"Development of the ARCA, a diverless chain connector for the high integrity of mooring lines"
ARCA – Articulated Rod Connecting Arm - Definitions

Constituted of:
1. A rod
2. A receptacle to hold the rod’s head
3. A cam sleeve to guide the rod through connection/disconnection
4. A unijoint at the rod’s bottom
5. A lever arm to satisfy chain OPB requirements
6. An articulation on the install line
7. Load cells for mooring line load monitoring.
ARCA – Articulated Rod Connecting Arm – how it works
Why we developed it?

- Allows diverless offshore connection and disconnection.
- Allows inspection, maintenance and replacement of the articulation.
- Separates structural (I-tubes) from mechanical function (articulation).
- Can lead to room savings in turrets.
- Maintains a flush keel at yard for easy integration.
- No seafastening before hook up.
- Allows installation and replacement of a more reliable Anchor Leg Load Monitoring System.
Why full scale testing?

- The performances of the cam for rotation have been extensively tested at 1/10 scale.

- However, the need for full scale testing was identified to correctly assess performances under real conditions in terms of:
  1. Contact pressures
  2. Friction coefficient
  3. Gaps
  4. Manufacturing tolerances
  5. Loads (pretension and winch pull)
**What do we test?**

1. The functionality envelope for connection/disconnection of the ARCA as a function of:
   - Line tension
   - Misalignment angle

2. The overpull needed at winch for installation
**Test bench capabilities:**

- Able to simulate line inclination of 30° to 70°
- Line/receptacle misalignment of +25/-19°
- OP angles simulated with cam rotation.
- Pretension simulation up to 200 tons.
- Pretension nearly constant during connection.
- Winch overpull simulation at chain table up to 200 tons
- Installation stroke over 6 meters.
- Simulated line twisting torque.
More than 220 connection/disconnection tests have been performed on the prototype up to now.

During a 40 year design life a maximum of one connection / disconnection every 5 years is expected for inspection.

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Tensions and overpull data are collected constantly over time, to identify key points during pulling.
Loads are plotted as a function of position to identify the points where friction is higher in the system.
The typical shape of a real test data is shown below. Maximum winch pull is evaluated and recorded for each combination of in plane and out of plane misalignments.
Test bench – prototype operation
Validation of the rotation as per defined envelope, but problems at entrance.

Modification: smoother skirt, cam bottom and rod pins shape.

Better entrance ok up to 10-15 degrees.

Decoupling between pins orientation and articulation shafts.

Entrance validated up to 25 degrees. High friction at centering.

Self aligning cam sleeve.

Validation of performances, with severe wear and rusted surface, with simulated marine growth.
Status
- Performance envelope achieved at phase 4.
- Endurance of the system is proven (more than 220 connections in extreme configurations for an expected maximum of 8 connections in design life).
- Large part of testing campaign has been performed with severe rust and wear.
- Large functional gaps ensure high tolerance to wear, corrosion and marine growth.

Next steps
- Fine characterization of friction to determine winch capacity on projects.
- Test with simulated marine growth to be performed.
- Finalization of the qualification dossier with classes.