The First Warning Sign

Electric utilities monitor hydrogen levels in network transformer and primary switch to detect fault conditions early

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As electric utilities create safer conditions throughout their secondary underground networks, they turn to technologies such as condition-based monitoring solutions to help evaluate the health of their equipment and detect potential issues before they occur. One condition to monitor is the dissolved gas content, specifically hydrogen, within the insulating oil of a power transformer or primary switch.

Unusual hydrogen levels are a primary indicator that a dangerous condition is developing such as overheating, sparking, or arcing. This paper explains how utilities can specifically monitor hydrogen levels to stay ahead of dangerous conditions.

Measure hydrogen levels with DGA for early fault detection

Industry technologies such as dissolved gas analyzers (DGA) allow a utility to monitor the presence of various dissolved gases and their respective levels within the oil of their transformers and primary switches. However, there is one dissolved gas that is particularly important for utilities to measure: hydrogen.

Hydrogen is a key gas to measure because it is a precursor to other dangerous gases and conditions. As shown in Figures 1 and 2, hydrogen is the first gas to be generated when a fault condition is building up in the transformer.

For this reason, the DIGITALGRID Dissolved Gas Analyzer (DGA) specifically measures the hydrogen content in the oil. Utilities use the DIGITALGRID DGA for early fault detection & response and smarter maintenance planning.

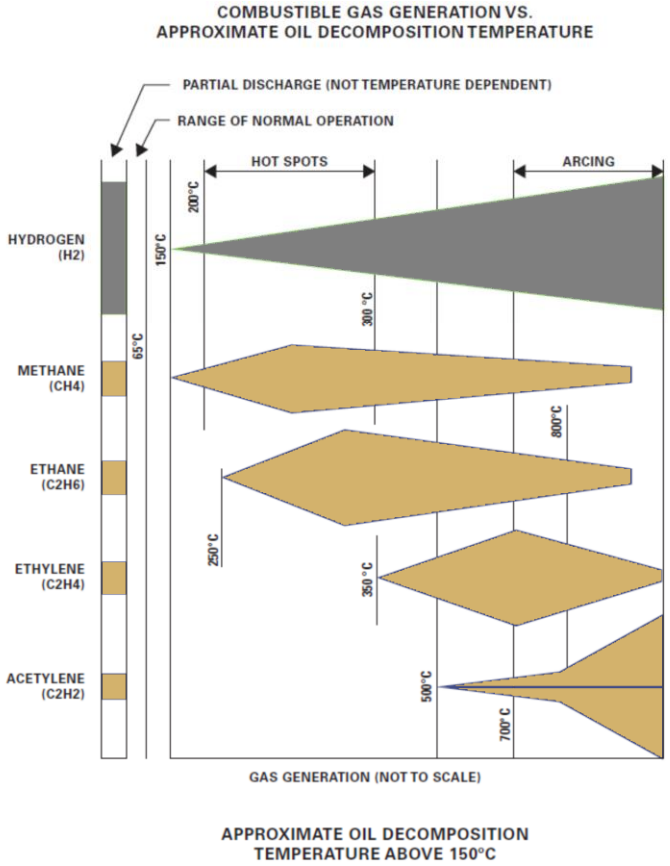

Figure 1: Combustible Gas Generation vs Temperature (Source: UtilityProducts, 2021)

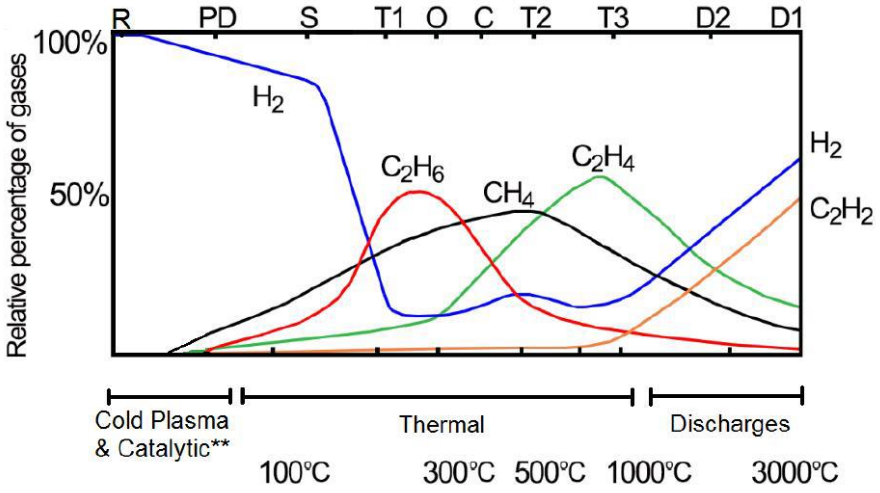

Figure 2: Hydrogen is a precursor to dangerous conditions

Conditions shown in Figure 2

- PD: Partial Discharge
- S: Stray Gassing
- T: Thermal
- O: Overheating
- C: Carbonization
- D: Discharges

Another advantage of monitoring hydrogen is to reduce equipment costs. In-line DGA technology was introduced to the industry in the mid-1990s and can measure several gasses; however, the more gasses that a DGA measures, the more expensive the analyzer becomes. To keep costs down while reliably understanding the health of the transformer, the DIGITALGRID DGA exclusively monitors hydrogen as the key leading indicator of fault conditions.

Set alarms and limits to stay ahead of fault conditions

Since the presence of hydrogen is a leading indicator for other dangerous conditions, utilities can use DIGITALGRID Monitoring Solutions to measure dissolved gas levels, monitor trends, and set alarms. Each utility can set their own thresholds and parameters for their customized alarms. Typically, electric utilities will set alarm parameters based on the following conditions:

- If hydrogen levels reach a point between 100-200 ppm of hydrogen (see Figure 3), or
- Hydrogen levels break their normal trend (i.e., a sharp increase in hydrogen levels compared to the normal linear increase).

Electric utilities can gain further insights into the health of their equipment by leveraging other sensors in the DIGITALGRID Monitoring Solutions portfolio such as monitoring the oil temperature, pressure, and levels within their transformer and primary switch.

Gas Description		Key Gas Concentration (in ppm)		
		Normal Limits* (<)	Action Limits** (>)	Potential Fault Type
Hydrogen	H_2	150	1,000	Corona, Arcing
Methane	CH_4	25	80	Sparking
Acetylene	C_2H_2	15	70	Arcing
Ethylene	C_2H_4	20	150	Severe overheating
Ethane	C_2H_6	10	35	Local Overheating
Carbon monoxide	CO	500	1,000	Severe overheating
Carbon dioxide	CO_2	10,000	15,000	Severe overheating
Total Combustibles	TDCG	720	4,630	

* As the value exceeds this limit, sample frequency should be increased with consideration given to planned outage in near term for further evaluation.

** As value exceeds this limit, removal of transformer from service should be considered.

This table is derived from information provided within ANSI/IEEE C57.104

Figure 3: Key Gas Concentrations

These additional oil sensors can be used in conjunction with the DIGITALGRID DGA to determine if a fault is developing or if their equipment is trending towards required maintenance. For example, if transformer oil temperature is too high, above 90°C, a utility should take action to investigate a potential fault at that power transformer location.

Move towards condition-based maintenance and reduce O&M expense

This trending analysis allows for smarter asset planning. By understanding dissolved gas trends and baseline levels, a utility can decide when preventative action needs to be taken.

Without a DGA, utilities would schedule routine maintenance based on a fixed time interval, and service technicians would collect and send oil samples to a lab for testing. Not only do utilities wait days for lab results, but this approach can also be risky if fault conditions develop on a transformer between the scheduled sample lab testing.

> **We can focus our limited O&M dollars on the equipment that needs maintenance.** With the data we collect, we can do condition-based maintenance rather than maintenance based on a fixed-time interval.
>
> -Electric Utility
> Consulting Engineer, Network

Instead, the DIGITALGRID DGA allows for continuous transformer analysis, minimizing crew dispatches to collect samples. The DIGITALGRID DGA delivers this analysis back to a dashboard, allowing a utility to monitor their hydrogen levels remotely without having field service technicians enter the vault.

Ultimately, utility professionals are trusted to maintain highly reliable power networks, minimize outages, improve safety, and prevent damage to equipment. To help achieve this standard, DIGITALGRID Monitoring Solutions enable utilities to predict, detect, and mitigate a potential problem before a condition becomes critical. This insight saves time, reduces capital equipment expense, minimizes O&M spend, and reduces potential personnel injuries.

We're here to help

To learn more about DIGITALGRID monitoring and control solutions, please contact us at **sales@digitalgridinc.com.**

References

"A review of dissolved gas analysis measurement and interpretation Techniques", IEEE Electrical Insulation Magazine, Norazhar Abu Bakar, A. Abu-Siada, Sheikh Islam, May 2014.

"Dissolved Gas Analysis for Transformers", NETA World, www.netaworld.org, Lynn Hamrick, ESCO Energy Services, 2009.

DIGITALGRID, Inc.

About Us

For more than 22 years, DIGITALGRID, Inc. has helped create safer secondary networks across the United States and Canada by providing control & monitoring solutions.

We design and manufacture highly reliable electronic communications equipment to withstand harsh environments and provide comprehensive engineering solutions utilizing power line carrier (PLC), fiber, hardwire, or cellular techniques across existing infrastructure.

For more information, please contact our team at sales@digitalgridinc.com.