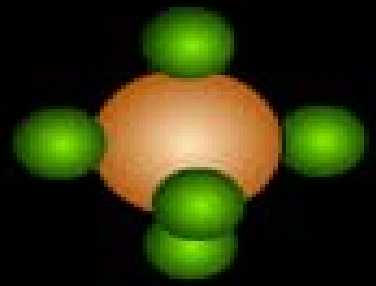
U.S. EPA's 2012 Workshop on SF_6 Emission Reduction Stragies

Justin Palmer
DILO Company, Inc.
Odessa, FL
727-853-2485
justinp@dilo.com
www.dilo.com

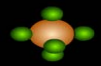


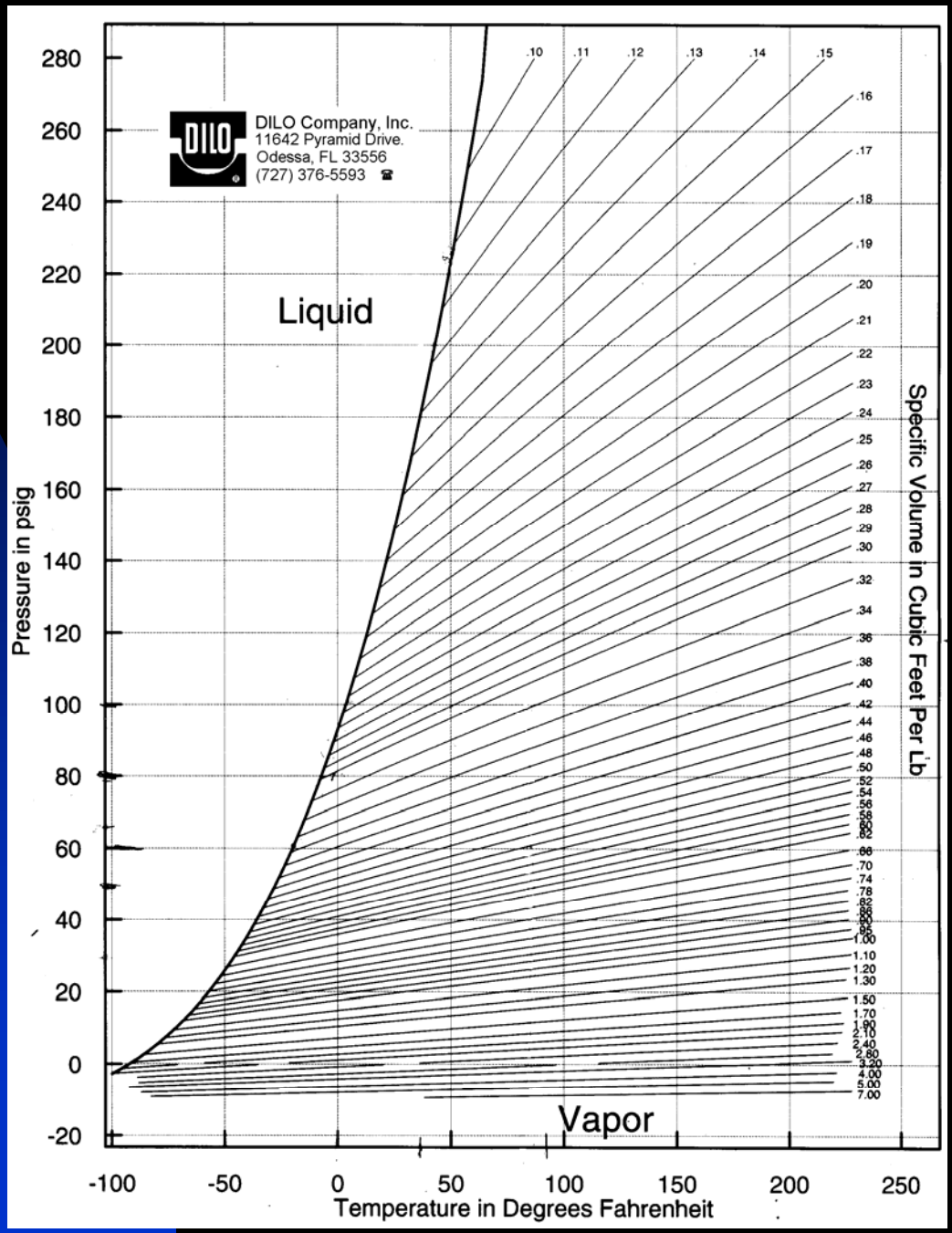
Topics of Discussion

- 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!




DILO Company, Inc.
11642 Pyramid Drive.
Odessa, FL 33556
(727) 376-5593
Liquid
Vapor
Pressure in psig
Specific Volume in Cubic Feet Per Lb
Temperature in Degrees Fahrenheit
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-100
-50
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50
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250
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.66
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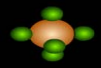
.74
.78
1.00
1.10
1.20
1.30
1.50
1.70
1.90
2.10
2.40
2.80
3.20
4.00
5.00
7.00

Achieving zero emissions: Calculate (cont'd)

- Use the following formula to determine the number of pounds (mass) of SF6 within a given volume:
- *Volume(ft 3) ÷ density= lbs.*
- For example: 80PSIG @ 80°F = 0.38 density. For a volume of 200 ft3:
- 200 *ft 3 ÷ 0.38 = 526.3 lbs.*



Achieving zero emissions (cont'd)

- Proper Recovery:
  - Determining how much SF_6 has been recovered:

$$\left(\frac{P_I - P_F}{P_I}\right) \times 100 = \%recovered$$

P_I = Initial breaker pressure in mmHg(absolute)
P_F = Final breaker pressure in mmHg(absolute)

  - Converting PSIG to mmHg (absolute):

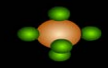
$$\left(\frac{\text{PSIG} + 14.5}{14.5}\right) \text{x } 760 = \text{mmHg (absolute)}$$

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

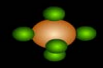
Proper Recovery (cont)

- SF_6 recovery comparison: (example 2)
- Medium voltage switch gear containing 25 lbs @ 10 PSIG
  - Recovery to 0 PSIG = 40.82% SF_6 removal
    - 14.8 lbs of SF_6 lost
  - Recovery to 37.5 mmHg = 97.08% SF_6 removal
    - .73 lbs of SF_6 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 SF_6 recovery on large gas volumes
- Scroll pump design considerations:
  - Hermetically sealed
  - Proper displacement/speed
  - Maintenance intervals
  - Blank off pressures ($\leq$ 1 torr/mmHg)
- Summary: when working on GIE with $\geq$ 100 lbs of SF_6 only scroll pumps capable of achieving blank off pressures of $\leq$ 1 torr should be used in conjunction with standard dry running compressor systems.



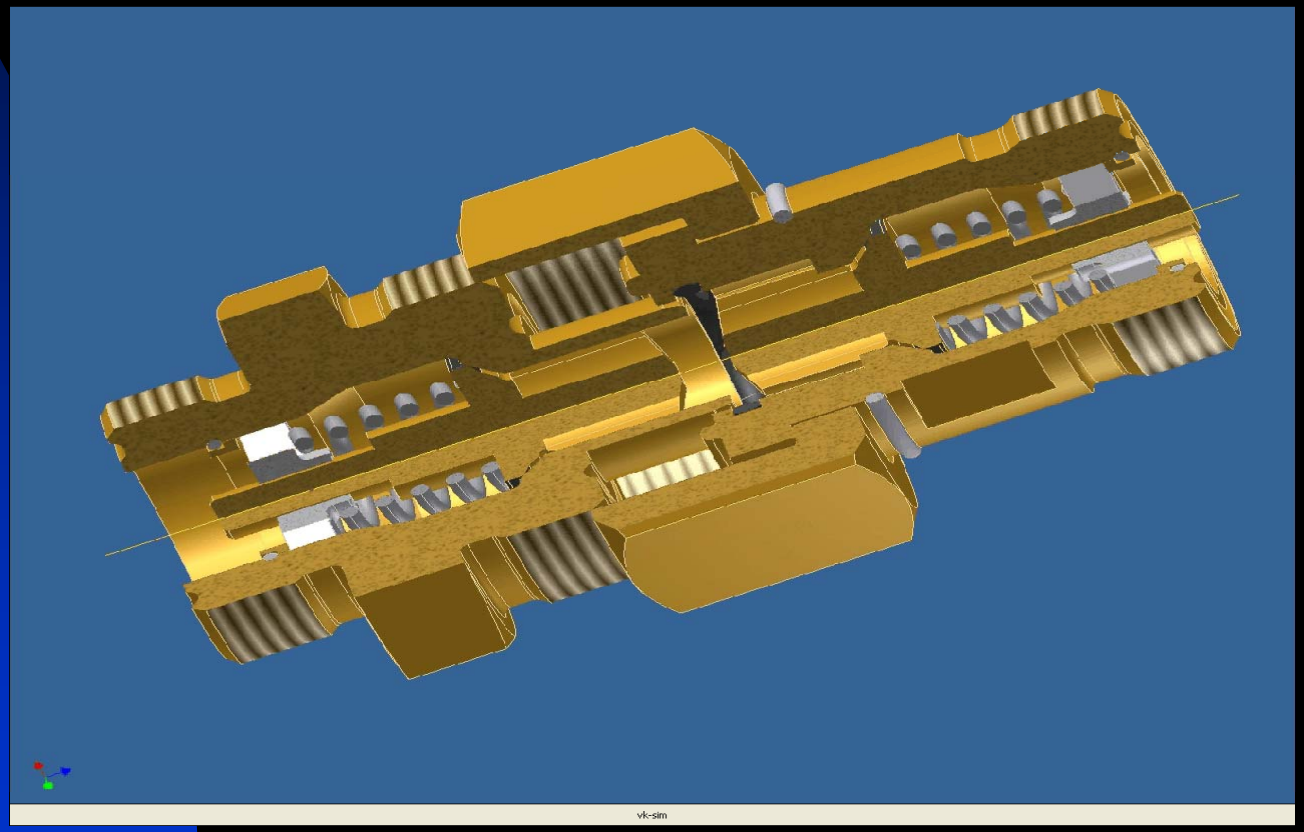
Fittings

- The Joys of recovering SF_6 from LV / MV distribution switches

Recovering SF_6 from 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 SF_6 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

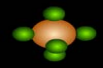
Test duration with the new unit: 3 - 5 min.

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 ≤ 1 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?**

- Contacts:

Justin Palmer
DILO Company, Inc.
727-853-2485
justinp@dilo.com

Lukas Rothlisberger
DILO Company, Inc.
727-232-0050
lukasr@dilo.com