VIPER INNOVATIONS

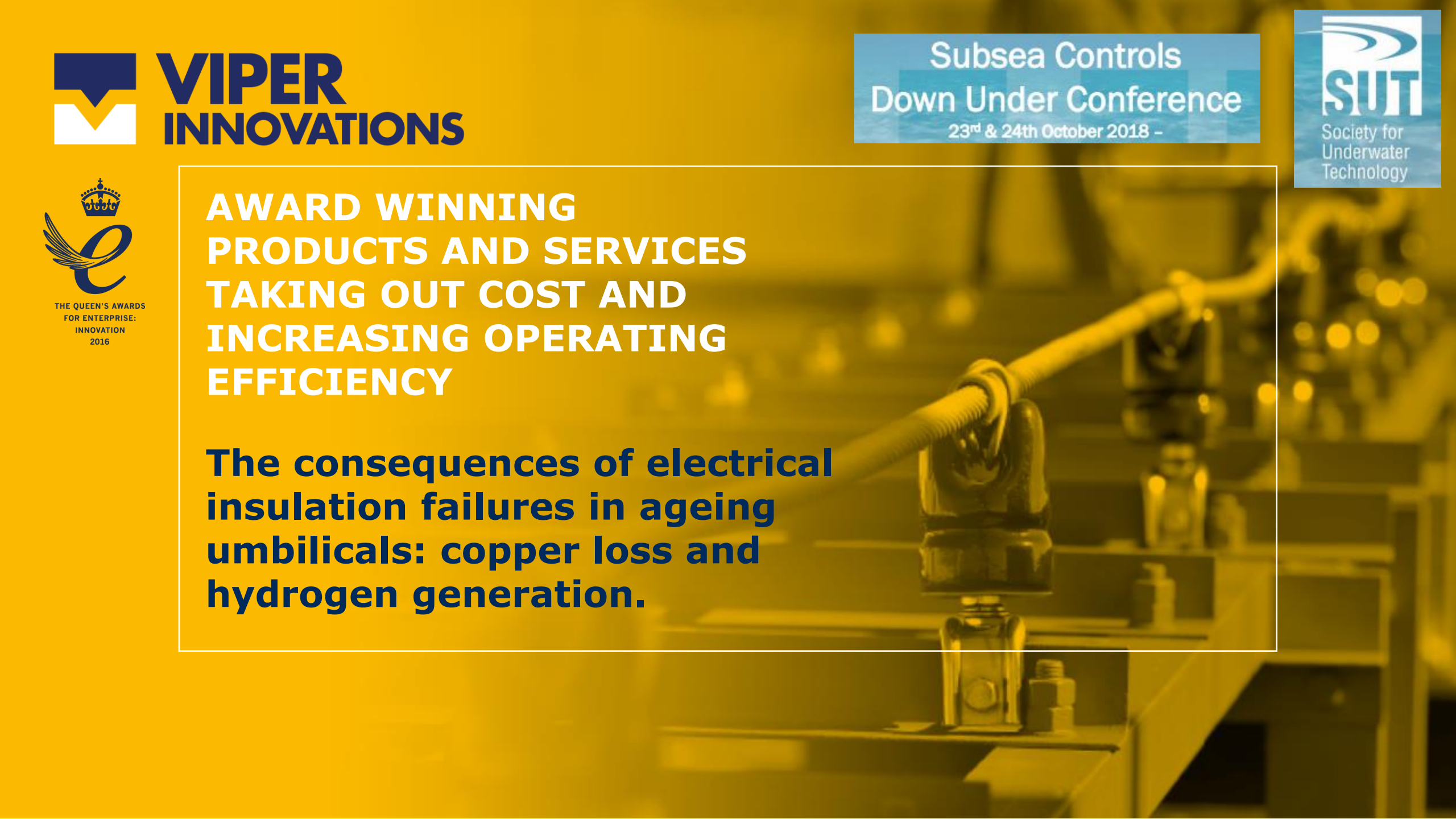
Subsea Controls Down Under Conference
23rd & 24th October 2018 –

SUT Society for Underwater Technology

THE QUEEN'S AWARDS FOR ENTERPRISE: INNOVATION 2016

AWARD WINNING PRODUCTS AND SERVICES TAKING OUT COST AND INCREASING OPERATING EFFICIENCY

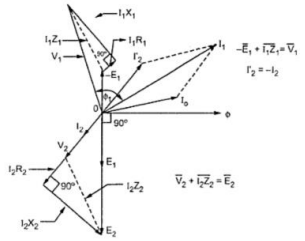
The consequences of electrical insulation failures in ageing umbilicals: copper loss and hydrogen generation.



Power Distribution Systems

- **Three main considerations**

AC or DC



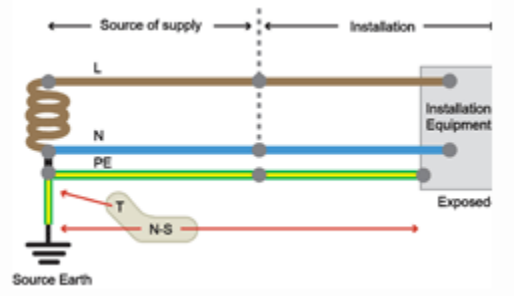
Single or Multi Phase

Earthing

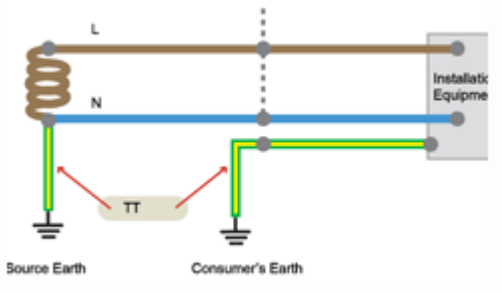
- Most subsea control systems utilise:
  Single phase, AC, ungrounded IT systems operating at <1000V
- Three phase systems have been used for long offset subsea controls
  Always ungrounded IT systems
- DC supplies are predominantly used in Subsea Controls by Schlumberger/OneSubsea

Earthing Arrangements

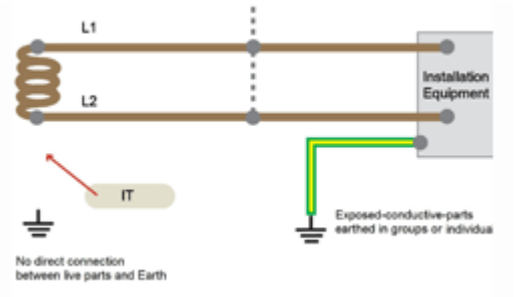
- IEC has standardised on three families of earthing – TN, TT, IT
- 1st Letter is connection between earth and supply
- 2nd Letter is connection between earth and device being supplied



TN



TT



IT

IT (Isolation Terra) Systems

- IT systems have no deliberate electrical connection to earth
- Continued supply on 1st ground fault
  - Could be down to Insulation resistance
  - Ground current on first fault is very small
  - Effectively grounds one side to turn IT system into a TT system

- **If a 2nd ground fault occurs**
  - Can lead to dangerous body currents lacking protection
  - Other phase(s) rise to phase-to-phase voltage – impressed on conductor. Increases electrical stress.
- 1st fault must be fixed ASAP

Insulation Monitoring Devices

Bender

Schneider

Viper Innovations

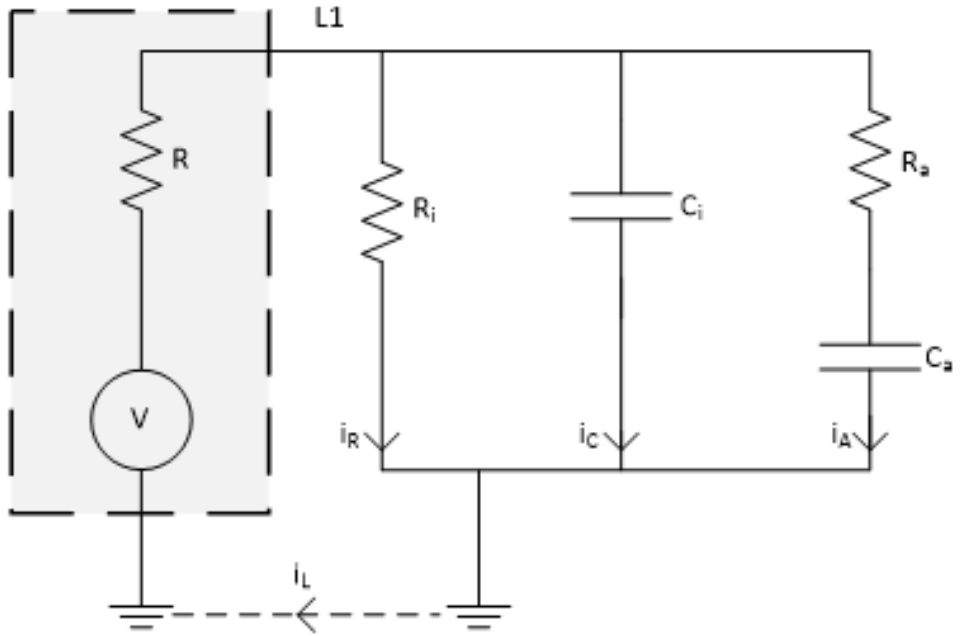
Megacon

Hakel

Irelec

Cable Insulation Integrity Measurement

Leakage current f () of 3 sub-currents



$$i_R = \frac{V}{R+Ri}$$

$$i_C = \frac{V}{R+\frac{1}{j\omega Ci}}$$

$$i_A = \frac{V}{R+Ra+\frac{1}{j\omega Ca}}$$

Where:

V= Applied Auxiliary Voltage

R=Internal Current Limiting Resistance

R_i= Insulation Resistance

C_i= Insulation Capacitance

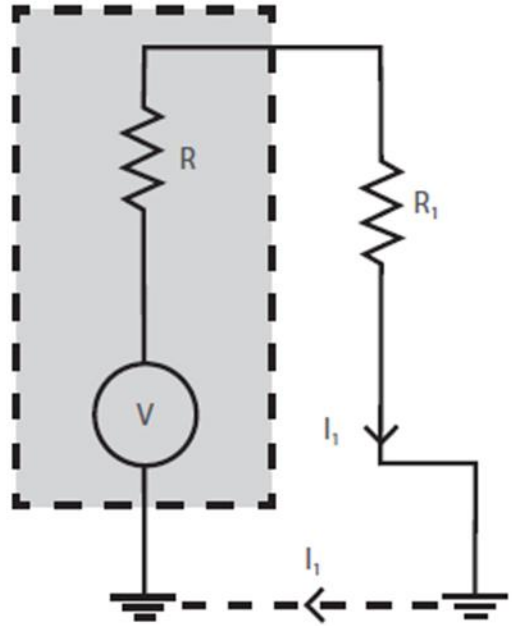
R_a= Dielectric Absorption Effective Resistance

C_a= Dielectric Absorption Effective Capacitance

Leakage Currents

The magnitude of the dc leakage current from the conductors to ground is a function of the IMD activation voltage and the insulation resistance of the cable. Simply by ohms law.

Insulation Resistance	Leakage Current	
	Competitor's IMD	Viper V-LIM
30kΩ	190µA	120µA
100kΩ	142µA	92µA



Where:

V= Applied Auxiliary Voltage

R=Internal Current Limiting Resistance

R_1= Insulation Resistance

I_1= Leakage Current

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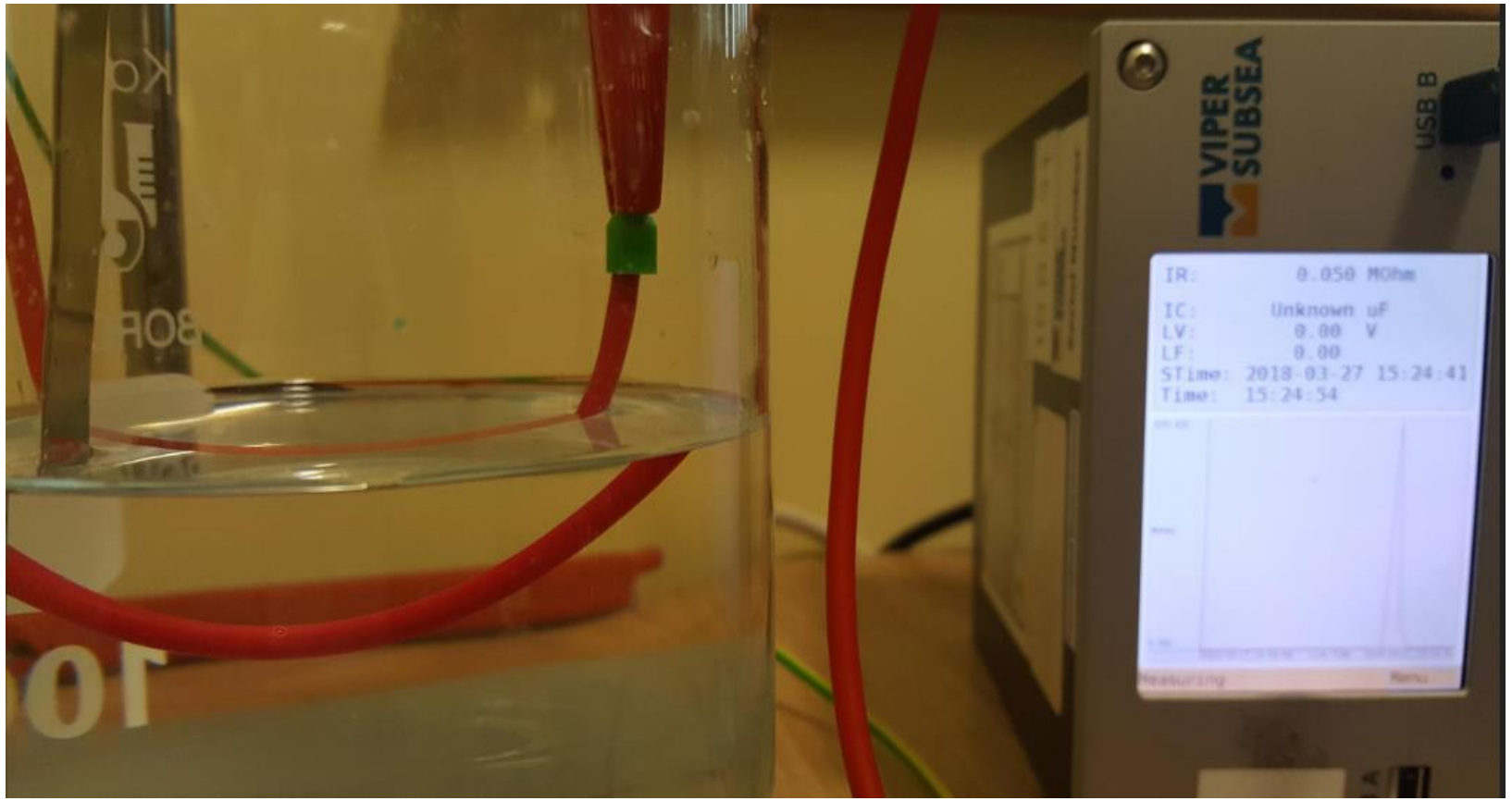
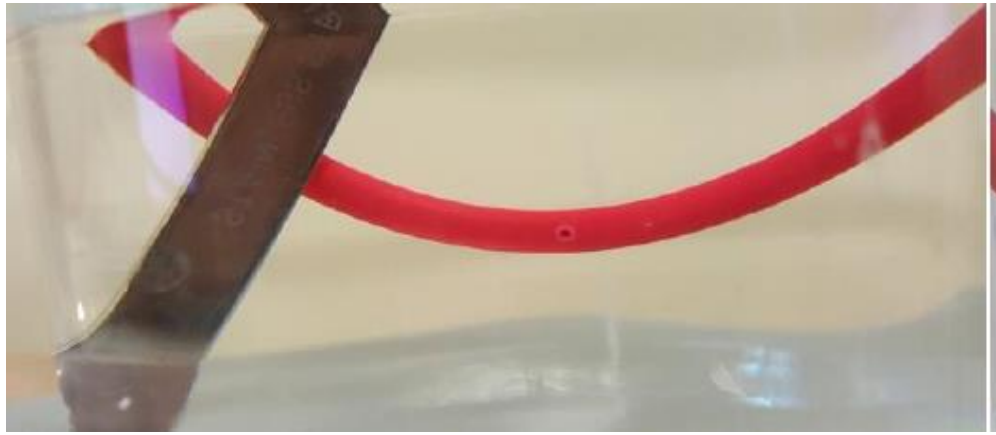
Experimental Set-Up



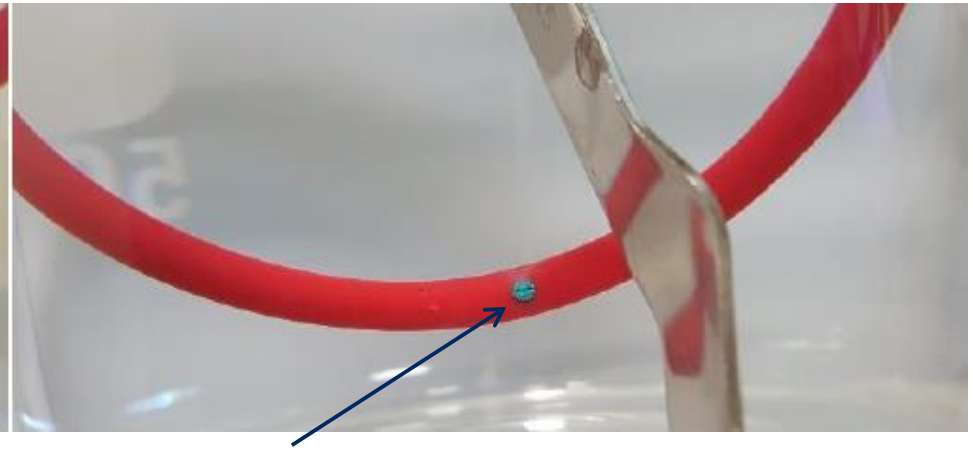
The IMD two-week effect

Single point damage to insulation equivalent to an insulation resistance of 30kΩ

Day 1



Day 14



Copper Corrosion

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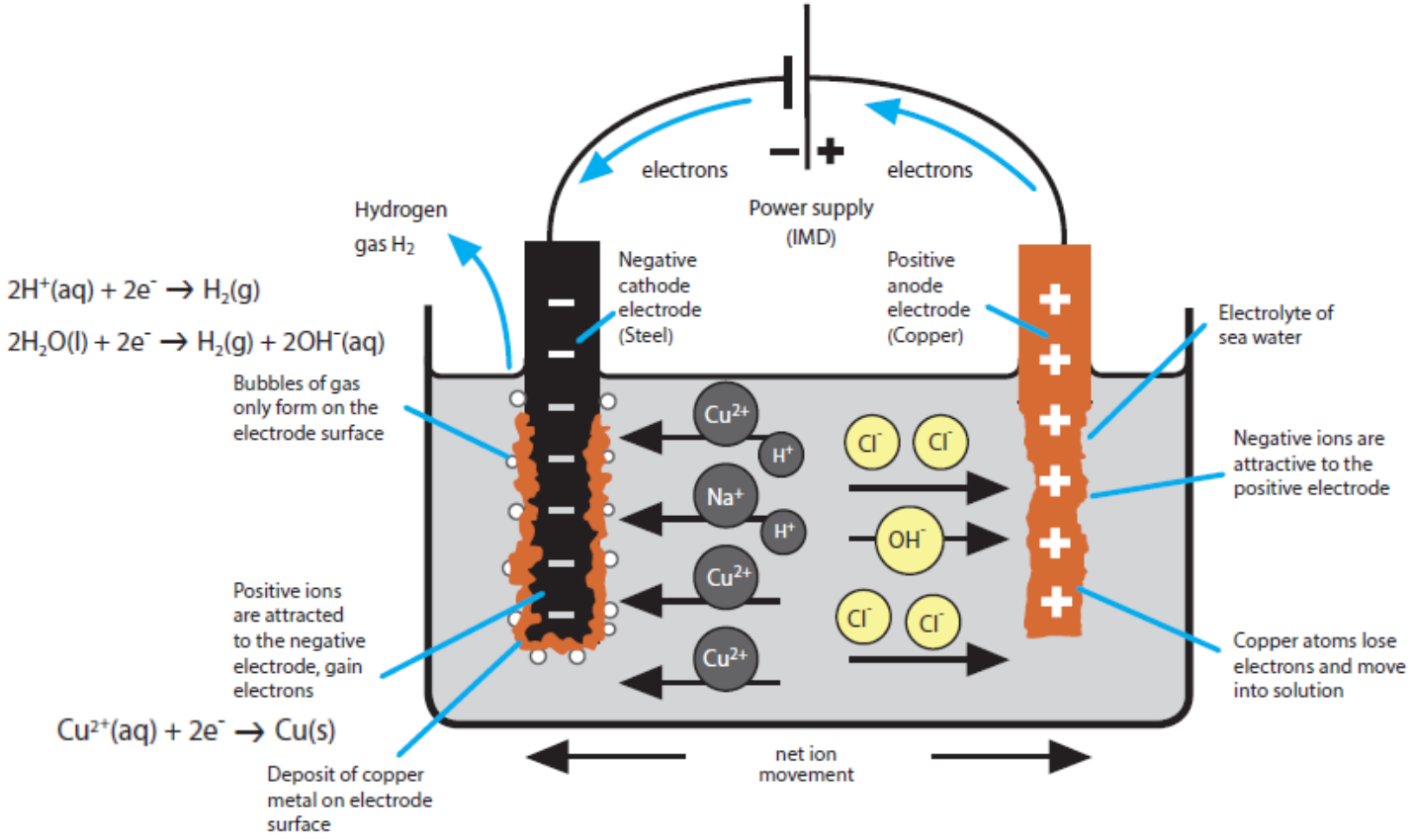
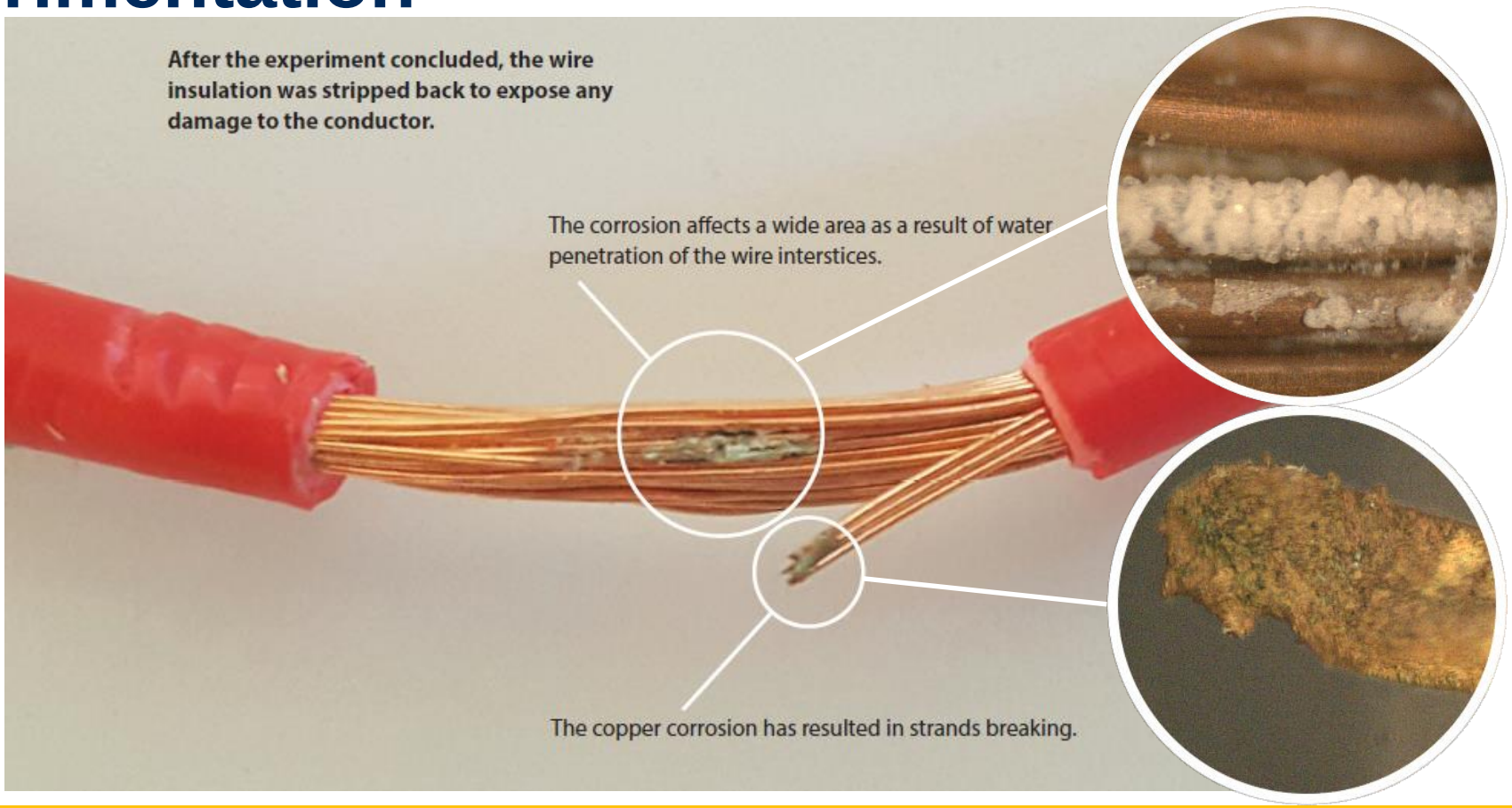
The IMD Electrochemical Cell



IMD Experimentation

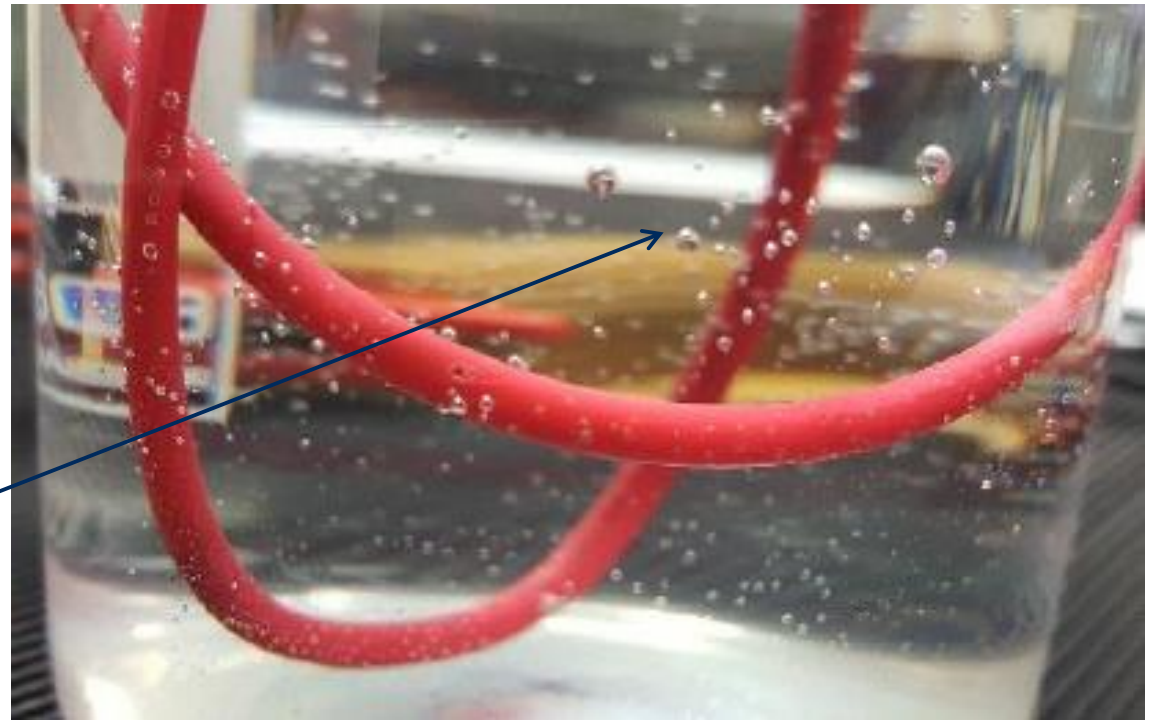


AC Power Experimentation

At the negative surface:

$Cu^{2+}(aq) + e^- \rightarrow Cu(s)$

$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-$



Hydrogen evolution

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AC Power Experimentation

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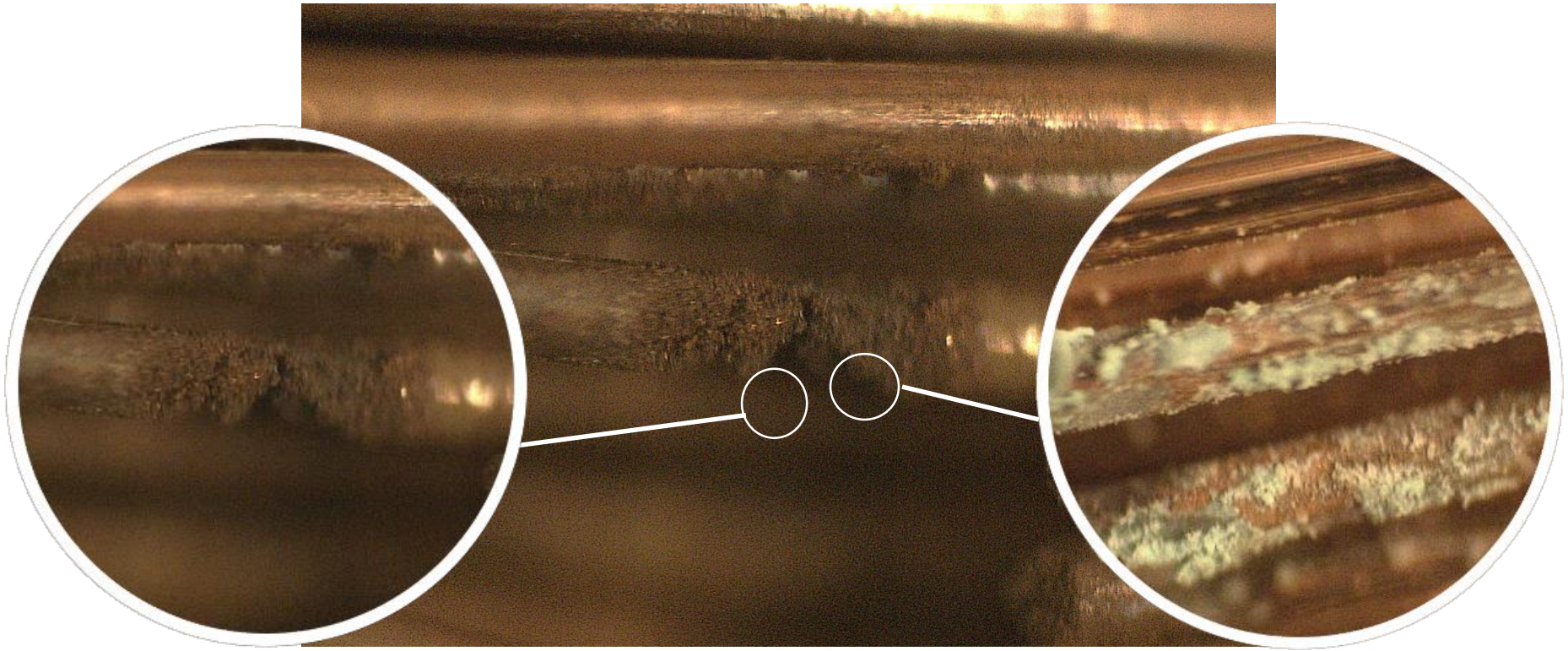
The two conductors after AC power applied



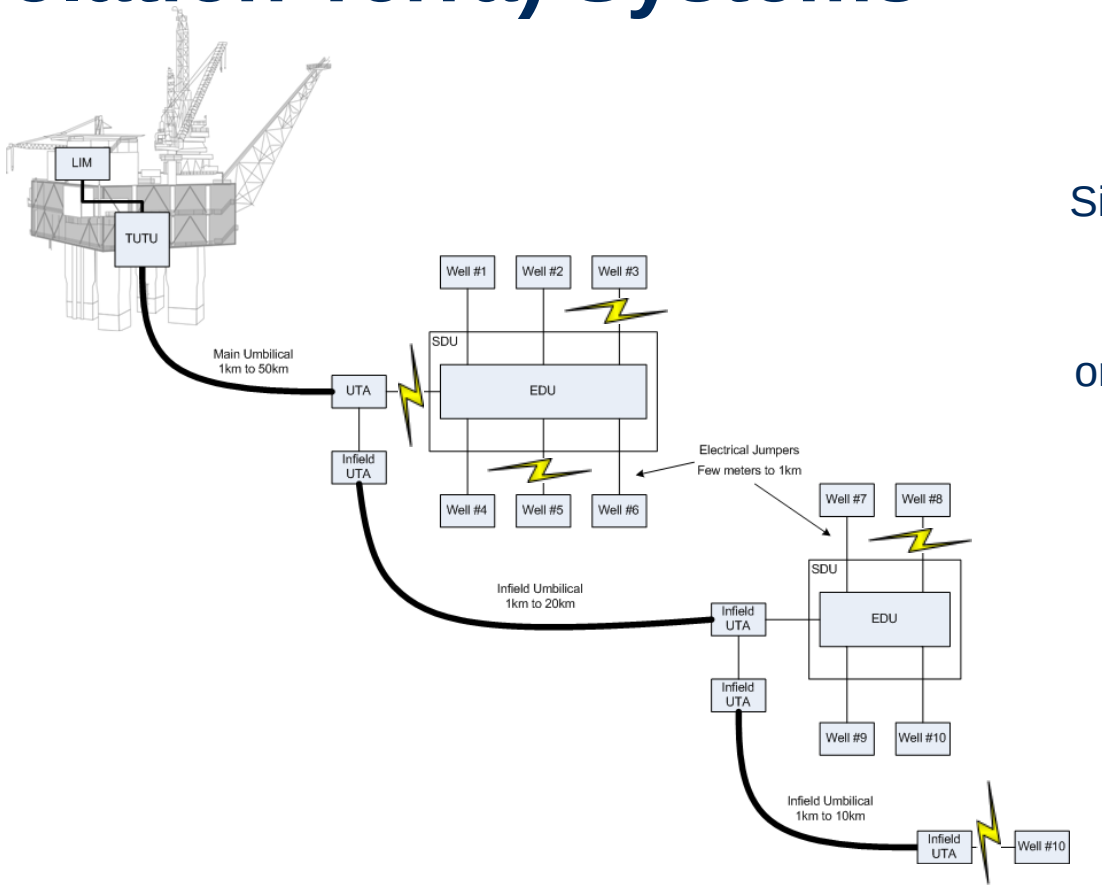
Tarnishing of copper: $2\ Cu(s) + O_2(g) \rightarrow 2\ CuO(s)$

Major Industry Problem:
Water ingress into electrical cables

The cost of subsea electrical failures is significant and includes:

- Marine intervention costs
- Replacement hardware costs
- Unplanned lost production

IT (Isolation Terra) Systems



Single Fault

or Multiple Faults

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Extending System Life with V-LIFE

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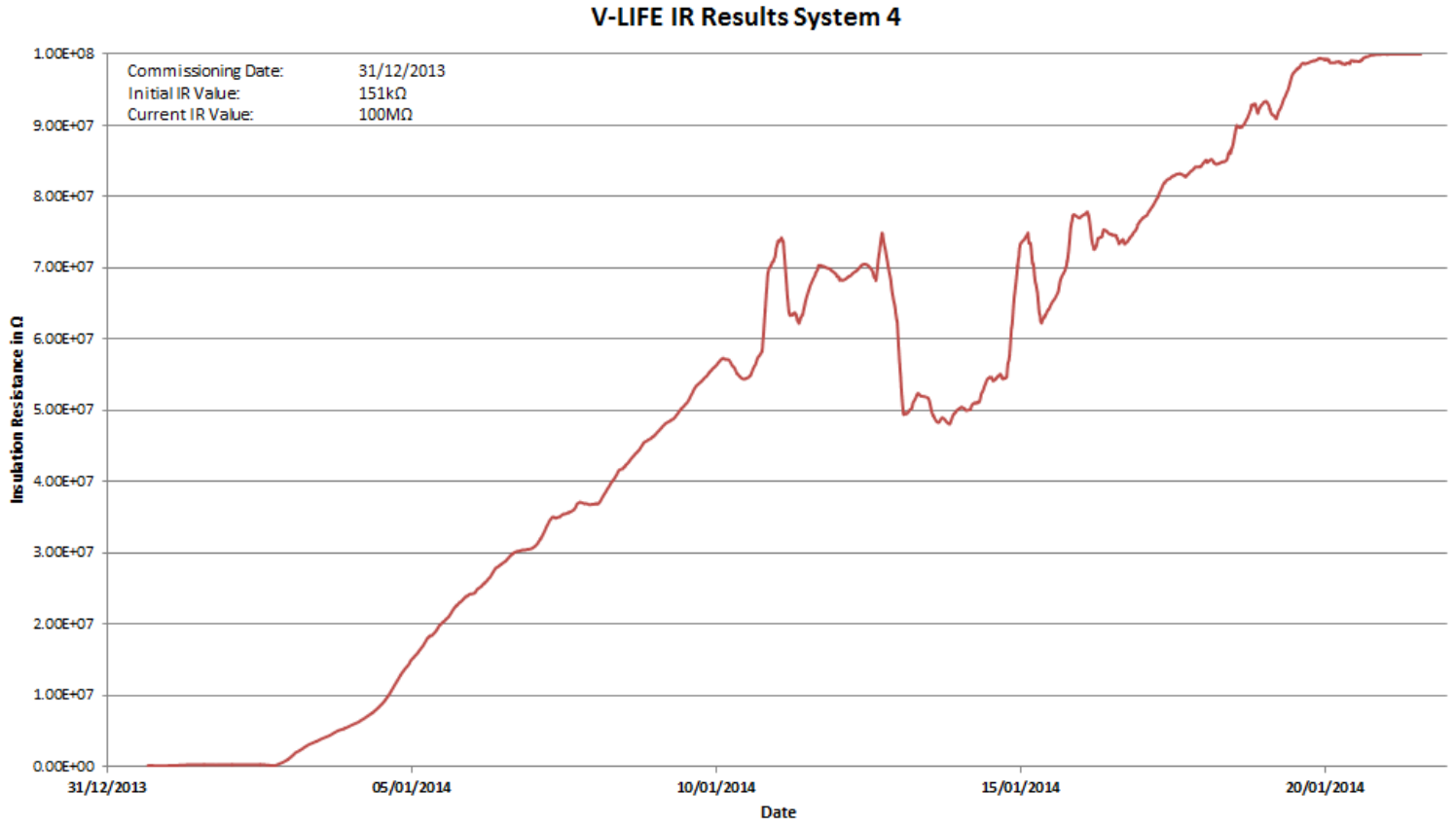
INNOVATION
2016

Example of restorative effect



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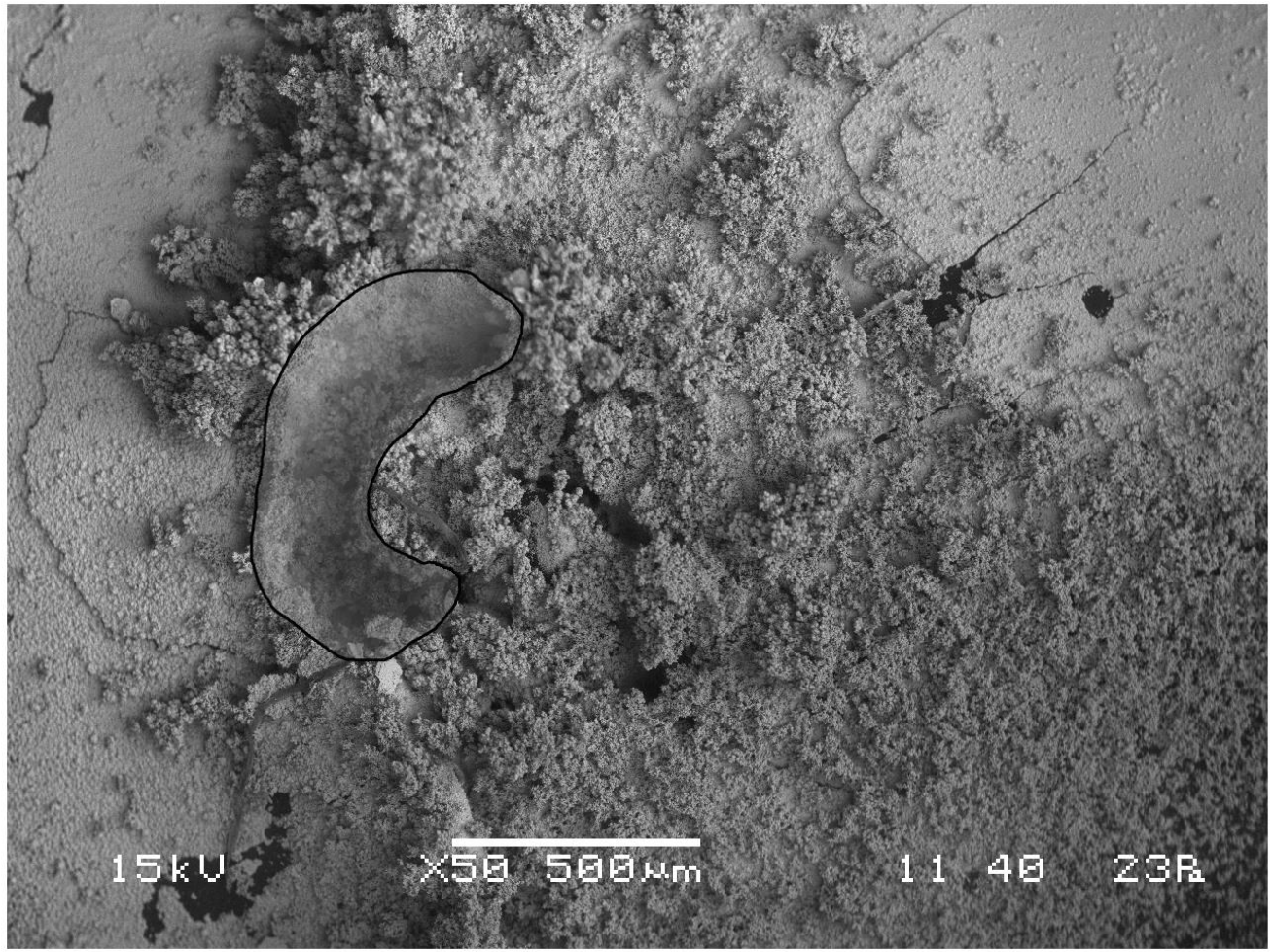
V-LIFE & passivation



V-LIM & V-LIFE Comprisons

Insulation Resistance	Leakage Current	
	Competitor's IMD	Viper V-LIM
30kΩ	190µA	120µA
100kΩ	142µA	92µA

Insulation Resistance	V-LIM / V-LIFE Leakage Current
3.5MΩ	45µA
30MΩ	13.3µA

Increase the insulation resistance to 3.5MΩ then the rate of copper loss will be reduced by more than 4 times over the rate of loss due to the standard third party IMD.
If the insulation resistance is increased to 30MΩ, then the factor increases to almost 15 times less copper loss.

Copper loss due to V-LIFE is never as high as that which would be experienced by connection of a standard third party IMD.

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Summary

- Low IR and use of a LIM results in copper loss
- Applying voltage to subsea lines with two earth faults can create significant conductor damage
- Hydrogen generation is a by-product of low IR in sea water on energised cables.
- Few subsea engineers understand the possible consequences of operating with low IR.
- V-LIFE results in less copper loss than systems without V-LIFE.

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Questions?