PG&E and the New Breaker SF_6 Leak Study

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Abstract:

This paper examines the implications of a recent study examining new high voltage circuit breakers (those installed between 1998 and 2002) containing sulfur hexafluoride (SF_6) and SF_6 leakage incidents. The study was completed by PG&E in partnership with EPA's SF_6 Emission Reduction Partnership for Electric Power Systems and Electric Power Research Institute (EPRI). The results of the study suggest that only a small proportion of new breakers leak and to reduce the amount of SF_6 lost per leak incident, it may behoove the utility to reduce the leak detection alarm threshold.

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PG&E Background

Pacific Gas and Electric Company (PG&E) has a long history of environmental excellence. Our environmental policy statement states this clearly:

> PG&E Corporation is committed to being an environmental leader by providing safe, economical, and reliable products and services in a responsible and environmentally sensitive manner.

PG&E demonstrates its commitment to this by participating in collaborative ventures such as the California Climate Action Registry, the Energy Star Program, the Green Lights Program, the Voluntary Reporting of Green House Gas Emissions and Reductions Program and is a founding member of EPA's SF_6 Emission Reduction Partnership for Electric Power Systems.

Pacific Gas and Electric Company (the utility) is located entirely within the State of California. It covers an area of approximately 70,000 square miles, serving 4.9 million electric customers with over 136,500 circuit miles of electrical lines[1]. There are also 3.9 million gas customers served by 45,000 miles of natural gas lines[2]. We serve this

[1] PG&E Corporation, First Annual Corporate Responsibility Report.
[2] Ibid

territory with an employee force of 20,300 men and women[3].. We sell gas and electric service to one in twenty Americans[4].

PG&E, EPA EPRI and the New Breaker Leak Study

PG&E recently partnered with EPA's SF_6 Emission Reduction Partnership for Electric Power Systems and EPRI to conduct a study examining new high voltage circuit breakers containing SF_6 and SF_6 leakage incidents. For the purposes of the study, "new" breakers were defined as those that were installed between 1998 and 2002

New Breaker SF_6 Leak Definition

PG&E defines a SF_6 leak as an SF_6 pressure drop of more than 10 psi from a fully charged breaker at installation with a base pressure of 80 psi. A breaker density monitor is used to monitor for and determine SF_6 leaks by measuring the breaker internal pressure and temperature. The monitor then "compensates" for the difference between the measured temperature and the reference standard of a fully charged breaker defined at installation and calculates the temperature compensated pressure. Should the compensated pressure inside the breaker fall by more than 10 psi, an alarm is sounded. It is understood that the most density monitors are rated at ± 2 psi.

In addition to the above, other utilities may define a SF_6 leak as a 10 percent decrease in SF_6 density as compared to the density of the fully charged breaker at installation. The same density monitor discussed above is used to determine leaks by measuring actual breaker internal pressure and temperature, compensating for the measured temperature and calculating the breaker current compensated pressure. This value is compared to the reference standard of the fully charged breaker to calculate a percentage; 100% representing a full breaker. Should this value fall by more than by more than 10 percent, an alarm is sounded. Figure 1 illustrates this scenario by detailing the drop in temperature compensated pressure as the result of a breaker's slow leak.

In either case, on alarm, an operator will inspect the equipment and probably "top up" the breaker by adding more SF_6 gas up to the 80-psi/100% setting. Depending on a number of variables, the breaker will probably be serviced and the leak identified and repaired.

New Breaker SF_6 Leak Study Data Review and Analysis

From the pool of "new" breakers, PG&E collected and reviewed the SF6 leak alarm data. Of the 537 new breakers, 41 experienced a SF_6 alarm between their installation and the Spring of 2004. As illustrated by Figure 2, of those 41 breakers that experienced the first alarm, 16 experienced a second alarm, 10 experienced a third alarm and 6 have experienced four or more alarms since installation.

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[3] PG&E Corporation Form 10K Fiscal Year ending 2003
[4] PG&E Corporation, First Annual Corporate Responsibility Report.

This data indicates that only a small proportion, approximately 8 percent of PG&E's new breakers leak. However, it also indicates that some leaks can be difficult to repair or that some breakers may be particularly susceptible to leaks.

Further reflection also suggests that as the density monitor alarm accuracy is 2 psi, and with the objective of determining leaks with a reasonable degree of certainty in the shortest period of time, waiting for a 10 psi drop may be unnecessary. To evaluate this hypothesis, the Ideal Gas law (PV=nRT) is used to evaluate the SF_6 loss at different density alarm set points. With initial inputs of 80 psig, the known mass of SF_6 at 80 psig and a temperature of 75 F to calculate the breaker volume, then calculating the mass of SF_6 left in the breaker at the same volume and temperature but at 70 psig, correlates to approximately a 10% decrease in SF_6 mass from the original charge at 80 psig.

If the density monitor alarm set point drop is changed to 5 psi, and the same inputs used, this correlates to approximately a 5% decrease in SF_6 mass from the original charge at 80 psig.

Likewise, a 10% reduction in density equates to a 10% loss in SF_6, as does a 5% reduction in density equate to a 5% loss in SF_6.

To evaluate the hypothesis, PG&E is currently looking at resetting a number of density monitors to 5 psi on breakers with larger than average charges. Should these breakers leak, the leak will be found earlier with only half the normal SF_6 loss.

For other utilities considering implementing a similar density monitor resetting study, PG&E has also found that some of the density monitor thermocouples are not mounted properly and may not accurately measure the breaker gas temperature. This inaccuracy may give false results. Internet research has also indicated that in some cases, the temperature used by the density meters had been entered in the wrong units and to also ensure that the connection between the density meter's pressure measuring device and the breaker is sealed[5].

[5] On-Line Condition Monitoring Systems For High Voltage Circuit Breakers A Collaborative Research Project 1997 – 2001; Project Participants: ABB, Alstom, BC Hydro, Doble, ESKOM, Manitoba Hydro, Siemens, SPI PowerNet, TransAlta Utilities, Manitoba HVDC Research Centre http://www.hvdc.ca/research/monitoring_paper.pdf

Figure 1

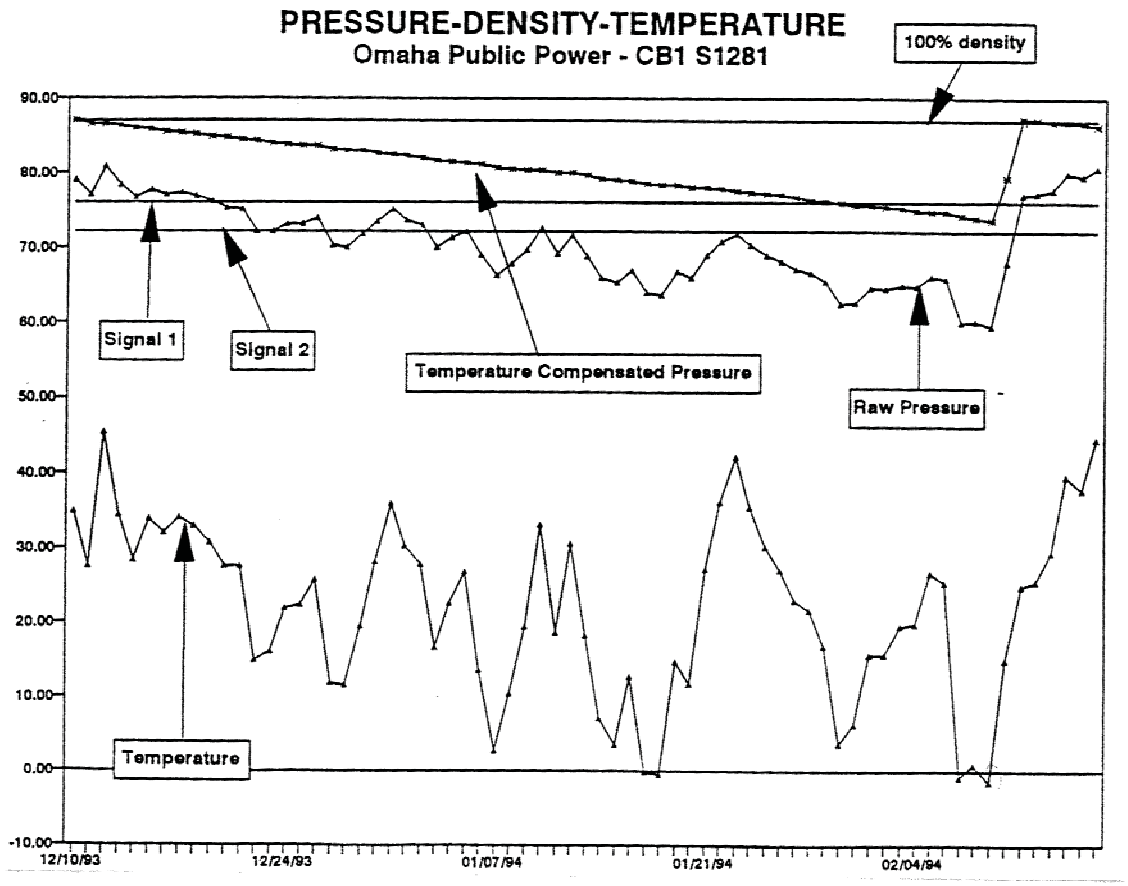
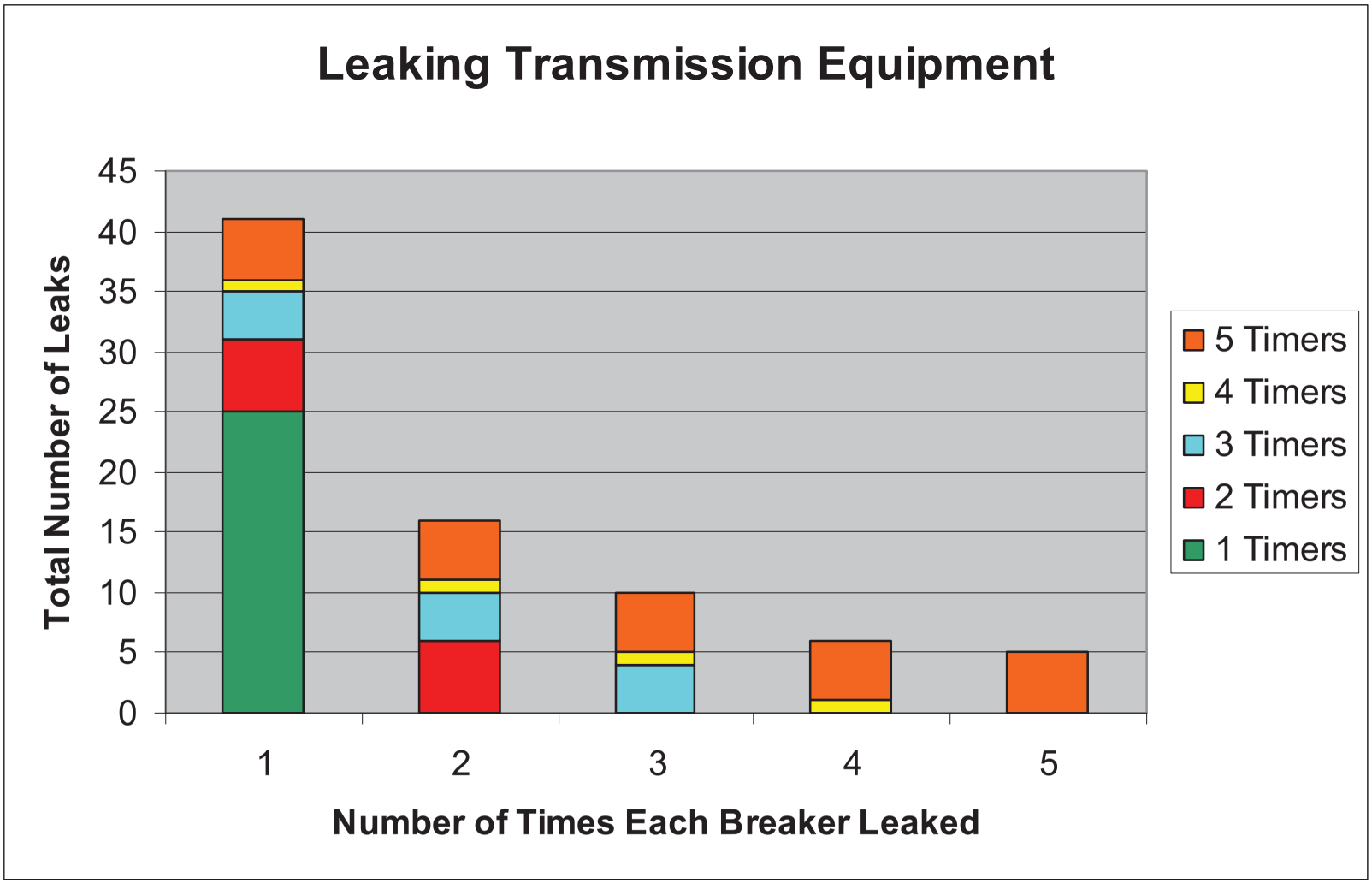


Figure courtesy of the Siemens Corporation

Figure 2


Leaking Transmission Equipment
Total Number of Leaks
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
Number of Times Each Breaker Leaked
5 Timers
4 Timers
3 Timers
2 Timers
1 Timers