



Sulfur Hexafluoride (SF₆) In Transmission and Distribution Equipment

APS's Proactive Leak Reduction Strategy and Progress
Robert Mills – EPA SF6 Workshop 2/4/09



APS's SF₆ Emission Reductions Baseline

- APS **attended** the SF₆ Emissions Reduction Partnership Workshop for the Electric Power Systems in 2001. Information obtained at the workshop heightened APS's awareness regarding the **potential negative environmental impacts** and **safety** concerns of using and handling SF₆ .
- **After the workshop APS initiated a study** to determine the company wide leak rate. The study in 2001 showed the emission leak rate of **18.38%** for 2001.
- APS determined it would be prudent to reduce SF₆ emissions as good environmental stewards and lessen considerable financial burden of leaking **28,430** pounds of SF₆ gas per year.
- **APS Management, Operation Crews, and Environmental and Safety sections worked together to disseminate information regarding the concerns** of leaking SF₆ equipment and improperly handling SF₆ .



APS's SF₆ Emission Reductions

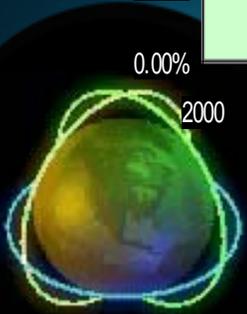
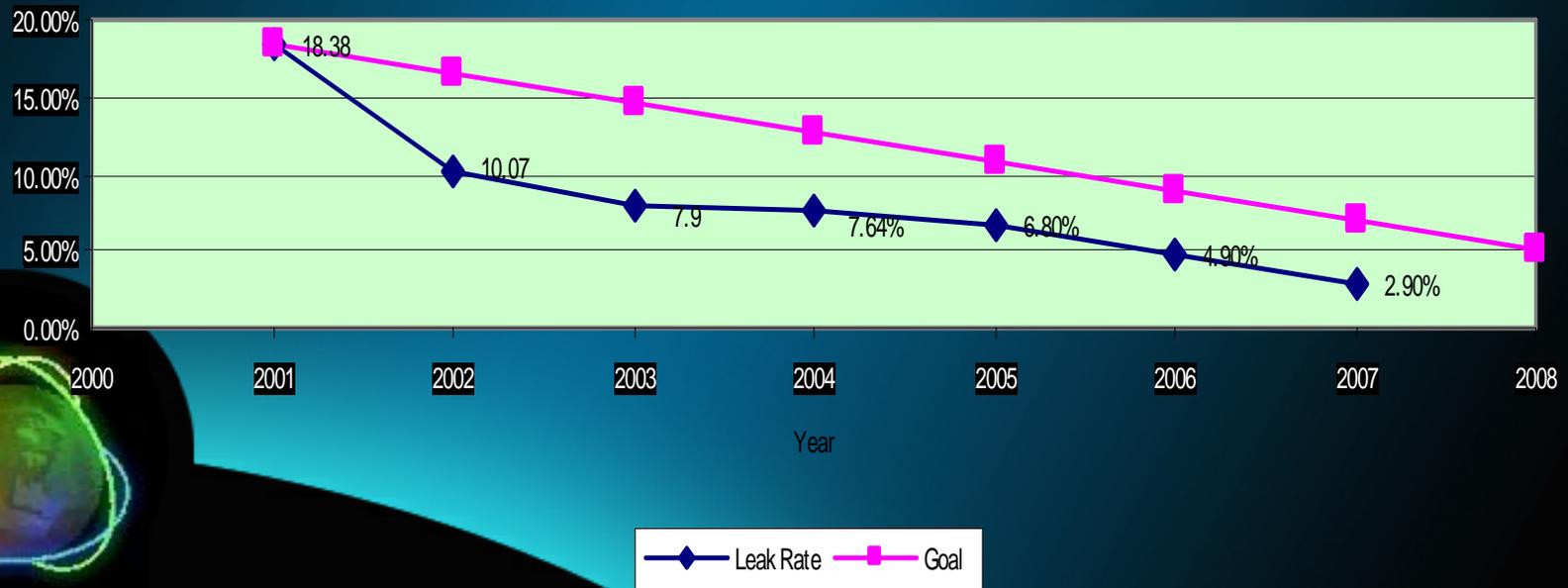
Baseline (continued)



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- From the 2001 study, APS took proactive steps to reduce our SF₆ emissions. These steps included contracting out experts to help identify the system weaknesses, replacing some of the most problematic leaking breakers and develop an emission reduction strategy. By the end of 2002, SF₆ emissions declined to **10.07%**.

SF₆ Leak Rate Base on EPA Caculations



APS's SF₆ Emission Reductions (continued)

- **The significant change was realized by identifying & replacing or repairing the worst leaking equipment. The successful reduction strategy helped to promote an aggressive approach to continue the emission reductions.**
- **To continue the proactive momentum, the Environmental Field Operations, Substation Maintenance and their Management worked collectively to convince constituents of the need to allocate additional funding to either repair or replace the leaking equipment.**



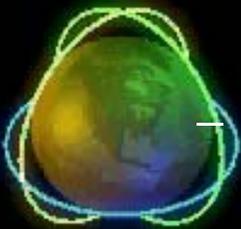
Cost Analysis Comparing Replacement or Repairing Equipment

Breaker Info	Work Orders/yr	SF6 lbs. Leaked in 2004	Repair Estimate	Replacement Estimate
OC522 a 230 kVA 2 pressure breaker (B583) Manufactured in 1965. Scheduled to be replaced 2006	16	2544		401,000
NV1756 is a 500kVA SF6 Breaker (B1010) SF6 during the calendar year for 2003 it had a total of 6 work orders and 629 lbs. Manufacture date is 1974.	2	130	Attempted to repair in 2004. approx. \$15,000	\$401,000 shared utility costs APS costs = \$98,924
CH556 is a 500kVA SF6 Breaker (B1216) Had a total of 9 work orders and 750lbs. of SF6 Leaks. Its manufacture date is 1974.	3	320	\$36,000	
CH556 is a 500kVA SF6 Breaker (B1216) Had a total of 9 work orders and 750lbs. of SF6 Leaks. Its manufacture date is 1974.	16	507		\$401,000
CH 1032 is a 345kVA SF6 Breaker (B1213) In 2003 it had a total of four work orders and 300 lbs. of SF6 Leaks. Its manufacture date is 1976. 568 pounds leaked form this equipment during 2004.	6	598	\$15,000	



APS's SF₆ Emission Reductions (continued)

- Concerted communication between APS Predictive Maintenance, Substation Maintenance, Environmental and Safety sections instigated reduction activities to include:
 - Environmental and safety professionals analyzed data and developed reports to help forecast leaking equipment & provide awareness regarding potential environmental concerns and safety issues from SF₆.
 - Training was provided and a safe handling procedure was developed, implemented and reviewed during tailboard meetings before maintenance activities began.
 - These sections worked together to create a strategic plan used to **repair six breakers** and **replace four** or more leaking breakers **per year**.
 - The Predictive Maintenance Section was tasked to identify the leaking interrupters/breakers.

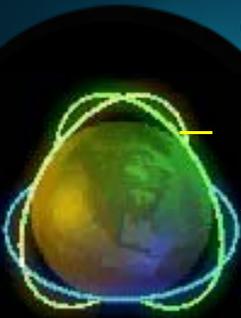


APS's SF₆ Emission Reductions (continued)



im Work [from www.metacafe.com].w

- The Substation Maintenance Technicians were tasked to repair small leaks, add gas to alarmed breakers and use scales to weight the gas added.
- Large leaks were contracted out (by TDS and Colt Power)
- **SF₆ recovery equipment** was purchased to capture the gas during maintenance by APS crews for **small jobs**.
- SF₆ was reclaimed for reuse by Proline Utilities Technologies. Proline was also used to remove SF₆ for large equipment work prior to repairing or replacing equipment.
- Operations staff were tasked to track leaking breakers through a targeted leakers list and evaluate the change out strategy.





Proline

Utility Technologies
SF6 Gas Management Services



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SF6**



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**Proline Recycling
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Recycle



**Store
Recycled SF6**



**Test to
IEC 60480**



**Commercial Transport
to Customer
For Reuse**

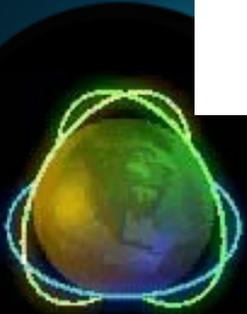
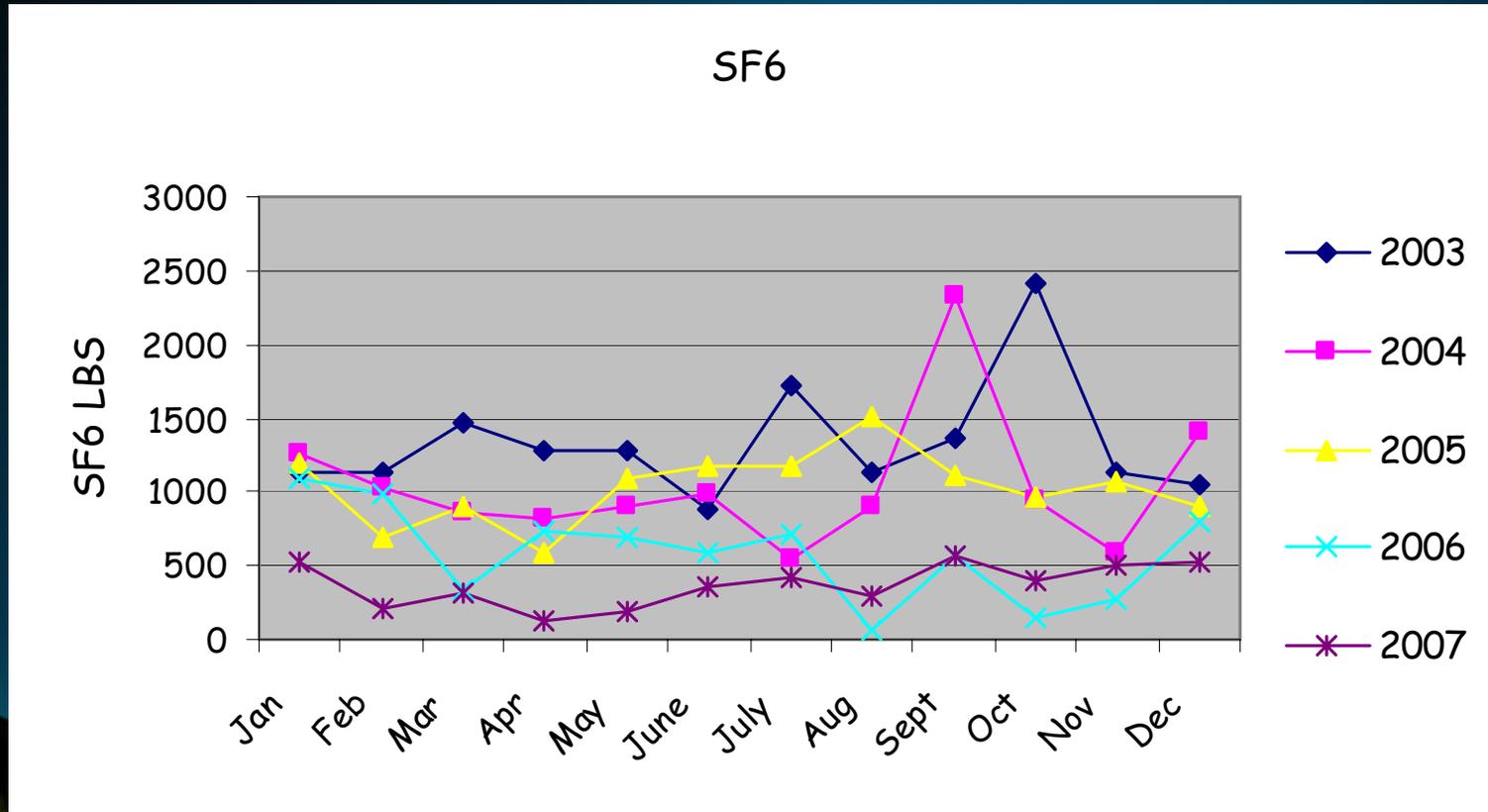


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Comparing APS SF₆ Emission Reductions Trends



APS's SF₆ Emission Reductions (continued)

- During 2004, APS joined the EPA SF₆ Emission Reduction Partnership.
- That same year, APS began using a laser-imaging camera to identify leaks and confirm that leaks have been successfully repaired. A highly trained reliability maintenance coordinator was assigned to snap images of actual leaking breakers.



APS Top 25 SF₆ Leakers List

Unit	EQUIP. LI	VOLTAGE	Wc	BREAKER DESCRIPTION	Eq #	Locatio	# of SF6 Added	scann	LINKS		
7479	WW1156	500	41	BRKR 550KV, 3000A, 40KAIR 2	B1284	WW	3768	Y	photo	REPORT	DATASHEET
7486	CH1552	500	19	BRKR 550KV, 3000A 40KAIR, 2	B1348	CH5	2122	Y	photo	REPORT	DATA SHEET
7486	CH556	500	41	BRKR 550KV, 3000A, 40KAIR 2	B1216	CH5	3888	Y	photo	REPORT	DATASHEET
7479	WW1022	230	28	BRKR 242KV, 2000A, 63KAIR 1	B1971	WW	739	Y	photo	REPORT	DATASHEET
7479	OC1022	230	15	BRKR 242KV, 1600A, 37KAIR, 1	B616	OC	719	Y	photo	REPORT	DATA SHEET
7486	CH1052	500	11	BRKR 550KV, 3000A 40KAIR, 2	B1223	CH5	1086	N	NOT SCANNED		
7486	CH1252	500	12	BRKR 550KV, 3000A 40KAIR, 2	B1265	CH5	1337	N	NOT SCANNED		
7486	CH1156	500	11	BRKR 550KV, 3000A, 40KAIR 2	B1217	CH5	1121	N	NOT SCANNED		
7486	CH1032	345	12	BRKR 362KV, 3000A 40KAIR 2P	B1213	CH3	626	Y	photo	REPORT	DATA SHEET
7486	CH256	500	10	BRKR 550KV, 3000A 40KAIR, 2	B1263	CH5	1091	N	NOT SCANNED		
7486	CH152	500	11	BRKR 550KV, 3000A 40KAIR 2P	B1262	CH5	1119	N	NOT SCANNED		
7486	NV1156	500	5	BRKR 550KV, 3000A, 40KAIR, 2	B1163	NV	431	N	NOT SCANNED		
7479	WW652	500	9	BRKR 550KV, 3000A, 40KAIR, 2	B1017	WW	671	Y	photo	REPORT	DATASHEET
7479	OC1322	230	7	BRKR 242KV, 4000A, 50KAIR 2	B1028	OC	325	N	NOT SCANNED		
7486	NV1852	500	7	BRKR 550KV, 3000A, 40KAIR, 2	B1009	NV	425	N	NOT SCANNED		
7486	CH652	500	16	BRKR 550KV, 3000A 40KAIR, 2	B1264	CH5	1618	N	NOT SCANNED		
7479	WW556	500	7	BRKR 550KV, 3000A, 40KAIR, 2	B1170	WW	629	Y	photo	REPORT	DATASHEET
7486	NV1756	500	6	BRKR 550KV, 3000A, 40KAIR, 2	B1010	NV	600	N	NOT SCANNED		
7479	PP822	230	15	BRKR 242KV, 2000A, 50KAIR 1	B1799	PP	90	Y	photo	REPORT	DATASHEET
7479	PP422	230	15	BRKR 242KV, 2000A, 50KAIR 1	B1797	PP	84	Y	photo	REPORT	DATASHEET
7479	LP722	230	3	BRKR 242KV, 2000A, 50KAIR, 2	B1161	LP	208	N	NOT SCANNED		
7479	WW452	500	5	BRKR 550KV, 3000A, 40KAIR, 2	B1169	WW	348				
7479	WW256	500	4	BRKR 550KV, 3000A, 40KAIR 2	B1168	WW	234	Y	photo	REPORT	DATASHEET
7486	NV1352	500	4	BRKR 550KV, 3000A, 40KAIR, 2	B1012	NV	346	N	NOT SCANNED		
7486	NV2152	500	3	BRKR 550KV, 3000A, 40KAIR, 2	B1008	NV	248	N	NOT SCANNED		

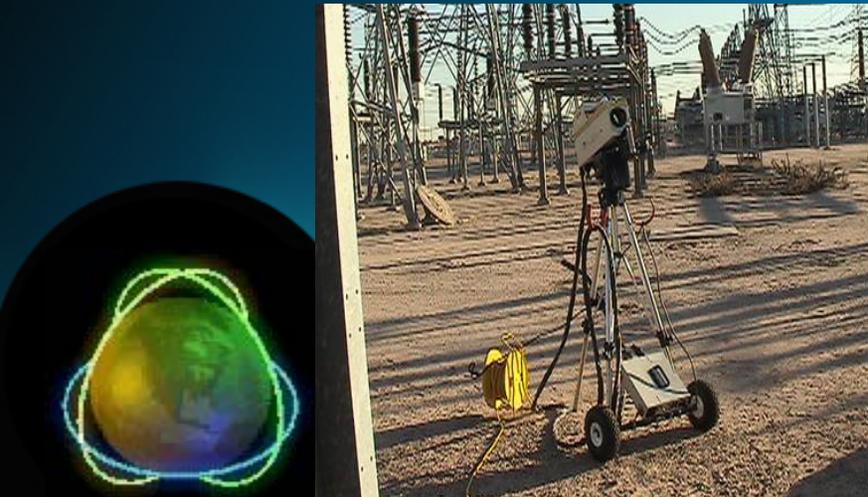
APS's SF₆ Emission Reductions (continued)

- During 2004 APS reported a SF₆ Leak rate of 7.6% (13,236 lbs of SF₆ emitted). This was accomplished by repairing or replacing seven of the Top 25 SF₆ leaking breakers which potentially eliminated nearly 5000 pounds of SF₆ emissions.
- Additionally, this eliminated 70 maintenance work orders and SF₆ gas replacement activities. The approximate loaded maintenance savings was equal to \$62 (avg. lineman wage/hr.) x 5 work hours (average maintenance visit time) x 70 (eliminated visits) = \$21,700 potential cost savings. The average cost of SF₆ was \$8.00/lb. This saved more than \$40,000 in purchases.



APS's SF₆ Program Equipment

Currently APS has a in-house professionals that operate an IR and laser camera for imaging. This gives our program better response time to identify leaks and provides more mobility to identify problems. In-house utilization of this technology greatly improved program efficiencies, as well as, improved the accuracy of the priority list of problematic equipment to be repaired or replaced.



APS's SF₆ Program Equipment

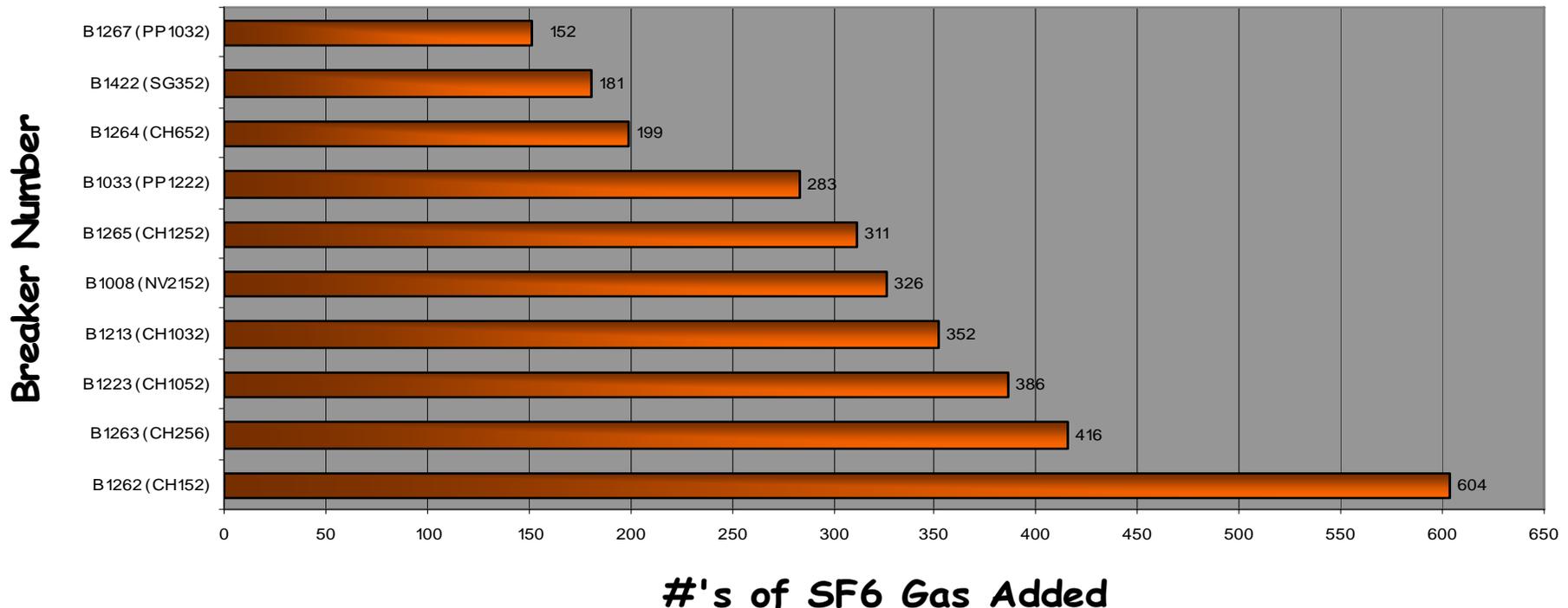
The APS Reliability Coordinator and his crew using the laser and IR cameras to ensure that repaired breakers leaks were properly sealed with the clamps.



The Top Ten Project

The “top ten” leaking breaker project was developed during 2006 and continues to the present. This tracking tool helped APS plan for several leakers to be removed from service and replaced with newer & lower volume breakers. Additionally, more leak seal repairs were conducted on the breakers instead of replacing equipment.

2008 Top Ten Breaker Problems Thru December



APS's SF₆ Program Equipment Analyzers/Detectors

Multi-Function Analyzer



Decomposition Detector Aciditor



Moisture Analyzer



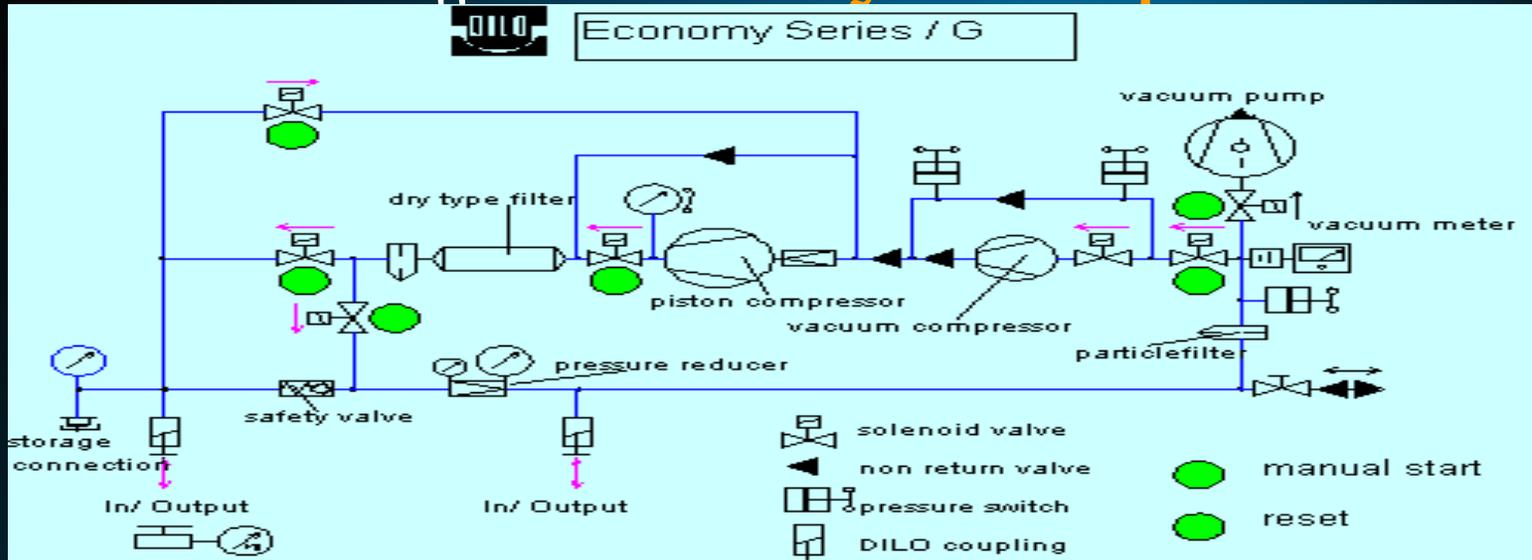
Volume Percentage
(Purity Detector)
SF₆/ CF₄ & SF₆/Air



Halogen based
Leak Detector



APS's SF₆ Recovery Compressors

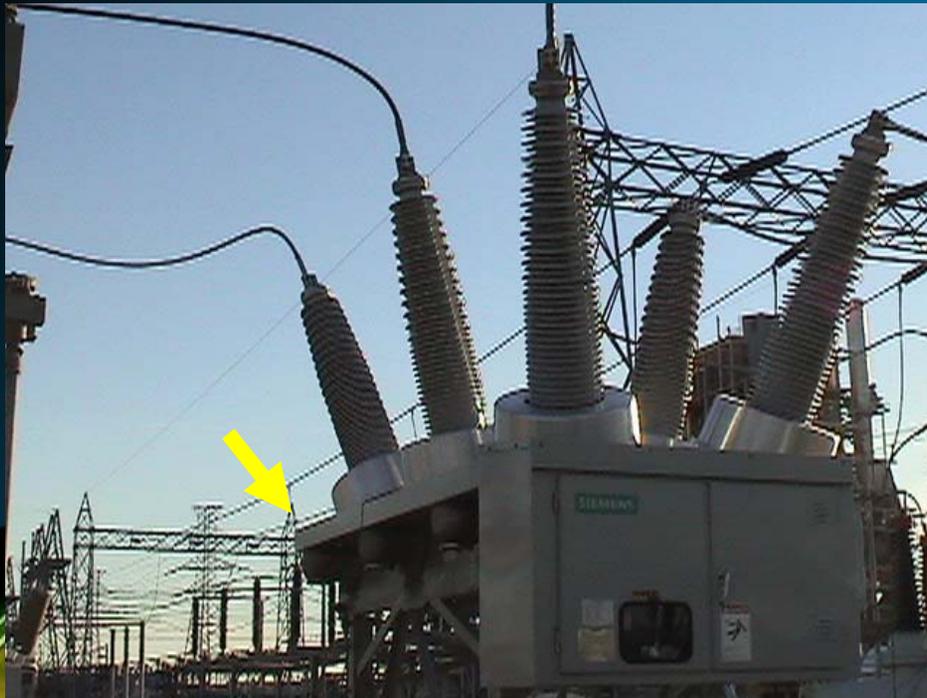


SF₆ Portable Recovery System MINI +

SF₆ Recovery Gas Cart



Using SF₆ LEAK DETECTION Devices



Using SF₆ LEAK DETECTION Devices



BEFORE
REPAIR



AFTER REPAIR

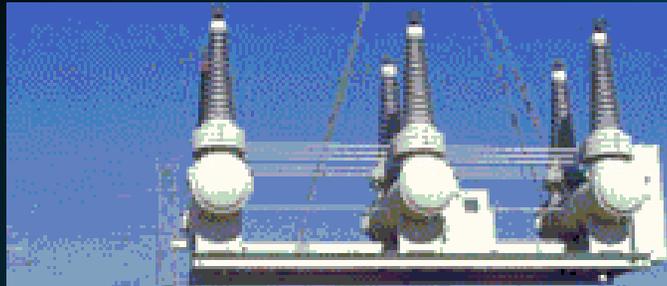


Ocotillo Switchyard Breaker Change-out (Example)

- APS has made major headway toward improving system reliability and environmental performance since in 2006 by replacing older equipment by targeting system weakness areas.
- One example is the replacement of a 230-kilovolt (kV) power circuit breaker in the Ocotillo Power Plant switchyard in Tempe.
- This was a 43-year-old Westinghouse breaker (weighing 32,200 lbs.) that was singled out and replaced with a new, **10,000 pound** Siemen's breaker. The old breaker remained in the switchyard and its parts were used for other breakers when needed.



Example of a Breaker Change-out (Ocotillo Switchyard)



APS's SF₆ Emission Reductions (continued)

- Successful projects like these effectively contribute to APS's SF₆ significant leak rate reductions. According to the EPA 2007 Annual Partnership Progress Report, "APS is achieving successful reductions each year since becoming a partner and a lower SF₆ emission rate than the Partner utilities' average".
- The report identifies that APS has reduced SF₆ emissions by **83** percent compared to 2001 emissions levels, preventing some **103,966** pounds of the gas from being released into the atmosphere. In terms of environmental impact, it's like taking more than **206,430** cars off the road for a year.
- The estimated costs saved by reduction in SF₆ Gas purchased are reportedly between **\$623,800 - \$935,690**

Communication Improvements

- By 2008 the reliability maintenance coordinator was provided imitate alarm information that is sent directly to his portable information device .
 - As soon as a breaker alarm is activated the coordinator is emailed by the system (see example below).
 - **LITCHFIELD: LH162 LOW SF₆ GAS ALARM. MARIO NAVARRO ADDED SF₆ GAS, ALARM CLEAR @ APPROX 1400.**
 - This immediate notification has enabled APS crews to respond quicker.
 - 99% of all leaks are fixed by APS crews today.
 - Most of the leaking breakers in APS's system have been scanned and evaluated for repairs or replacement
- By the 1st quarter of 2009 environmental coordination will assist to track the monthly leak rate to ensure that the list is updated more promptly.



Conclusion



meeting_with_the_boss.wmv

- APS has successfully reduced SF₆ emission. This can be attributed to:
 - Good communication that **shows cost saving incentives** and **management support of promoting APS as a good environmental steward.**
 - A **highly trained staff** and crews that identify problematic leaking equipment and properly handling of SF₆ and the awareness of potential environmental concerns as a greenhouse gas.
 - The **use of state-of-the-art technology** to improve response time and enhance repair or replacement effectiveness.
 - A proactive **SF₆ Reduction** plan that **continues** to evaluate reduction effectiveness.



Thank you for your time !

