EXPERIENCE WITH INFRARED LEAK DETECTION OF FPL SWITCHGEAR

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“SF₆ LEAK DETECTION”

Sulfur hexafluoride (SF₆) is a “greenhouse gas” that is used extensively in power industry equipment. With age, equipment leaks. Traditional leak detection methods have not been adequate.

The Environmental Protection Agency (EPA) is interested in controlling the release of SF₆. On April 13, 1999, FPL joined an “SF₆ EMISSIONS REDUCTION PARTNERSHIP” with the EPA.

The partnership requires that FPL:

- **Maintain ACCURATE INVENTORY of SF₆**
- **Monitor and REDUCE the OVERALL LEAK RATE**
- Implement SF₆ RECYCLING
- Tightly **MANAGE** the Use of SF₆
- Yearly reporting of SF₆ EMISSIONS
GREENHOUSE GASES
WORK LIKE A GREENHOUSE

Glass is transparent to short-wave radiation emitted by the sun but opaque to long-wave re-radiated radiation, infrared (heat light).

SF₆ absorbs infrared & traps heat (heat light).
CURRENT SITUATION:

PARTNERS MUST DEAL WITH TWO FUNDAMENTAL ISSUES

• HOW TO EFFECTIVELY MANAGE & DOCUMENT SF₆ USE
• HOW TO EFFECTIVELY DETECT AND HANDLE SF₆ LEAKS
“SF₆ LEAK DETECTION”

ANALYSIS:

ECONOMIC DECISION MODELS WERE DEVELOPED TO DETERMINE:

SHOULD WE INVEST IN LEAK DETECTION EQUIPMENT & PERFORM THE SERVICE INTERNALLY, OR “OUTSOURCE”?

A FIVE YEAR PRESENT WORTH ANALYSIS REVEALED SIGNIFICANT ADVANTAGES IN “OUTSOURCING”
“SF₆ LEAK DETECTION”

ANALYSIS:

A **MANAGEMENT INTERACTION DIAGRAM** was first developed to aid in defining structure, procedures, and bid specifications.

**CORPORATE PHILOSOPHY** was then agreed to across all affected departments.
**“SF₆ LEAK DETECTION”**

**INVENTORY SERVICES:**
- Inventories all incoming SF₆
- Purchases
- Reclaimed
- Inventories all issues of SF₆

**GAS MANAGEMENT “CONTRACTOR”**
- Fill new breakers
- Reprocess SF₆ during maintenance
- Remove, reprocess, & reclaim SF₆ gas during decommissioning
- Test & certify processed gas for return to stores
- Perform administrative tracking

**STATIONS**
- Schedules contractor through env.
  - Normal maintenance
  - New installations (filling & leak detect)
  - Emergency response
- Develops annual leak detection strategy
- Develops annual repair strategy
- Tops off leaking breakers

**POWER SYSTEMS ENVIRONMENTAL**
- Administrates SF₆ contractors
- Coordinates overall SF₆ management
- Handles “emergency response”
- Compiles annual SF₆ analysis

**MATERIAL MANAGEMENT SYS.**
- Track & quantify movement of SF₆ gas:
  - In-service inventory of SF₆
  - Purchased SF₆
  - Issued SF₆
  - Sold SF₆
  - Inventory transfers of SF₆
  - Reprocessed SF₆
  - Stored SF₆ inventory

**CORPORATE ENVIRONMENTAL SERVICES**
- One point contact for the EPA-MOU
- Prepares “Emissions Inventory Form”
- Prepares first year MOU requirements

**LEAK DETECTION CONTRACTOR**
- Checks for leaks on new breaker installations
- Performs routine leak detection services
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CORPORATE PHILOSOPHY:

• ALL NEW BREAKERS WILL BE LEAK CHECKED

• THE EXISTING SF₆ POPULATION WOULD BE LEAK CHECKED

• EQUIPMENT NEEDING PERIODIC TOPPING-OFF WILL BE LEAK CHECKED

• PERMANENT FIXES ARE PREFERRED OVER TEMPORARY REPAIRS (EPOXIES, ETC.)

• GAS IMAGING TECHNOLOGY WILL BE USED
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ANALYSIS:

TRADITIONAL METHODS SUCH AS SNOOPING, SNIFFING, ETC., WOULD NOT PROVIDE ADEQUATE RESULTS ACROSS THE POPULATION OF INTEREST AND WITHIN THE TARGETED TIME WINDOW

BACK-SCATTER ABSORPTION GAS IMAGING (BAGI) COULD MEET THESE REQUIREMENTS
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ANALYSIS:

BACK-SCATTER ABSORPTION GAS IMAGING (BAGI) WAS ORIGINALLY DEVELOPED BY LAWRENCE LIVERMORE NATIONAL LABORATORY FOR THE NAVY DURING INITIAL SURVEILLANCE OF DISABLED MARINE VESSELS THE NAVY NEEDED TO KNOW IF THE ATMOSPHERIC ENVIRONMENT WAS SAFE; THIS NEED DROVE THE DEVELOPMENT OF BAGI

THE SYSTEM HAS BEEN PATENTED UNDER BAGI TECHNOLOGY (US PATENT #4,555,627)
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HOW IT WORKS:

The system uses an infrared laser to illuminate an object. A camera tuned to filter out all but the back-scattered infrared light (reflected light) produces a video image of the specimen. Infrared is absorbed by SF₆ and produces a dark image at the location of any SF₆ gas cloud.
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HOW IT WORKS:

With No SF₆ Leak
- Incident Laser Light
- Laser Camera

With SF₆ Leak
- Incident Laser Light
- Back Scattered Laser Light
- Gas Cloud
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FIELD RESULTS:

Performance limits:
- Range is 20 to 30 meters
- Must be a “reflective” or “back-scattering” surface
- Excessive background SF₆ may obscure the leak
- “Best results” obtained with leak as close as possible & incident “beam perpendicular to SF₆ plume”
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FIELD RESULTS:

Current machines:
- Use CO₂ laser power & a video imaging camera
- The base unit & camera are bulky but research is being done to reduce its size
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RESULTS:

• IN APPROXIMATELY 4 MONTHS THE “LEAK DETECTION CONTRACTOR” HAD COMPLETED LEAK DETECTION OF 460 SF₆ BREAKERS

• 9% (40 BREAKERS) OF THE BREAKER POPULATION WERE FOUND WITH DETECTABLE LEAKS

• 15% OF THE LEAKS WERE MINOR (LOOSE FITTINGS, ETC.) AND WERE CORRECTED ON SITE BY THE “LEAK DETECTION CONTRACTOR”

• 85% OF THE LEAKS WERE SIGNIFICANT AND HAD TO BE REFERRED TO “OPERATIONS” FOR SCHEDULED REPAIRS

• 5% OF THE LEAKING BREAKERS WERE IN WARRANTY
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RESULTS:

LEAKING BREAKERS BY AGE

TYPICAL WARRANTY IS ONLY 5 YEARS
RESULTS:

% LEAKERS BY MANUFACTURER & MODEL

BOTH MODELS ARE SCHEDULED FOR REPLACEMENT
RESULTS:

WHERE WERE THE LEAKS FOUND??

- 62% WERE FOUND AROUND FITTINGS, PIPING CONNECTIONS, & GAGE CONNECTIONS
- 16% WERE FOUND AROUND ACCESS GASKETS
- 12% WERE FOUND ON BUSHING SEALS
- 5% WERE FOUND AROUND DRIVE RODS
- 5% WERE FOUND AT WELDS
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CONCLUSIONS:

• “OUTSOURCING” LEAK DETECTION HAS BEEN ADVANTAGEOUS IN COST AND SPEED OF PROJECT COMPLETION

• INFRARED LEAK DETECTION ALLOWS FOR IDENTIFICATION OF SF₆ LEAKS WHILE EQUIPMENT IS STILL IN-SERVICE

• INFRARED LEAK DETECTION CAN NOT TELL VOLUME OF LEAKING GAS, BUT IT CAN IDENTIFY WHERE THE LEAKS ARE & OFTEN IDENTIFIES LEAKS UNDETECTABLE WITH OTHER TECHNIQUES

• THE “PARTNERSHIP” HELPED TO FOCUS EFFORTS ON CREATING A STRUCTURE & PROCESSES THAT ASSURE LONG TERM CONTROL AND CONTINUED REDUCTION OF SF₆ LEAKS