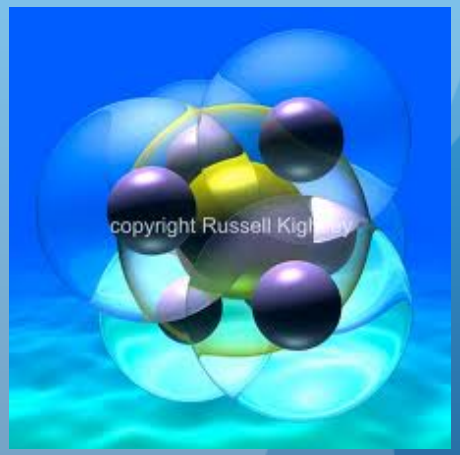
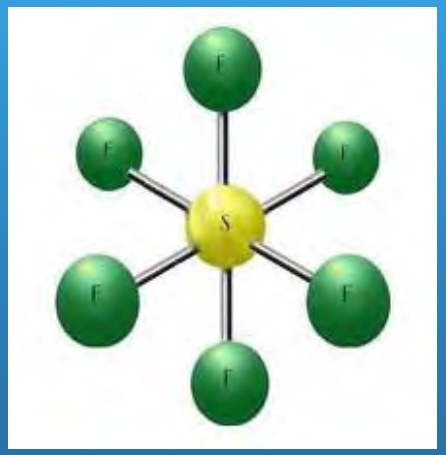
LLNL SF6 Management





Presented to:

Fugitive Emission Working Group

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SF6 use at LLNL – a summary

- SF6 has been used at LLNL for many years in a variety of applications:
  - Dielectric medium for power distribution (utilities)
  - Dielectric medium for power supplies (R&D)
    - Accelerators
    - X-ray heads
    - Electron microscopes
  - Miscellaneous R&D applications, including:
    - Water and air tracers
    - Semiconductor chip research

LLNL's Major SF6 Uses Locations

Current SF6 Uses

- Electrical Utilities (power production/distribution)
  - Used in B424 Main Switch Gear
  - Used in 89 sectionalizing switches and large circuit breakers

Current SF6 Uses (cont.)

- Research and Development
  - High voltage power supplies and switches
    - X-ray heads (radiography)
    - Electron microscopes
  - Tracer for water transport modeling
  - Chemical sensor instrumentation testing
  - Gamma ray detection studies
  - Mass spectroscopy

Current SF6 Uses (cont.)

- Accelerators
  - LLNL currently operates two main particle accelerators (and two smaller ones).
    - Building 190 (Center for Accelerator Mass Spectrometry)
    - Building 235
  - Building 194 Linear Accelerator may resume operations (depending on funding and programmatic mission)
  - SF6 used as dielectric gas in accelerator tanks/chambers
    - Arc suppressant

Current SF6 Uses (cont.)

- Semiconductor research
  - Limited application at LLNL (Building 153)
  - Limited use (R&D, not production)
    - Etching substrates
    - Some of the SF6 is converted in the process

Scope of SF6 use Onsite

LLNL Breakdown of SF_6 Use

SF_6 Application	Number of Custodians[1]	Number of Containers[1]	Volume of SF_6 (estimate, in pounds (lbs))
Accelerators	6	57 (mostly large cylinders)	20,000 lbs (14,000 lbs in use, approximately 6,000 lbs in cylinders)
Utilities	3	11 (split between large and pony cylinders)	3,136 lbs (2,136 lbs in use, approximately 1,000 lbs in cylinders)
R&D (semiconductor research)	1	12	123 lbs[2]
R&D (power related)	11	39 (mostly large cylinders)	Approximately 4,500 lbs[2]
R&D (miscellaneous)	38	42 (mostly small pony and lecture bottles)	Approximately 1,000 lbs[2]

[1] The number of custodians and containers may vary over time because of the changing nature of the operations (R&D activities in particular).

[2] The estimated volume for each of the R&D applications does not include the amount of gas in various pieces of R&D equipment (which is not tracked and has not been fully evaluated to date).

Historical LLNL SF6 Emissions

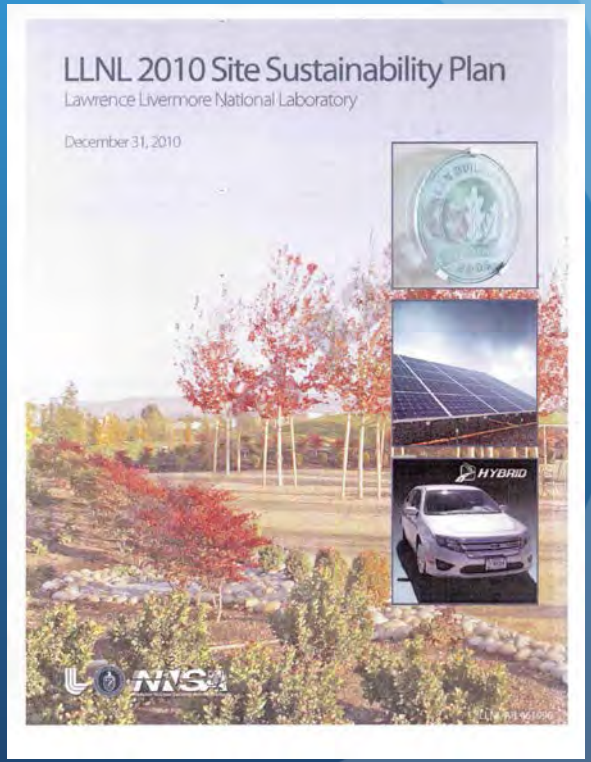
- No accurate emission data exists for past years
  - LLNL never tracked emission data (SF6 only recently considered harmful)
  - Problems existed with inventory data
    - Relied on purchase data rather than data from projects
- Rough estimates (based on purchase data for ongoing projects) indicates that prior to 2005, LLNL probably emitted hundreds to thousands of pounds of SF6 yearly
  - Largest emitters were accelerators, electrical production/distribution (losses from maintenance), and large scale R&D projects

"Regulatory" as Well as Scientific Climate Change

- Starting in 2007 (Kyoto Protocol), emphasis placed on role of greenhouse gases in climate change
- According to Intergovernmental Panel on Climate Change, SF6 has a Global Warming Potential approximately 23,900 times higher than CO2 (1 lb of SF6 emitted is equivalent to 11 metric tons of CO2)
- In 2009, President Obama issued Executive Order 13514 "Federal Leadership in Environmental, Energy and Economic Performance" which mandates that federal facilities decrease their GHG emissions.

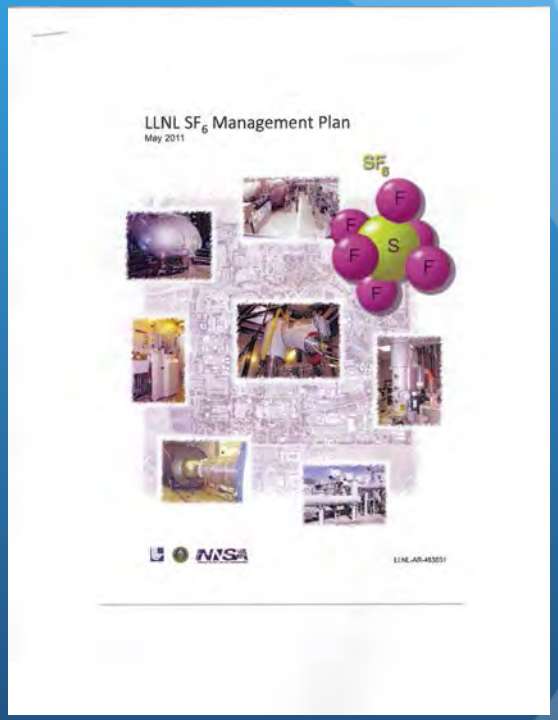
Regulatory Change (cont.)

- In 2010, DOE prepared its "Strategic Sustainability Performance Plan" which identified targets (by 2020, DOE facilities will decrease GHG emissions by 28 percent)
- In 2010, LLNL prepared the "LLNL 2010 Site Sustainability Plan" which provided some direction on achieving this reduction. Detailed goals not included for SF6, but commitment was made that LLNL would prepare an SF6 management plan.
- In 2010, the State of California promulgated regulations governing SF6 use and reporting



LLNL's SF6 Management Plan

- To meet LLNL commitments, LLNL issued the "LLNL SF6 Management Plan" in May 2011
  - Purpose of Plan
    - Document existing SF6 uses
    - Describe current and future efforts to minimize SF6 emissions
    - Provide framework for how LLNL will manage existing and future SF6 uses



LLNL's SF6 Management Plan (cont.)

- GOAL – LLNL IS COMMITTED TO REDUCING OR ELIMINATING SF6 EMISSIONS TO THE **EXTENT PRACTICAL**
  - Some of the original proposals to eliminate SF6 were not deemed feasible, due to:
    - SF6 has certain unique properties which make it essential for certain applications
      - Excellent dielectric media
      - It can re-associate or self heal when exposed to high voltage
      - Certain equipment designed to operate only with SF6 (substitutes would require change in operating parameters)
    - Certain applications that need SF6 are critical to LLNL's missions

LLNL's SF6 Management Plan (cont.)

- Relationship of SF6 Management Plan to LLNL's Environmental Management System (ISO14001)
  - SF6 Management Plan describes LLNL's SF6 Program (uses, current and future emission reduction programs, and the broad SF6 management program)
  - LLNL's GHG Environmental Management Plan (EMP) EMP-LLNL-2010-003 is the tool for documenting specific goals and targets (includes SF6)
    - Allows for more flexibility in adjusting goals
    - EMP can document successes and progress toward goals

EMS
Environmental Management System

Past and Ongoing Reduction Efforts

- Goal – minimize the number of SF6 uses/containers/custodians
  - Elimination of SF6 in some uses (LLNL's Beam Research Program now uses CF3I for some applications, newer sectionalizing switches use SF6 alternative)
  - Inventory reduction efforts
    - 10 percent reduction in SF6 containers at LLNL over the last 18 months
  - Significant efforts made to incorporate capture/reclamation systems

Site 300 FXR – an R&D Success Story

- Site 300's Flash X-Ray project has made incremental improvements to its operations since 1997.
  - Measure of success – program has evolved from releasing approximately 5,000 lbs of SF_6 prior to 1997 to an estimated 920 lbs several years ago to less than 115 lbs today
  - Examples of improvements
    - Gas scrubbers to extend SF_6 life (minimized new gas purchases)
    - Portable reclamation unit for capturing SF_6 in hoses during maintenance
    - Installation of electronic scales for accurate inventory management
  - Proposed improvement
    - Valve relocation – by locating valves closer to filters, less gas is held in lines which may be lost during maintenance, even with reclamation unit

Site 300 FXR (cont.)

- Improvements have not only minimized the amount of gas released, but also has resulted in significant labor and cost savings ($14,500 in reduced SF6 purchases annually)
- FXR's successes are being considered at other locations (i.e., B191 with the x-ray diagnostics used in the "Spherical" and "Gun" shot tanks)
- FXR improvements have led to the project receiving a 2011 NNSA Environmental Stewardship award and was one of only 15 DOE EStar awards chosen for 2011

Other Efforts (Accelerators)

- B190 CAMS accelerator proposed improvements
  - Main accelerator at CAMS has been one of the largest emitters of SF6
    - Accelerator design led to frequent maintenance
    - Maintenance required gas transfer of approximately 13,000 lbs of SF6 (single largest use of SF6 onsite)
    - Age and configuration of transfer system led to significant loss of gas
  - Improvements made
    - New transfer process incorporates halogen sniffers before and during transfers
    - Increased emphasis on tightening flanges/connections
  - Proposed new improvements
    - Rebuild one of the gas compressors (greatest potential for catastrophic loss)
    - Purchase of dedicated gas recovery system
    - Replacement of aging valves on gas transfer system

Other Efforts (Utilities)

- LLNL's Maintenance and Utilities Services Division (MUSD) have taken proactive steps to reduce SF6 use and minimize emissions
  - Replaced utility system circuit breakers with vacuum interrupting breakers that don't require SF6
  - Employed SF6 recovery systems for maintenance on the U424 Switchgear
  - Revised maintenance procedures to include pressure monitoring of sectionalizing switches to detect any pressure drops (indicating a possible leak)

Broad-scale SF6 Management

- SF6 is specifically addressed in the Greenhouse Gas EMP
- SF6 operations addressed in LLNL's work control processes (integration work sheets)
- Use of LLNL's "Chemtrack" for accurate inventory accounting
- SF6 purchase procedures (included on the LLNL Controlled Items Services List)
- SF6 emission and inventory reporting efforts (to comply with State of California regulations)

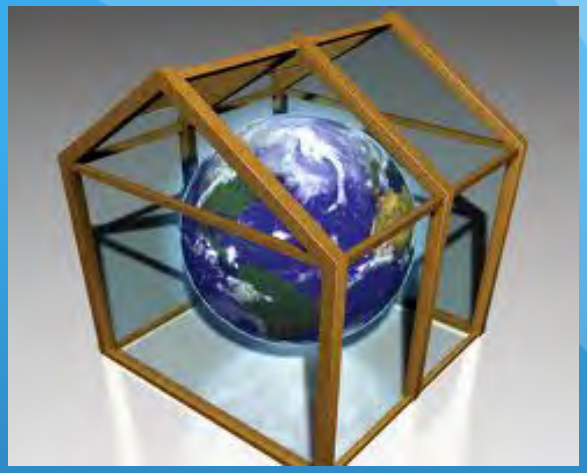
SF6 Operational Goals

- LLNL employees using SF6 may be asked to:
  - Estimate current annual SF6 emissions (for regulatory reporting)
  - Establish a strategy for replacing older, less reliable equipment
  - Implement SF6 recycling/reclamation
  - Ensure only knowledgeable personnel handle SF6
  - Submit annual progress reports (depending on type of operation)

Steps to Achieve Goals

- Maintain system integrity of equipment
- Incorporate leak monitoring into operations
- Incorporate capture/reclamation systems
- Follow proper disposal protocol for SF6 containers
- Increased awareness of proper use of gas handling apparatus

SUMMARY



- LLNL is committed to the proper management of SF6 in order to minimize emissions.
- LLNL has and will continue to:
  - Raise SF6 awareness
  - Manage inventories
  - Minimize indiscriminate releases of SF6