U.S. EPA’s 2012 Workshop on SF$_6$
Emission Reduction Strategies

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Topics of Discussion

- Simple & Effective means of reducing emissions:
  - Zero emissions during gas recovery.
    - Know quantity to recover
    - Proper blank off pressure
  - Advancements in pump technology
  - Proper fitting selection (LV/MV Switchgear)
    - Say no to Schrader valves!
    - Gas tight cutting device for decommissioning
  - Advancements leak detection technology
    - Vacuum chambers
How do you achieve zero emissions during SF6 recovery?

Know how much you need to recover.

- Read the nameplate.
  - Problems:
    - Incorrect or no nameplate capacity

- Calculate gas quantity.
  - Volume of gas vessel
  - Ambient temperature

- Problem:
  - No possible if exact internal volume is unknown!
Achieving zero emissions: Calculate (cont’d)

- Use the following formula to determine the number of pounds (mass) of SF6 within a given volume:
  \[ \text{Volume (ft}^3\text{)} \div \text{density} = \text{lbs}. \]
- For example: 80PSIG @ 80°F = 0.38 density. For a volume of 200 ft³:
  \[ 200 \text{ ft}^3 \div 0.38 = 526.3 \text{ lbs}. \]
Proper Recovery:

- Determining how much SF₆ has been recovered:

\[
\left( \frac{P_i - P_f}{P_i} \right) \times 100 = \text{recovered}
\]

\( P_i = \text{Initial breaker pressure in mmHg (absolute)} \)

\( P_f = \text{Final breaker pressure in mmHg (absolute)} \)

- Converting PSIG to mmHg (absolute):

\[
\left( \frac{\text{PSIG} + 14.5}{14.5} \right) \times 760 = \text{mmHg (absolute)}
\]
Proper recovery (Cont’d)

- SF$_6$ recovery comparison: (example 1)
- GIE containing 2,200 lbs @ 87 PSIG operating pressure
  - Recovery to 0 PSIG = 85.71% SF$_6$ removal
    - 315 lbs of SF$_6$ lost
  - Recovery to 200 mmHg = 96.21% SF$_6$ removal
    - 86 lbs of SF$_6$ lost
  - BLANK OFF PRESSURE AT THE END OF RECOVERY PROCESS SHOULD BE < 50 mbar / 37.5 mmHg (Torr)
  - AS OF 2011 THE ABOVE STATEMENT IS NO LONGER ACCURATE
  - Whenever possible always recover to <1 Torr
**Proper Recovery (cont)**

- **SF₆ recovery comparison: (example 2)**
  - Medium voltage switch gear containing 25 lbs @ 10 PSIG
    - Recovery to 0 PSIG = 40.82% SF₆ removal
      - 14.8 lbs of SF₆ lost
    - Recovery to 37.5 mmHg = 97.08% SF₆ removal
      - .73 lbs of SF₆ lost
    - Recovery to 0.1 mmHg = >99.99
      - <.025 lbs of SF₆ lost
  - Achieving a very low blank off pressure is critical due to very low operating pressures.
Advancements in Pump Technology:

- Due to advancements in scroll pump technology, oil lubricated vacuum pump or diaphragm compressors should no longer be used during SF₆ recovery on large gas volumes.

- Scroll pump design considerations:
  - Hermetically sealed
  - Proper displacement/speed
  - Maintenance intervals
  - Blank off pressures (≤ 1 torr/mmHg)

- Summary: when working on GIE with ≥ 100 lbs of SF₆ only scroll pumps capable of achieving blank off pressures of ≤ 1 torr should be used in conjunction with standard dry running compressor systems.
The Joys of recovering SF$_6$ from LV / MV distribution switches
Commonly used connections (Schrader Valve) make gas recovery very time consuming due to Cv value (restriction)

Recovery times of 300 l vessel using DILO Mini Plus Recovery System. PE 6 bar to 50 mbar (87 psig to 37.5 Torr)

- DILO DN8 connection 180 minutes
- DILO DN6 connection 110 minutes
- Schrader valve 1,110 minutes
Appropriate Connection
Recovering SF$_6$ from Distribution Switches

- Gas tight cutting device allowing for fast recovery when decommissioning Distribution Switches
Recovering SF₆ from Distribution Switches

Summary

- Most currently used Distribution Switches come equipped with a valve unsuitable for proper gas recovery
- Specify appropriately sized fill valve from switch manufacturer
- Use gas tight cutting device when decommissioning equipment
 Advances in Leak Detection Technology:

New Technology:
- Automated & automatic leak detection chambers

Test duration with the new unit: 3 - 5 min.

Traditional leak test duration: 4 hours
Automated & Automatic Leak Detection Chambers
Leak Detection Chambers:

- Fully automated systems capable of evacuating, filling, testing, and recovery with zero gas handling done by operators!
- Depending on size of chamber, can be used to test a complete system (breaker or switch, etc.) or individual components (tank, manifolds, tubing runs, etc.)
- Use of vacuum chamber completely eliminates any SF6 loss during the test procedure.
- Detection limit \( \leq 1 \text{ ppb} \) (parts per BILLION)
- Extremely fast response time (<5 minutes for large vessels.
- Leakage is quantified down to 1 ppb!
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**QUESTIONS?**

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