UK Marine Case Studies

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Introduction

Customer provides pipe laying, cable laying and another support functions to the Oil and Gas industry, worldwide.

They have around 30 vessels.

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First Contact With Customer

- ‘Introduction to Motor testing’ Seminar
- Quoted AWA static tester
- Asked to quote for on-board testing services
- Won several orders to test the main diesel-driven generators and thrusters on a number of vessels
- Tests performed during maintenance stop prior to forthcoming dry docks, but some also performed during dry docks.

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Case Study 1 – 6.6kV Diesel-Driven Generator

Tested main stator, main rotor, exciter stator and auxiliary windings all with good results.

The 3 phase exciter rotor windings failed during the megohm test.

Results Summary		Test Date/Time 22/03/2016 16:38:27	
Test ID:	3 PH Res & Meg Exciter	Repair/Job #	
Tested By		Tested For	
Room #		MCC	
Location	Seven Oceans	Building	Port Engine Room
Memo	3 Phase Exciter Winding 2		
Temp Status	Tested		
Temp	28.0°C 82.4°F	PI Status	No Test Performed
IR Temp Compensation	Thermoplastic	Volts (V)	
Resist Status	PASS	DA Ratio	
L1-L2 (Ohms)	0.0626 Corr: 0.0607	PI Ratio	
L2-L3 (Ohms)	0.0632 Corr: 0.0613	HiPot	No Test Performed
L3-L1 (Ohms)	0.0632 Corr: 0.0613	Volts (V)	
Max Delta R %	0.899	I(µA)	
Coil 1 (Ohms)	0.0313 Corr: 0.0304	Resist (Mohm)	
Coil 2 (Ohms)	0.0313 Corr: 0.0304	Surge Status	No Test Performed
Coil 3 (Ohms)	0.0319 Corr: 0.0309	Peak Volt(V) L1	
Megohm Status	OVER CURRENT	Peak Volt(V) L2	
Volts (V)	390	Peak Volt(V) L3	
I(µA)	75.5	Max P-P EAR(%)	No Test
Resist (Mohm)	5	EAR 1-2/2-3/3-1(%)	--/--/--

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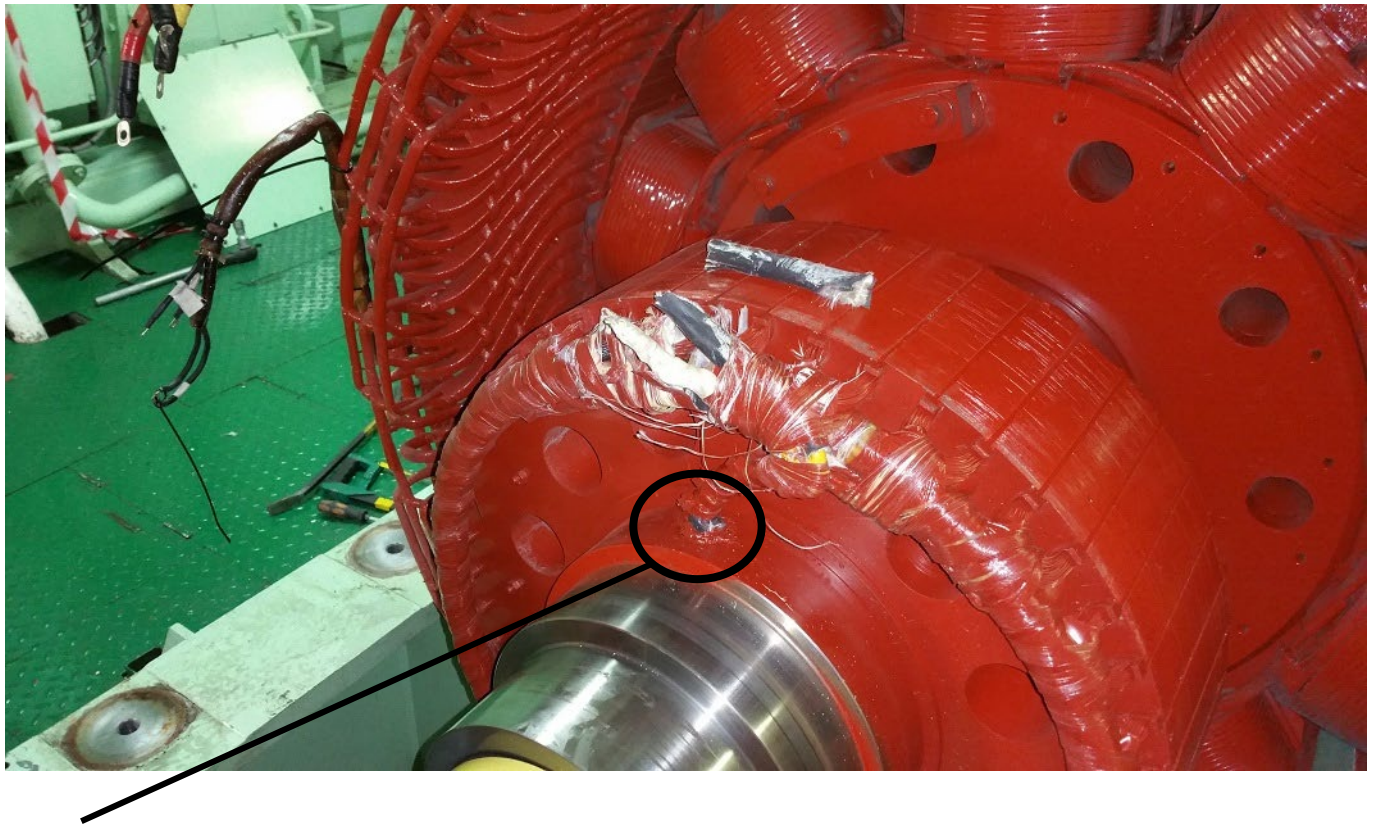
Fault Location

Customer asked his motor rewinder to verify our results, as he was on-board performing other work. He confirmed result, and decision was made to strip the machine there and then.



Phase cables chaffing on edge of hole, where cables pass through shaft

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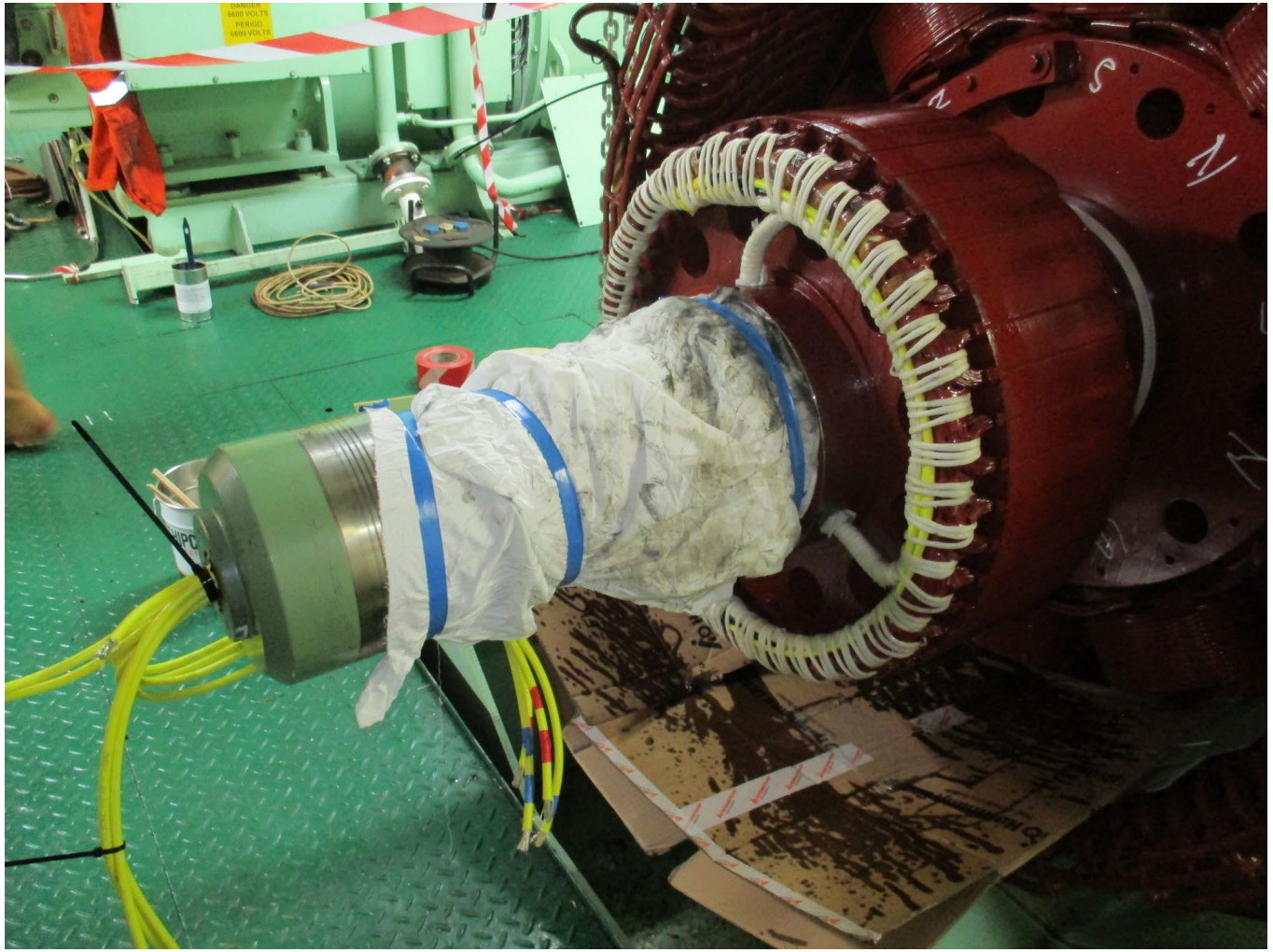
Repairs in Progress



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Customer Comment

Customer was extremely surprised that this fault was present, as the generator had shown no issues during operation.

The machine would likely have failed very quickly if left undetected, particularly since the fault was on a rotating part of the machine.

This proved the value of annual inspections, allowing developing faults to be identified and rectified during maintenance periods.

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Case Study 2 – 690V Diesel-Driven Generator

3 phase exciter rotor on a different vessel. Again, no issues being experienced with generator during operations.

Results Summary		Test Date/Time 17/06/2016 12:03:04	
Test ID:	3 PH Res & Meg Exciter	Repair/Job #	
Tested By		Tested For	
Room #		MCC	
Location		Building	Engine Room
Memo	EXCiTER WINDING 3 PHASE		
Temp Status	Tested		
Temp	25.0°C 77.0°F	PI Status	No Test Performed
IR Temp Compensation	Thermoplastic	Volts (V)	
Resist Status	DELTA R	DA Ratio	
L1-L2 (Ohms)	0.0514 Corr: 0.0504	PI Ratio	
L2-L3 (Ohms)	0.0426 Corr: 0.0417	HiPot	No Test Performed
L3-L1 (Ohms)	0.0514 Corr: 0.0505	Volts (V)	
Max Delta R %	18.327	I(µA)	
Coil 1 (Ohms)	0.0301 Corr: 0.0295	Resist (Mohm)	
Coil 2 (Ohms)	0.0212 Corr: 0.0208	Surge Status	No Test Performed
Coil 3 (Ohms)	0.0213 Corr: 0.0209	Peak Volt(V) L1	
Megohm Status	PASS	Peak Volt(V) L2	
Volts (V)	500	Peak Volt(V) L3	
I(µA)	0.4992	Max P-P EAR(%)	No Test
Resist (Mohm)	1002; 354 At 40°C	EAR 1-2/2-3/3-1(%)	--/--/--

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Winding Resistance Test

- Most 3 phase windings are very balanced, typically 2% or less.
- 18% is a clear sign of a problem, but verify bad connections are not causing this.
- Customer did not believe results, as generator was running without any issues…
- Decided to use boroscope to see if there were any obvious signs of a problem

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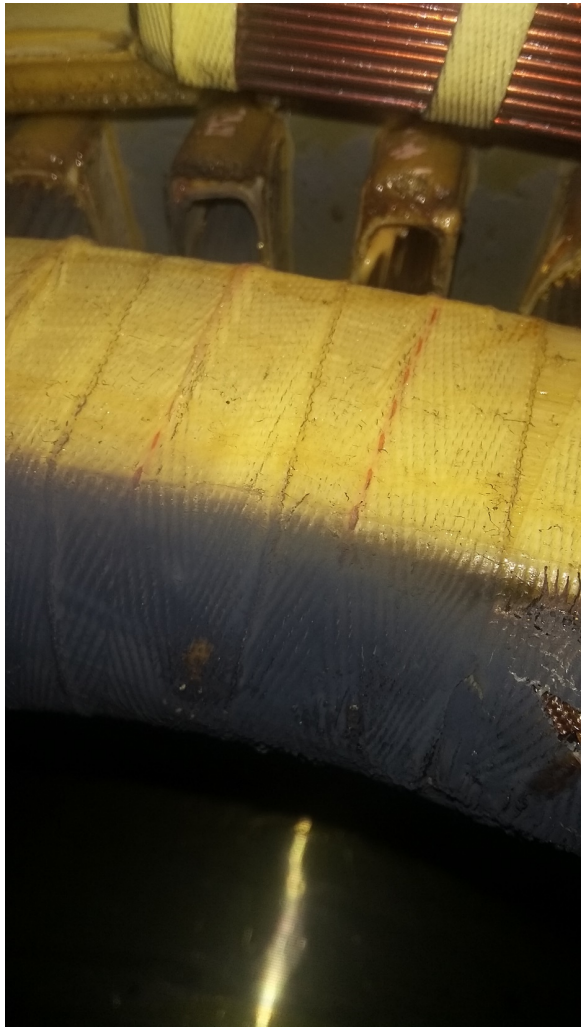
Discolouration of Winding ?



Boroscope inspection gave justification for further detailed inspection.

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Fault Found

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Fault Found

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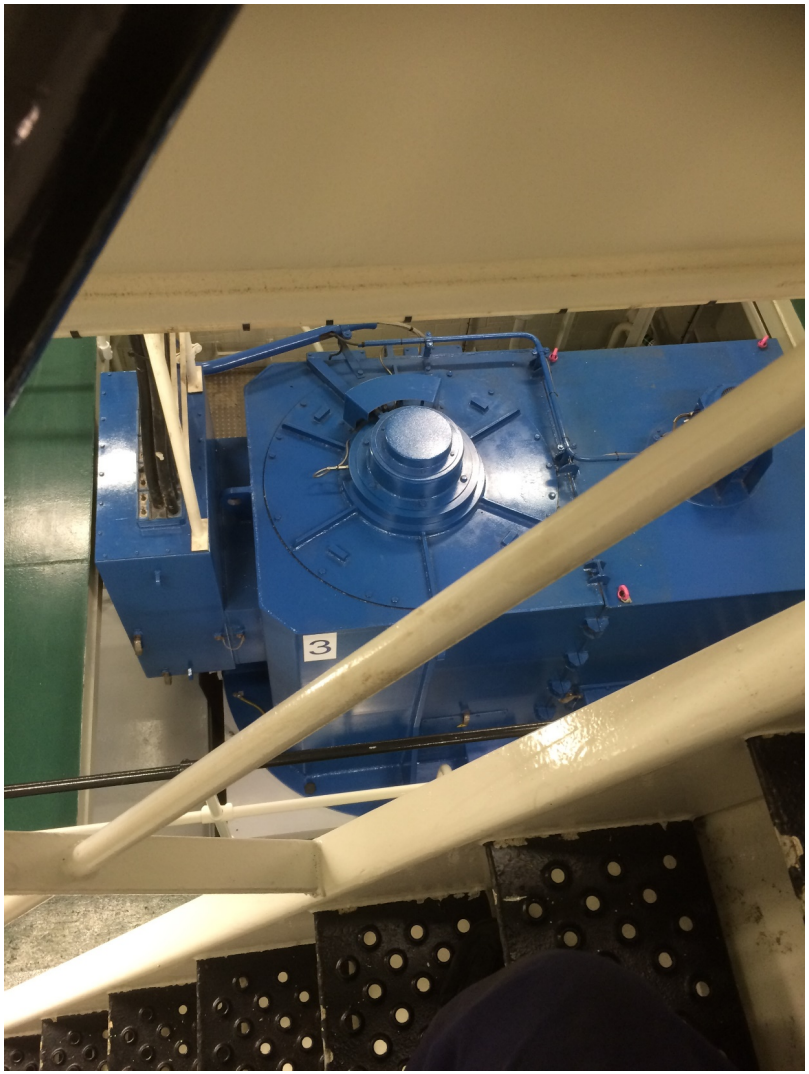
Case Study 3 – 690V Thruster Motor



Thruster motors are crucial to pipe laying ships as they help maintain very accurate positioning of the vessel as pipes are being laid, via the GPS dynamic positioning system.

If a thruster motor suddenly trips, position may be lost, resulting in the pipe line being damaged.

Large fines can also be laid on companies if they cannot meet the requirements of the DP system.

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Failed Megohm Test – Low IR Reading

Results Summary		Test Date/Time 25/03/2016 17:54:04	
Test ID:	660v Thruster	Repair/Job #	
Tested By		Tested For	
Room #		MCC	
Location	Seven Waves	Building	Aft Thrusters
Memo	Failed first megohm test. Checked connections with same results.		
Temp Status	Tested		
Temp	23.1°C 73.6°F	PI Status	No Test Performed
IR Temp Compensation	Thermoplastic	Volts (V)	
Resist Status	PASS	DA Ratio	
L1-L2 (Ohms)	0.00173 Corr: 0.00171	PI Ratio	
L2-L3 (Ohms)	0.00174 Corr: 0.00172	HiPot	No Test Performed
L3-L1 (Ohms)	0.00175 Corr: 0.00173	Volts (V)	
Max Delta R %	0.791	I(µA)	
Coil 1 (Ohms)	0.00087 Corr: 0.00086	Resist (Mohm)	
Coil 2 (Ohms)	0.00086 Corr: 0.00085	Surge Status	No Test Performed
Coil 3 (Ohms)	0.00088 Corr: 0.00087	Peak Volt(V) L1	
Megohm Status	MIN MEGOHM	Peak Volt(V) L2	
Volts (V)	510	Peak Volt(V) L3	
I(µA)	5.900	Max P-P EAR(%)	No Test
Resist (Mohm)	86; 26 At 40°C	EAR 1-2/2-3/3-1(%)	No Test

IR value @ 40º C is below our minimum of 50 MΩ. IEEE 43 states the safe minimum IR value @ 40º is 5 MΩ, but this is very low when we are testing for reliability of the machine.

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Customer Doubts

Customer quoted the standard of 5 MΩ, and said our result was not highlighting a problem.

However, the other six thrusters all showed IR values of several GΩs.

Chief Engineer was wanting us to complete our work as quickly as possible and so was resisting investigation.

Vessel was only 18 months old, so Chief Engineer believed it was unlikely that there was a problem already.

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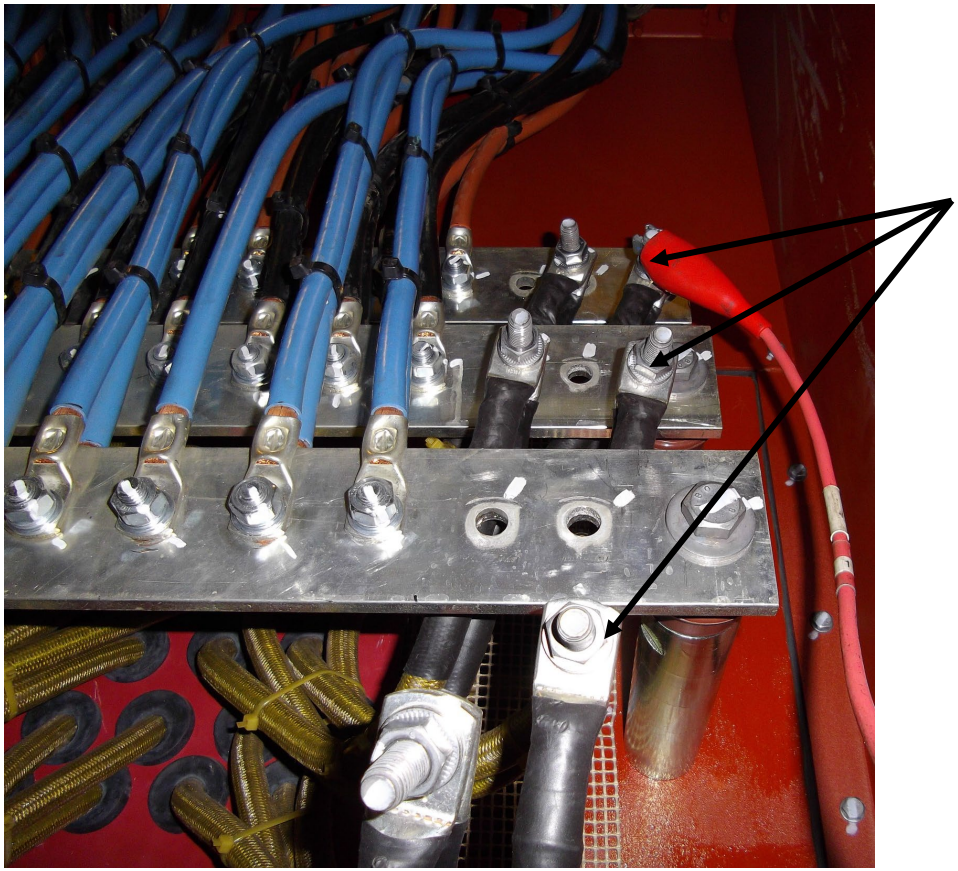
Next Step



To test motor windings without the power cables in circuit

Winding leads removed from bus bars – much quicker than removing all the power leads !

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Second Test Without Power Cables

Results Summary		Test Date/Time 26/03/2016 16:16:29	
Test ID:	660v Thruster	Repair/Job #	
Tested By		Tested For	
Room #		MCC	
Location	Seven Waves	Building	Aft Thrusters
Memo	Tester leads conected directly on phase U motor leads only. Power cables therefore out of the circuit during test.		
Temp Status	Tested		
Temp	30.0°C 86.0°F	PI Status	No Test Performed
IR Temp	Thermoplastic	Volts (V)	
Compensation			
Resist Status	No Test Performed	DA Ratio	
L1-L2 (Ohms)		PI Ratio	
L2-L3 (Ohms)		HiPot	No Test Performed
L3-L1 (Ohms)		Volts (V)	
Max Delta R %		I(µA)	
Coil 1 (Ohms)		Resist (Mohm)	
Coil 2 (Ohms)		Surge Status	No Test Performed
Coil 3 (Ohms)		Peak Volt(V) L1	
Megohm Status	PASS	Peak Volt(V) L2	
Volts (V)	500	Peak Volt(V) L3	
I(µA)	0.0328	Max P-P EAR(%)	No Test
Resist (Mohm)	15263; 7631 At 40°C	EAR 1-2/2-3/3-1(%)	No Test

IR of 7.6 GΩ @ 40º C, confirming that the motor is ok, and the likely cause of the low reading are the power cables.

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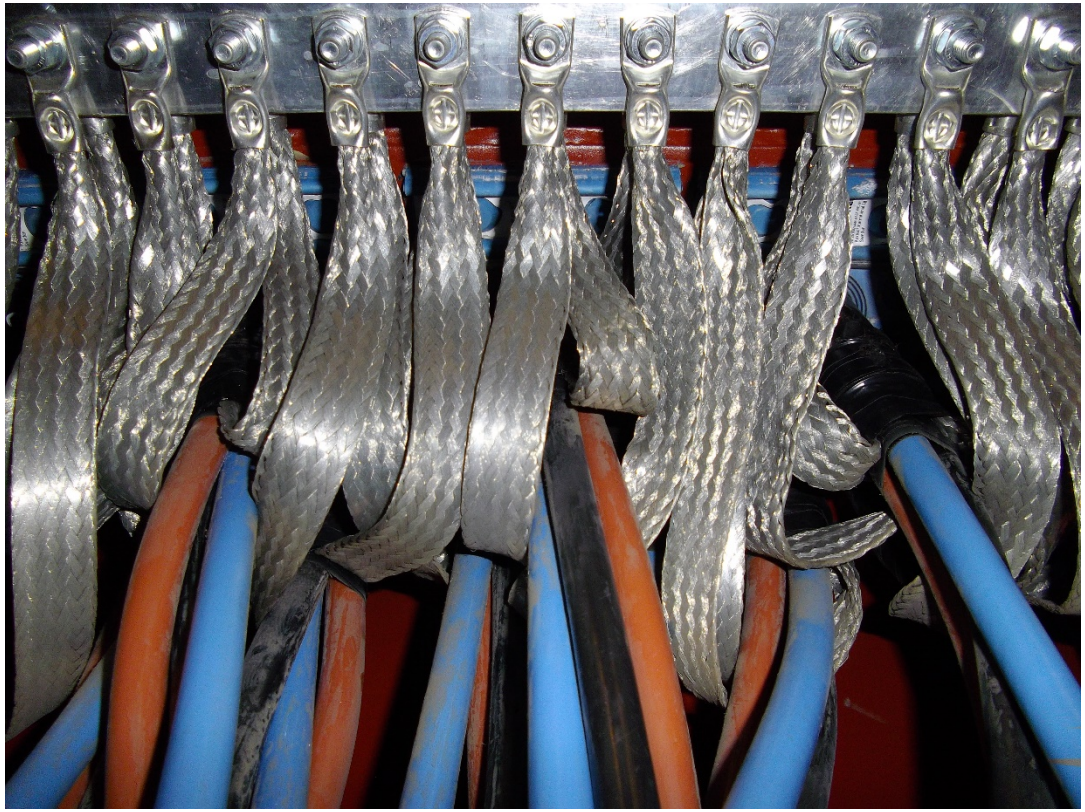
Fault Located



Earthing straps were badly installed and caused chaffing to the cable insulation.

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Outcome of Tests

Customer claimed a warranty repair on the shipyard, as the vessel was only 18 months old.

Moral of the case:

After verifying your connections and proving the tester is working correctly, you have to believe your tester, however unlikely the results !

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Savings For The Customer

It is always important to try and calculate a monetary saving made by finding such faults.

In these three cases, our customer stated that a saving of US$ 4 Million had been made, by avoiding unplanned downtime and penalties charges.

Test equipment is a major investment, especially for 12kV testers and above. But when compared to the savings that can be made from finding faults in critical motor prior to failure, the cost is often insignificant !

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