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## UTILITY SERVICES AND TECHNOLOGIES- GAS ANALYSIS, MANAGEMENT, AND RECYCLING

# 1 - The Impact of SF<sub>6</sub> on the Environment



# Impact of SF<sub>6</sub> on the environment



**SF<sub>6</sub> GWP 22200**  
(IPCC 2001)



## SF<sub>6</sub> 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

# Life Cycle Assessment (LCA)



## LCA of medium voltage network:

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

***Ref: "Life Cycle Assessment: SF<sub>6</sub>-GIS technology for Power Distribution Medium Voltage" Study commissioned by ABB, AREVA T&D, EnBW Regional, RWE Energies, SIEMENS, SOLVAY.***

### LCA for High Voltage Network



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<sub>6</sub>-GIS technology for Power Distribution Medium Voltage" Study commissioned by ABB, EnBW Regional, RWE Energies, SIEMENS, & SOLVAY.*

## Electrical Initiatives to Reduce SF<sub>6</sub> Emissions

- Improvement of the Gas handling procedure.
- Systematic gas re-uses.
- Voluntary emission reduction programs.



## Electrical Industry Initiatives



WG B3.02 TF 01 “Guide to SF<sub>6</sub> Handling” then became “SF<sub>6</sub> Recycling Guide”. Brochure 234.



IEC Technical Report 61634 about “Use and Handling of SF<sub>6</sub> in HV Switchgear and Control gear. Under revision.

IEC 60 376 Under revision. (2005)

IEC 60 480 Ed 2. Oct. 2004



*IEC 60 376*

*IEC 60 480*

Evolution of the Standards

Improvement in SF<sub>6</sub> recovery  
and on site purification



*Gas recovery units*



User Analysis on Site

# Electrical Industry Initiatives

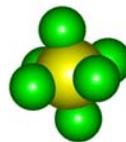


IEC 60376 Ed.1	Standard	IEC 60376 Ed. 2 (Proposal)	IEC 60480 Ed.1	IEC 60480 Ed.2	
				Rated absolute pressure <200kPa	Rated absolute pressure >200kPa
<0.05% w	Air and/or CF <sub>4</sub>	Air<1% vol CF4<0.4% vol	No maximum acceptable impurity levels specified	<3% vol	<3% vol
15 ppmw	H <sub>2</sub> O	25 ppmw		95 ppmw	25 ppmw
10 ppmw	Mineral oil	10 ppmw		10 ppmw	
Acidity expressed in HF:0.3 ppmw Hydrolysable fluorides expressed as HF:1.0 ppmw	Total gas decomposition products	Acidity expressed in HF:6 ppm vol		50 µl/l total or 12 µl/l for (SO <sub>2</sub> +SO <sub>F</sub> 2) or 25 µl/l HF	



## UTILITY SERVICES AND TECHNOLOGIES- GAS ANALYSIS, MANAGEMENT, AND RECYCLING

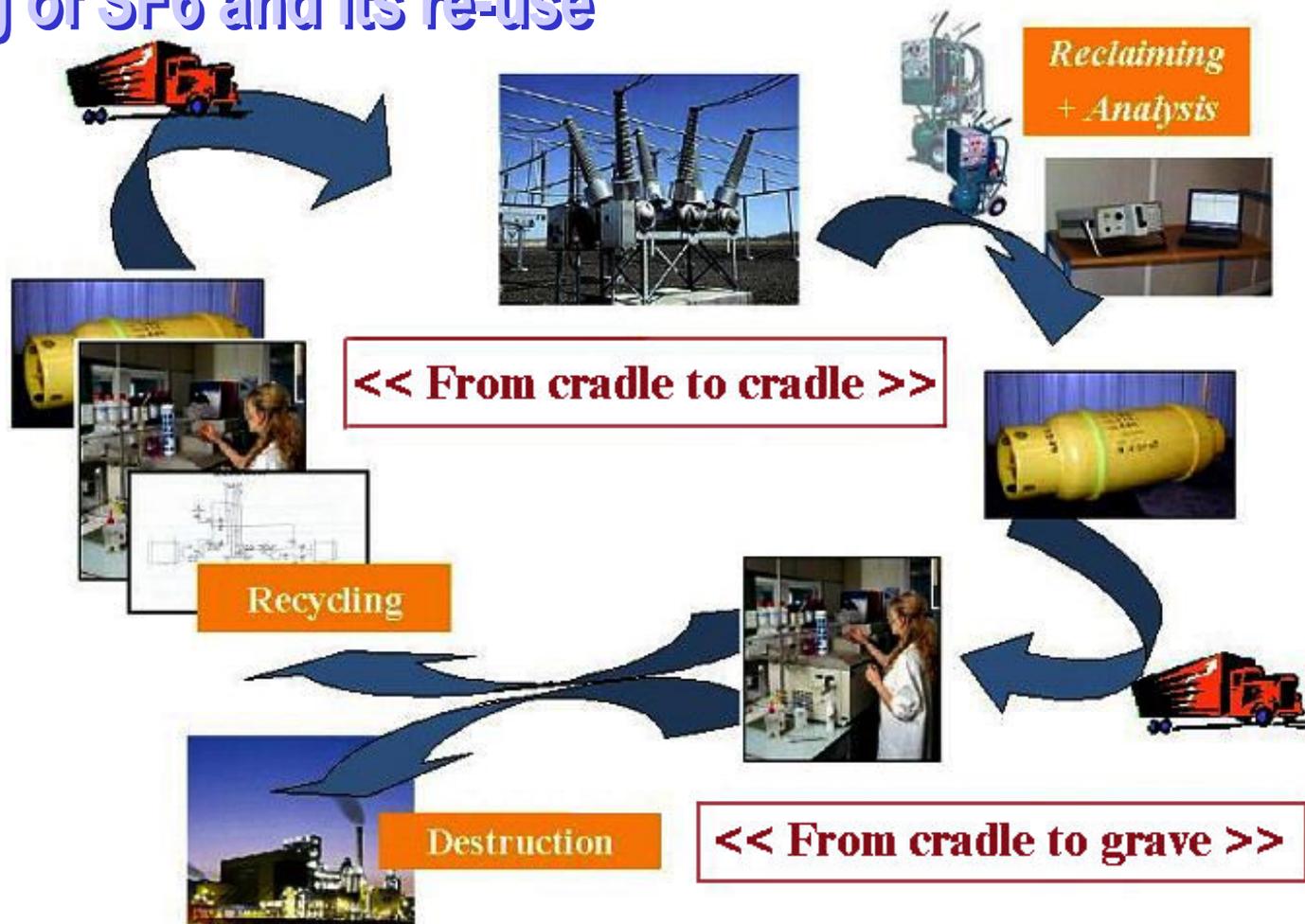
# 2 - The AREVA T&D / AVANTEC Procedure for SF<sub>6</sub> Recovery & Recycling



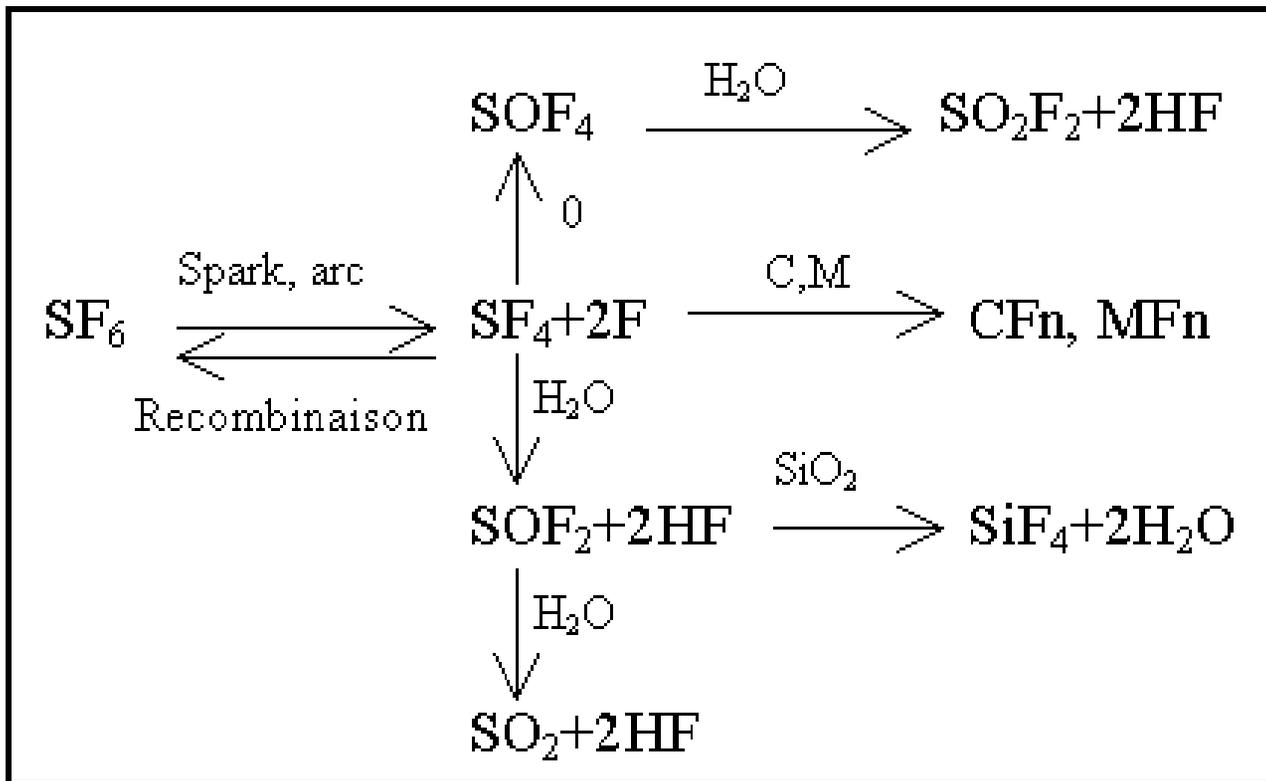
# AREVA T&D / AVANTEC Procedure for Recovery & Recycling



## Recycling of SF6 and its re-use

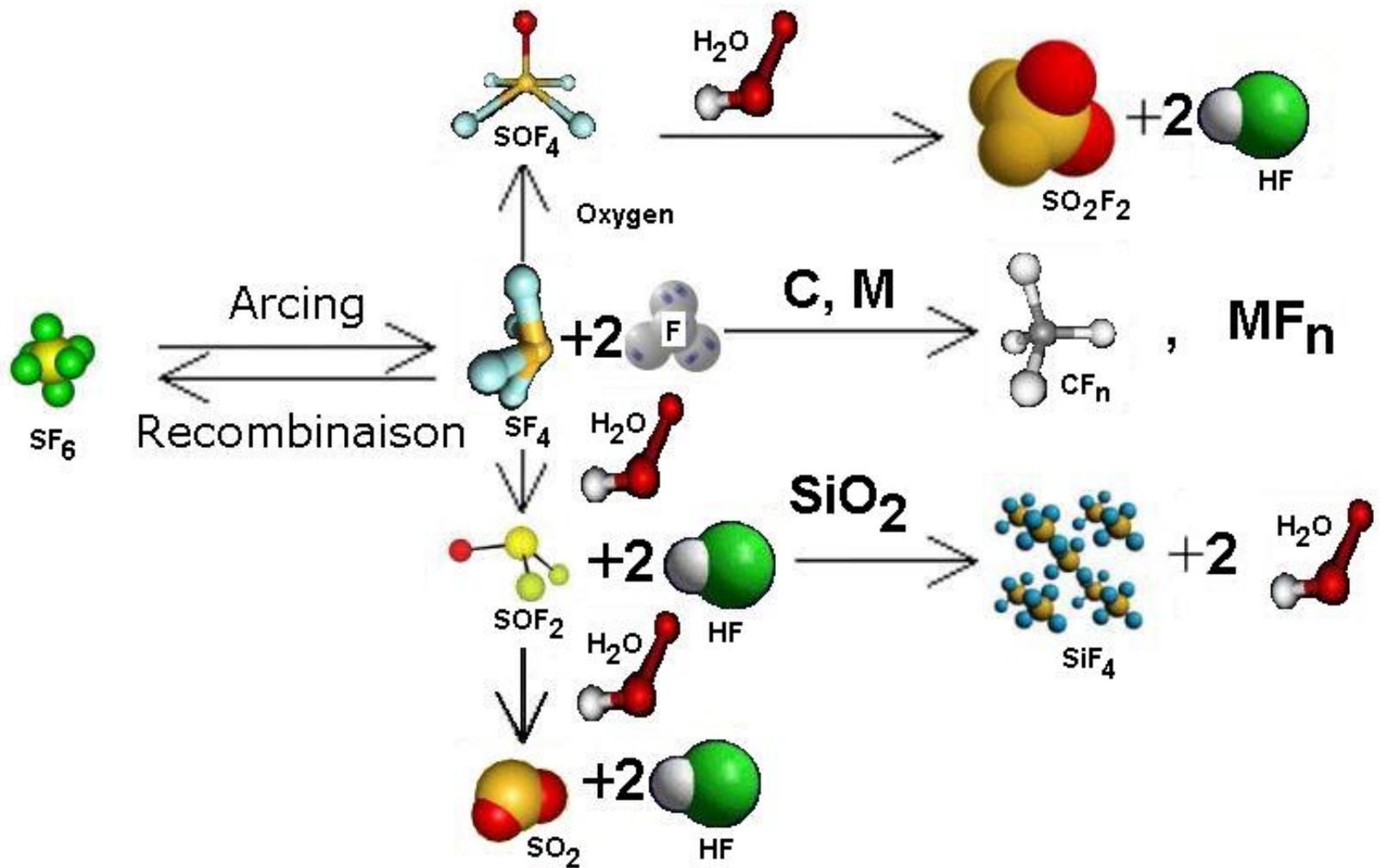


# Normal Current Interruption in SF<sub>6</sub>



**Reaction diagram showing the decomposition of stable products**

# Normal Current Interruption in SF<sub>6</sub>



# UTILITY SERVICES AND TECHNOLOGIES- GAS ANALYSIS, MANAGEMENT, AND RECYCLING

## 3 - Gas Analysis





**Gas Phase  
Chromatography  
(GPC) at site.**

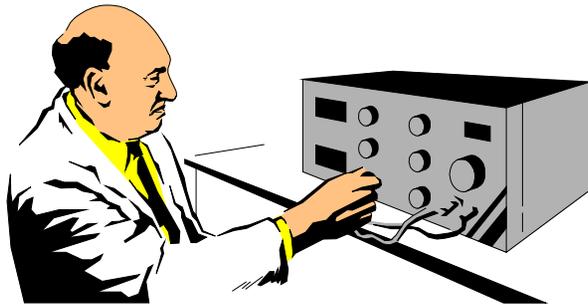
**AREVA T&D GPC and laptop**

## Characteristics of gas to be purified



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

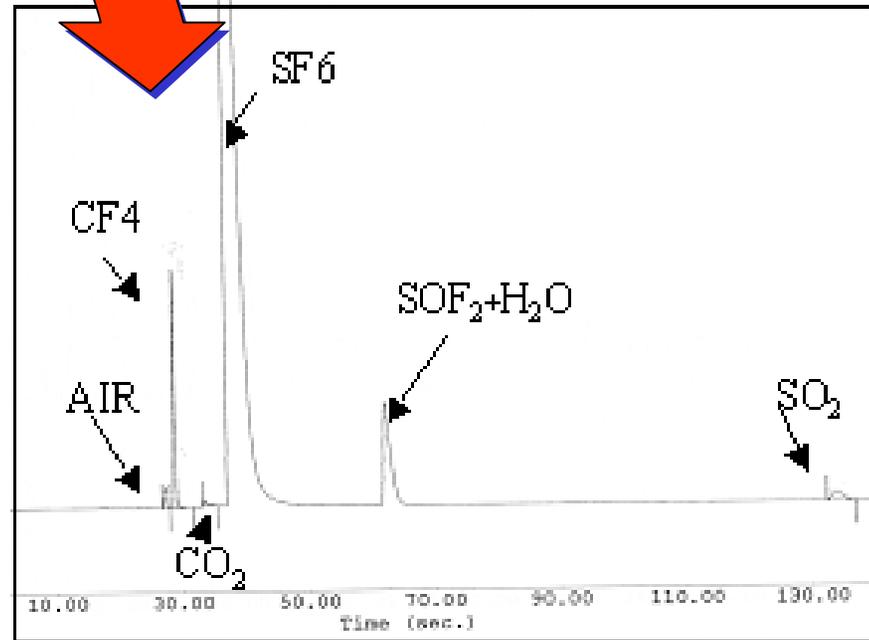
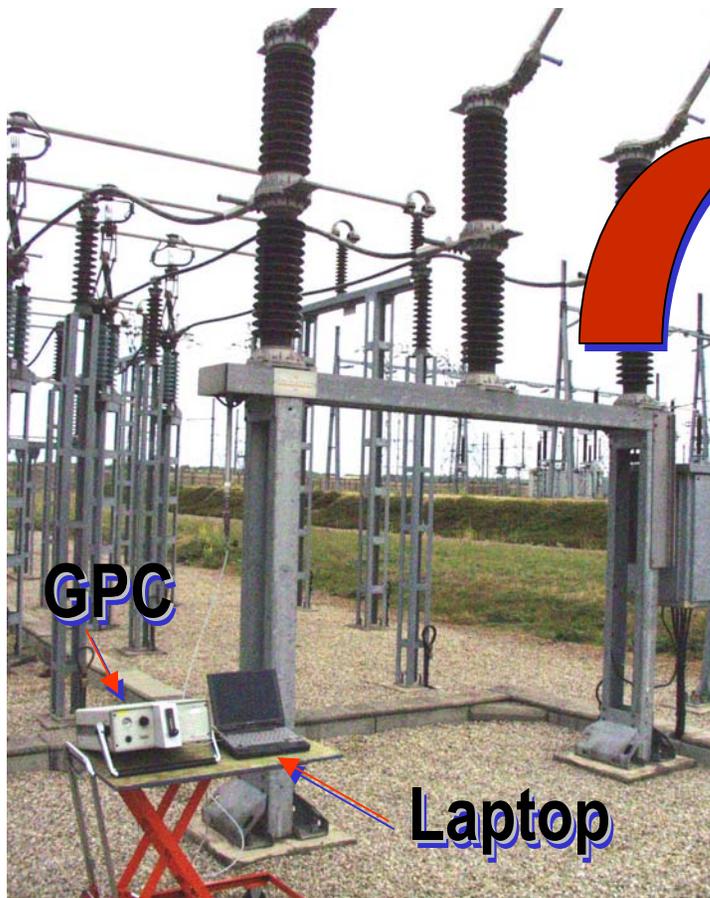
- Acidity level less than 4,000 ppm
- Or/and non-condensable gases less than or equal to 7,500 ppm or  $\text{CF}_4$  less than or equal to 1,000 ppm



# Characteristics of gas



## Gas Phase Chromatography at site



# Characteristics of gas



## Example of result of an analysis

Air (% v)	CF <sub>4</sub> (% v)	CO <sub>2</sub> (ppmv)	COS (ppmv)	SO <sub>2</sub> (ppmv)	SO <sub>2</sub> F <sub>2</sub> (ppmv)	SOF <sub>2</sub> (ppmv)	S <sub>2</sub> F <sub>10</sub> (ppbw)	Acidity (ppmv HF)
0.676	0.215	88	35	2270	/	2289	25	1200





## Sample taking of liquid phase:

- checking of the purity,
- checking the acidity in terms of HF and CF<sub>4</sub> content,
- non-condensable gases

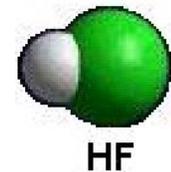
*ANALYSIS AT RECLAIMING CENTER  
METHOD USED BY AVANTEC*

- The purity of SF<sub>6</sub> by the GPC Method.
- The water content (Karl Fisher method).
- Non condensable gases.
- Acidity in terms of HF.



The  $S_2F_{10}$  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<sub>6</sub>, IEC 60376 Ed. 2. (to be published in 2005).**



## UTILITY SERVICES AND TECHNOLOGIES- GAS ANALYSIS, MANAGEMENT, AND RECYCLING

### 4 - Handling of the SF<sub>6</sub>



# Filling procedure for gas recovery containers

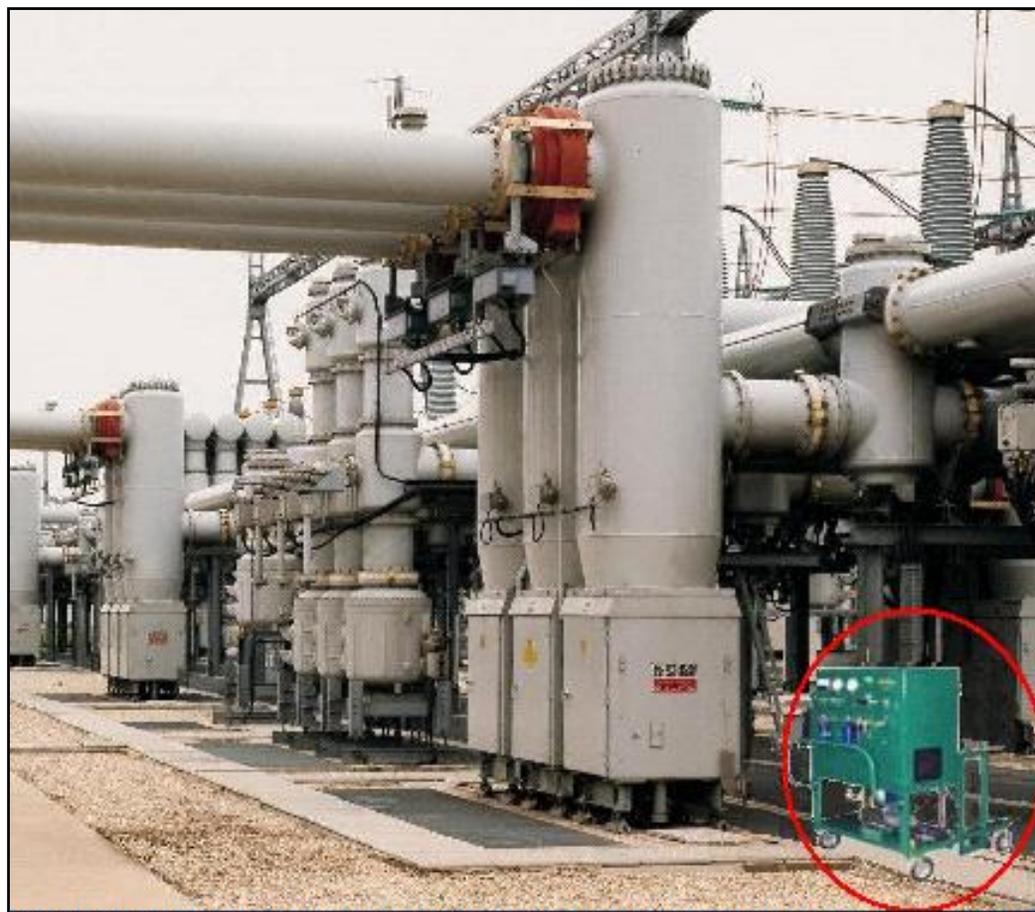


**Containers used specially for transport and for containing used SF<sub>6</sub> which may contain TOXIC and CORROSIVE impurities.**

- 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



# Transportation of used gas



## Procedure for the Return of Packaging of used SF<sub>6</sub> to the Plant.



## Label for Transport of used gas



**SULPHUR  
HEXAFLUORIDE  
USED**



**C - Corrosive**

**T+ - Very toxic**

- 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)

**UN 3308** : Toxic, corrosive liquefied gas, N.O.S

**Contains** : Sulfur hexafluoride - class 2

## UTILITY SERVICES AND TECHNOLOGIES- GAS ANALYSIS, MANAGEMENT, AND RECYCLING

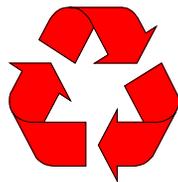
### 5 - SF<sub>6</sub> Gas Purification Techniques



# SF<sub>6</sub> Gas Purification Techniques



- As a pre-treatment, when the content of non-condensable gases in SF<sub>6</sub> 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 SF<sub>6</sub> .
- Then the purification process is run.
- Regeneration in the liquid phase.



# SF<sub>6</sub> Gas Purification Techniques



- Polluted SF<sub>6</sub> 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.



## SF<sub>6</sub> Gas Recycled



## UTILITY SERVICES AND TECHNOLOGIES- GAS ANALYSIS, MANAGEMENT, AND RECYCLING

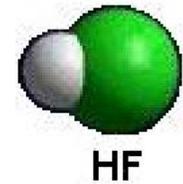
### 6 - Destruction & Assessment



# Destruction



- 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<sub>6</sub> contains more than 7,500 ppmv of air, the efficiency of the process is very poor.



**Gas must be destroyed.**



# Destruction



- When the gas is heated above 1,000 °C, SF<sub>6</sub> starts to dissociate into reactive fragments, mainly Hydrogen and Oxygen to form SO<sub>2</sub> and HF.



- At 1,200 °C 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.**

# Assessment



- **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 :

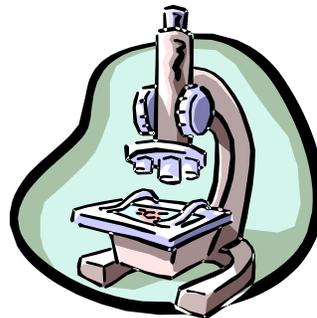
Three years of experience have shown that several tens of tons of SF<sub>6</sub> gas have been processed with a total loss of less than 2 %.

- **Objective:** to reduce the losses to 0.5 %.



# UTILITY SERVICES AND TECHNOLOGIES- GAS ANALYSIS, MANAGEMENT, AND RECYCLING

## 7 - Conclusions

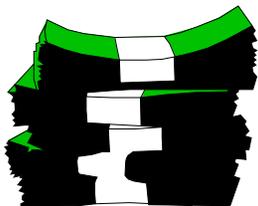


## Conclusions: Recycling

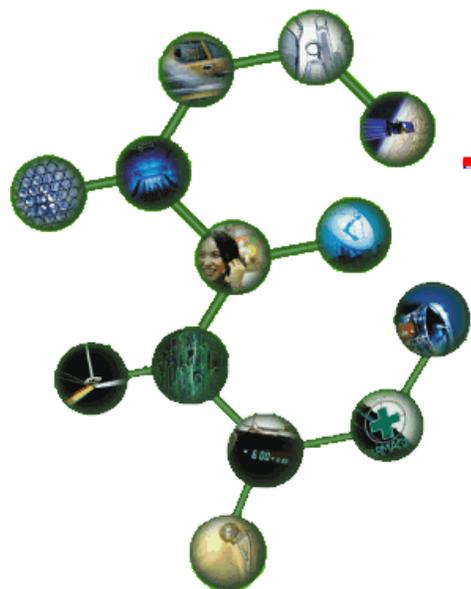


### Environmental Advantage:

- Save energy
- Decrease need of new SF<sub>6</sub> gas
- Available purification on site  
(Reduce waste transportation)



### FINANCIAL ADVANTAGE



**Thank you for your attention.**

**Time for Questions.**

