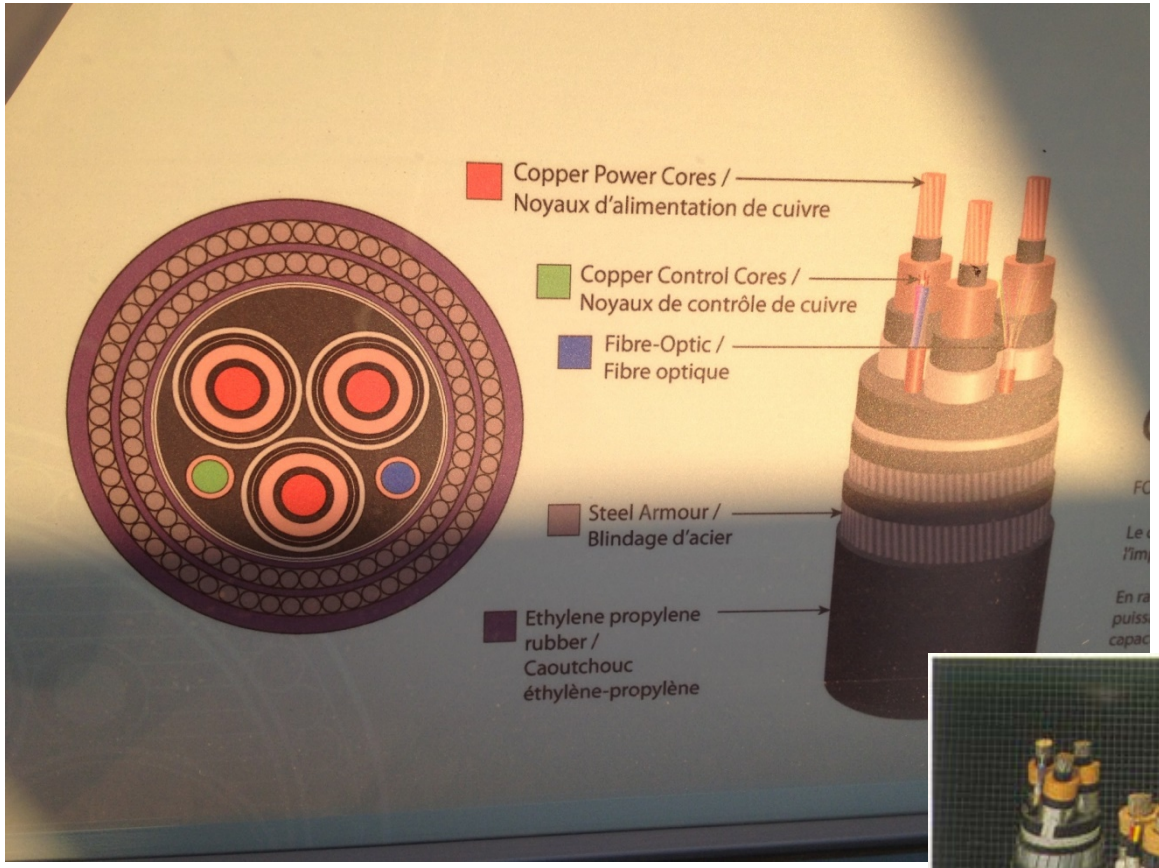
The Submarine Cable Specialists

Workshop: Durability of Cables and Moorings
In Tidal Flows 31 March 2016

Submarine Cable Corrosion in High Current Environments

A “New” Problem?

Mike Nichols - ETA Ltd

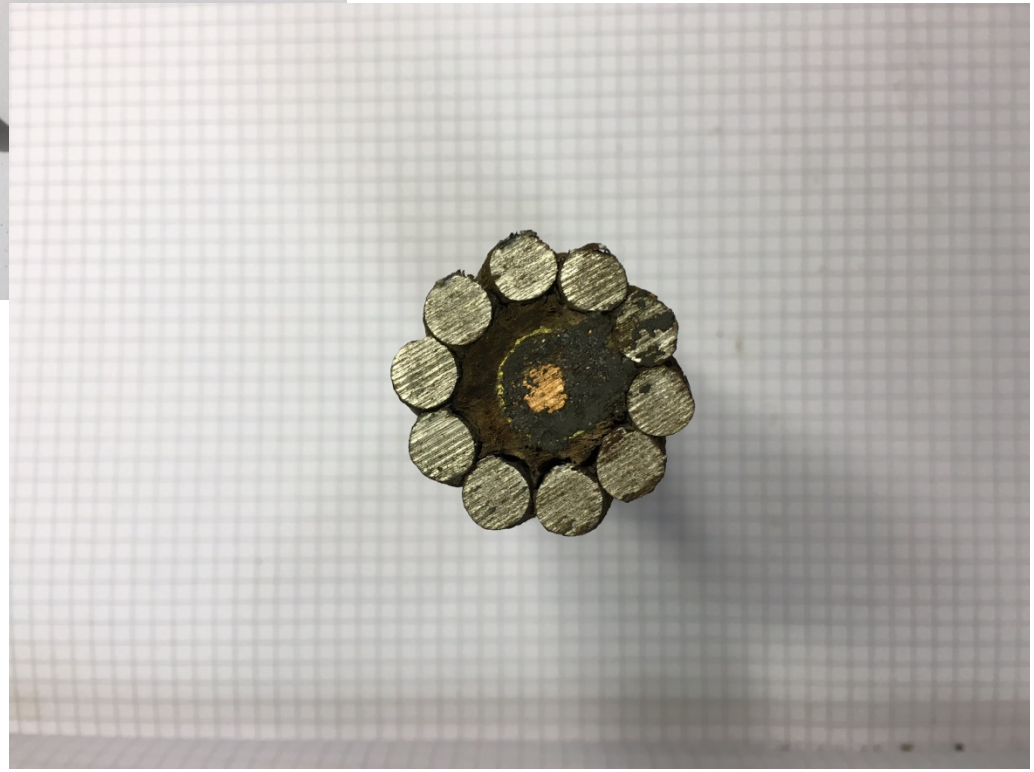

Copper Power Cores /
Noyaux d'alimentation de cuivre
Copper Control Cores /
Noyaux de contrôle de cuivre
Fibre-Optic /
Fibre optique
Steel Armour /
Blindage d'acier
Ethylene propylene
rubber /
Caoutchouc
éthylène-propylène


LINA
KOMATSU

Am I concerned about cable corrosion?

Fact or Fiction?


Ref 317
RPL V.8
Sennen Cove Bay Roberts No3
34 mm single armour, single copper core
telegraph table

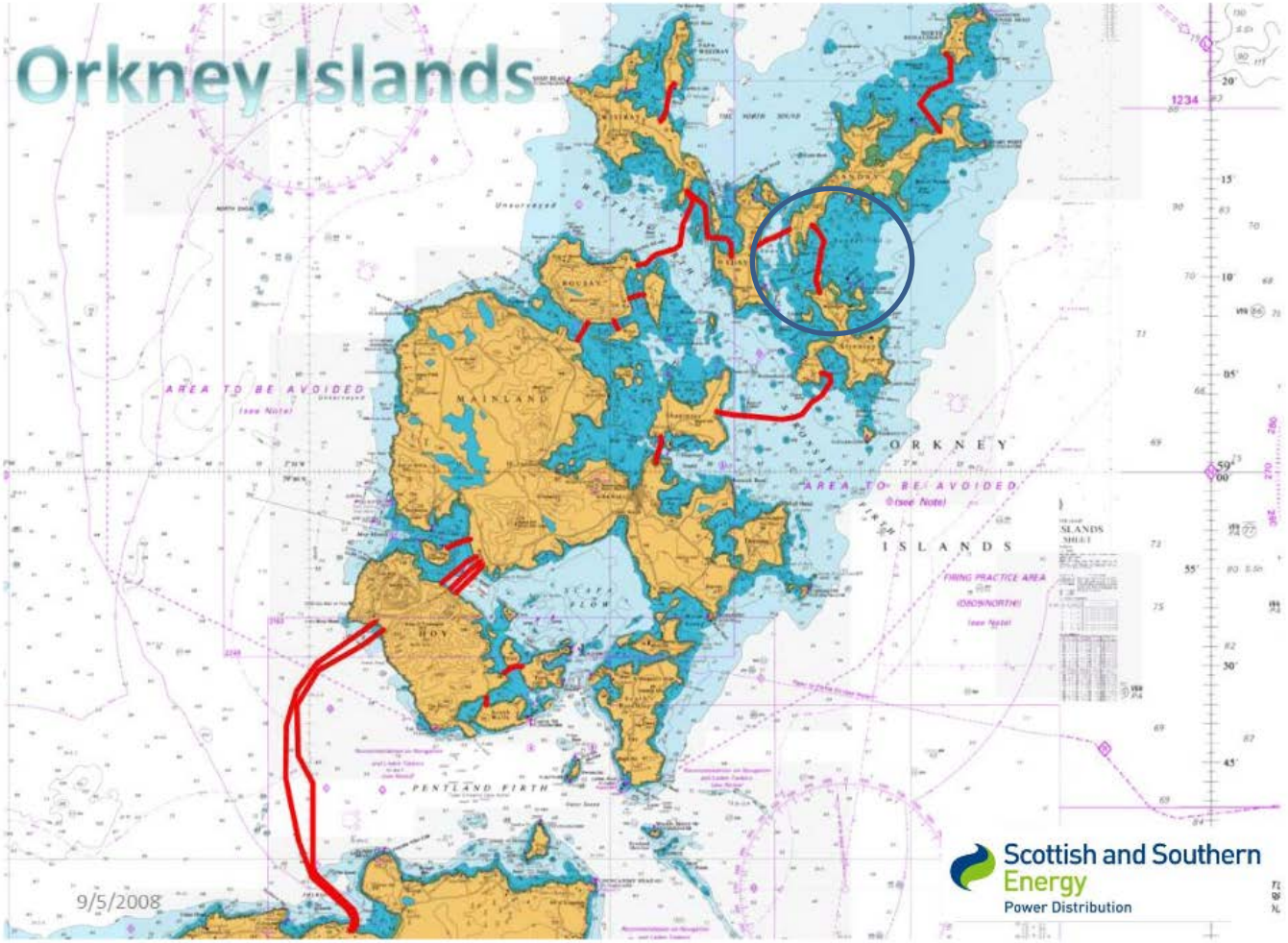



EMEC T7 survey 09:06:45 21.06.2013

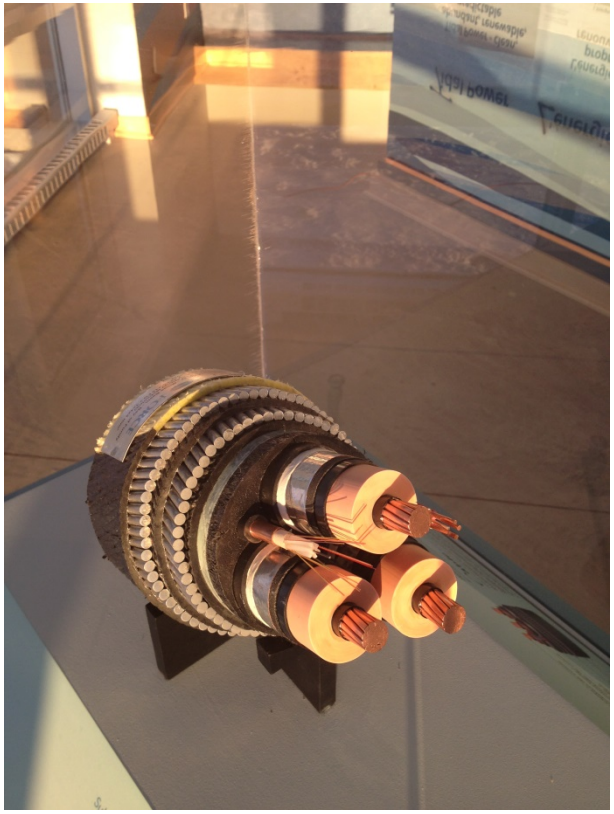

Tidal 7 CVI 15:14:50 04.03.2012
349
26.9m
=31

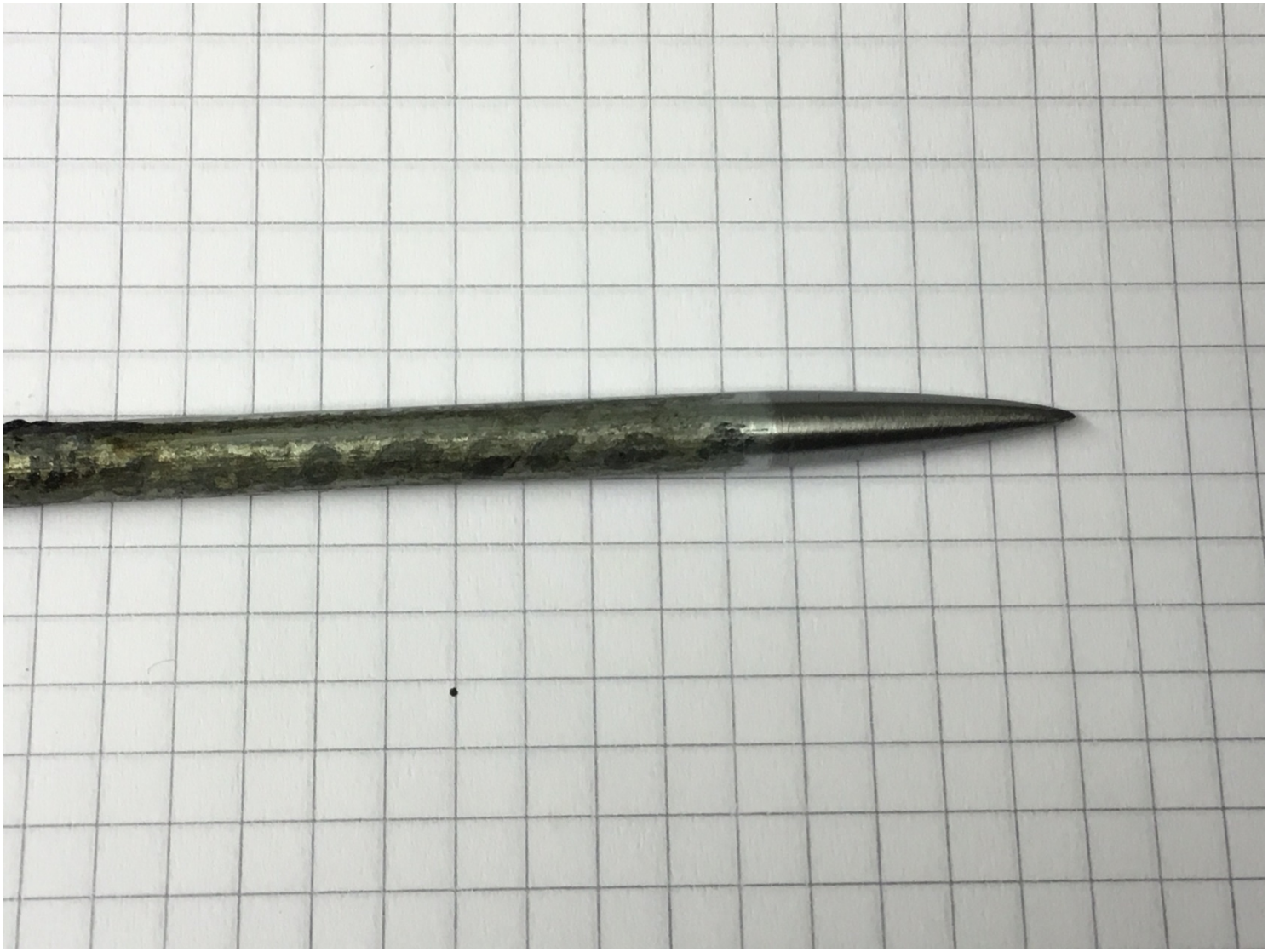
What's new?

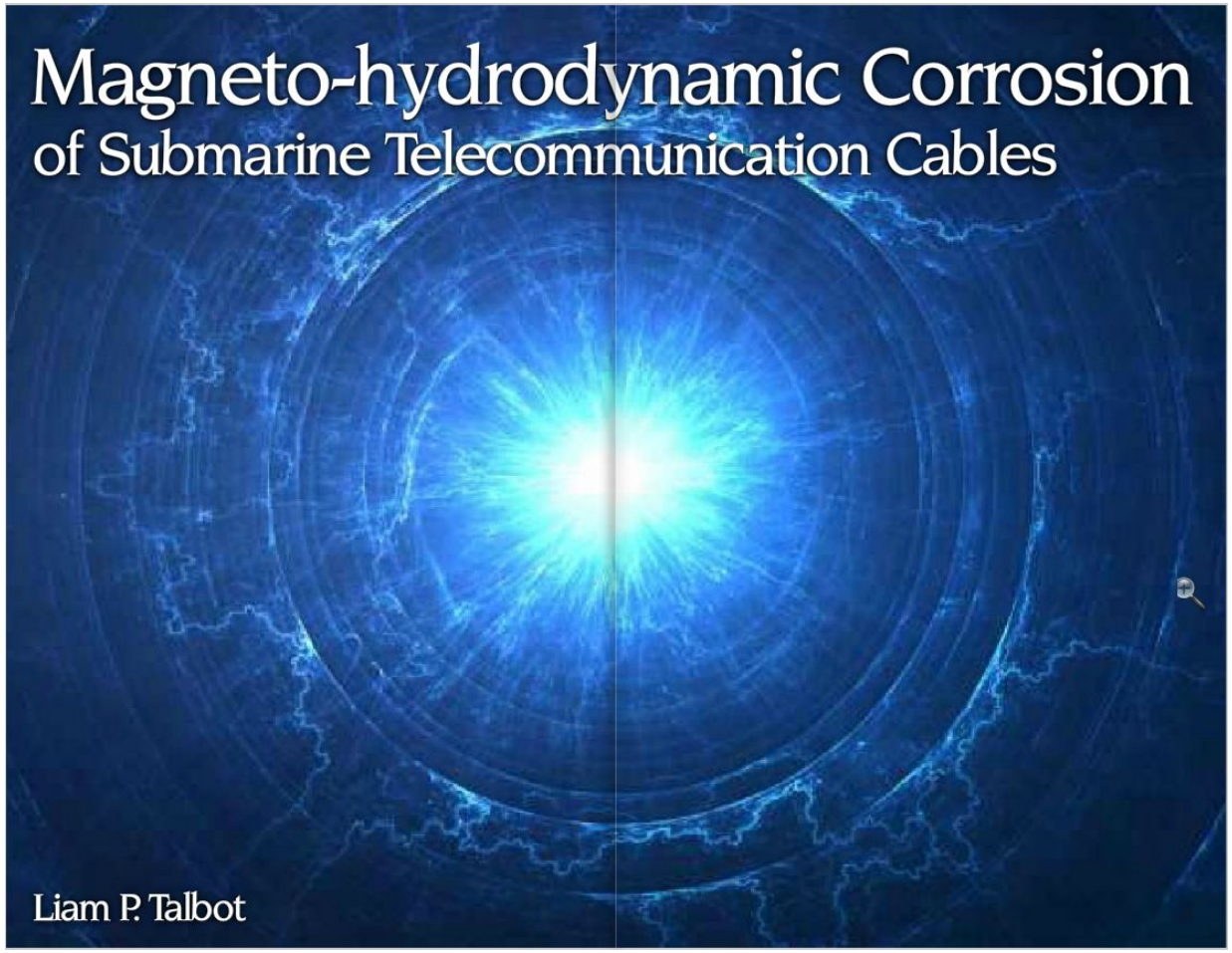
A memory is stirred – Late 1970s



m

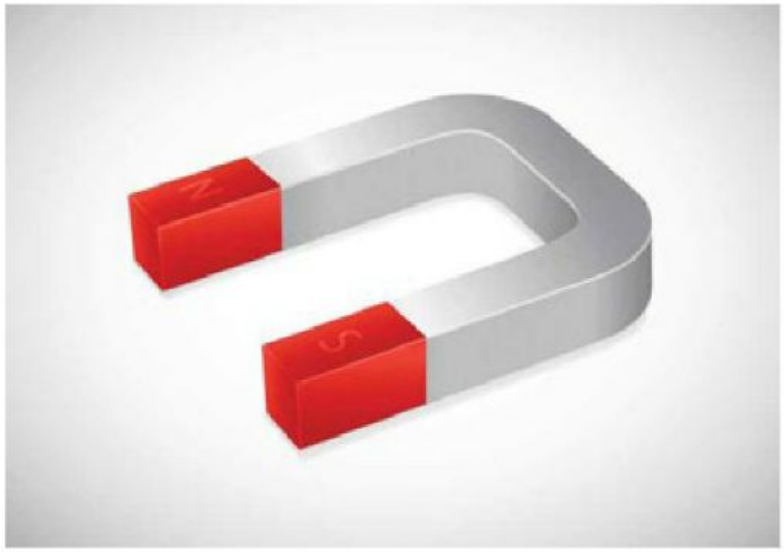





Magneto-hydrodynamic Corrosion
of Submarine Telecommunication Cables
Liam P. Talbot

When a conductor and magnetic field move relative to each other a potential difference is induced across the conductor. This phenomenon also holds when expanded on a global scale; where perturbations in the Earth's magnetic field induce currents on the Earth's surface.

Known as Geomagnetically Induced Currents they can flow in any conducting structure; and since saltwater is an electrical conductor GIC can act as a voltage source across the Earth's oceans - making submarine cables particularly susceptible.



GIC in stationary conductors are limited to variations in the Earth's magnetic field, which are infrequent and detectable. However, in areas of fast flowing saltwater, the conductor's movement relative to the Earth's magnetic field induces large currents.

If a situation arose where the flow of seawater was transverse to the submarine cable then - due to Fleming's left hand rule- a current would be induced along the longitudinal axis of the cable.

Galvanised steel armour offers some protection; however, if this coating is damaged and the steel is exposed, it will present a path of least resistance to the GIC. An electric current flowing along the exposed cable will gradually corrode the steel due to electrolysis, weaken the armour and eventually lead to cable failure.

Several cable breaks have been attributed to magneto-hydrodynamic corrosion and each displays a characteristic conical corrosion of the armour wire. The steel corrodes to a sharp point; tapering over approximately 150mm.

I suspect that the dimensions of this tapering relates to the electric current, and thus water speed. If this is the case, then this relationship can be used for forensic and predictive calculations.

Geomagnetically Induced Current

Geomagnetically Induced Currents affect everything from transmission grids to oil platforms. However, it is submarine cables that are most at risk as the induced current is not dependent on variations in the Earth's magnetic field: since moving water is flowing perpendicular to the cable, where GIC of tens to hundreds of amperes can be generated across a volume of ocean.

The steel armour of submarine cables is protected by a corrosion resistant coating. However, if this is damaged and the steel is exposed to the conductive seawater, corrosion can occur due to electrolysis.

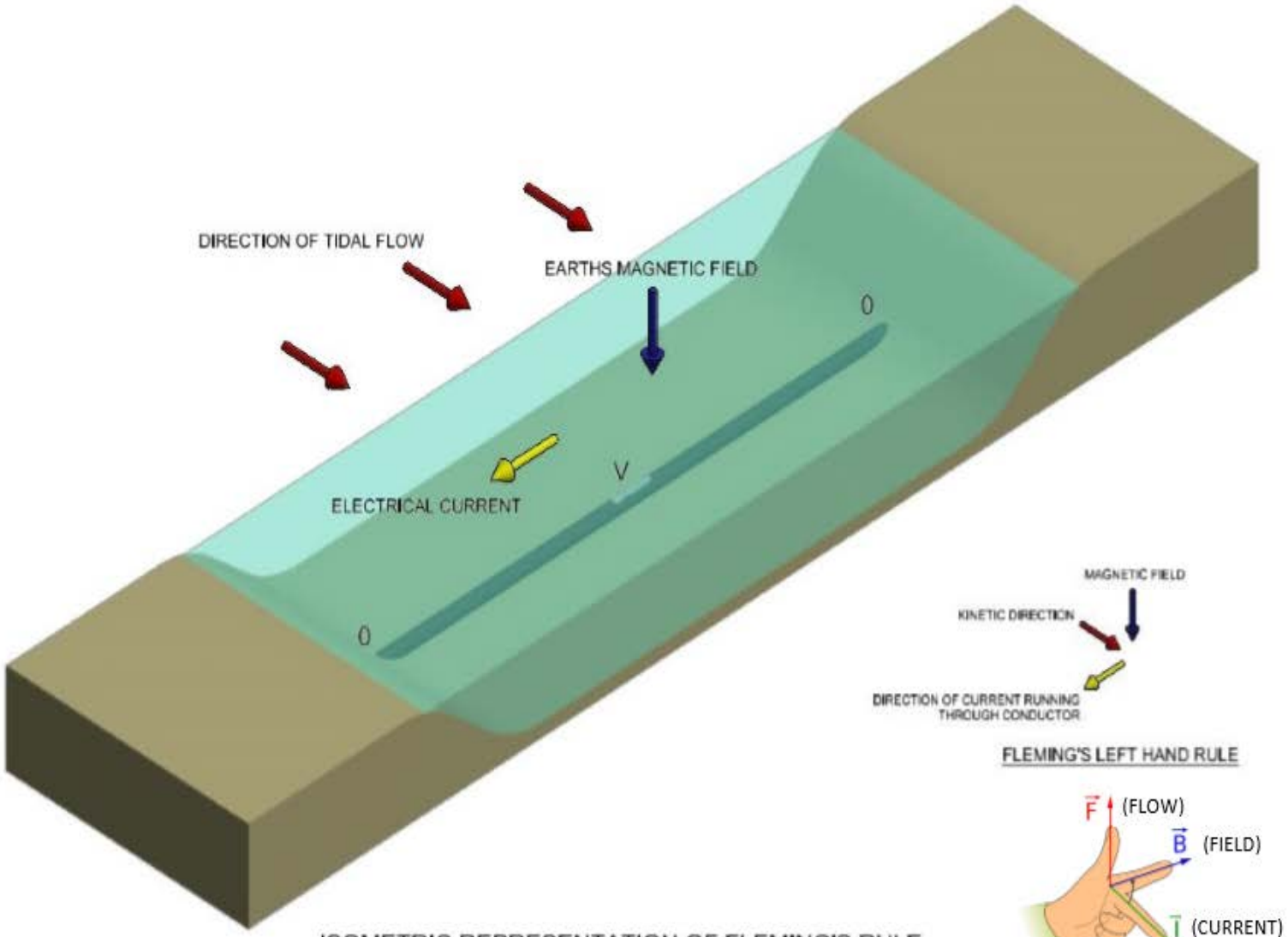
Electromagnetic Induction

Electromagnetic induction can be explained using the Lorentz Force and the conservation of energy: the direction of induced current opposes the change in magnetic flux which induces the current. If a charge q, moves with velocity v, in a magnetic field of strength B, making an angle θ, then the magnetic Lorentz force is,

$$F = qvBsin\theta$$

If v and B are perpendicular, $\theta = \frac{\pi}{2}$, $sin\theta = 1$, and,

$$F = qvB$$



ISOMETRIC REPRESENTATION OF FLEMING'S RULE
ASSOCIATED WITH A SUBSEA CABLE
IN A STRONG TIDAL FLOW

Literature Search
Japanese Paper

Completion of Submarine Cable Lines Combining Low Environmental Impact with Low Cost

*by Munehiro Furugen *, Yukio Noha *, Hideya Maekado *, Chihiro Yokoyama *2, Yukio Koshiishi *2, Shigeru Ebashi *2, Kunio Iwasaki *3, Takashi Kijima *3, Takumi Yamaguchi *4 and Hiroshi Kaizu *4*

ventional submarine cables to the neighborhood of 20 years. Photo 1 shows the condition of a typical cable. This cable was laid 28 years ago, and there are places where the steel armor wire has frayed and parted so that on routes where the cable is lying on the seabed there is a chance that insulation faults could occur. And since the frayed ends of the steel armor wires are needle-sharp, published studies have long shown that the problem is not merely that of mechanical friction wear but of electrical corrosion.

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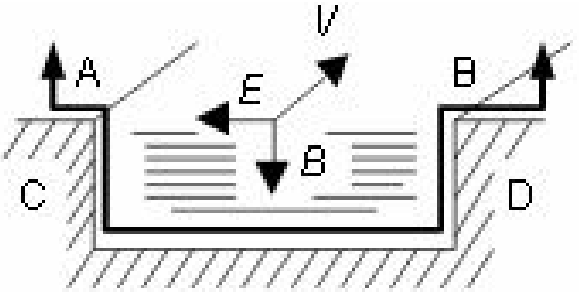
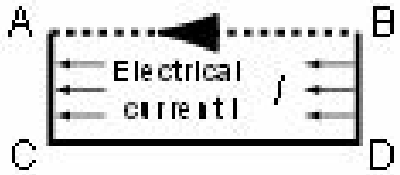
Japanese Paper

(1) EMF generated by tidal flows: This is due to the EMF generated by the earth's magnetic field and tidal flows and electrical current flows into and out of the armor wire near points where there are changes in flow velocity.

Japanese Paper



Electrical current flows in seawater from B to A; flows in to armor between A and C; flows out from armor between D and B (electrical corrosion)



EMF generated by perpendicular component of earth's magnetic field and tidal flows

Table 1 Damage to steel armor wires of cables installed in Okinawa.

	Hisamatsu-Irabu #2	Bisezaki-Ie #2	Ishigaki-Taketomi #2
Years in service	27	19	16
Length	5.0 km	6.8 km	4.6 km
Max. water depth	14 m	92 m	33 m
Tidal current speed	1.5 knots	1.6 knots	0.6 knots
Condition of armor	Major damage to steel wire	Several steel wires damaged	Steel wires exposed

The role of “l” (length)

The induced *emf* across the ends of the steel rod will now be,

$$V = vBl\sin\theta$$

Set up Experiment
University of Plymouth - UK

Project Interim Report

By

Matthew Thomas

Symmetrical Corrosion of Armour Wires on Submarine Cables

Dr Jahir Rizvi
December 2015

MARINE SCIENCE & ENGINEERING WITH PLYMOUTH UNIVERSITY

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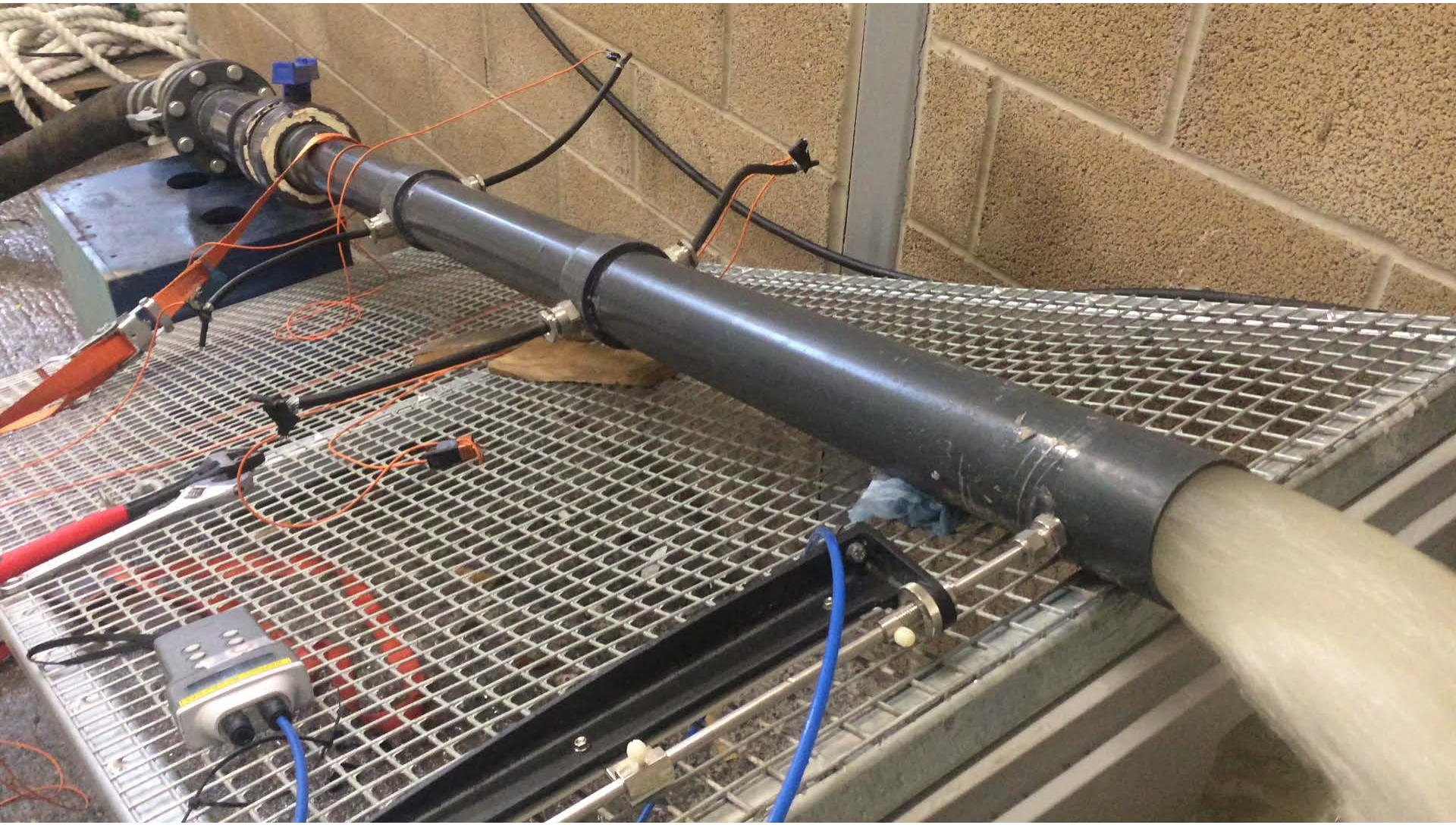
V -Experimental Set Up

V- Experimental set up



Measurement

Results/Future

- Work in Progress –Experiment is running now
- Confirm phenomena on small scale
- Upscale to achieve predictable results
- Determine actual risk and effective mitigation measures.

Implications for Marine Current Turbine Cables

- Armour protection
  - Galvanising
  - Plastic Coating
  - Solid sheaths
- Armour Materials
  - Reinforced plastic
- Direction of cable installation
  - In line with current flow

Related Experience
CATAC Connector

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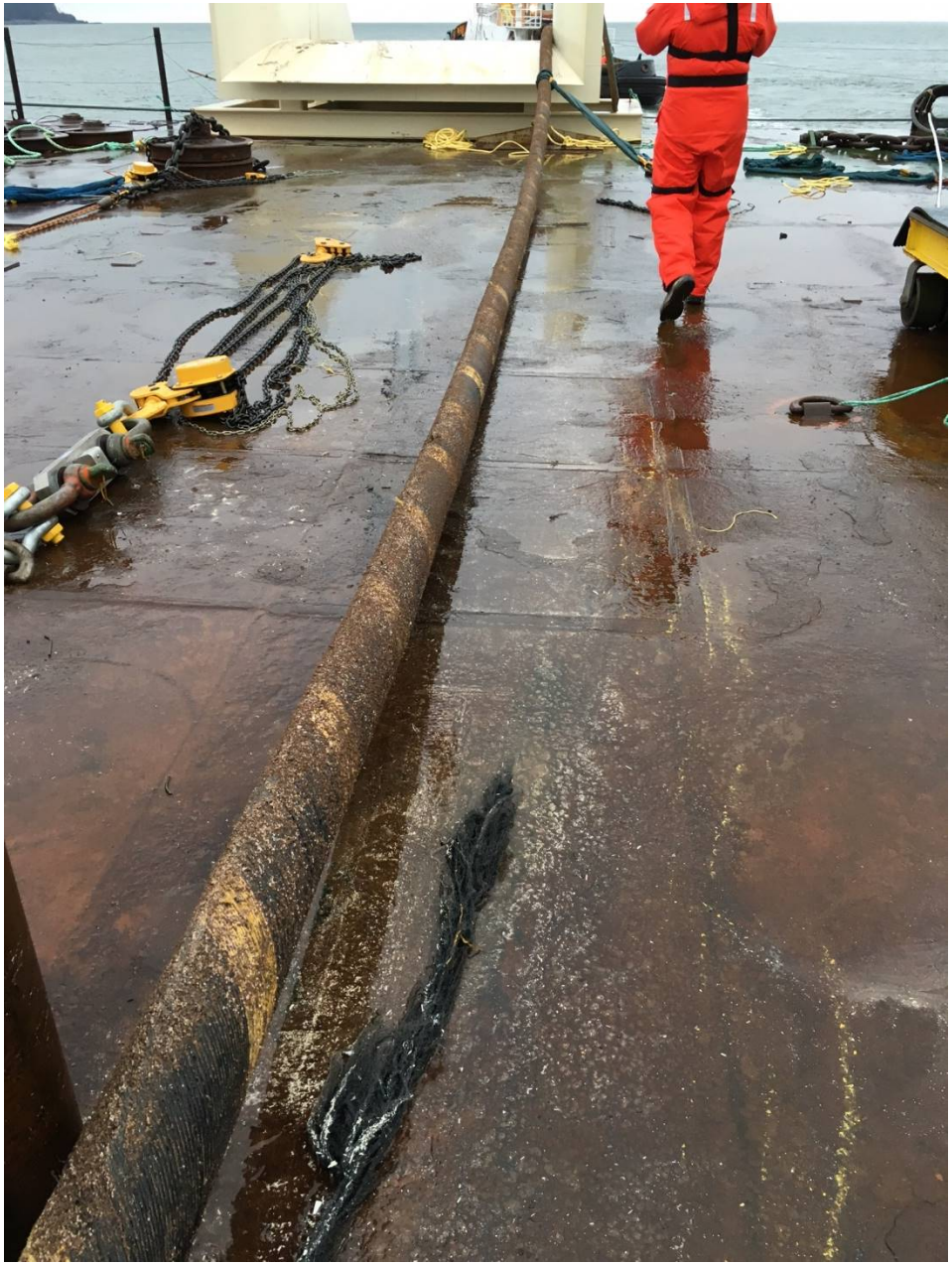
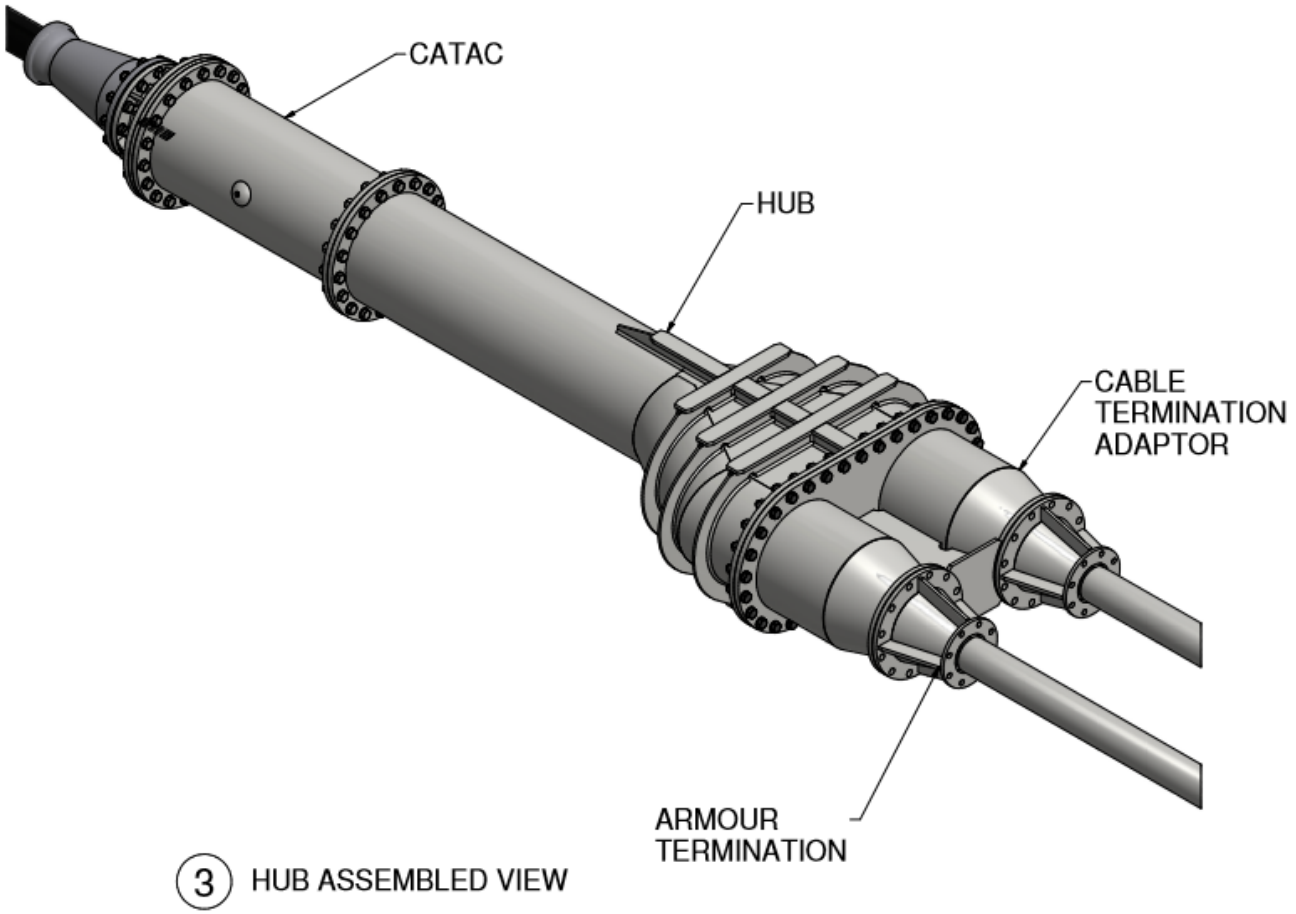
1-800-UR-RENTS

After 1 year

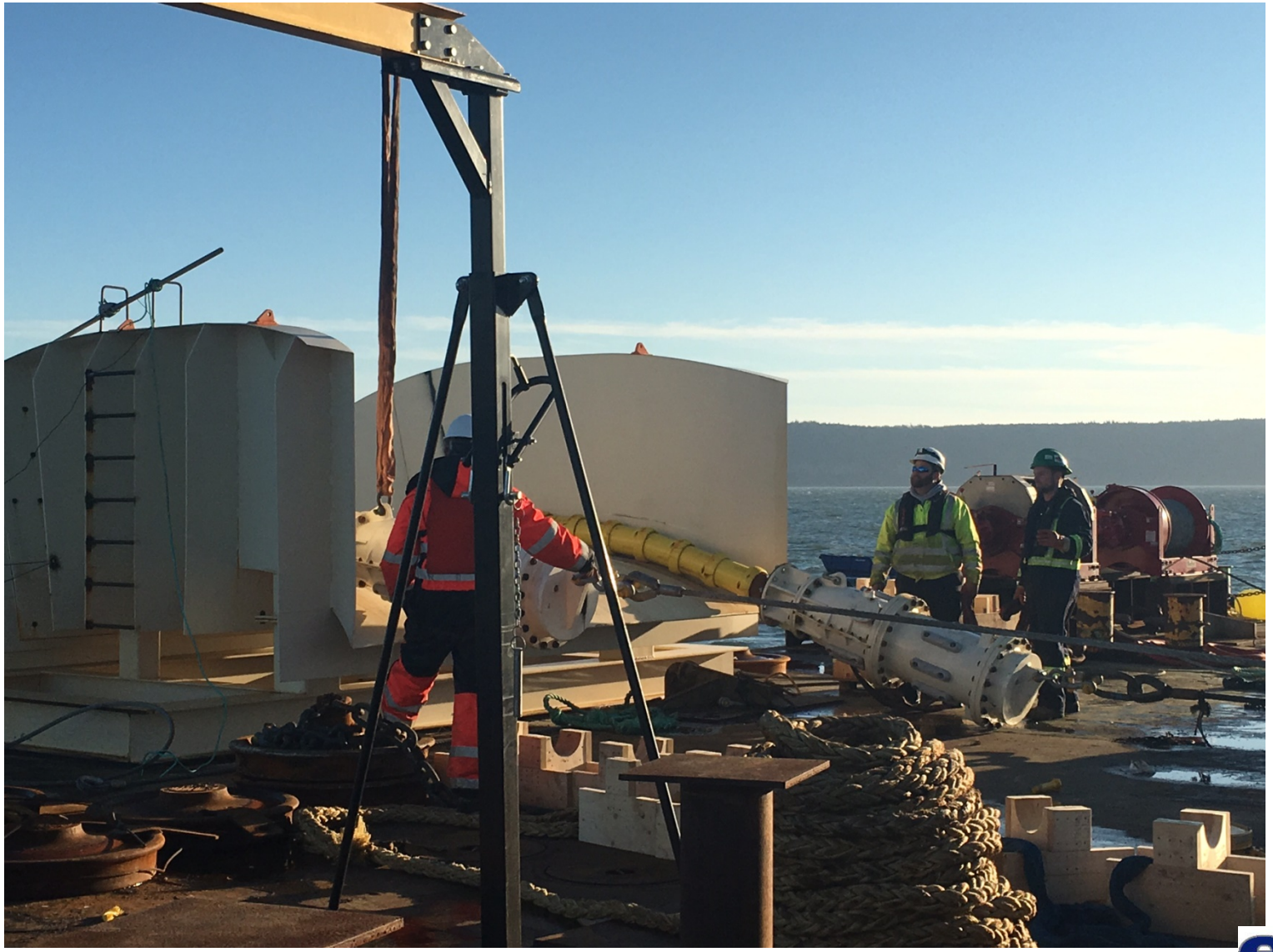


CATAC Condition – Deployment wire

Recent work


CATAC
HUB
CABLE
TERMINATION
ADAPTOR
ARMOUR
TERMINATION
3 HUB ASSEMBLED VIEW

Recent Work



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Conclusions:

Magneto
Hydrodynamic
Corrosion

- Is this a valid cable armour corrosion mechanism?
- Seek validation by experience and experiment.
- Confirm risk levels and timescales
- If so investigate and confirm most efficient mitigation measures.

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