

Pitfalls in Modern HV Electrical Machine Procurement – Case Study

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Acknowledgement

Ray Calleja

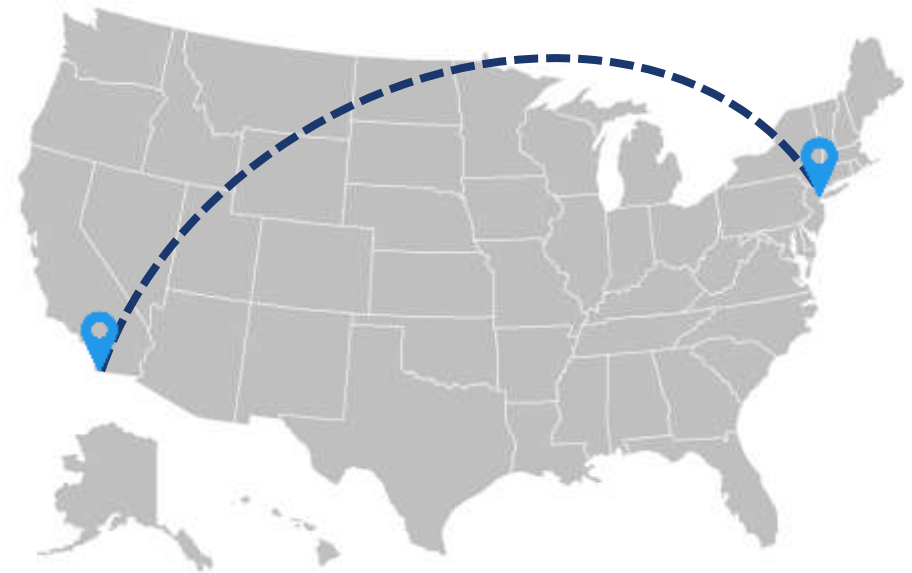
National Maintenance Manager Large Industries

Air Liquide

Australia



Sydney to Perth
2044 miles



New York to LA
2462 miles



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first in **INDEPENDENT** electrical asset management

About Air Liquide

World leader in gases, technologies and services for Industry and Health, Air Liquide is present in 80 countries with close to 50,000 employees and serves more than 2 million customers and patients. Oxygen, nitrogen and hydrogen have been at the core of the company's activities since its creation in 1902. Air Liquide's ambition is to be the leader in its industry, delivering long-term performance and acting responsibly.

Air Liquide ideas create value over the long term. At the core of the company's development are the commitment and constant inventiveness of its people.

Air Liquide anticipates the challenges of its markets, invests locally and globally, and delivers high quality solutions to its customers and patients, and the scientific community. The company relies on competitiveness in its operations, targeted investments in growing markets and innovation to deliver profitable growth over the long-term.

Air Liquide's revenues amounted to € 15.3 billion in 2012, and its solutions that protect life and the environment represented around 40% of sales. Air Liquide is listed on the Paris Euronext stock exchange (compartment A) and is a member of the CAC 40 and Dow Jones Euro Stoxx 50 indexes

Sequence of Events N2 Compressor Motor

- Manufactured 2010 – Partial Discharge Couplers installed at manufacture in accordance with specification
- Commissioned 2012 at Altona Air Separation Unit
- Initial PD Test 15th Jan 13 followed by test on 27th March 13
- Inspection initiated and visual evidence of Partial Discharge activity observed
- Failure modes confirmed stator to be replaced
- Subsequent PD tests conducted 27th March 14 significant discharge measured
- Replacement stator supplied Dec 14

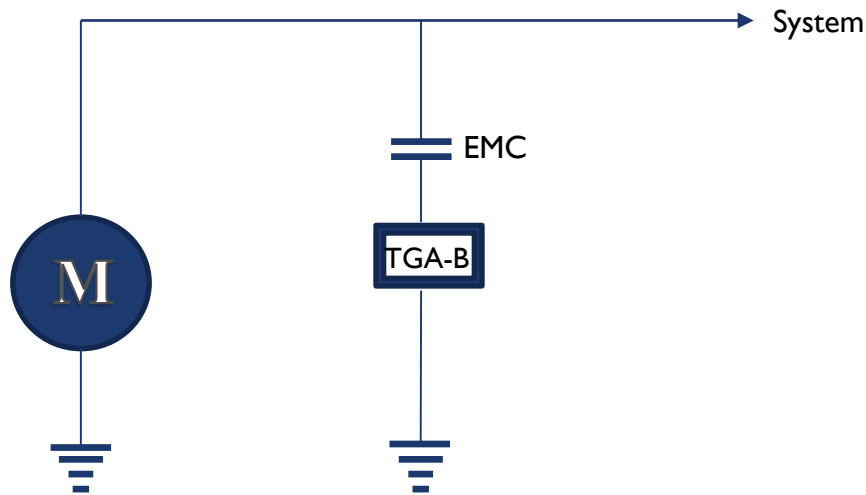
Machine Details

- N2 Liquefier Compressor Motor
- 5400 HP, 11000 Volts, 2 Pole



Partial Discharge Installation

PD Configuration



PD Couplers - EMC



Partial Discharge Summary Numbers

PHASE READINGS

Phases	Test Data	Qm +	Qm -	NQN +	NQN -	% Ranking
Phase U	15/01/2013	457	243	912	371	93
Phase V	15/01/2013	626	375	1339	689	95
Phase W	15/01/2013	544	213	1144	331	95

PHASE READINGS

Phases	Test Data	Qm +	Qm -	NQN +	NQN -	% Ranking
Phase U	27/03/2013	520	233	1071	376	95
Phase V	27/03/2013	643	509	1378	937	95
Phase W	27/03/2013	552	231	1188	341	95

PHASE READINGS

Phases	Test Data	Qm +	Qm -	NQN +	NQN -	% Ranking
Phase U	20/03/2014	494	199	1034	345	94
Phase V	20/03/2014	661	298	1316	565	95
Phase W	20/03/2014	557	246	1149	386	95



Partial Discharge Trend

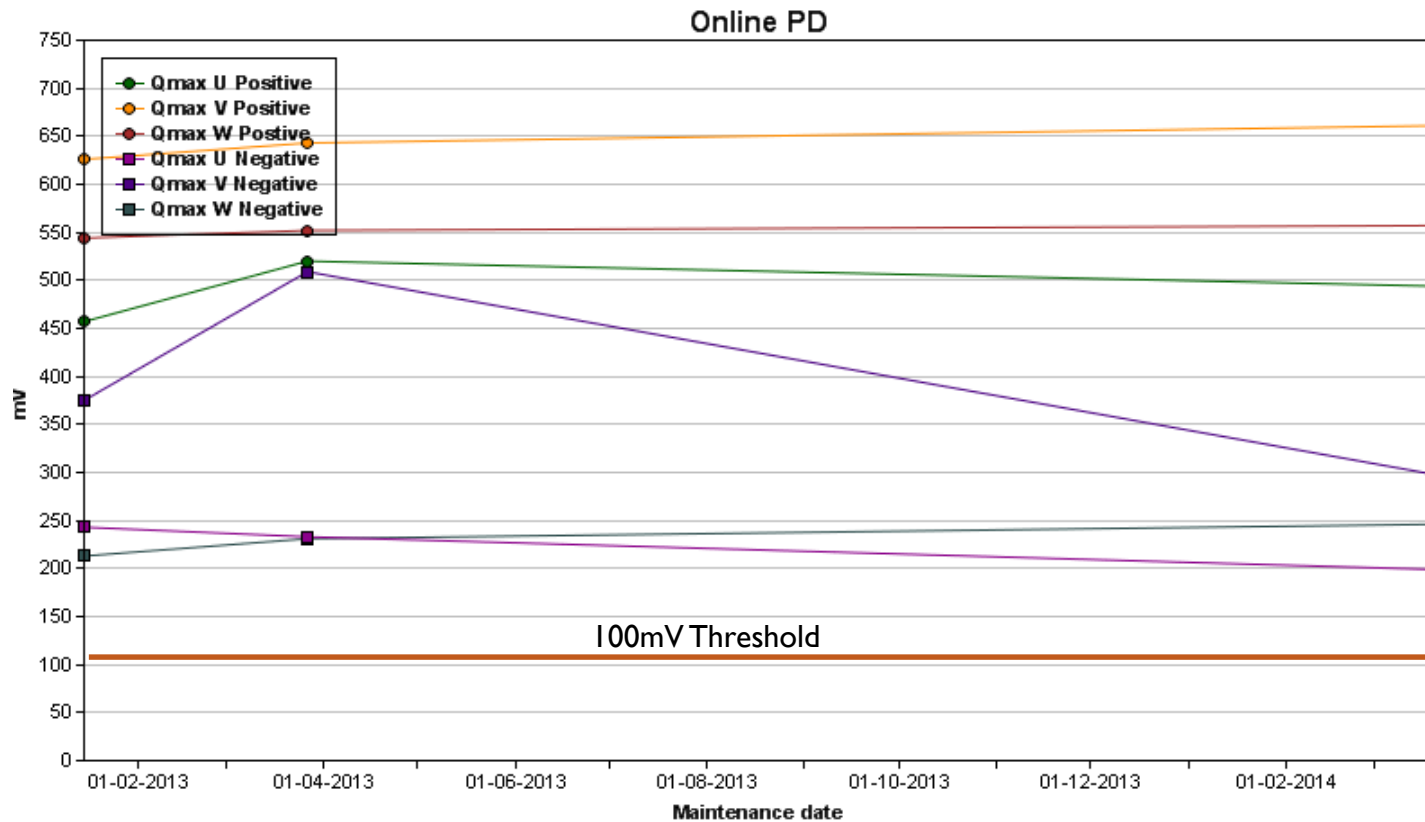
Box Plot

Offline PD

Online PD

Machine PD Distribution

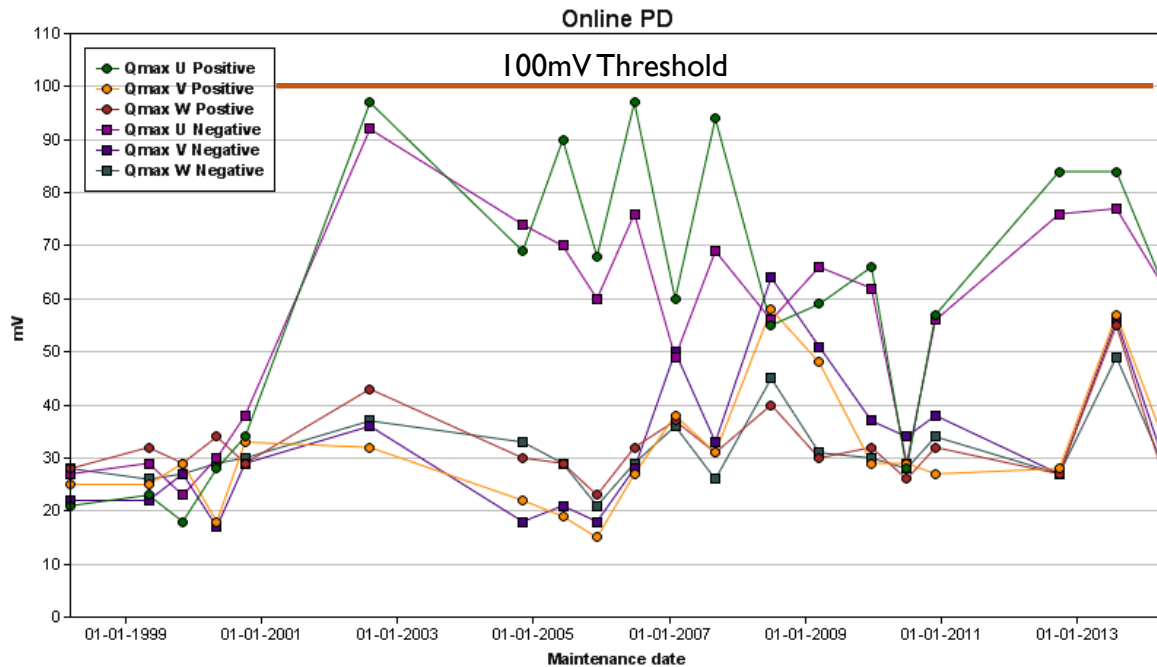
Showing readings that have been measured in: Millivolts



Typical Trend – 20 year winding

Machine PD Distribution

Showing readings that have been measured in:



- Qmax U positive (mV)
- Qmax V positive (mV)
- Qmax W positive (mV)
- Qmax U negative (mV)
- Qmax V negative (mV)
- Qmax W negative (mV)

Date Range:
 Min. Max.

Inspection Images



Inspection Images



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Inspection Images



Derived Failure Mechanism(s)

- Void Discharges
- Grading Coat Discharges
- Slot Discharges Electrical
- Endwinding Discharges



2 Year
Service Life

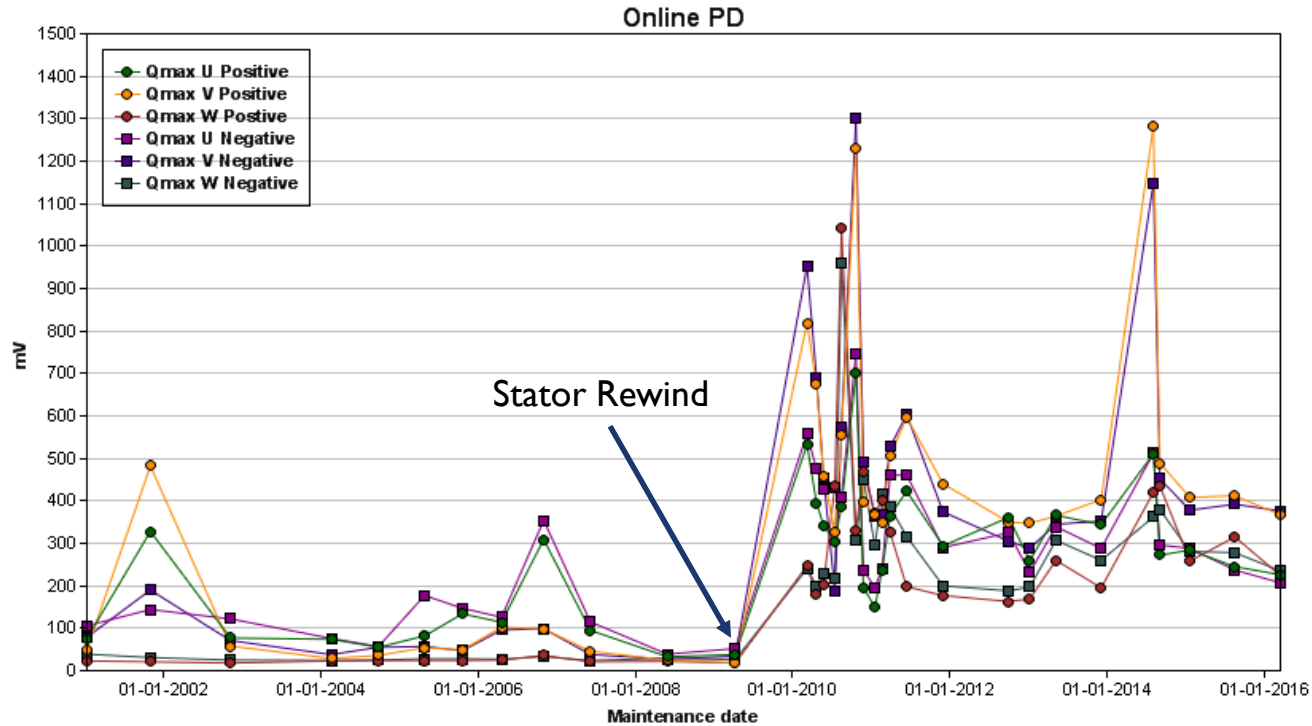


IMPROPER
MANUFACTURE



Similar Issues Other Plants

Showing readings that have been measured in: Millivolts



- Qmax U positive (mV)
- Qmax V positive (mV)
- Qmax W positive (mV)

- Qmax U negative (mV)
- Qmax V negative (mV)
- Qmax W negative (mV)

Date Range:

Min. Max.



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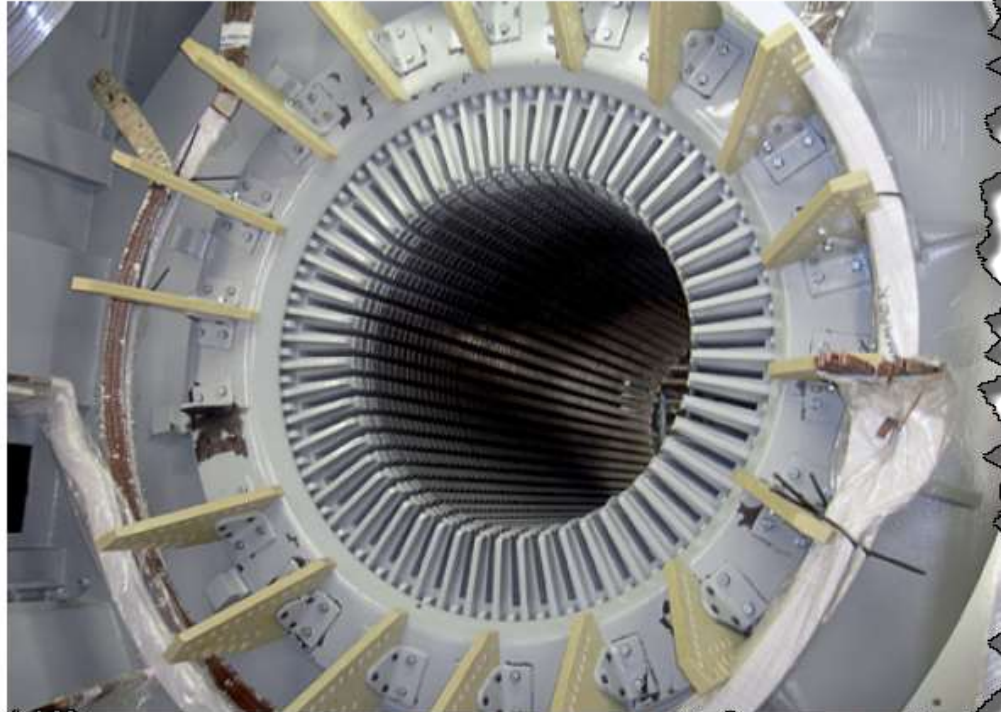
The Problem



Marketing Department's Spin

GENERATOR OVERHAUL MEETS LATEST TECHNICAL STANDARDS

The 42kVA generator, operating at 11.5kV, was originally built in 1986, but after more than 25 years in service, the time had come for an overhaul. Using the OEM drawings, combined with the latest CAD, the engineers at [REDACTED] were able to start on the initial design stages and plan the logistics that would allow the contract to be completed on time.



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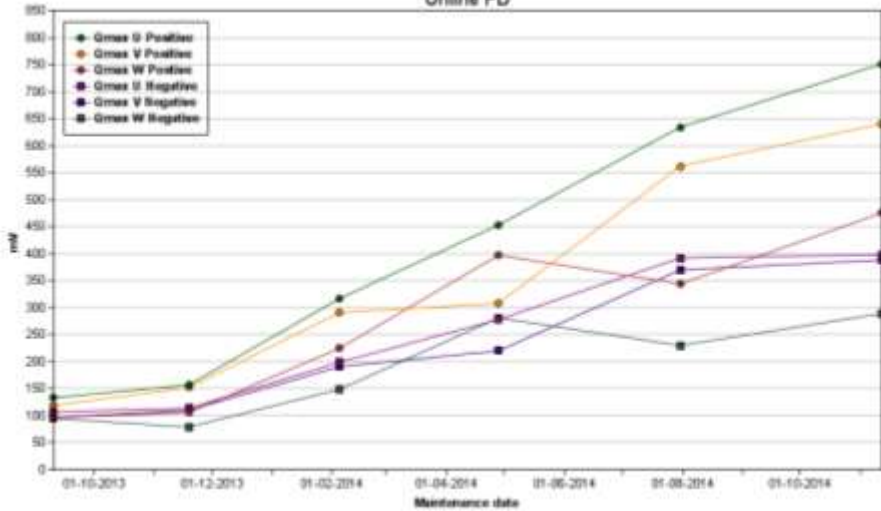


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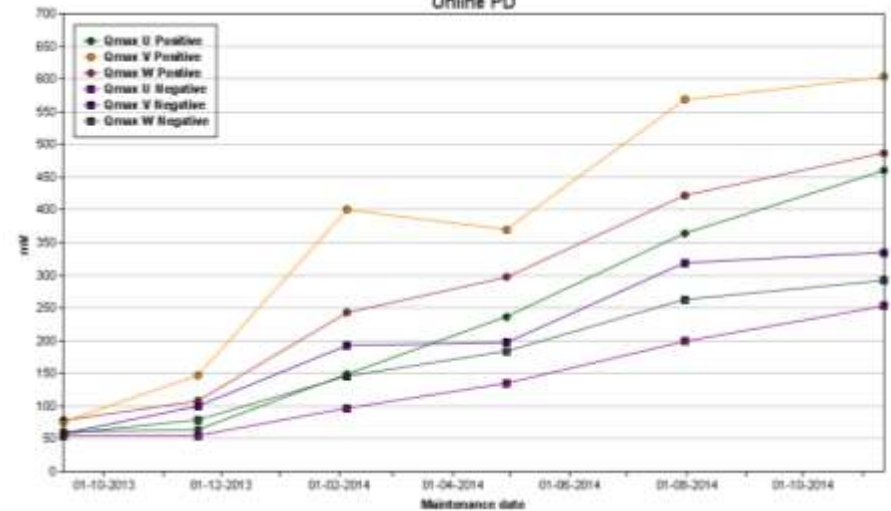
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The Problem - Geo Thermal

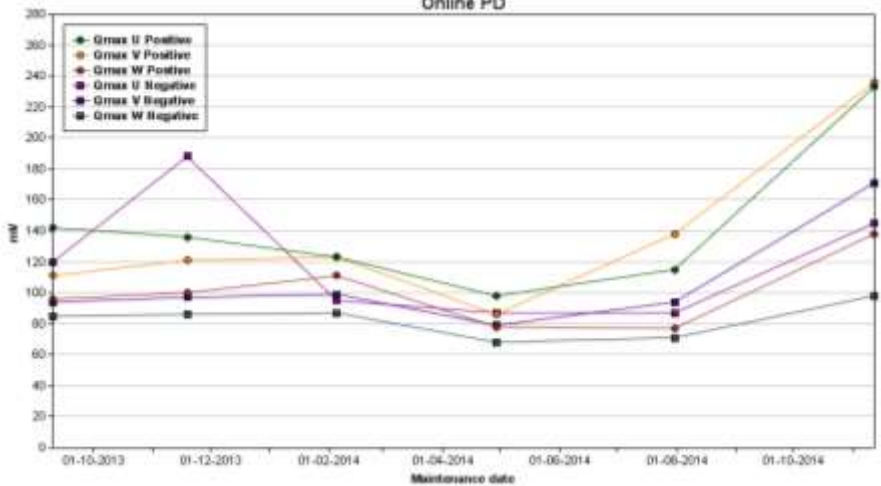
Online PD



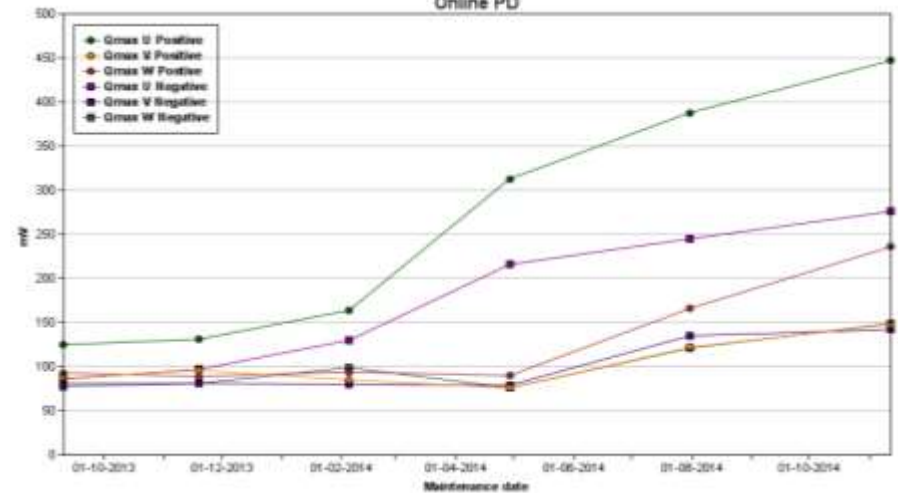
Online PD



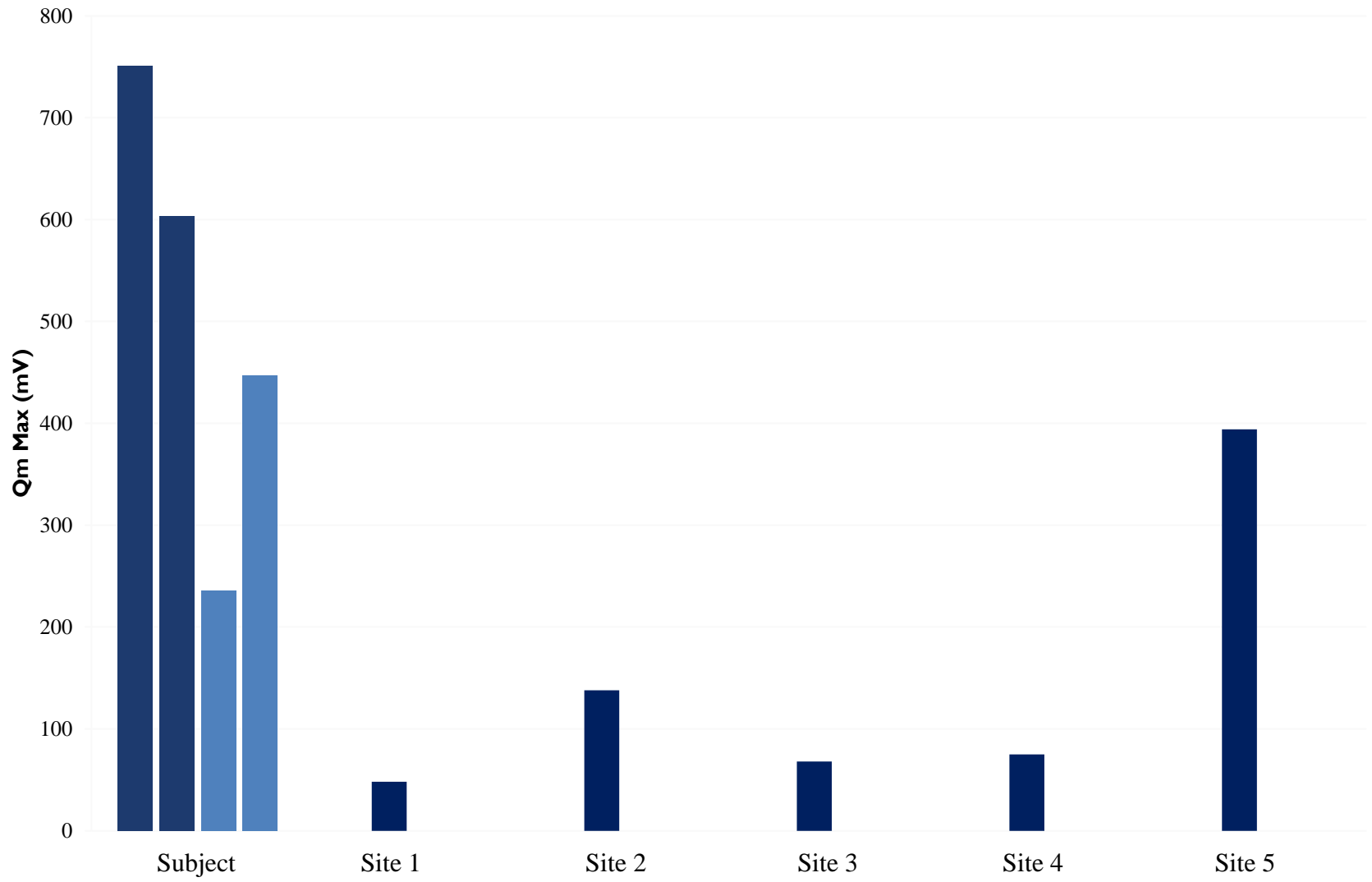
Online PD



Online PD



Benchmark Qmax – Other Sites



Key Learnings

The following Key learnings came from this experience;

- Modern high voltage stator winding manufacturing techniques can lead to susceptibility to early onset of partial discharge activity – buyer beware
- General specifications may not necessarily limit exposure to having stators delivered with partial discharge issues – be prescriptive
- Objective measurement through partial discharge monitoring and verification by visual inspection were conclusive in establishing dominant failure mechanisms within the two year old Air Liquide stator winding and other examples

Questions



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