REALTIME ANALYSIS OF SF6 DECOMPOSITION PRODUCTS

By Keith C. Lee and Ian G. N. Wylie, Powertech Labs Inc.

Developed under a joint B.C. Hydro and EPRI research program, the Powertech SF6DPD provides a quick and accurate measurement of SF6 decomposition products in field situations. Testing SF6 directly from the equipment eliminates the sampling and delay associated with lab analysis.

Low-level decomposition products are extremely unstable and their concentrations may be significantly reduced in the time between sampling and analysis. Using this detector, rapid screening of a SF6 filled electrical equipment is possible. Developing problems can be easily identified and outages minimized.

The SF6DPD is a first step in isolating and identifying incipient problems such as arcing, partial discharge or corona in SF6. The high sensitivity and rapid response time identifies the gas zone where a problem is occurring and with further examination using other analytical techniques such as UHF, the exact location and nature of the problem can be identified. The detector is able to handle sampling from energized equipment at system pressure. Personnel safety can also be rapidly assessed before maintenance begins so that appropriate procedures and precautions can be implemented.

The interpretation of the results from using the SF6DPD depends on the equipment. In non-switching equipment such as bus runs, the presence of any decomposition products should be of concern. In compartments where switching is involved, decomposition products may be formed under normal conditions. In the case of circuit breakers with an internal absorbent, the presence of decomposition products may indicate normal operation. The levels will vary depending on the equipment and each situation. The concentration should decrease over a period of a few days as the absorbent removes these decomposition products. If the levels do not decrease and there is no further switching, this may indicate that the absorbent is spent or that there is an ongoing problem. This is certainly the case if there is a continual increase in the concentration of decomposition products in the absence of any switching operations.

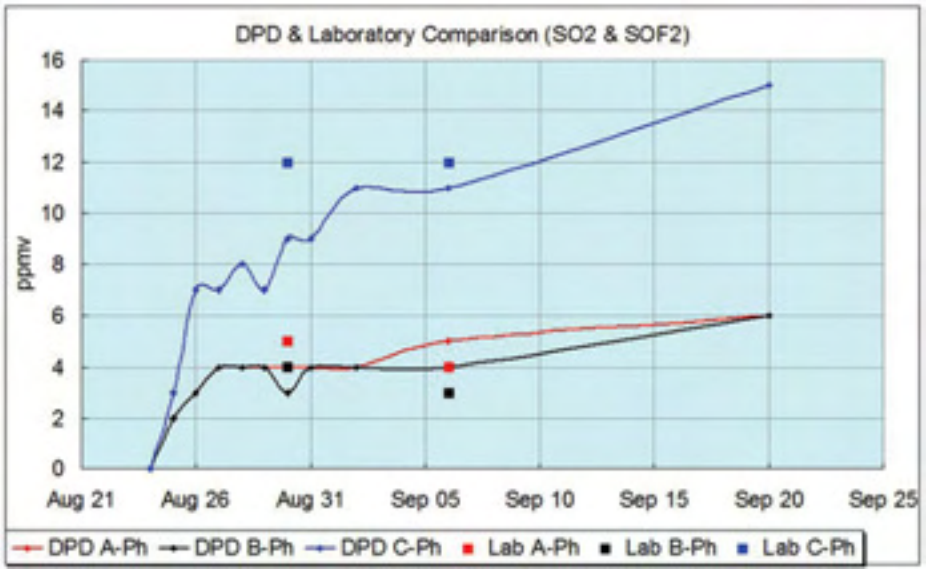

Figure 1 Monitoring of decomposition product levels in a bus

The SF6DPD detects and displays the total concentration of SF4, SOF2 and SO2. SF4 is one of the initial products formed from the decomposition of SF6. However, due to its high reactivity, it is rarely present in significant levels. SOF2 is the most predominant SF6 decomposition products and the primary decomposition path for SOF2 produces the more stable SO2 (and HF). Detection of low ppm levels of SOF2 enable incipient faults to be identified earlier, an obvious advantage over instruments that are only sensitive to SO2 or HF.

Using a 3 m long 1/4" stainless steel braided PTFE sampling line, a measurement can be typically taken with the release of less than 2 g of SF6. A vent gas recovery kit may also be used to further reduce the release of SF6 during sampling.

The following examples demonstrate how the SF6DPD has been used successfully in the field.

FIELD TEST RESULTS

Field tests were carried out at a 2,000 MW generating station. All 53 gas zones were tested on site by using both the SF6DPD and a customized portable micro gas chromatograph (GC). Samples were also taken and sent to a laboratory for analysis using a laboratory GC. Using the SF6DPD and GC, all on-site tests were completed in less than 10 hours. If gas detector tubes were used, 53 detector tubes would have been required and there would not have been any saving in time. Two of the tested zones gave positive responses from the SF6DPD and confirmatory tests. Samples from the zones that tested positive using the SF6DPD were also sent to the laboratory. The SF6DPD gives results that are comparable to those obtained by the more sophisticated, more time-consuming and more expensive laboratory tests.

PARTIAL DISCHARGE AT A BUS

UHF analysis showed signs of the presence of loose particles in A-phase of a 230 kV bus. The bus was de-energized

Continued on Page 10

5 to 10 arc flash explosions occur in electric equipment every day in the US*

Are YOU protected?

Everyday, workers in the electrical maintenance and utility industry work in environments that may expose them to hazards that could cause severe or fatal burn injuries. In the event of a momentary electric arc, everyday non-flame resistant work clothes can ignite and will continue to burn. Untreated fabrics continue to burn until the fabric is totally consumed and non-flame resistant synthetic fabrics will burn with melting and dripping causing severe contact burns to skin. The use of flame resistant clothing will provide a level of thermal protection, and after the source of ignition has been removed flame resistant garments will self-extinguish.

***AGO INDUSTRIES INC.** manufactures **ARC/FR APPAREL** to help protect workers in the electrical maintenance and utility industry from the hazards of electric arc flash exposures.*

Shirts • Pants • Coveralls • Coats • Jackets • Faceshields • Hoods

Comply with NFPA 70E • Garments to ASTM F1506 Standards

AGO
INDUSTRIES INC.

PO Box 7132
London, Ontario
N5Y 4J9
CANADA

PH: 519-452-3780
FX: 519-452-3053
EM: mail@arcfr.net

Featuring

INDURA Ultra Soft®

PBI gold

* CapSchell Inc.

www.arcfr.net

Continued from Page 8

for other maintenance work and analyzed with the SF6DPD two weeks later. The delay in analysis was not planned and all three phases showed almost identical readings of about 5 ppmv. Since all three phases are normally connected through a common filling line, the decomposition products would have diffused through the common filling lines to the other phases.

The bus was put back on line and a subsequent analysis by the SF6DPD identified A-phase contained more than 50 ppmv of decomposition product. A lab sample was taken and it was analyzed to have 650 ppmv SOF2 and 50 ppmv SO2. This unusually high level of decomposition products indicated a problem with that phase. Using time of flight measurements with the UHF monitor, the source was pinpointed to an insulator.

In this example, the SF6DPD was used as a preliminary diagnostic tool to focus on the suspected problem area.

MONITORING OF ARCING IN 230 KV BUS ZONES

Another 230 kV bus with a common fill point was analyzed with the SF6DPD and found to contain about 1 ppmv of decomposition product in all 3 phases. A monitoring program was initiated on each of the three phases. The level of decomposition products in C-phase eventually increased to beyond 50 ppmv and laboratory analysis of the gas confirmed levels of between 230 and 370 ppmv. As shown in Figure 1, the high sensitivity of the SF6DPD allows an early detection of the problem phase. The portability of the SF6DPD allows samples to be analyzed frequently. The immediate availability of results is crucial in rapid diagnosis of the problem.

When the bus was opened for examination and servicing, it appeared that a spring in C-phase had broken from the insulator assembly inside the bus and was causing arcing that eventfully produced a hole through the conductor.

Figure 2 Damage caused by arcing

INVESTIGATION OF PARTIAL DISCHARGE IN A BUS

A 500 kV bus of about 25 metres in length showed a concentration of one ppmv with the SF6DPD. Due to the large volume of gas in the bus, even such a low level may indicate a significant problem. Further investigations using a UHF analyzer located the problem to partial discharge activity in one area. This diagnosis was made possible only because of the high sensitivity of the SF6DPD. Again, the SF6DPD was used as the initial diagnostic tool and other techniques were used to pinpoint the source of the problem.

ACCEPTABLE LEVEL OF DECOMPOSITION PRODUCTS

The following may be used as a guideline when using the SF6DPD:

Bus – Since a bus has no switching activity, the SF6DPD should show no reading (less than 1 ppmv). If a low-level reading is observed, a monitoring program should be initiated. If the reading continues to rise, then another tool, e.g., UHF, should be brought in to isolate the source of the decomposition product. As shown in the above examples, isolating the different phases or compartments of a bus will further narrow down the source.

Switchgear – Decomposition products are usually produced during switching operations. The absorbent used in most switchgear will reduce the level of decomposition products with time. If a consistently high level (e.g., greater than 20 ppmv) is detected with no reduction with time, then perhaps the absorbent package needs to be replaced or replenished. It is also possible that a problem exists inside the switchgear that causes partial discharge when the switch is idle. The SF6DPD can be used to monitor the level of decomposition products in real time (as long as the level is less than 50 ppmv) to help with the diagnostic process.

Figure 3 Powertech SF6DPD

CONCLUSION

The Powertech SF6DPD is an accurate, easy to use and inexpensive instrument for field personnel to measure SF6 decomposition products from in-service equipment. The real time display of results at the ppm level saves maintenance staff time and money by diagnosing an incipient fault well before it manifests itself into a catastrophic outage.