SF₆ Gas Emission Reduction
From
Gas Insulated Electrical Equipment
In Japan

The Federation of Electric Power Companies
The Japan Electrical Manufacturers’ Association
Japan
Contents

• Joint Study
• Voluntary Action Plan
• SF₆ Gas Emission from 1996 to 1999
• Future Perspective for SF₆ Gas Emission
Background on SF₆ Usage in Japan

Steady Expansion of Electricity Demand

Increase in the Amount of Equipment

Restriction in Japan
- Difficulty of Land Acquisition
- Severe Climate Condition

SF₆ Gas Insulated Equipment is Indispensable
Outlook of Substation
Gas Insulated Substation solves Scenic problem.

KITAKUMAGAYA SUBSTATION (275kV, 900 MVA)
(An air-insulated-type open air substation)

TAKANAWA SUBSTATION (275kV, 1020 MVA)
(A gas-insulated-type underground Substation)

Space Saving and Less Visual Impact
By SF6 Gas Insulation
Joint Study on SF₆ Emission Reduction

• **Principle**
  - Effective substitute gas has not been found yet.
  - It is necessary for us to continue the use of SF₆ gas from now on too.
  - Countermeasures for the REDUCTION of SF₆ gas EMISSION are vital.

• **Membership**
  • Representatives of:
    - Academy, electric power companies, electric equipment manufacturers, and gas producers in Japan
Joint Study on SF₆ Gas

Academy (Universities in Japan)

Electric Power Companies

Electric Equipment Manufacturers

Gas Producers

Chairman: Prof. Takuma (Kyoto Univ.)
from 1996 to 1998
Joint Study on SF₆ Gas

- **Actual Usage in Japan**
  - Total SF₆ amount for electric industry
  - Annual increase of SF₆ in Japan
- **Investigation on Site**
  - Gas leakage rate
  - Gas purity & humidity
  - Decomposition product
- **Requirement for Reuse of SF₆**
SF$_6$ Amount and GIS Unit on Site

![Graph showing SF$_6$ Gas Total Amount and Number of GIS Units over time from 1960 to 1995. The graph includes a legend indicating yellow diamonds for SF$_6$ Gas Volume of Inventory and red diamonds for Number of GIS Units.](image-url)
Averaged SF₆ Balance Sheet in Japan (From 1990 to 1995)

Gas Producers
Production : 2,300 tons
Oversea Export : 200 tons
Domestic Use : 2,100 tons

Equipment Manufacturers

Electric Power Companies

Other Industries

Other Industries

200 t (emission)

400 t (emission)

50 t (emission)

1,500 t

550 t

100 t (Return)
<table>
<thead>
<tr>
<th>Voltage Level</th>
<th>Maintenance</th>
<th>Removal</th>
<th>Leakage</th>
</tr>
</thead>
<tbody>
<tr>
<td>110 kV or higher</td>
<td>Recovery down to 0.05 MPa(gage)</td>
<td>Fully released</td>
<td>0.1%/year</td>
</tr>
<tr>
<td>Lower than 110 kV</td>
<td>Fully released</td>
<td>Fully released</td>
<td></td>
</tr>
</tbody>
</table>
Investigation on Site
(300 Points on 40 Circuit Breakers in Operation)

<table>
<thead>
<tr>
<th>Leak Rate</th>
<th>Purity</th>
<th>Humidity</th>
<th>Decomposition Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Above 98.7 vol%</td>
<td>Below 118 volppm</td>
<td>Not detected</td>
</tr>
<tr>
<td>Annual Leakage from O-ring</td>
<td>[g/m²/year]</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Gas Volume per O-ring</td>
<td>1</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>Below 0.1% / year</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The detectable levels of measurement are HF>0.25volppm, SO2>0.05volppm, SOF2>10volppm and SO2F2>10volppm
# Quality Control Criteria for SF₆ Gas

<table>
<thead>
<tr>
<th>Water content</th>
<th>Permissible limits</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF₆ gas purity</td>
<td>95 vol. %</td>
<td>97 vol. %</td>
</tr>
<tr>
<td>Air</td>
<td>(5 vol. %)</td>
<td>(3 vol. %) including CF₄</td>
</tr>
<tr>
<td>Equipment without current interruption</td>
<td>1000 ppm (vol.)</td>
<td>500 ppm (vol.)</td>
</tr>
<tr>
<td>Equipment with current interruption</td>
<td>300 ppm (vol.)</td>
<td>150 ppm (vol.)</td>
</tr>
<tr>
<td>Dissolved gases/decomposition products</td>
<td>–</td>
<td>No color reaction in detecting tube</td>
</tr>
</tbody>
</table>

To Be Reused
# Recovery Targets for SF₆ Gas

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Recovery Terminal Pressure</th>
<th>Recovery Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower than 110 kV</td>
<td>110 kV or higher</td>
</tr>
<tr>
<td></td>
<td>Lower than 110 kV</td>
<td>110 kV or higher</td>
</tr>
<tr>
<td>Before 1995</td>
<td>No Recovery</td>
<td>No Recovery</td>
</tr>
<tr>
<td>During testing</td>
<td>0 - 0.05 MPa· G</td>
<td>Approx. 70%</td>
</tr>
<tr>
<td>During manufacture</td>
<td>No Recovery</td>
<td>0 - 0.05 MPa· G</td>
</tr>
<tr>
<td>During installation/maintenance</td>
<td>No Recovery</td>
<td>0 - 0.05 MPa· G</td>
</tr>
<tr>
<td>During removal</td>
<td>No Recovery</td>
<td>No Recovery</td>
</tr>
<tr>
<td>In the future (from 2005 onward)</td>
<td>0.015 MPa· abs (114 Torr) or lower</td>
<td>97% or higher</td>
</tr>
<tr>
<td>During testing/Manufacture/Installation/maintenance</td>
<td>0.005 MPa· abs (38 Torr) or lower</td>
<td>99% or higher</td>
</tr>
</tbody>
</table>
SF₆ Gas Recycling Flow & Standard

SF₆ Gas Recycling Flow & Standard

Refine Decomposition

Nonstandard Gas

Gas Suppliers

Manufacturers

Utilities

Reuse

Reuse

Reuse

Recycle Standard

<table>
<thead>
<tr>
<th>Requirement for Reused SF₆</th>
<th>SF₆ Recovery Ratio in Internal Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purity</td>
<td>:97 vol %</td>
</tr>
<tr>
<td>Humidity</td>
<td>:150 vol ppm</td>
</tr>
<tr>
<td>Decomposition Products: Not Detected</td>
<td>90% in 2000</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. Leakage Rate from Equipment in Operation:  
   >> Regarded as 0.1%/year

2. Target for Recovery Rate at Each Stage:  
   >> Established

3. Quality Control Criteria for SF₆ Recycling:  
   >> Established

4. Gas Recycling Flow:  
   >> Agreed by the respective parties
SF₆ Emission in Manufacturers & Utilities

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount of Emission [ton]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>2000</td>
</tr>
<tr>
<td>1995</td>
<td>4000</td>
</tr>
<tr>
<td>2000</td>
<td>6000</td>
</tr>
<tr>
<td>2005</td>
<td>8000</td>
</tr>
<tr>
<td>2010</td>
<td>10000</td>
</tr>
</tbody>
</table>

- **Manufacturers**
- **Utilities**
- **SF₆ Total Amount on Site**

- **Emission Reduction**
Voluntary Action Plan

Organizations of Utilities and Manufacturers (FEPC) (JEMA)

The Voluntary Action Plan in April 1998

Administrative Organ

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF₆ Emission</td>
<td>280 ton</td>
<td>70 ton</td>
</tr>
</tbody>
</table>

EA: Environment Agency
MITI: Ministry of International Trade and Industry
Voluntary Actions
By Electric Power Companies

Target for Recovery Rate
• Usage (during maintenance work)
  1990 – 1995  60%  >>  by 2000  90%
                        by 2005  97%
• Disposal (during replacement work)
  1990 – 1995  0%  >>  by 2005  99%
Voluntary Actions by Equipment Manufacturers (1)

Target for Emission

- Within 3% of purchased volume
- During equipment test in factory/installation on site

1990 – 1995 400 ton >> by 2000 240 ton
   by 2005 30 ton
Voluntary Actions by Equipment Manufacturers (2)

Target for Gas Recovery & Usage

- Development of high performance gas handling equipment
- Development of compact gas insulated equipment with minimum SF₆ gas
Compact Gas Insulated Equipment
(550 kV Circuit Breaker)

SF₆/Phase: 2000 kg  1050 kg  720 kg
SF₆ Gas Handling Equipment

Outline of Equipment

Dimensions:
2700(w) x 2000(D) x 2000(H) mm
Weight: 3500 kg (with 300L tank)
Voluntary Actions By the Concerned Parties

• **Improvement of Gas Inventory System**
  – Record of SF$_6$ gas amount at every job
  – Annual report to government relating to progress of SF$_6$ gas recovery

• **Promotion of Gas Recovery**
  – Achieving the target values

• **Promotion of Gas Recycling System**
  – Re-use in the electric power industry
Estimation of SF₆ Gas Emissions

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© Without Action
Future Perspective for SF$_6$ Gas Emission

- Excellent characteristics of SF$_6$ gas
- Effective substitute gas has not been found yet
- We have to use SF$_6$ gas with great care
- Emission to environment should be reduced, aiming at the target values

- **Electric Power Industry Total:**
Thank you for your attention