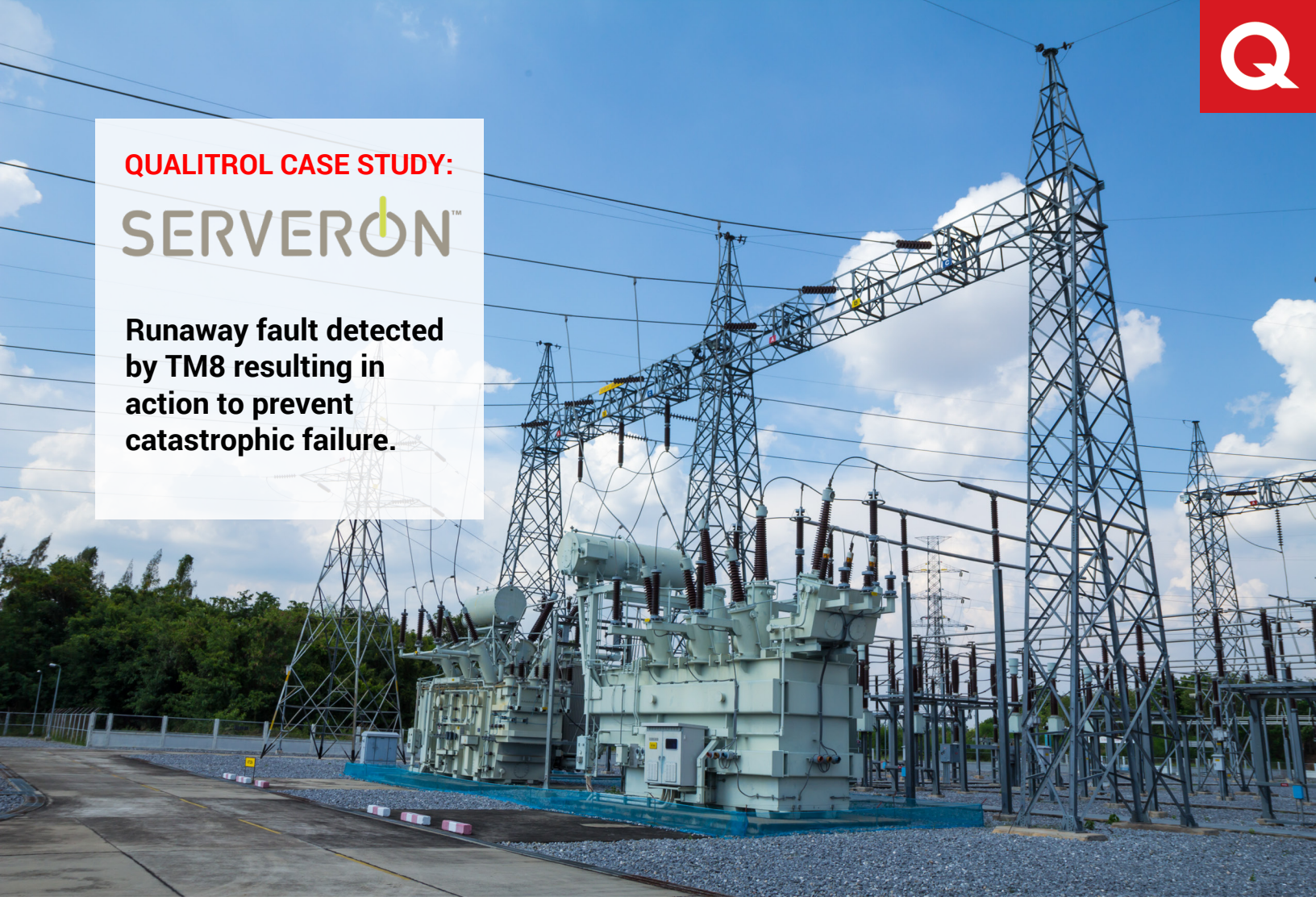

QUALITROL CASE STUDY:

SERVERON™

Runaway fault detected by TM8 resulting in action to prevent catastrophic failure.

On August 28th, 2016 a Serveron DGA was being used to monitor a 3-phase, 1100 MVA, 345 kV GSU.

The transformer had been installed less than two years earlier. During this transformers first three months of operation there was some generation of combustible gases. Online DGA was used to correlate gas production with times when only half the cooling banks were in operation. When all the coolers were running, gas generation ceased. Troubleshooting identified that one pump was running backwards. When the wiring was corrected no further gas generation was observed.

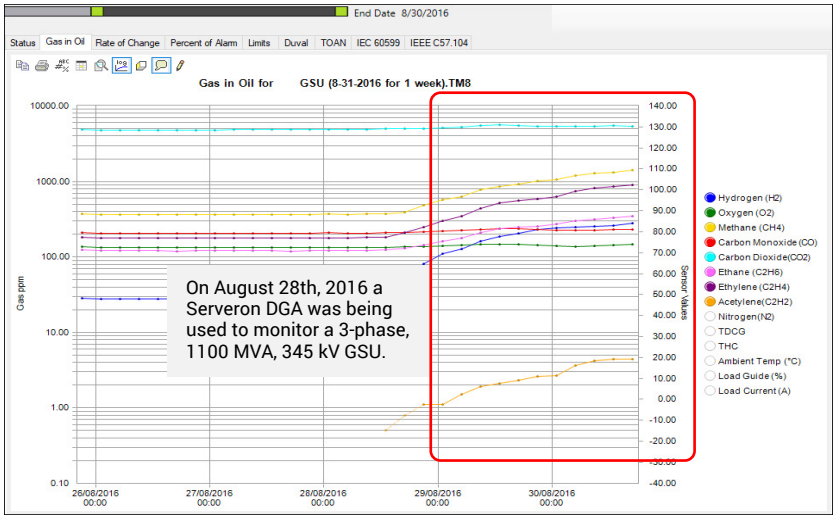

Figure 1: *TM View Screen showing the time at which gases started to increase. Log Scale is used to best illustrate the very large increase of gases on a single graph*

QUALITROL COMPANY LLC, 1385 Fairport Road, Fairport, New York 14450
(585) 643-3717 www.qualitrolcorp.com **Email:** info@qualitrolcorp.com

QUALITROL®
Defining Reliability

As a result of its initial problem with the pump, dissolved gas concentration was at a high base level over the following 21+ months; Gas concentrations were high but stable. In the afternoon of 28th, gas concentration started to climb. By midnight there was a steady increase in the concentration of all gases. While the gas concentration increase was significant it was not enough to trigger the buchholz relay and so the transformer was allowed to continue to operate. Load was reduced on the transformer with no change in gassing rates as measured by the Serveron online DGA monitor. The transformer was taken offline on August 30th to perform an internal inspection and repairs if possible.

Reviewing the DGA data in TMView resulted in the following indications at the point in time when the transformer load was reduced to Zero

Diagnostics Method	Result
Duval Triangle 1	Thermal Faults [300°C < T < 700°C]
Duval Triangle 5	Border of Hot Spots in Paper and Hot Spots in oil
Duval Pentagon 1	Thermal Faults [300°C < T < 700°C]
Duval Pentagon 2	Thermal Fault with carbonisation
TOAN	Overheated Oil: Immediate attention required, consider removal from service.
IEC 60599	Condition 2: Thermal Faults [300°C < T < 700°C]
Doernenburg Ratios	Thermal Faults [300°C < T < 700°C]
IEEE C57.104-2008	Condition 4. Immediate action required

Table 1: *Comparison of diagnosis of DGA data as provided by TM View*

All diagnosis systems (Table 1) pointed to a thermal fault >300°C with some suggestion that there was paper involved. While the ratios of gases before this gas generation event occurred would have indicated the same diagnosis (See Figure 1 & Figure 2 where the diagnosis remains in the same location) it was the rapid change in gas concentration, as alarmed by the Rate of Change alarming function in TM8 that drove the utility to take action, resulting in the eventual full shedding of load for inspection.

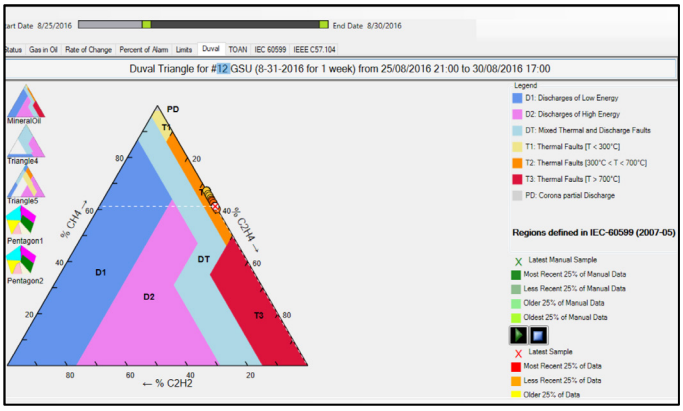

Figure 1: *Duvals TRIANGLE 1. Thermal Fault 300°C – 700°C*

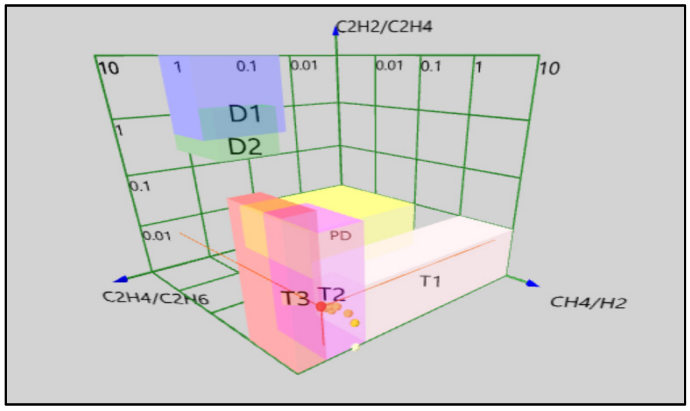

Figure 2: *Rodgers Ratio indicating condition T3: Thermal Fault 300°C – 700°C*

QUALITROL COMPANY LLC, 1385 Fairport Road, Fairport, New York 14450
(585) 643-3717 www.qualitrolcorp.com **Email:** info@qualitrolcorp.com

QUALITROL® Defining Reliability

OUTCOME

Upon physical inspection it was revealed that localised burning of paper had occurred. The inspection revealed a severely damaged crimped connection between LV cables connecting an LV winding-exit to a bushing. The paper wrapping that connection was dark coloured.

Figure 3: *Damaged connection was easily separated when manipulated.*

Figure 4: *Crimped terminals and cables connected to the bushing's intermediate copper plate.*

A detailed failure analysis consisting of electrical diagnostic testing and internal inspection concluded:

1. The gas generation was found to be due to overheated crimped connections. This was caused by a combination of high eddy losses in the crimps, poor oil circulation in the high-current insulated crimped bundled-areas and to a lesser extent by an uneven current distribution.
2. The most heavily damaged crimped connection had a degenerative condition initiated by a very high working temperature calculated to be >300ºC (consistent with indication per Table 1) which caused a thermal runaway resulting in the sudden gassing increase.
3. The windings were not impacted

Remedial work was undertaken, and the transformer was subsequently put back into service.

"SERVERON TM8 On-line DGA saves another transformer from catastrophic failure."

In this case the transformer was known to have had historic gassing issues but was stable. After a period under full load the transformer started to produce large increase in gases which was notified to the user by a "rate of change" alarm on the Serveron TM8.

Only Online DGA would provide this level of resolution in data and it was this detailed insight that allowed the transformer operator to take the transformer offline before a catastrophic even occurred. Additionally, as a result of online DGA being in place, providing unequivocal proof of a significant fault it would have been straightforward for the utility to make the case to have the transformer repaired under warranty.

Source: Rivera. I, Data from 8-gas on-line analyser used to avert failure of critical 345 kV transformer within 2 years of installation, DistribuTECH – February 4-6, 2007

Dates, times and other details may have been changed to maintain the anonymity of the owner / operator in this case study. All DGA data, timelines and technical specification are factually accurate.

QUALITROL COMPANY LLC, 1385 Fairport Road, Fairport, New York 14450
(585) 643-3717 www.qualitrolcorp.com **Email:** info@qualitrolcorp.com

QUALITROL®
Defining Reliability