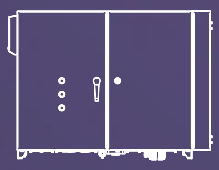


# CONNECTING DATA TO DECISIONS

Case Studies - Volume 2

Linking Total Transformer Monitoring & Actionable Information
to Drive Business Value for Utilities

camlin energy

# CONTENTS

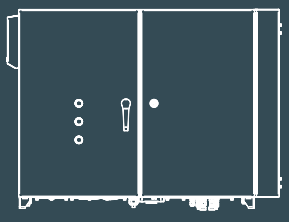
# TRANSFORMING DATA TO DRIVE DECISION MAKING

Power transformers are integral to the flow of energy and dynamic communication and could be viewed as the nerve centre in the era of digitalization of energy systems. However, environmental and operational factors can affect the health of an aged transformer fleet and reduce the capabilities and readiness for the technological change.

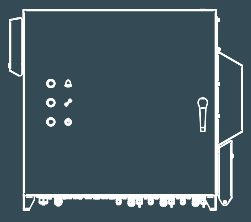
The use of a more holistic and integrated approach to transformer monitoring can significantly help to optimize maintenance and mitigate risk. Holistic means the treatment of the whole transformer, taking into account operational data, environmental data, external factors and previous experiences, rather than just a single diagnostic parameter such as DGA. The chances of identifying the failure mode or defect can dramatically increase, allowing asset owners to understand their risk and ultimately make prompt and better-informed decisions.

The following case studies demonstrate successful examples when the utility was able to plan preventive actions and maintenance thanks to the study of the correlation of two or more parameters.

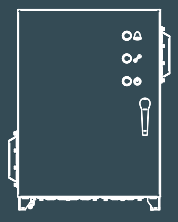
# TOTUS MONITORING



TOTUS G9

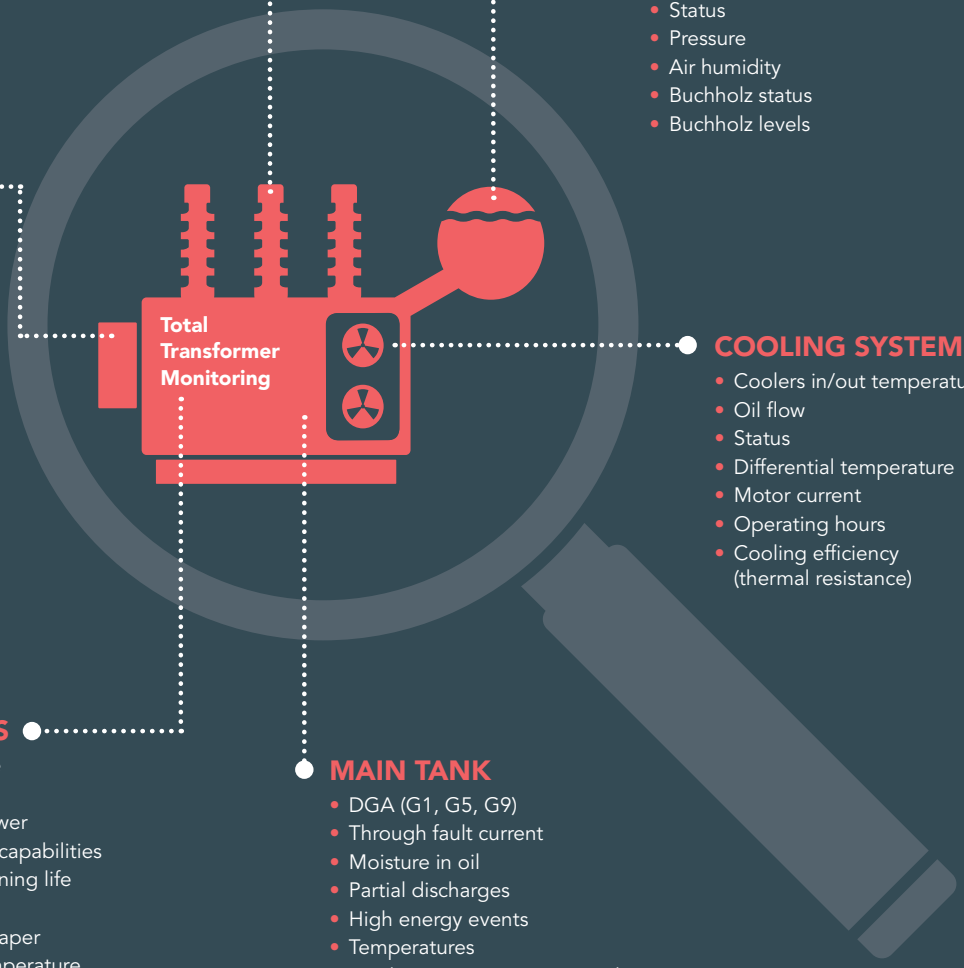


TOTUS G5



INTEGO

# A holistic transformer monitoring approach




## BUSHINGS

- Capacitance
- TanDelta / Power factor
- Partial discharges
- High energy events
- Voltage

## CONSERVATOR AND OIL PROTECTION

- Oil levels
- Status
- Pressure
- Air humidity
- Buchholz status
- Buchholz levels

## OLTC

- Tap position
- Differential temperature
- Status
- DGA
- Motor current
- Number of operations
- Acoustic emissions*

## COOLING SYSTEM

- Coolers in/out temperature
- Oil flow
- Status
- Differential temperature
- Motor current
- Operating hours
- Cooling efficiency (thermal resistance)

## ANALYTICS

- Load/Voltage
- Hot spots
- Apparent power
- Overloading capabilities
- Aging/Remaining life
- Losses
- Moisture in paper
- Bubbling temperature
- Transformer condition

## MAIN TANK

- DGA (G1, G5, G9)
- Through fault current
- Moisture in oil
- Partial discharges
- High energy events
- Temperatures
- Auxiliary equipment status/Alarms
- Fiber optic direct hot spots
- GIC

* Focus area for future development

**Only when monitoring all the key components and parameters, in synergy, can the factors of health, risk and reliability be better understood.**

# ITALIAN TRANSMISSION UTILITY

**Details**
Floating corona shield cone surrounding HV lead in phase V.

**Evidence**
HEE persistence > 6%, PD phase V, critical gas levels.

The TOTUS installed allowed for real time, continuous monitoring of the asset and detected fluctuations in PD occurring for several hours in a day and then remaining silent for weeks, showing very high energy (> 20 V, > 80nC).

This highlighted the existence of a lose/broken grounding connection in the corona shield cone immersed in the transformer tank, enabling the transmission utility to apply a proper action flow, leading to the failure prevention and optimization of the maintenance plan.

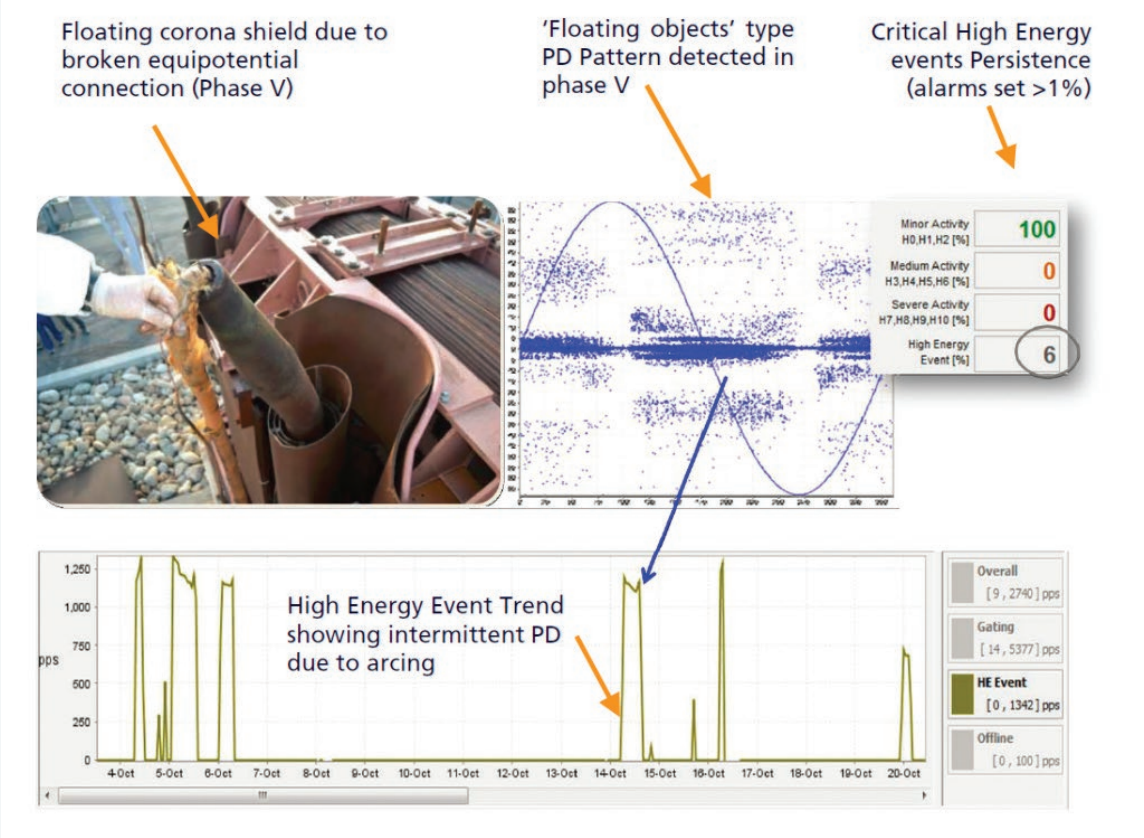



Figure 1: High Energy Event evidences, Phase V

# ITALIAN DISTRIBUTION COMPANY

**Details**
Protrusion on cap. stress ring above HV winding, phase U.

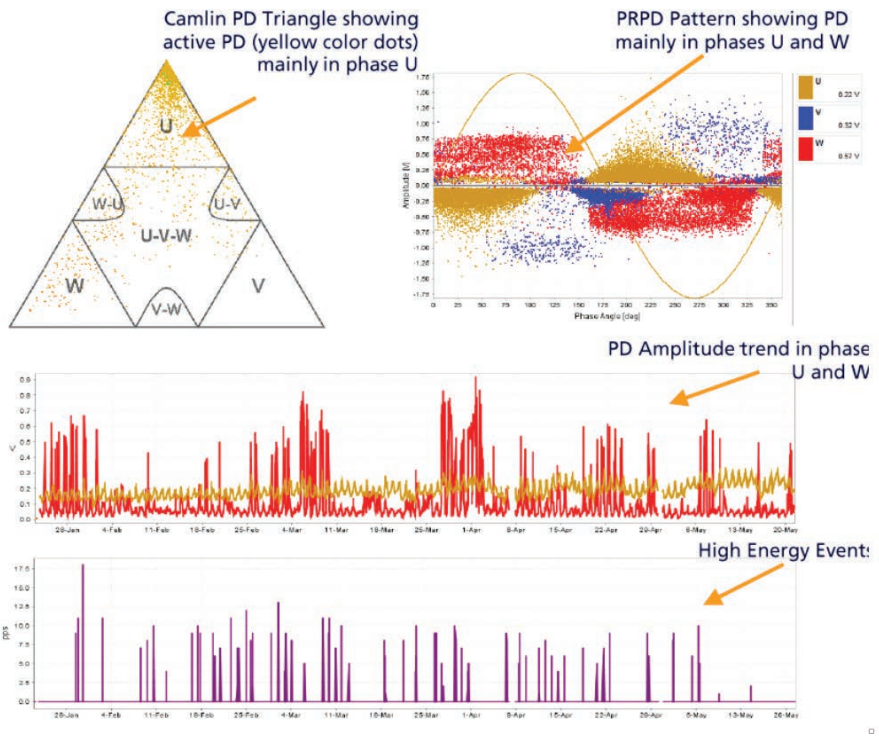
**Evidence**
Medium PD activity persistence > 80%.
Located in phase U.

Manufactured in 2010, a suspect Hydrogen and Acetylene concentration was noticed in the transformer after an Oil Lab evaluation in 2011. Transformer OEM supposed stray gassing phenomena. The INTEGO TM was installed by the Utility and confirmed that cause was not stray gassing but a PD defect in one of the phases (phase U). Sporadic PD activities can where also present in phase W.

The transformer was inspected, evidences reported in Figure 1. Show the INTEGO TM provided an effective diagnosis and location thanks to the Camlin PD Triangle.

Furthermore, the INTEGO TM allowed the Distribution company to reinforce their thesis and provided proof to the OEM of the absence of stray gassing phenomena.

Figure 1. PD stress ring evidences, Phase U



# CANADIAN TRANSMISSION UTILITY

**Details**
Partial breakdown within bushing control layers.

**Evidence**
Sudden capacitance relative increase (2.8%) and PD in bushing (phase H2) detected by TOTUS TTM.

TOTUS TTM monitoring unit was installed in October 2017 on a 504 MVA AT provided with >30-year-old bushings (1980).

Catastrophic faults have been experienced by the utility onsame bushings.

On April 2018, a sudden capacitance change from Phase H2 was detected.

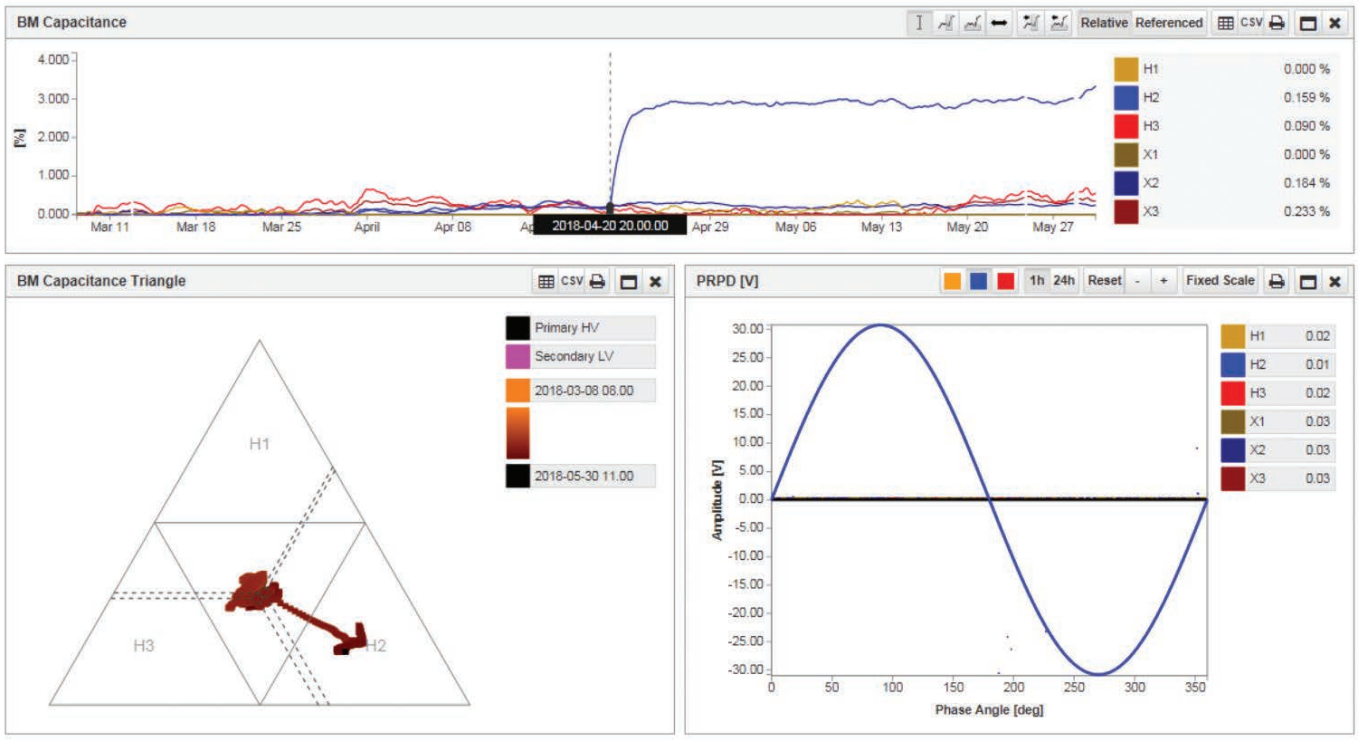
Deviation recorded (> 2 %) was consistent with a short circuit between layers for a 345 kV bushing. Furthermore, the evidence was confirmed by Offline tests.

The TOTUS TTM played a vital role, successfully highlighting the deviation and preventing a high risk event.

The Canadian utility was able to highlight a sudden capacitance increase within the Autotransformer H2 bushing.

In addition, an effective Condition Based Maintenance was enabled, which allowed the utility to minimize the overall costs of ownership and maintenance.

Figure 1: Sudden Capacitance increase, Phase H2



## The TOTUS TTM played a vital role, successfully highlighting the deviation and preventing a high risk event.

From an asset management point of view, the increasing does not represent an immediate risk factor for the Bushing provided that future records do not highlight further sudden changes in the Capacitances.

As a result, the transformer was left operational until the Offline measurement session.

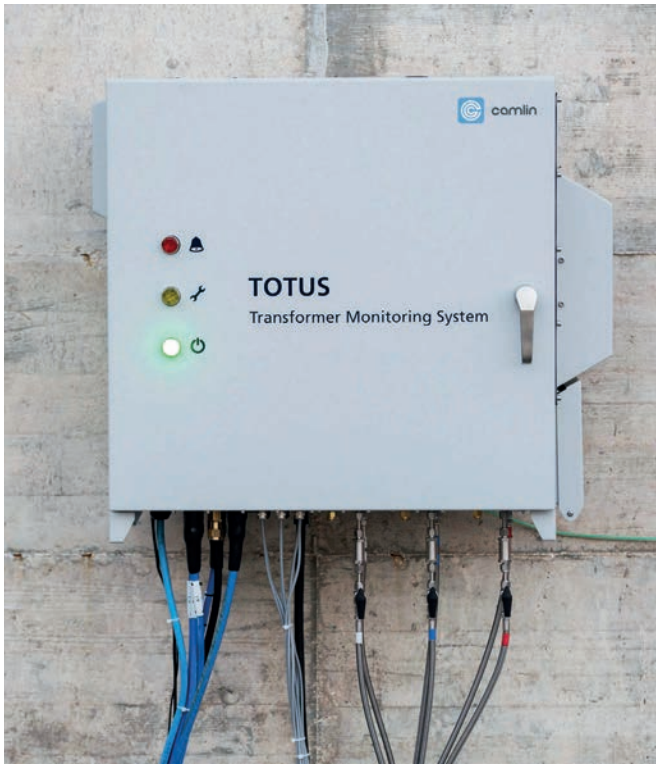
It must be highlighted that the Offline test was conducted 38 days after the event (28th of May) leading to an extremely successful Condition Based Maintenance with an extremely important impact on economic losses due to an extended outage.

Bushing Offline Tests confirmed the Capacitance Increasing!

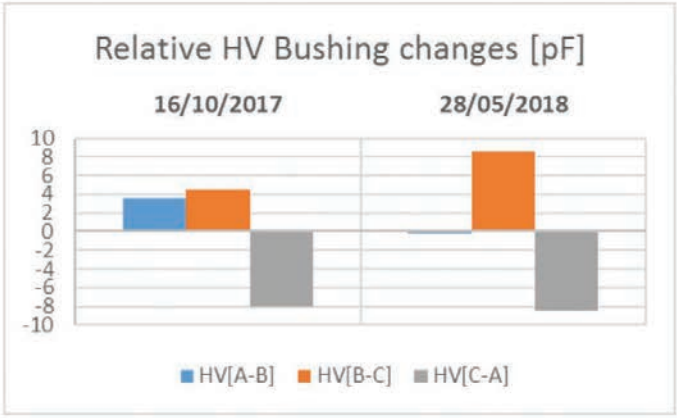
Straight interpretations of the results were not immediate, meaningful conclusions therefore took time.

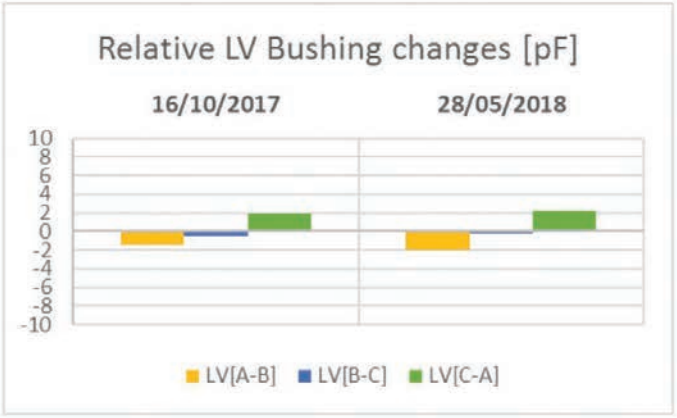
NOTE: nameplate has been determined in the '70s and the accuracy may not be same as nowadays.

| | NP | 16th Oct 2017 | 28th May 2018 |
|---|---|---|---|
| Phase H1 | 428 pF | 419.078 pF | 423.785 pF |
| Phase H2 | 415 pF | 415.472 pF | 423.94 pF |
| Phase H3 | 419 pF | 410.956 pF | 415.376 pF |
| Phase X1 | 339 pF | 338.054 pF | 339.888 pF |
| Phase X2 | 340 pF | 339.498 pF | 341.884 pF |
| Phase X3 | 339 pF | 340.043 pF | 342.159 pF |




For the above reasons, Camlin evaluated the relative deviation between the phases and the results compared between the two measurement sessions:



# EUROPEAN DISTRIBUTION COMPANY

**Details**
Monitoring as a control system for corrective actions.

**Evidence**
Oil gassing highlighted (H2). suspect was an oil sharing between LTC and main tank. corrective action was planned and TOTUS DGA used to monitor and confirm the effectiveness of the mitigation.

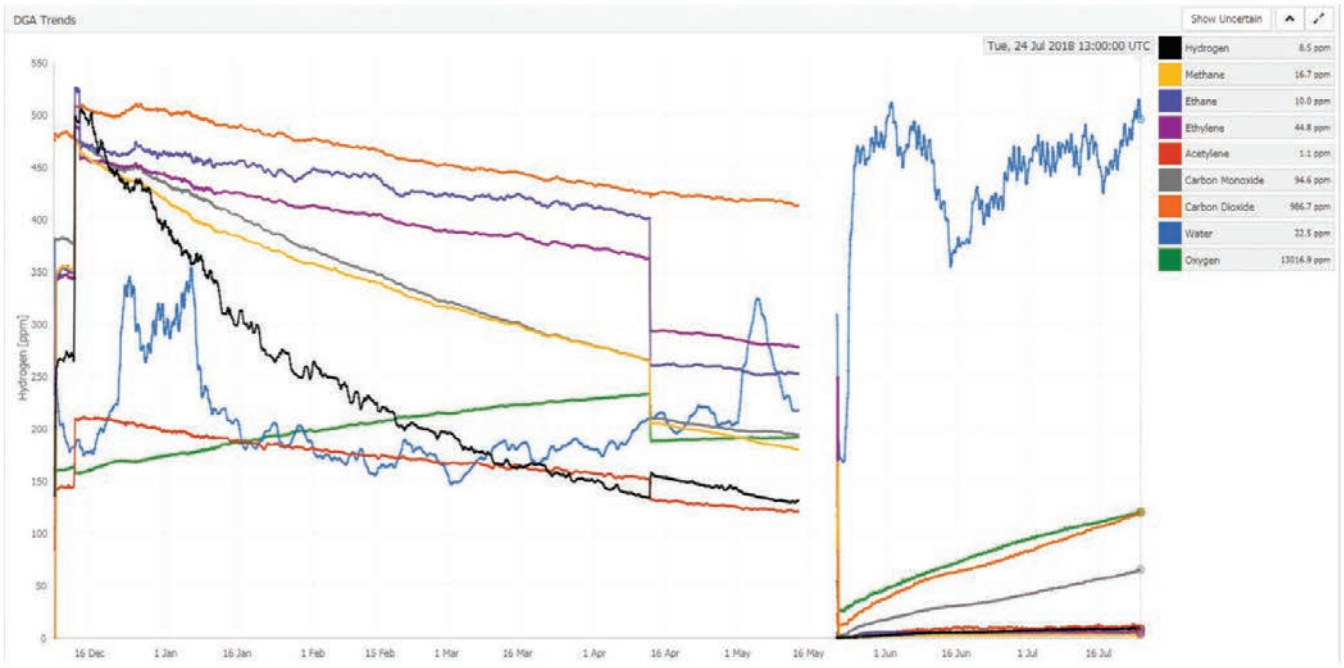
A TOTUS DGA monitoring unit was installed in December 2017 on a 31.5 MVA transformer.

Historical DGA Lab analysis highlighted Hydrogen increasing over time and the utility, following a preliminary investigation, suspected the gassing was caused by the LTC tank which shared oil with main tank.

Follow-up action to resolve the case was determined and the final decision was to operate the transformer with a fixed tap position. This would avoid the gas formation and the expectation is a progressive decreasing of the ppm absolute concentration.

The TOTUS DGA tracked the readings to ensure no further gas creation. This enabled the utility to keep the Transformer in service longer, enabling an effective life extension.

Figure 1: DGA Behavior from Installation date.

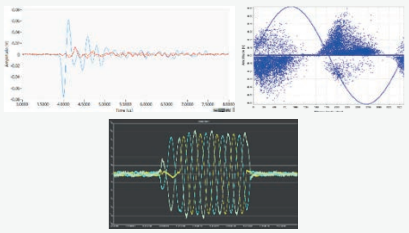


# ACTIONABLE INFORMATION CREATING BUSINESS VALUE

1


## Generate the Data

- Detect Anomolies, alarm triggered



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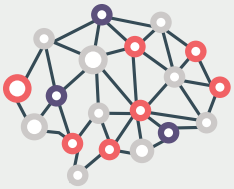
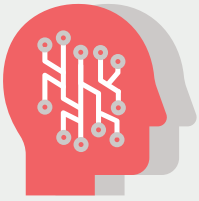


## Transform Data to Information

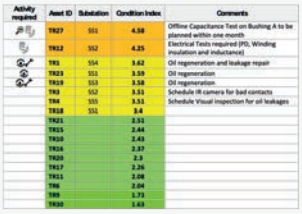
- Correlate the anomilies
- Determine possible failure mode

3



## Apply Knowledge to Information

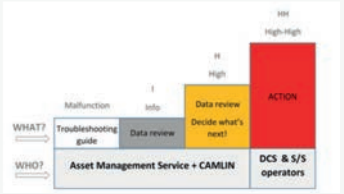
- Combine parameters into condition index to represent transform
- Confirm failure mode to trigger best offline test
- Determine prescriptive actions



4

## Apply Wisdom to Drive Decision Making

- Understand risk to operations
- Budgets, environmental issues
- Correlate with external parameters
- Alignment with maintenance planning



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