Case Study 2062006

Transformer On-line monitoring

October 2006 – April 2007

Physical Acoustics Corporation

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

CASE STUDY 2062006

- 3 phase, 300/336 MVA, 230/100/44 kV
- FOA Class
- This transformer exhibited periodic sudden increases of combustible gases.
- Unit was tested acoustically in June 2006 with two areas of acoustic activity detected
- A DGA was performed using a portable gas chromatograph
- DGA indicates a thermal fault of high temperature

DATE	INST	H2	CO	CO2	CH4	C2H6	C2H4	C2H2	TDCG
6/7/06	PAC's Portable DGA	171	148	814	782	609	**1423**	11	3144

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

CASE STUDY 2062006

- Due to the criticality of this transformer, an all-acoustic on-line monitoring system (Sensor Highway II) was installed on this unit.
- The day of the installation, a new DGA sample was taken with surprising results (see table below).
- The TDCG value increased from 3,144 ppm to 16,089 ppm changing the condition of this transformer from Condition 3 to Condition 4 according with IEEE Std. C57.104.
- A high temperature (>700 °C) thermal fault is suspected

DATE	INST	H2	CO	CO2	CH4	C2H6	C2H4	C2H2	TDCG
6/7/06	PAC's Portable DGA	171	148	814	782	609	1423	11	3144
10/18/06	PAC's Portable DGA	2480	634	1636	5126	1782	6035	32	16089
10/19/06	Utility's Portable DGA	2501	657	1671	5441	1702	6104	32	16437
10/18/06	Utility's LAB	1563	<25	1337	5867	2230	6815	37	16527

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

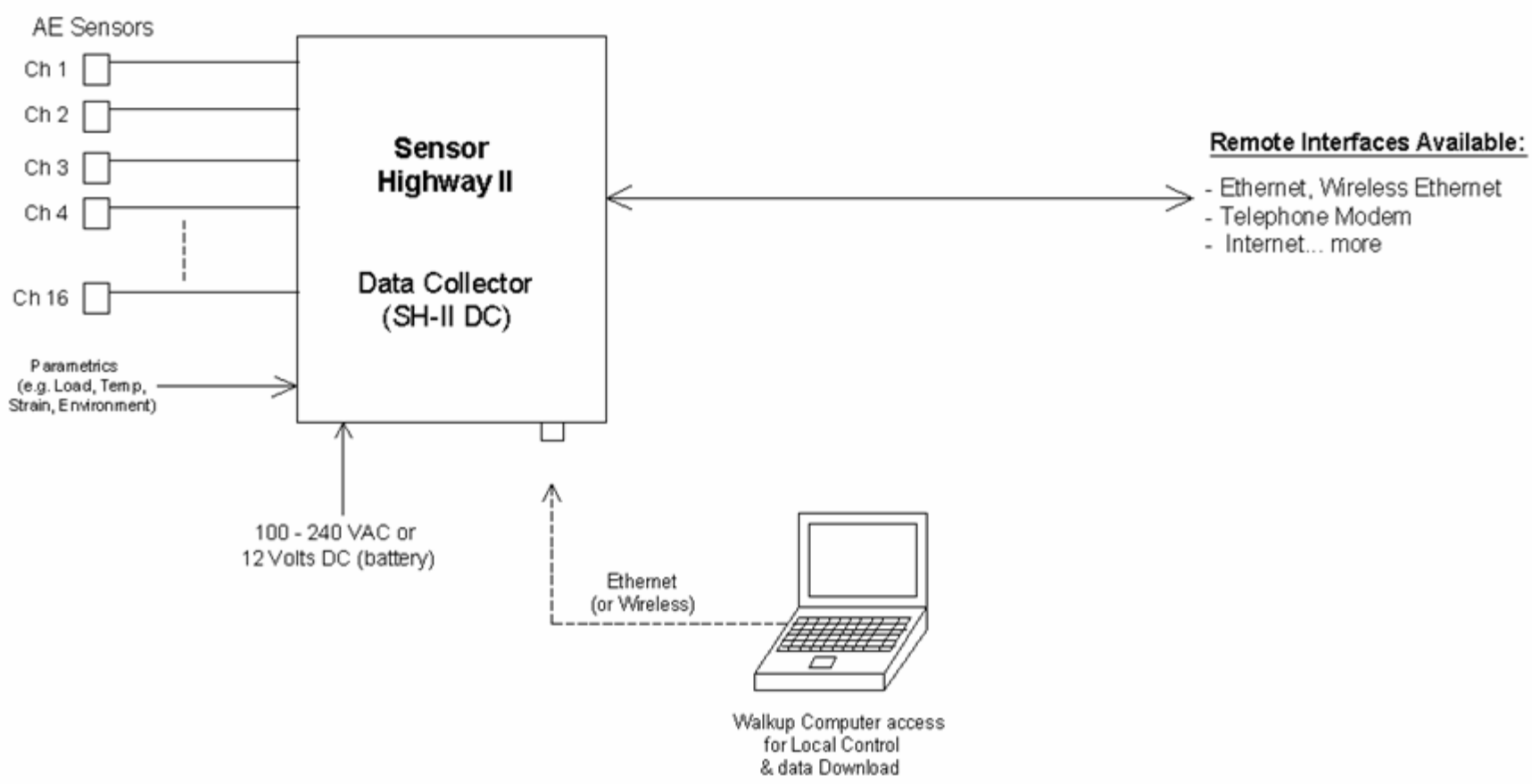
AE Sensor Highway II

- 16 AE Channels with independent signal processing (always active, no multiplexing)
- Four 4-20 mA and digital I/O
- Connectivity to Ethernet with options for other interfaces (wireless and cell phone).
- NEMA 4 Enclosure ~ 20” x 16” x 6” with removable bottom panel.
- ~ 40 pounds
- Compact Flash Interface (up to 4 GB)
- Wide temperature range (- 35 to +70 C)
- Power: 85-260 VAC or 9-28 VDC
- Low Power AC/DC operation (12W + sensor requirements ~ 48 W)

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

Sensor Highway II



PHYSICAL ACOUSTICS CORPORATION

MISTRAS
A World of NDT Solutions

ON-LINE MONITORING

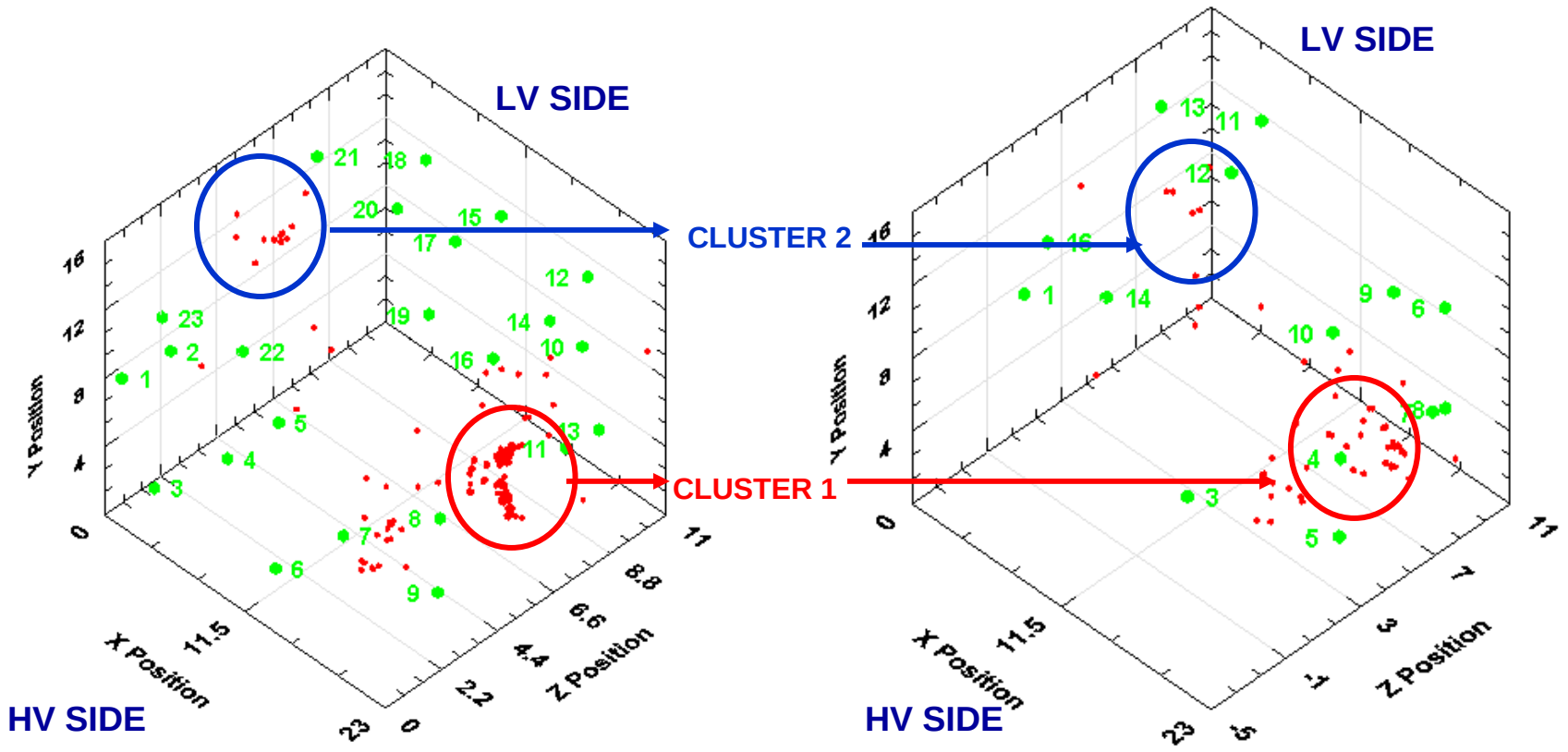
- On-line monitoring started in October 2006
- The same two areas of activity detected in June 2006 were detected during the entire monitoring period (Clusters 1 & 2).
- An on-line multiple combustible gases monitor was also installed
- No changes in TDCG were detected by the DGA monitor
- The two areas of acoustic activity corresponded to:
  - Middle section of Phase A coil
  - Upper part of Phase C coil
- The on-line system collected data from October 2006 – April 2007

PHYSICAL ACOUSTICS CORPORATION

MISTRAS
A World of NDT Solutions

3D LOCATION PLOT

- Two areas of acoustic activity were detected (Clusters 1 & 2).



RESULTS 24 SENSORS SYSTEM

JUNE 2006

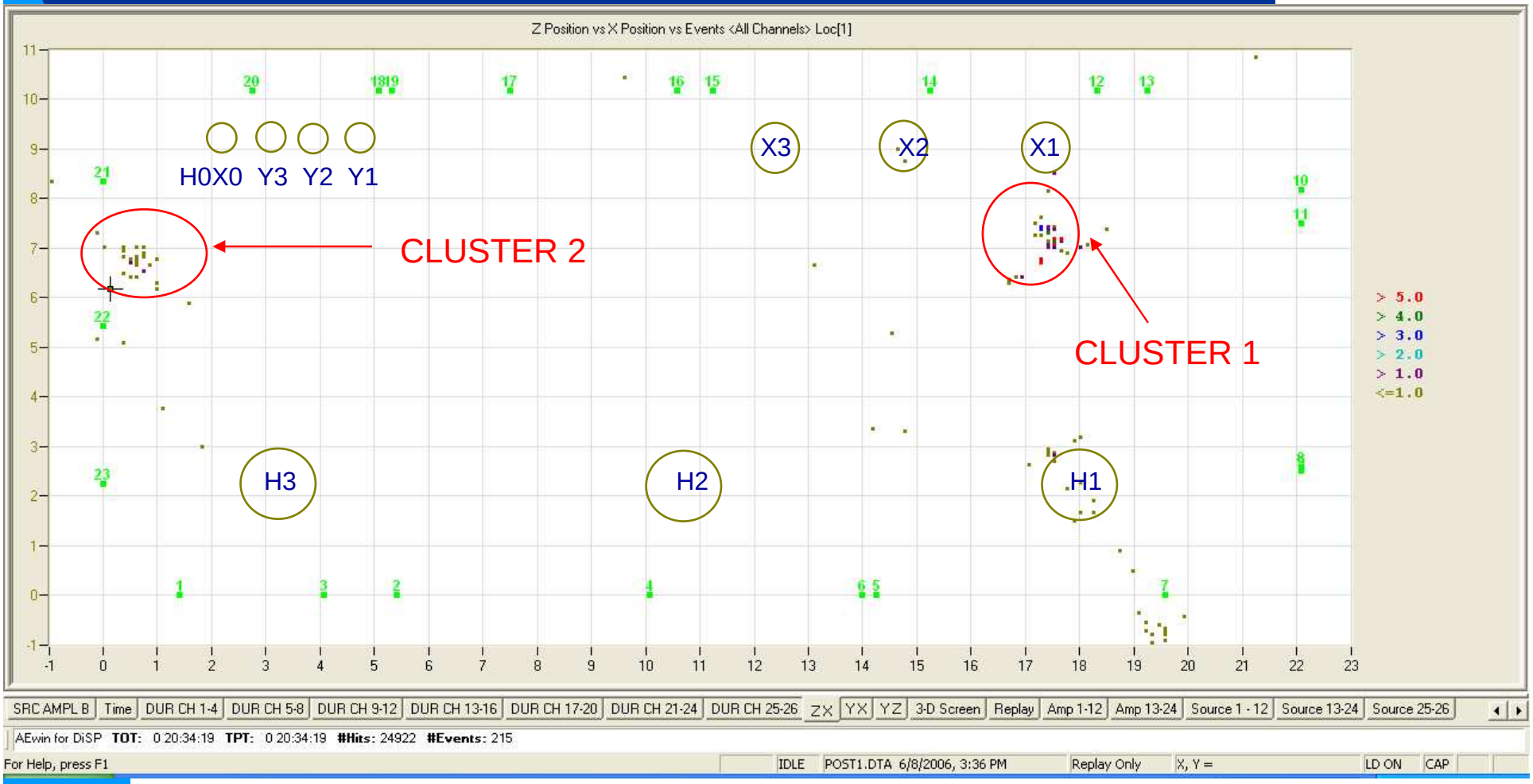
RESULTS ON-LINE SYSTEM

OCTOBER 2006

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

TOP VIEW

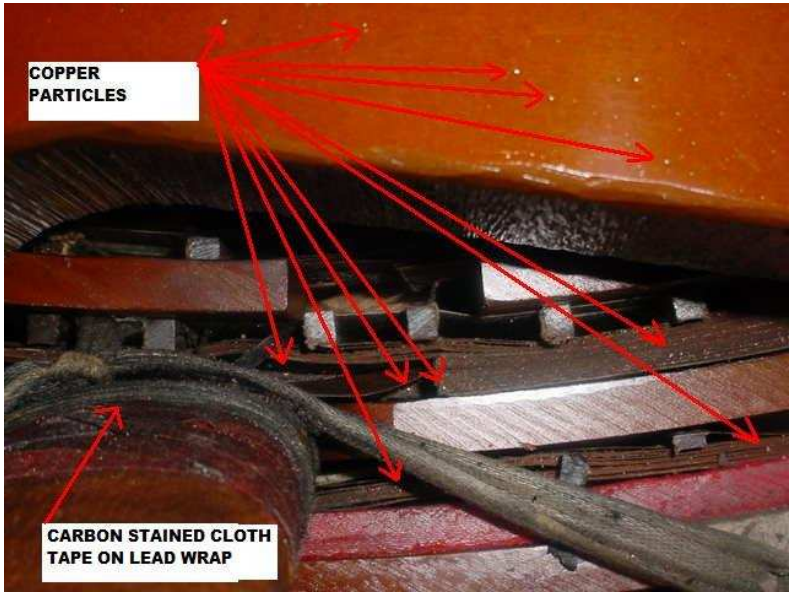


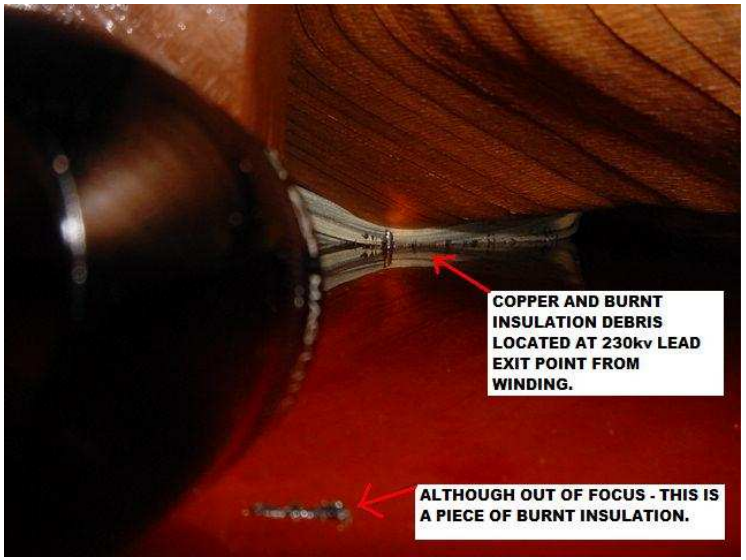
PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

ON-SITE OVERHAUL (April 2007)

1. The general vicinity of the H3/X3/Y3 winding assembly was noted as being considerably littered with dark/carbonaceous paper.
2. This unit by design incorporates the direct flow cooling system; speculation is that this material most likely originated from the inner layers of this winding assembly with the oil flow providing the vehicle for spreading this debris.





3. There is also considerable coverage of copper particulate in and around the top of this winding. This material ranges in size from “dust” to pieces similar in stature to that of a “pinhead” with a small percentage of larger “BB” size pieces found.

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

ON-SITE OVERHAUL (April 2007)

- Subsequent testing was conducted.
- TTR identified and out of tolerance measurement associated with the Y3 winding.
- Winding resistance testing revealed an abnormality with the Y3 winding.
- Megger testing did not reveal any concerning issues.
- By design, the Y3 winding is located within the H3/X3 assembly. Based on the test data, it is likely that the paper and copper discharge found was originating from the Y3 winding being pushed out via normal oil flow.

TTR TEST – Calculated Ratio – 3.018

H1/Y1	3.012	Difference: 0.20%
H2/Y2	3.015	Difference: 0.10%
H3/Y3	3.046	Difference: 0.94% --- Failed

WINDING RESISTANCE TEST

Y1	55.1 Ω
Y2	55 Ω
Y3	78.3 Ω - Failed

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

OPENED @ FACTORY (NOVEMBER 2007)

- Factory inspection indicated that the failure mode at the fault location was turn to turn in the layer winding.
- The unit remained in operation for several months under these conditions; it is possible the fault could have opened up the delta an C phase and the TV could have been running open delta.

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

CONCLUSIONS

- This Case Study demonstrate the usefulness and effectiveness on an all acoustic on-line monitoring system.
- The continuous on-line monitoring of this unit allowed this utility to continue the operation of the transformer during a critical load period and also provide an accurate location of the fault.
- The practicability and accuracy of portable gas chromatographers is also shown
- The overhaul performed on-site indicated that the fault was not on the external part of the winding.
- Traditional electrical tests indicated a problem on the Y3 winding.
- Factory internal inspection confirmed the existence of a turn-turn fault on the area indicated by acoustic and electrical tests
- Important observation: even Combustible gases did not increase from October 2006 – April 2007, Acoustic Activity was still been detected

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions

QUESTIONS:

Arturo Núñez

Substation Reliability Services and Products Manager

anunez@pacndt.com

+1 (267) 968-3289

PHYSICAL ACOUSTICS CORPORATION

MISTRAS A World of NDT Solutions