IMPLEMENTATION OF TREATMENT & RECOVERY OF THE SF₆ GAS CONTAINING A HIGH AMOUNT OF DECOMPOSITION PRODUCTS DUE TO HIGH VOLTAGE ELECTRICAL INTERRUPTIONS

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1 - The Impact of SF$_6$ on the Environment
2 - The AREVA T&D / AVANTEC Procedure for SF$_6$ Recovery & Recycling
3 - Gas Analysis
4 - Handling of SF$_6$
5 - SF$_6$ Purification Techniques
6 - Destruction & Assessment
7 - Conclusions
1 - The Impact of SF$_6$ on the Environment
Impact of SF₆ on the environment

SF₆ GWP 22200
(IPCC 2001)

SF₆ AND ELECTRICITY SECTOR:

O.1 % of man made GWP gases
Contribution of electricity sector: 0.012 %
W&E European electricity contribution: 0.008 %

* Source CAPIEL
LCA of medium voltage network:

Major global warming is due to the energy losses during the life of the equipment.

Ref: “Life Cycle Assessment: SF₆-GIS technology for Power Distribution Medium Voltage” Study commissioned by ABB, AREVA T&D, EnBW Regional, RWE Energies, SIEMENS, SOLVAY.
Studies show that the total environment impact of Air Insulated Switchgear is higher than Gas Insulated Substations. The Switchgear represents less than 10% of the total networks Global Warming Impact.

Ref: “Life Cycle Assessment: SF$_6$-GIS technology for Power Distribution Medium Voltage” Study commissioned by ABB, EnBW Regional, RWE Energies, SIEMENS, & SOLVAY.
Electrical Initiatives to Reduce SF$_6$ Emissions

- Improvement of the Gas handling procedure.
- Systematic gas re-uses.
- Voluntary emission reduction programs.
WG B3.02 TF 01 “Guide to SF₆ Handling” then became “SF₆ Recycling Guide”. Brochure 234.


IEC 60 376 Under revision. (2005)

IEC 60 480 Ed 2. Oct. 2004
Evolution of the IEC Standards

**IEC 60 376**

**IEC 60 480**

Improvement in SF$_6$ recovery and on site purification

User Analysis on Site

Gas recovery units
## Electrical Industry Initiatives

Scottsdale, AZ, December 1-3, 2004

<table>
<thead>
<tr>
<th>IEC 60376 Ed.1</th>
<th>Standard</th>
<th>IEC 60376 Ed. 2 (Proposal)</th>
<th>IEC 60480 Ed.1</th>
<th>IEC 60480 Ed.2</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rated absolute pressure &lt;200kPa</td>
<td>Rated absolute pressure &gt;200kPa</td>
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<tr>
<td>&lt;0.05%w</td>
<td>Air and/or CF₄</td>
<td>Air&lt;1% vol CF₄&lt;0.4% vol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 ppmw</td>
<td>H₂O</td>
<td>25 ppmw</td>
<td>No maximum acceptable impurity levels specified</td>
<td>&lt;3% vol</td>
</tr>
<tr>
<td>10 ppmw</td>
<td>Mineral oil</td>
<td>10 ppmw</td>
<td></td>
<td>25 ppmw</td>
</tr>
<tr>
<td>Acidity expressed in HF:0.3 ppmw Hydrolysable fluorides expressed as HF:1.0 ppmw</td>
<td>Total gas decomposition products</td>
<td>Acidity expressed in HF:6 ppm vol</td>
<td>50 µl/l total or 12 µl/l for (SO₂+SOF₂) or 25 µl/l HF</td>
<td></td>
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</tbody>
</table>
2 - The AREVA T&D / AVANTEC Procedure for SF₆ Recovery & Recycling
Recycling of SF6 and its re-use

<< From cradle to cradle >>

<< From cradle to grave >>

Reclaiming + Analysis

Recycling

Destruction
Normal Current Interruption in SF₆

Reaction diagram showing the decomposition of stable products
Normal Current Interruption in SF₆

Scottsdale, AZ, December 1-3, 2004
3 - Gas Analysis
Gas analysis

Gas Phase Chromatography (GPC) at site.

AREVA T&D GPC and laptop
Characteristics of gas to be purified

Limits of the gas sample to be reclaimed (in ppmw):

- Acidity level less than 4,000 ppm
- Or/and non-condensable gases less than or equal to 7,500 ppm or CF₄ less than or equal to 1,000 ppm
Characteristics of gas

Gas Phase Chromatography at site

Scottsdale, AZ, December 1-3, 2004
### Characteristics of gas

**Example of result of an analysis**

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<tbody>
<tr>
<td><strong>Air (% v)</strong></td>
<td><strong>CF₄ (% v)</strong></td>
<td><strong>CO₂ (ppmv)</strong></td>
<td><strong>COS (ppmv)</strong></td>
<td><strong>SO₂ (ppmv)</strong></td>
<td><strong>SO₂F₂ (ppmv)</strong></td>
<td><strong>SOF₂ (ppmv)</strong></td>
<td><strong>S₂F₁₀ (ppbw)</strong></td>
</tr>
<tr>
<td>0.676</td>
<td>0.215</td>
<td>88</td>
<td>35</td>
<td>2270</td>
<td>/</td>
<td>2289</td>
<td>25</td>
</tr>
</tbody>
</table>

Scottsdale, AZ, December 1-3, 2004
Sample taking of liquid phase:

- checking of the purity,
- checking the acidity in terms of HF and CF$_4$ content,
- non-condensable gases

ANALYSIS AT RECLAIMING CENTER
METHOD USED BY AVANTEC
- The purity of SF$_6$ by the GPC Method.
- The water content (Karl Fisher method).
- Non condensable gases.
- Acidity in terms of HF.
Laboratories Analysis

The $S_{2}F_{10}$ content by the Perkin Elmer-Auto system XI (Turbochrom software).

- The non-volatile residues.

- The oil content by infrared absorption.

ANALYSIS AT RECLAIMING CENTER
METHOD USED BY AVANTEC
After the recycling of the gas, controls are processed in order to check if the gas purity is in accordance to standard IEC 60480 Ed. 2 (Oct. 2004) or better with the specification for technical grade SF$_6$, IEC 60376 Ed. 2. (to be published in 2005).
4 - Handling of the SF$_6$
Containers used specially for transport and for containing used SF₆ which may contain TOXIC and CORROSIVE impurities.

- Each container is tested every five years.
- Checking the filling ratio (70 bars filling ratio is 1.04 Kg/l.)
- Checking the filling weight and avoid overfilling.
Gas recovery unit in a GIS substation
Site Gas Recovery Units

Scottsdale, AZ, December 1-3, 2004
Transportation of used gas

Procedure for the Return of Packaging of used SF₆ to the Plant.
SULPHUR
HEXAFLUORIDE
USED

C - Corrosive

R 26/27/28 - Very toxic by inhalation, in contact with skin and if swallowed
S 7/9 - keep container tightly closed and in a well-ventilated place
S 38 - in case of insufficient ventilation, wear suitable respiratory equipment
S 45 - in case of accident or if you feel unwell, seek medical advice immediately
(show the label where possible)

T+ - Very toxic

UN 3308 : Toxic, corrosive liquefied gas, N.O.S
Contains : Sulfur hexafluoride - class 2
5 - SF₆ Gas Purification Techniques
- As a pre-treatment, when the content of non-condensable gases in SF₆ is too high (more than 7,500 ppm weight) a process of distillation has to be used by separation between the gas phases of air and SF₆.
- Then the purification process is run.
- Regeneration in the liquid phase.
- Polluted SF$_6$ is pushed with a pneumatic pump, then rises inside the process column, passes through adsorbents layers, filtered through a 5 microns filter and recovered.

- A valve allows a direct sampling to determine the purity level of the recovered gas.
SF₆ Gas Purification Techniques

SF₆ Gas Recycled
6 - Destruction & Assessment
- When the gas contains more than 4,000 ppmv of acidity, expressed in HF, is it too corrosive to be passed through the purification process.

- Also, when the SF$_6$ contains more than 7,500 ppmv of air, the efficiency of the process is very poor.

Gas must be destroyed.
- When the gas is heated above 1,000 ºC, SF$_6$ starts to dissociate into reactive fragments, mainly Hydrogen and Oxygen to form SO$_2$ and HF.

- At 1,200 ºC the gas is destroyed at 99%.

- Products of the reaction are removed by passing through a calcium hydroxide solution in order to neutralize the acids and form sulfates and fluorides.

Gas was destroyed.
- **Target:** to meet new standard IEC 60480 Ed. 2. and even better, the future IEC 60 376 Ed. 2.

- **Experience** shows that typical concentration of impurities is much better:

  Three years of experience have shown that several tens of tons of SF₆ gas have been processed with a total loss of less than 2 %.

- **Objective:** to reduce the losses to 0.5 %.
7 - Conclusions
Conclusions: Recycling

Environmental Advantage:
- Save energy
- Decrease need of new SF$_6$ gas
- Available purification on site (Reduce waste transportation)

FINANCIAL ADVANTAGE
Thank you for your attention.

Time for Questions.