installation planning and analysis
  - Operational assumptions
  - Qualitative Risk Analysis (QRA)
  - Foundation design
  - Vessel loadout
  - Foundation deployment
  - Storage and injection unit deployment
  - Operational hook-up
  - Recovery (reverse)

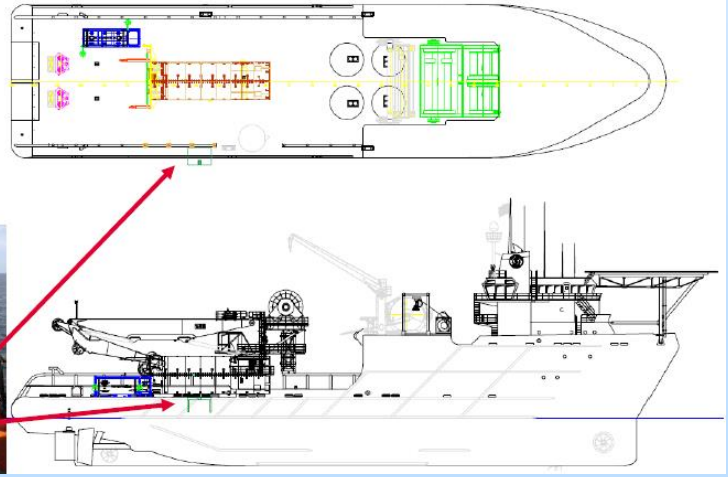
Vessel Loadout



Typical Light Construction Vessel

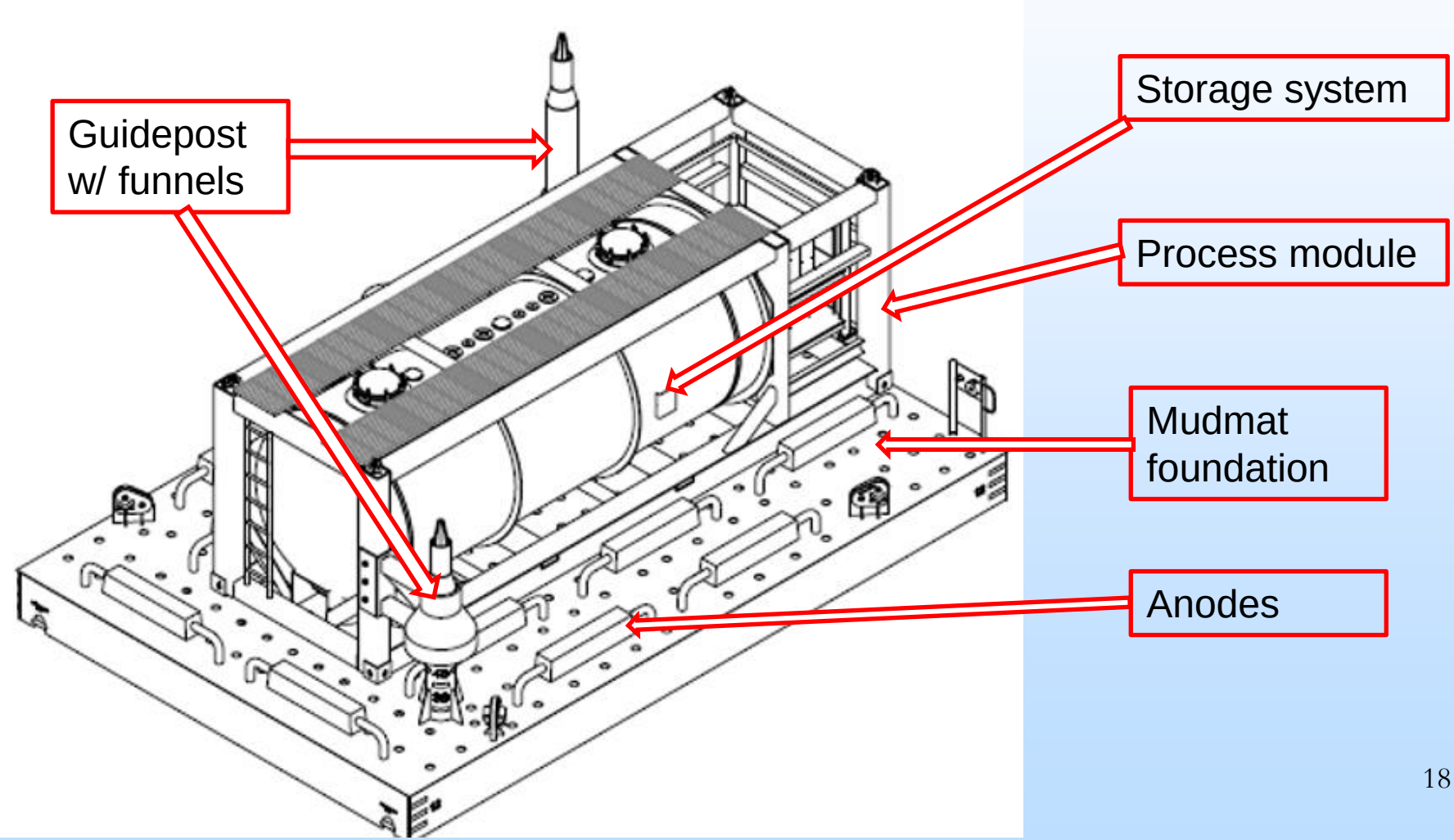
- Dimensions – 288’ x 66’ x 29.6’ (87.78m x 20.12m x 8.99m)
- Clear Deck – 116’10” x 54’ (35.36m x 16.46m)





Technical Status

- Foundation with Chemical Storage & Injection Unit



Lessons Learned

- Impact of COVID wrt,
  - Procurement, longer leads, stocking levels, pricing
  - Personnel, out of office work environment and illness
- Impact of regulations
  - Testing of tank
  - Over-road hauling

Project Summary

- Analysis and testing of sub-assemblies and components proceeding as planned, but with delays.
- Oil company under Letter of Intent wrt demonstration
- Systems Integration Testing (SIT), anticipated near end of year (2021).

2-minute animation depicting our solution can be viewed @ https://www.linkedin.com/posts/artjschroeder_subsea-innovation-offshore-activity-6687433705331544064-g6_V

Bibliography

- List peer reviewed publications generated from the project per the format of the examples below.

None to date