SF_6 Emissions Management at Jefferson Lab

Kevin Jordan PE

Jefferson Lab

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Emissions Management Overview

- SF_6 Gas Usage
- SF_6 Transfer System
- Remote Cesiator
- System Leak Check
- SF_6 Savings

High Voltage Power Supply for FEL

Emissions Management Message

- SF_6 is used to suppress arcing in high voltage DC electron sources at Jefferson Lab FEL
  - There are 2 separate systems; FEL Gun & Gun Test Stand (GTS)
- In the mid 1990's we vented to service and/or modify DC Photo-cathode gun – 3 or 4 times per week
  - Vent to atmosphere
- In 1998 I installed a recovery system to save time and $$
  - Filling system from "K" bottles is slow & gas is expensive
- Remote Cesiator installed in 2008 reduced need to pass gas & open tank from few per week to 1 or 2 per month
  - This is to do the periodic *Heat Clean*
- Summary; We vented, then recovered SF_6, then re-engineered system to enable cesiation remotely
  - Each step reducing the cost & effort of the operation

SF_6 Gas Usage

- Free Electron Laser DC Photocathode Electron Gun
  - Operate at 500 kV
  - Condition to 600 kV
  - Capacity > 150 lbs
  - Various incarnations operating since ~1995
- Gun Test Stand DC Photocathode Electron Gun
  - Operate at 500 kV
  - Capacity ~ 112 lb
  - Operational since 2007

FEL High Voltage Power Supply – Open

SF_6 Transfer System Components

- High voltage tank
- Piping connecting tank to bag
- 2 independent pumps
- Control panel
- Flexible storage bag
- Dryer and filter
- Valves and piping
  - 12 valves
  - 2” piping

FEL DC Photocathode Electron Gun

GTS Control Panel

SF_6 Transfer System Requirements

- Transfer SF_6 automatically or manually between storage bag and HV tank and/or gun w/out significant loss of gas or contamination
- Instrument air connection to HVPS tank for back filling after SF_6 transferred
- Tank pressure must never be >15 PSIG
- Must evacuate tank before filling w/ SF_6
- Tank pressure relief vented outside – reconnected to storage bag to capture SF_6 leaking through relief vent
- Initial filling from “K” bottles directly into gas bag

SF_6 Transfer System - Storage

Flexible storage bag is key

SF6 Storage Bag for GTS – outside, filled

SF6 Storage Bag for FEL – inside, empty

SF_6 Transfer System - Pumps

- Pressure/Vacuum pump (P1)

  - Thomas carbon vane pump
  - Difficulty < 20 Torr, therefore cannot not fully recover gas
  - Originally used as pressure & vacuum pump
- Vacuum pump (P2)

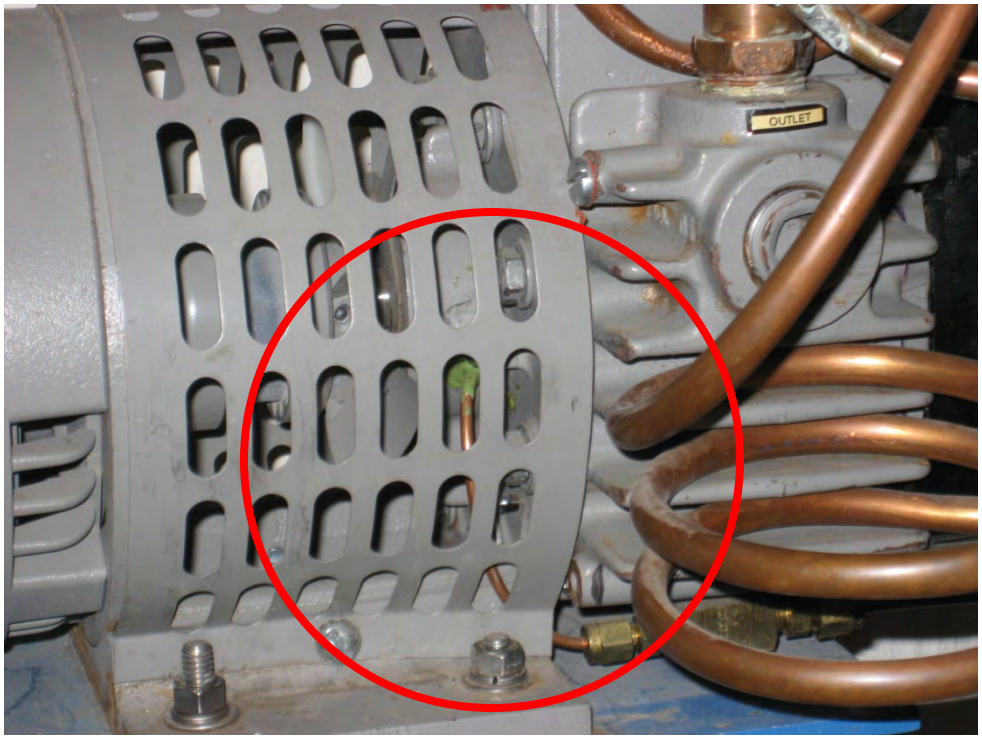
  - Alcatel 2063C pump
  - Rated for mild corrosive gasses, speed of 43 CFM
  - Used for recovering gas and for evacuating tank

SF_6 Transfer System – Valves/Piping

FEL Valves, Piping, Pump, Control Panel

GTS Valves and Piping

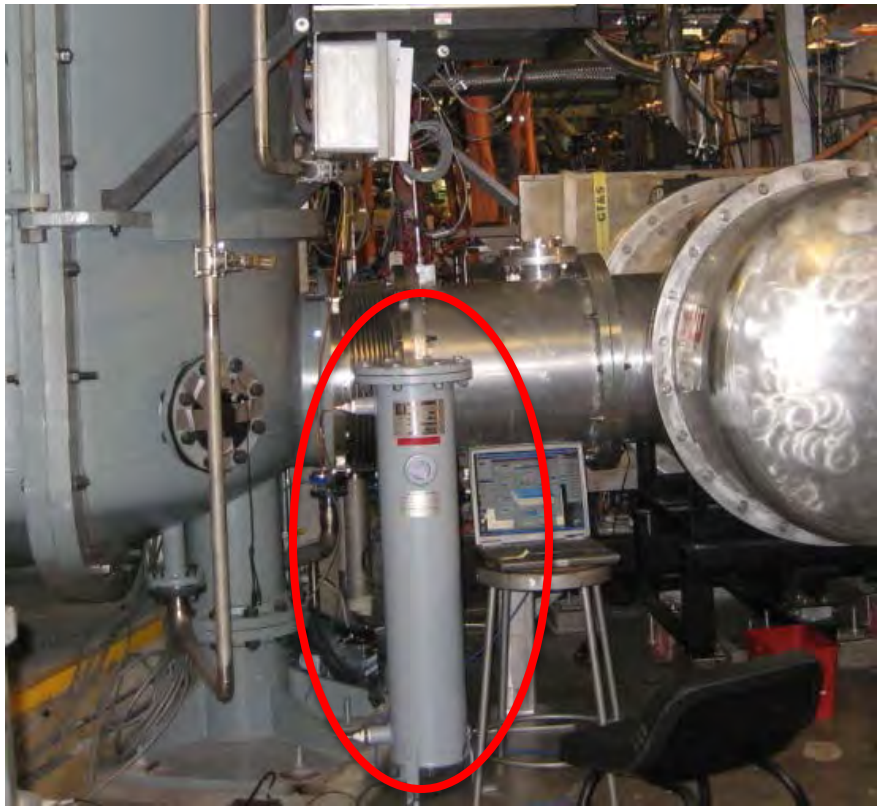
SF_6 Transfer System
Seal Vent is Captured



Relief valve connected back into system
Also additional cooling is added for heat generated by *heavy* SF_6 molecule

SF_6 Transfer System – Dryer & Filter

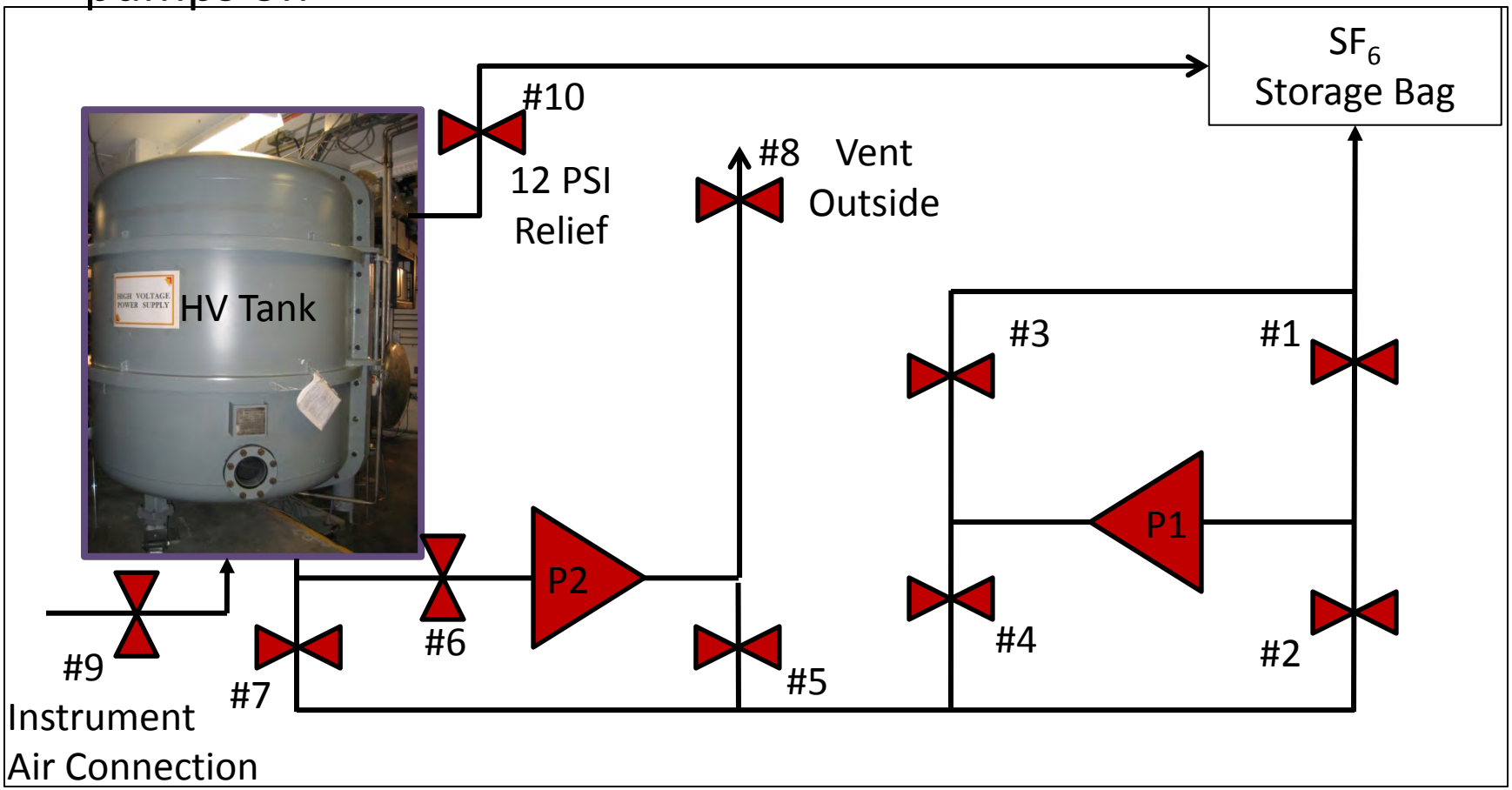
- Filter added to FEL to preemptively avoid creating Fluorine ions
- Dryer
  - Added later in response to arcing in GTS system
  - Successfully avoided having to replace SF_6
  - Dryer rotates between GTS and FEL and runs as needed



Dryer/Filter connected to FEL DC electron gun and HV tank

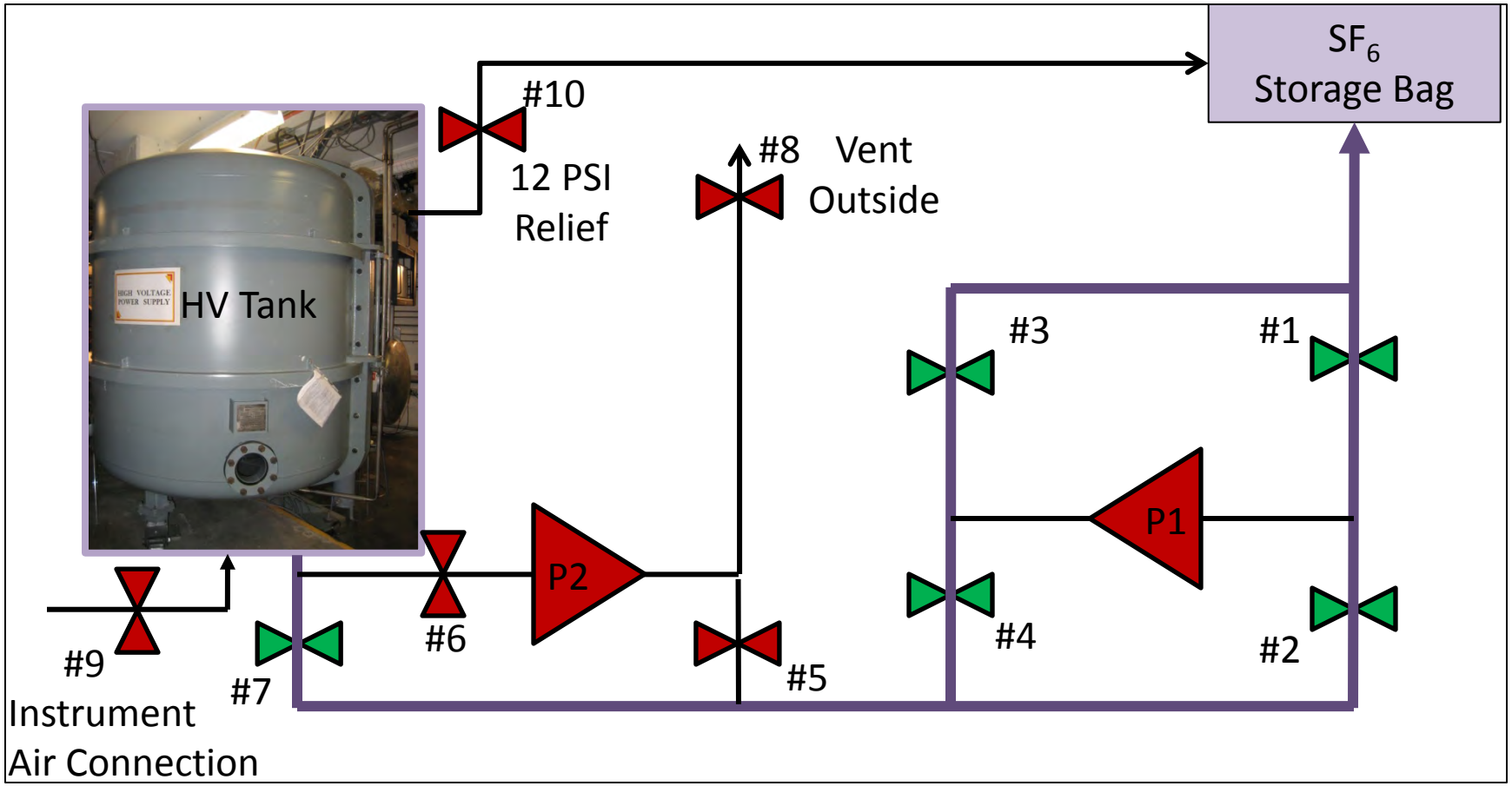
SF_6 Transfer System – Gas Recovery

1. Initial State: Full HV Tank is at 10 PSIG SF_6, all valves closed, all pumps off



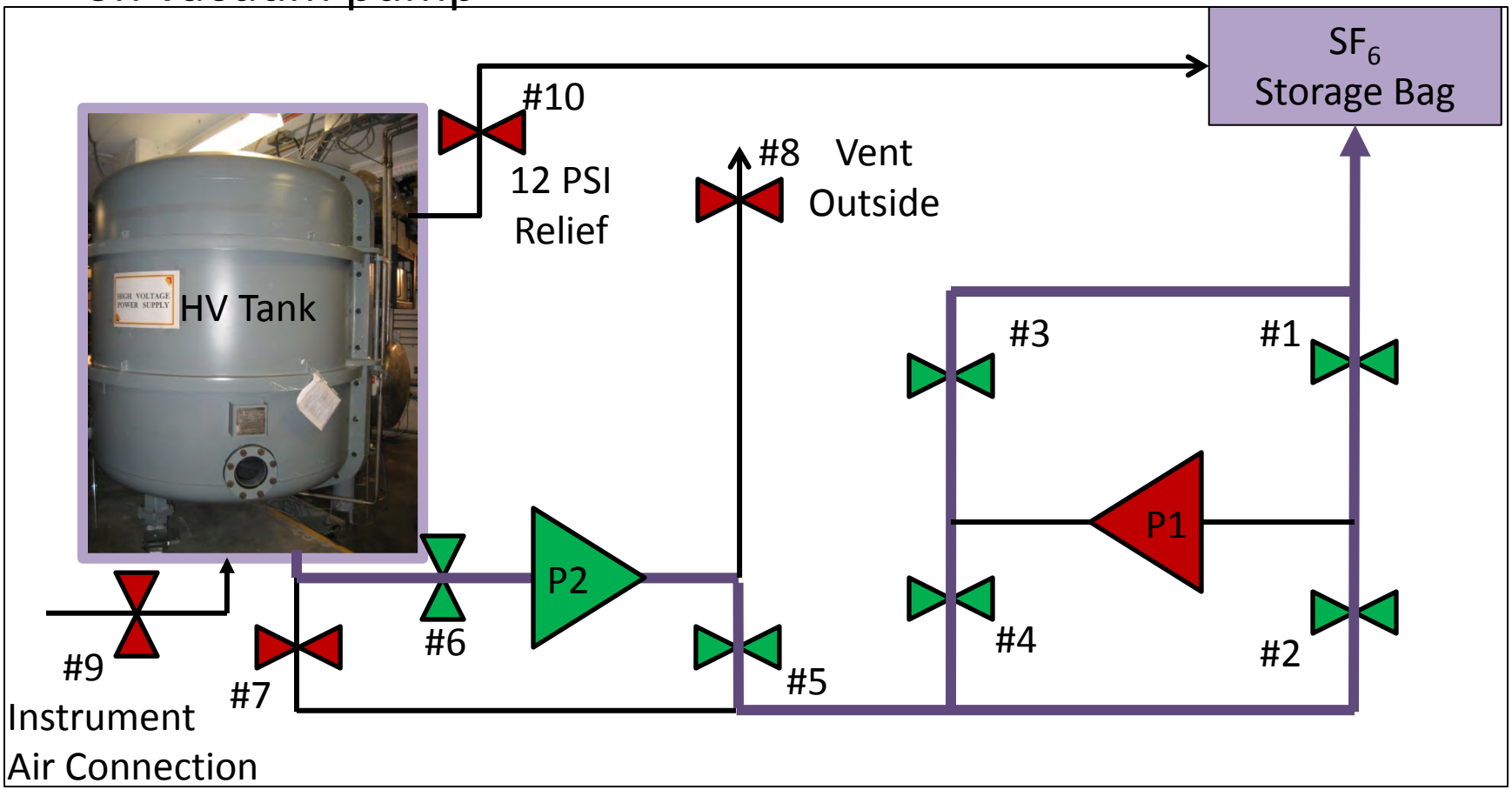
SF_6 Transfer System – Gas Recovery

2. To equalize the pressure, open valves 1, 2, 3, 4, & 7



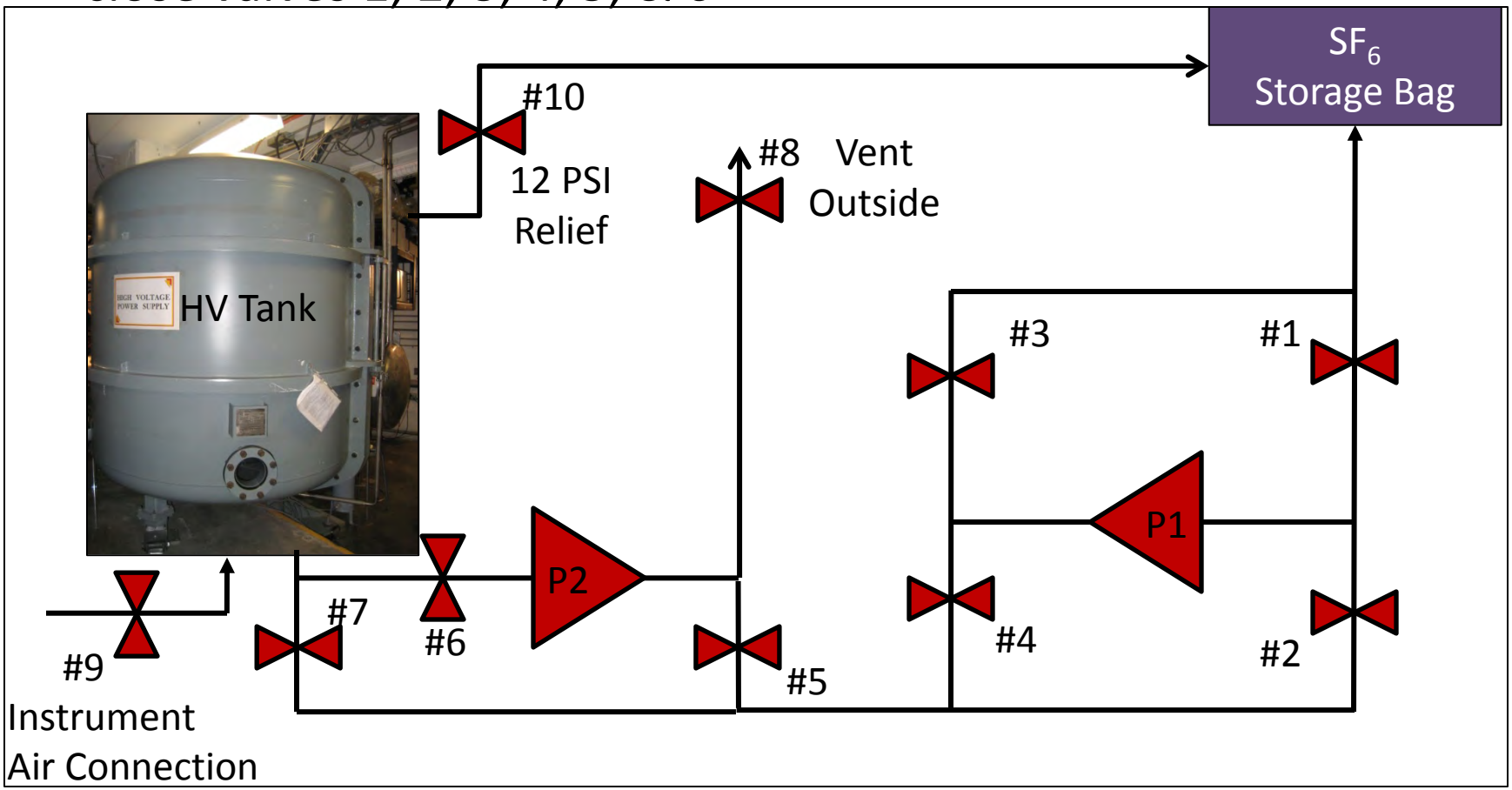
SF_6 Transfer System – Gas Recovery

3. When tank is at 0 PSIG, open valves 5 & 6, close valve 7, turn on vacuum pump



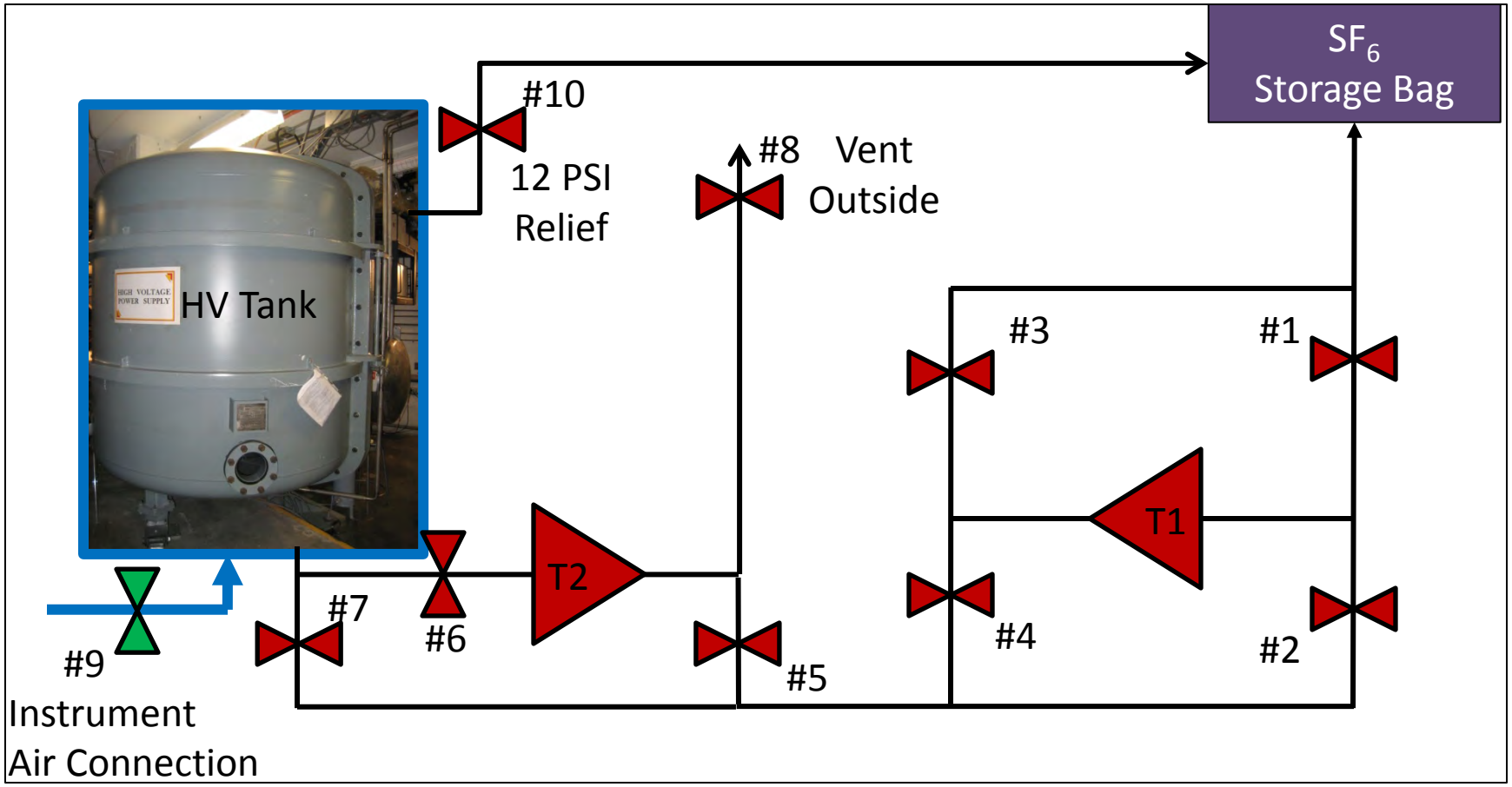
SF_6 Transfer System – Gas Recovery

4. When tank is evacuated to 10 Torr, turn off vacuum pump, close valves 1, 2, 3, 4, 5, & 6



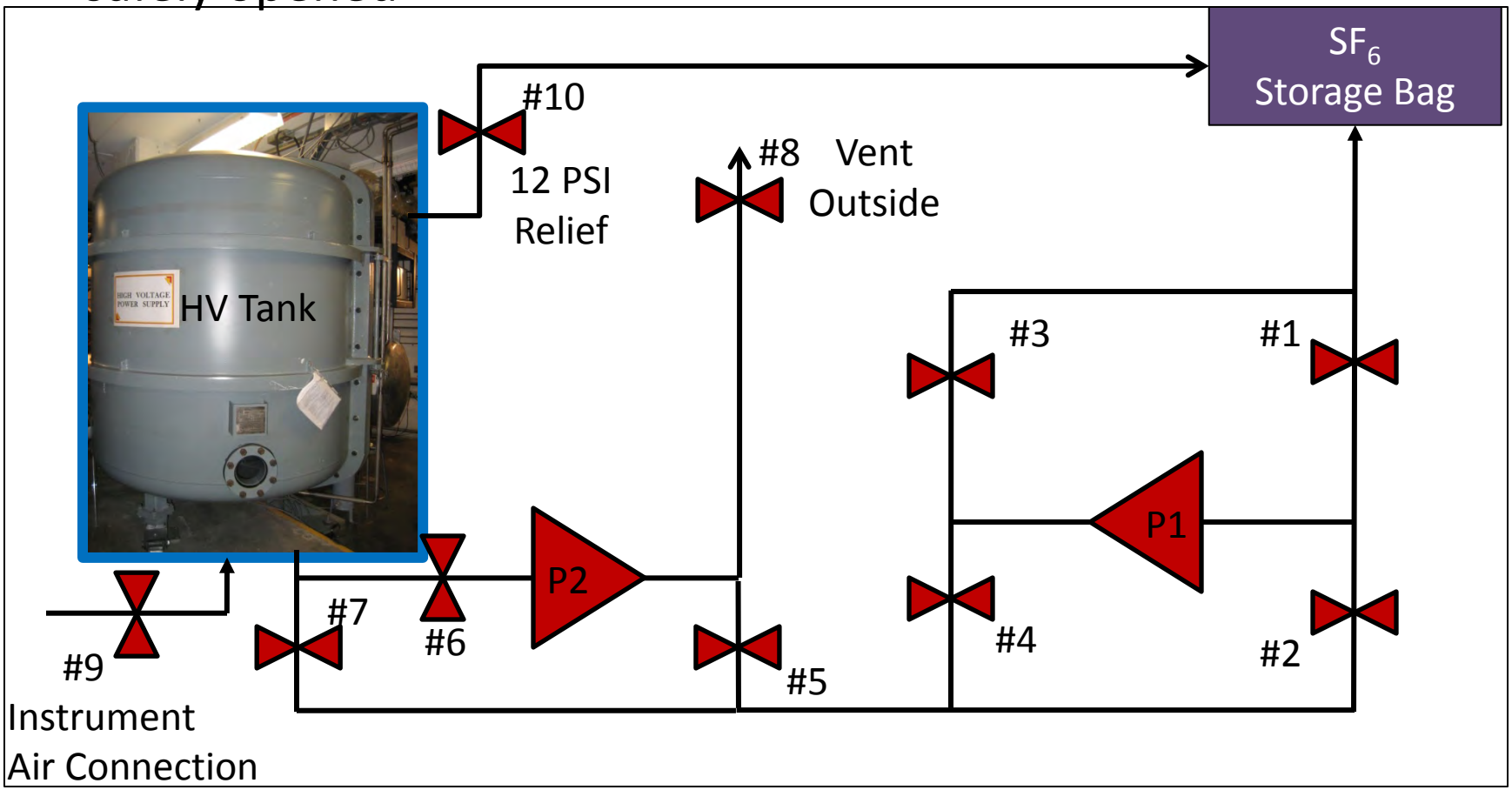
SF_6 Transfer System – Gas Recovery

5. Open valve 9 to back fill tank with instrument air



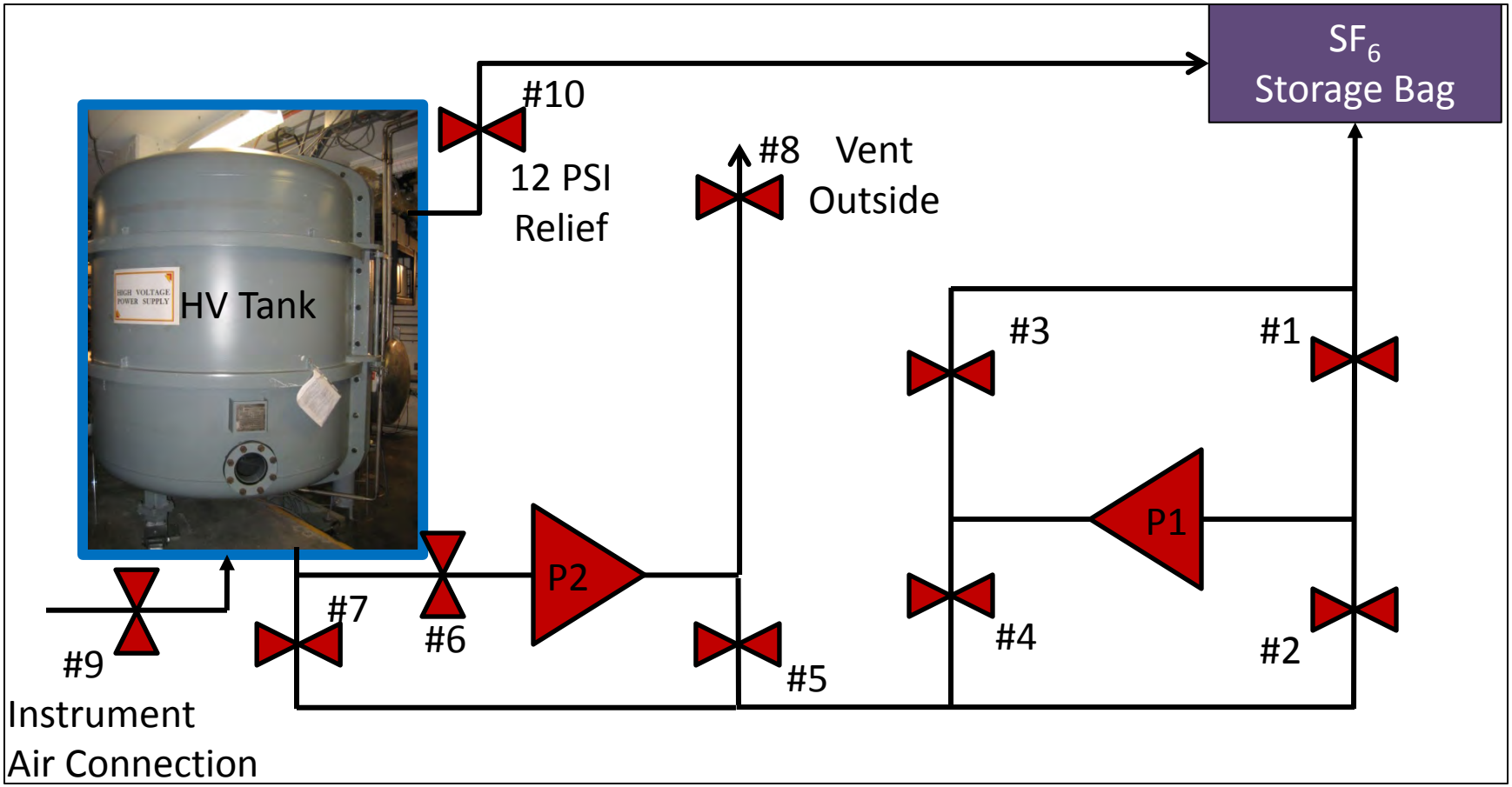
SF_6 Transfer System – Gas Recovery

6. When tank is at 0 PSIG, close valve 9 - HV Tank can now be safely opened



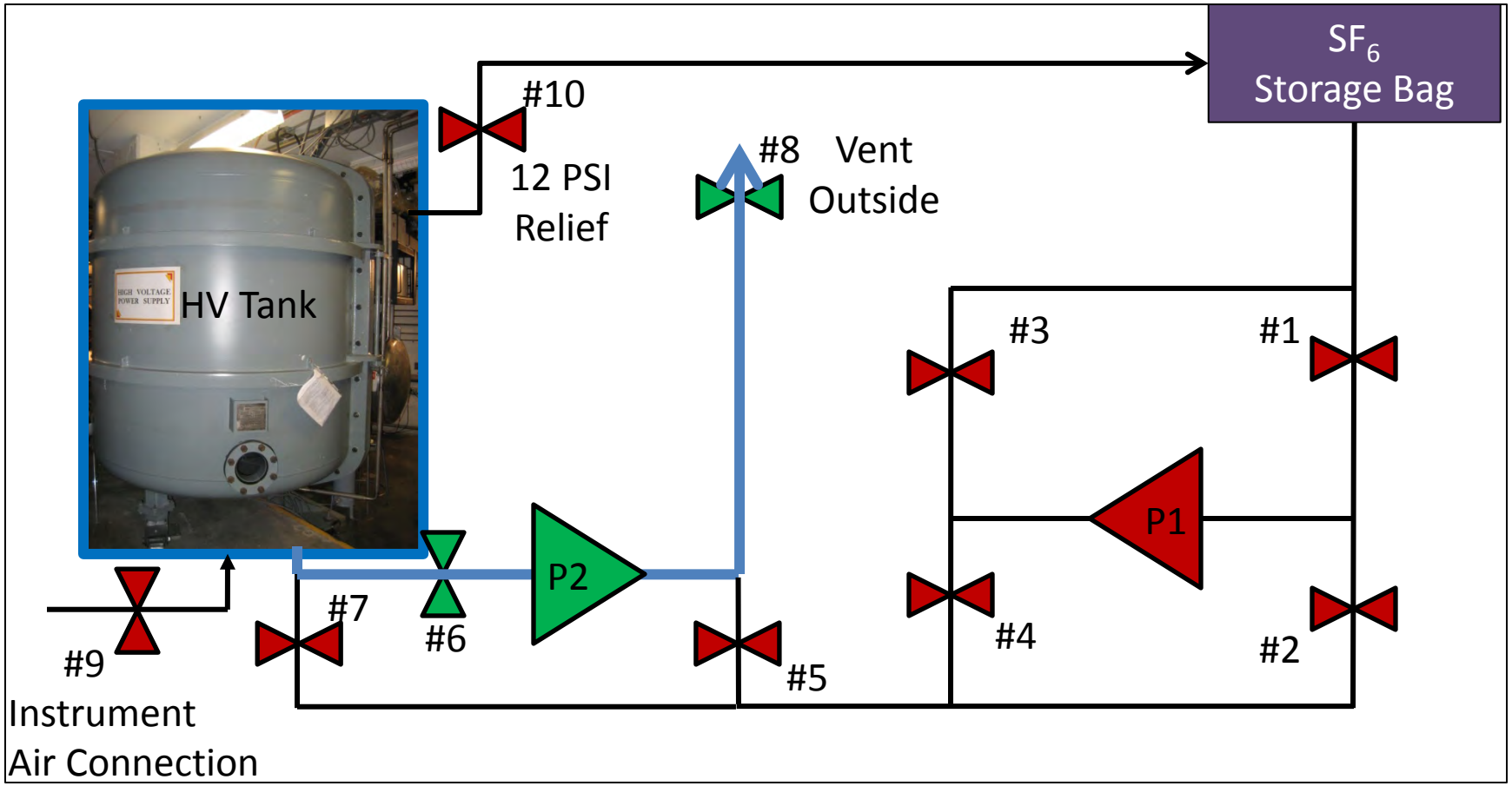
SF_6 Transfer System – Fill HV Tank

1. Initial State: HV Tank is open to air, all valves closed, all pumps off



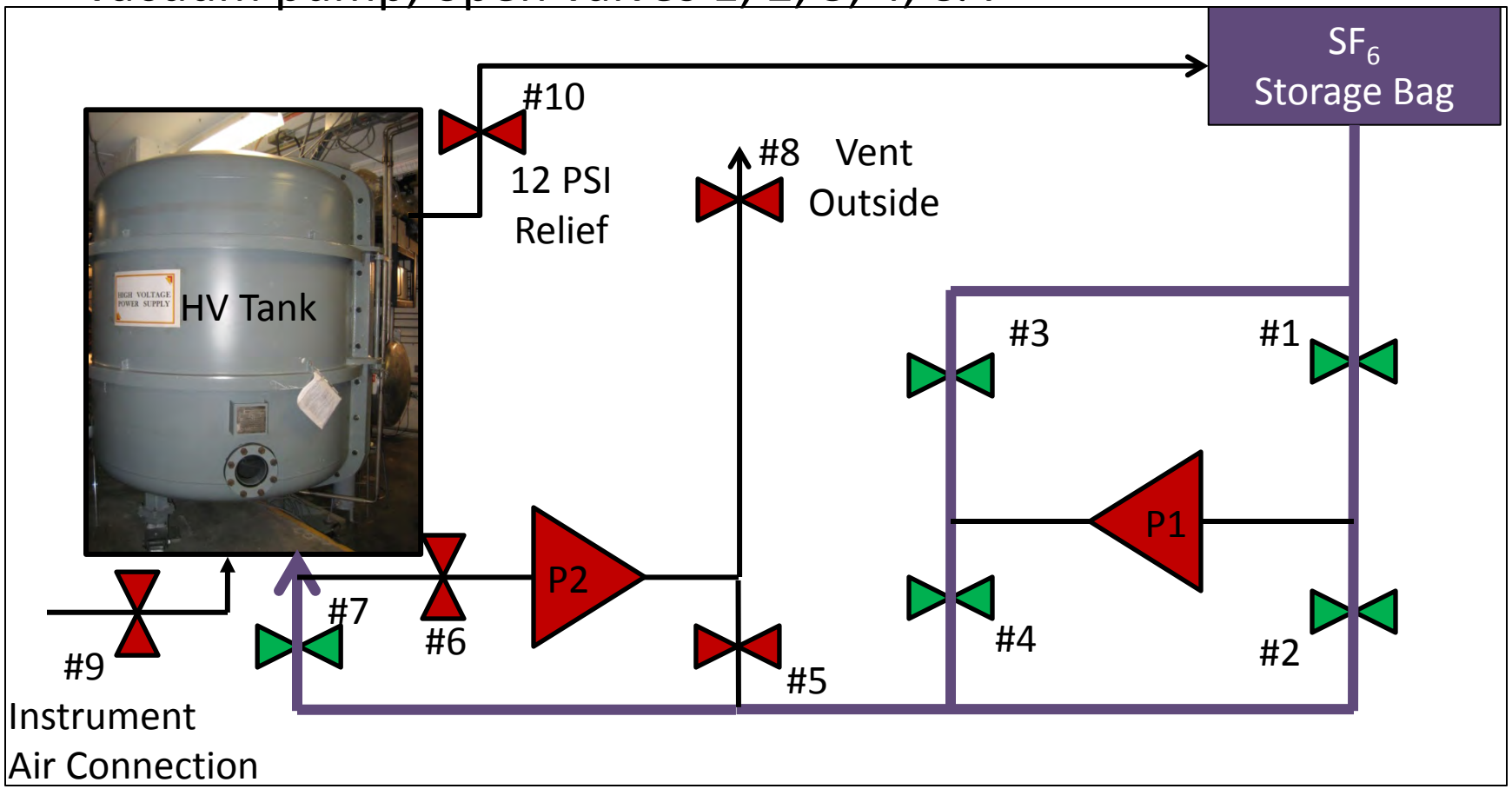
SF_6 Transfer System – Fill HV Tank

2. To Evacuate Tank: Open valves 6 & 8, turn on vacuum pump



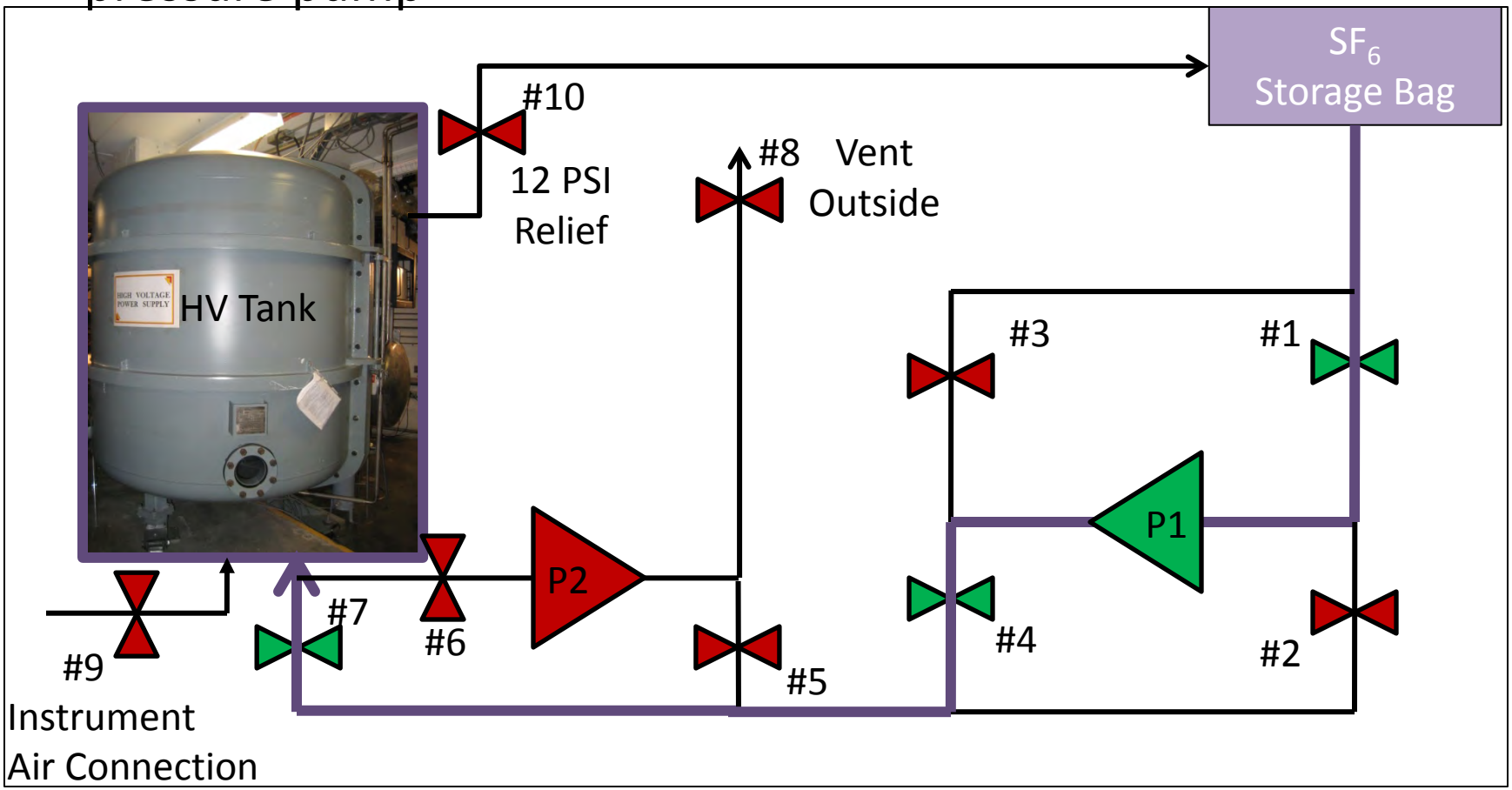
SF_6 Transfer System – Fill HV Tank

3. When tank reaches 10 Torr, close valves 6 & 8, turn off vacuum pump, open valves 1, 2, 3, 4, & 7



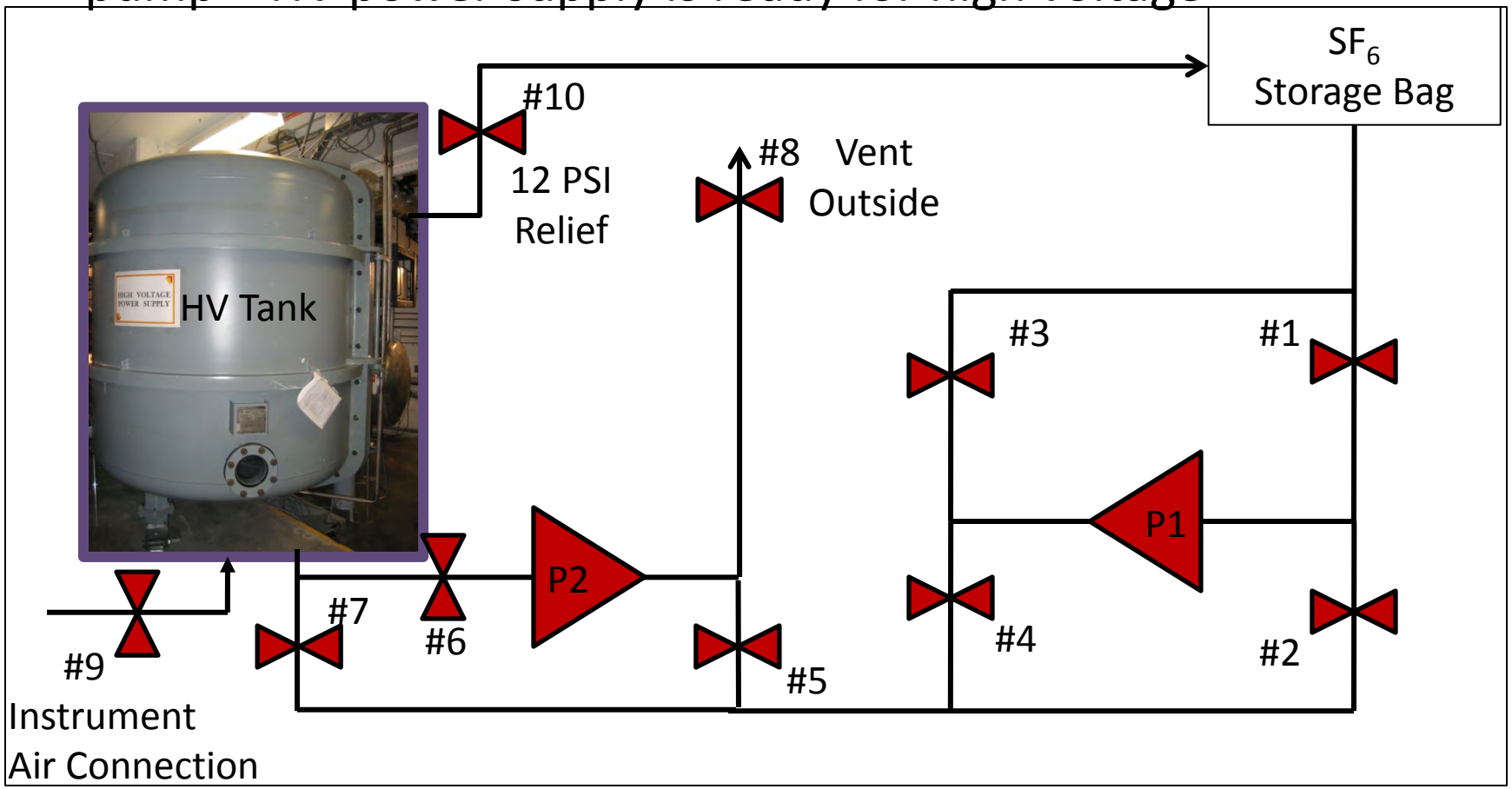
SF_6 Transfer System – Fill HV Tank

4. When tank reaches 700 Torr, close valves 2 & 3, turn on pressure pump



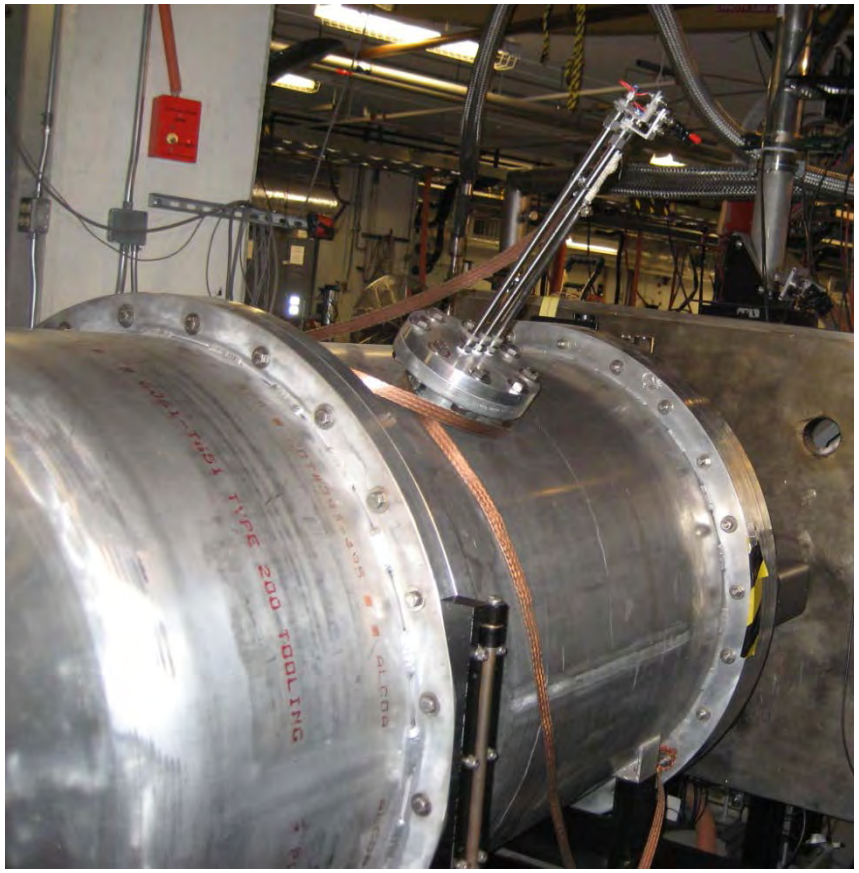
SF_6 Transfer System – Fill HV Tank

5. When tank is at 10 PSIG, close all valves, turn off pressure pump – HV power supply is ready for high voltage



Remote Cesiator

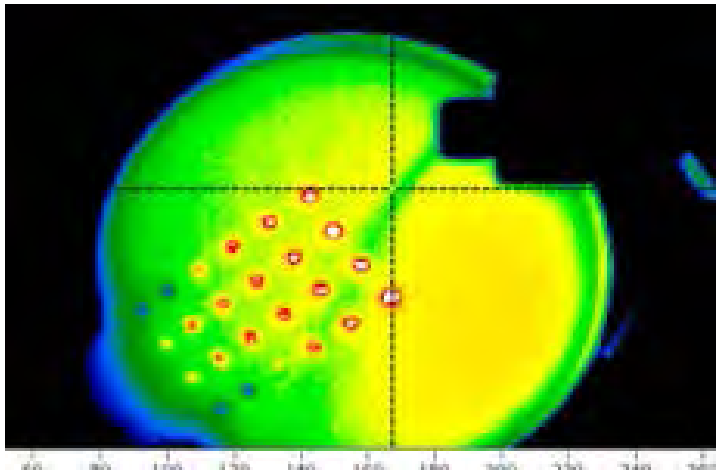
- Recesiation required 2-3 times/week
- Previously had to open gun every time
- Adaptation allows recesiation to take place without opening gun
- Now only open for heat cleaning every 3 weeks



FEL Electron Gun w/ Remote Cesiator

Leak Management

- FLIR A20M camera to identify leaks in SF6 equipment and transfer system
- Inspired by FEWG presentation
- Experiment was to see how well it works
  - Image taken using incandescent lamp behind valve – cool SF_6 shows up as delta T
  - SF_6 is NOT easily seen, I may be doing something wrong…



FLIR A20 / Small SF_6 leak from valve

SF_6 Savings

- FEL SF_6 Transfer System (since 1997)
  - FEL gun emptied and refilled ~500 times
  - 25 bottles used since 1999 (115 lbs/bottle x 25 = 2,875 lbs)
  - FEL system saved 72,125 lbs SF_6 (150 lbs x 500 – 2,875 lbs)
    - Save $1,586,000 (at $22/lb SF_6)
    - Save 782,000 $MTCO_2e$
- GTS SF_6 Transfer System (since 2007)
- FEL+GTS systems saved ~900,000 $MTCO_2e$ and ~$1.5 M (2010 $)

Contact Information

Kevin Jordan PE
Jefferson Lab
Free Electron Laser

757-876-1742
jordan@jlab.org

FEL User Facility