

SF₆ Emission Reduction

Steve Lowder

Bonneville Power Administration

2010.06

Emission Reduction

- Emission Reduction is *the reason* for why we do all of this - because:
 - ◆ Each lb of SF₆ has an atmospheric lifetime of 3,200 yrs
 - ◆ SF₆ has 23,900 times the Global Warming Potential that CO₂ does => 1 lb of SF₆ = 11 tons of CO₂

Emission Reduction

- Emission Reduction depends on several key factors:
 - ◆ Accurate tracking of all SF₆ inventories
 - ◆ Accurate tracking of what is put into leaky equipment (for historical trending & repair)
 - ◆ Accurate measurement of what is put into new equipment
 - ◆ Processes for reducing SF₆ emissions
 - ◆ Locating and repairing SF₆ leaks

Disclaimer

- This presentation will refer to equipment and services purchased by BPA as part of its SF₆ monitoring program.
- These references should not be viewed as an endorsement of such equipment/services nor an exclusion of any other equipment/services.

BPA's Annual Emission Rate

- Emission Rate% (EPA):

$$\left(\frac{\text{Weight of SF}_6 \text{ emitted (using mass-balance)}}{\text{Total equipment nameplate weight}} \right) \times 100$$

- Less than 1% since reporting started in 1999
- Contributing Factors:
 - ◆ Newer equipment (87% of SF₆ breakers ≤ 20 yrs old)
 - ◆ Detailed tracking system (checked monthly)
 - ◆ Maintenance crews are actively tracking & repairing leaky equipment

BPA's Emission History

Timeframe	SF ₆ lost (lbs)	Total nameplate SF ₆ (lbs)	Leak rate
Prog start 1999.04	3,738	417,826	0.89%
Calendar Yr 2000	4,441	447,402	0.99%
Calendar Yr 2001	1,676	434,139	0.39%
Calendar Yr 2002	1,416	494,134	0.29%
Calendar Yr 2003	1,402	523,330	0.27%
Calendar Yr 2004	1,505	542,884	0.28%
Calendar Yr 2005	708	587,203	0.12%
Calendar Yr 2006	1,396	598,934	0.23%
Calendar Yr 2007	1,674	572,484	0.29%
Calendar Yr 2008	2,636	576,144	0.46%
Calendar Yr 2009	5,160	574,845	0.90%

Accurate Tracking of All SF₆ Inventory

- Separate Excel spreadsheets for each of:
 - ◆ 24 Maintenance Districts
 - ◆ 8 Construction crews
 - ◆ 1 Technical Training Group
 - ◆ Warehouse
- Each spreadsheet is reviewed monthly to:
 - ◆ Verify balance (like a checkbook)
 - ◆ Catch issues early so they can be corrected in a timely manner

Accurate Tracking of All SF₆ Inventory

- Items tracked (Maintenance, Construction, Technical Training):
 - ◆ SF₆ received from Warehouse
 - ◆ SF₆ supplied with equipment (from vendor)
 - ◆ SF₆ pulled from equipment
 - ◆ SF₆ sent to Warehouse
 - ◆ SF₆ put into new or leaky equipment
 - ◆ Inter-crew transfers
 - ◆ Inventory of what is in bottles & gas carts

Accurate Tracking of All SF₆ Inventory

- Items tracked (Warehouse):
 - ◆ SF₆ purchased from vendors
 - ◆ SF₆ sent in from the field
 - ◆ SF₆ sent to vendor for reclamation
 - ◆ SF₆ sent out to field
 - ◆ Inventory of what is in stock
 - ◆ Inventory of what is in quarantine awaiting reclamation

Tracking SF₆ Put Into Leaky Equipment

- Separate Excel spreadsheets for each Maintenance District. Items tracked:
 - ◆ Date
 - ◆ Equipment ID number
 - ◆ Weight of SF₆ used to fill the equipment (1st choice: differential weight; 2nd choice: differential pressure)
 - ◆ Comments on leak location
 - ◆ BPA-owned or customer-owned
- This data allows us to monitor historical trending and target worst leakers for repair.

Accurate Measurement of SF₆ Used in Substation Equipment

- Environmental Stewardship 2010 KTT: *Evaluate & select an SF₆ scale that is: accurate, durable, portable, low-profile, and cost-effective.*
- Planned scale usage:
 - ◆ Measure SF₆ put into leaky equipment (discontinue the differential pressure method)
 - ◆ Measure SF₆ shipped in from the field that is wet, impure or faulted.

Processes to Reduce SF₆ Emission

- 2009 Dilo Presentation - "SF₆ Emissions Reductions Through Recovery/Recycling/Reuse":
 - ◆ Pulling to "0" psig and then opening the equipment will result in about 15% of the SF₆ contained in the pressure vessel being vented to atmosphere.
- BPA experienced this in 2009 during inspection of some 500-kV breakers. Total SF₆ lost during inspections was about 450 lbs.
- Utilities should evacuate below "0" psig when equipment will undergo internal service or retirement.

Location and Repair of SF₆ Leaks

- Benefits:

- ◆ Reduced emissions
- ◆ Improved moisture & purity levels
- ◆ Improved equipment reliability and availability
- ◆ Bottom line: Reduced maintenance costs

- Leak Location Tools:

- ◆ FLIR "GasFindIR LW" SF₆ leak-detection camera
- ◆ Prior to purchasing the FLIR unit, BPA contracted with Equipment Imaging & Solutions



Location and Repair of SF₆ Leaks

- Leak Location: Leak-detection cameras have pin-pointed leaks in locations such as:
 - ◆ Porcelain bushing flanges (moisture/grout): Redress o-ring groove, replace o-ring, fill grout seam with DC 832 RTV, apply DC 1292 to flange surfaces to form a weather seal
 - ◆ Fittings & piping: Some types of fittings and piping are subject to leaks and require replacement
 - ◆ O-ring seals: O-rings can get pinched, deteriorate or have foreign matter across them



Location and Repair of SF₆ Leaks (Based on 2008 Tracking Data)

ID & Location	Vessel Nameplate (lbs)	SF₆ leaked in 2008 (lbs)	Comments (repairs made in 2009.06)
O-2946 (Rogue)	64	125.1 (196%)	Replaced 5ea end-bell & 4ea bushing o-rings. No leaks so far.
O-2609 (SnoKing)	64	32.4 (51%)	Replaced copper-nickel tubing with stainless steel, replaced defective "T" connector. No leaks so far.
O-3219 (Vantage)	560	124.0 (22%)	Repaired leak on A-phase where tubing enters tank wall. Used Loctite 545 hydraulic sealant. No leaks so far.

2009 Reporting

- BPA has reported 2009 emission data to the following entities:
 - ◆ EPA
 - ◆ DOE
 - ◆ Climate Registry
 - ◆ States of Washington and California (in 2010, Oregon will require data).

Conclusion

- BPA is committed to reducing its annual SF₆ emission by doing the following in 2010:
 - ◆ Requiring all crews to report their SF₆ inventory on a monthly basis to catch and correct any inventory issues in a timely manner.
 - ◆ Purchase accurate scales for substation maintenance and construction crews to use.
 - ◆ Eliminating the differential pressure method of determining the amount of SF₆ put into leaky substation equipment (once scales have been purchased and distributed).
 - ◆ Continued repair of leaky SF₆ equipment based on historical leak data.