Overview

There are a number of applications where Rare Gases (Xe, Kr, Ne) are used, but not consumed.

Rare gas recovery offers the potential for reduced costs and increased security of supply.
Presentation Overview

Rare Gas Applications

Rare Gas Production

Recovery

Purification
Rare Gas Applications

248 & 193nm UV lithography
neon and small quantities of krypton

Excimer Lasers
UV emission from Rare Gas – Halide Dimers
• KrF (Kr, F2, balance Ne): 248 nm
• ArF (Ar, F2, balance Ne): 193 nm
Rare Gas Applications

Flat panel annealing
neon and xenon

Rare Gas Applications

Ion etch

krypton and xenon
Dry etch

xenon difluoride
# Rare Gas Production

Composition of Atmospheric Air (Volume %) with the air…

<table>
<thead>
<tr>
<th>Gas</th>
<th>Volume %</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₂</td>
<td>78.06</td>
</tr>
<tr>
<td>O₂</td>
<td>20.95</td>
</tr>
<tr>
<td>Ar</td>
<td>0.93</td>
</tr>
<tr>
<td>CO₂</td>
<td>0.033</td>
</tr>
<tr>
<td>Ne</td>
<td>0.0018</td>
</tr>
<tr>
<td>He</td>
<td>0.000524</td>
</tr>
<tr>
<td>CH₄</td>
<td>0.0002</td>
</tr>
<tr>
<td>Kr</td>
<td>0.00011</td>
</tr>
<tr>
<td>H₂</td>
<td>0.00005</td>
</tr>
<tr>
<td>N₂O</td>
<td>0.00005</td>
</tr>
<tr>
<td>Xe</td>
<td>0.0000087</td>
</tr>
<tr>
<td>O₃</td>
<td>0.000007</td>
</tr>
<tr>
<td>H₂O</td>
<td>1.57 (@ 50% RH &amp; 25°C)</td>
</tr>
</tbody>
</table>
It begins with the air… Gases are obtained through air separation.

Linde ASU Kazincbarcika, Hungary
Rare Gas Production

Neon Process Flow

Large Air Separation Unit (ASU) with neon column
Air intake > 150,000 m³/h or oxygen capacity > 30,000 m³/h

Crude Ne
50% Neon
20-25 %N₂
15-20% He
Rest H₂, O₂

Neon Separation

Pure Neon

1st enrichment
Separation
Rare Gas Production

**Krypton & Xenon Process Flow**

Large Air Separation Unit (ASU) with rare gases column

- Air intake > 150,000 m³/h or oxygen capacity > 30,000 m³/h

**Kr/Xe Enrichment**

- 99%

**Kr/Xe Separation**

- Pure Kr / Xe

1st enrichment  
2nd enrichment  
Separation
Rare Gas Production

From the source to customer

Tonnage ASU → Transport of Crude gas → Enrichment & Separation → Specialty Gases Production → Cylinder transport → Customer

TONNAGE  BULK  RARE GASES  SPECIALTY GASES  DISTRIBUTION
There are a number of applications where Rare Gases (Xe, Kr, Ne) are used, but not consumed. The used gas can be captured and purified.

Recovered Rare Gases can be repurified to meet the same purity specifications.

Unlike adding production capacity, recovery can often be done quickly and relatively inexpensively.
Rare Gas Recovery

Cryogenic Recovery
Rare Gas Recovery

Compressor System

- HIGH PRESSURE DIAPHRAGM COMPRESSOR PUMP (P-1)
- TURBO MOLE-DRAG VACUUM PUMP (P-3)
- LOW PRESSURE DIAPHRAGM ROUGHING PUMP (P-2)
Rare Gas Recovery
The Rare Gases can be purified using the same systems that produce the purified gases from air.
Rare Gas Purification

From the source to customer

1. **Tonnage ASU**
2. **Transport of Crude gas**
3. **Enrichment & Separation**
4. **Specialty Gases Production**
5. **Cylinder transport**
6. **Customer**

**SPECIALTY GASES TONNAGE**

**BULK RARE GASES**

**DISTRIBUTION**

**TONNAGE**

**RARE GASES**

**SPECIALTY GASES**

Collected Rare Gases
There are a number of applications where Rare Gases (Xe, Kr, Ne) are used, but not consumed. In these applications the used gases can be collected and purified. Rare gas recovery offers the potential for reduced costs and increased security of supply.
Thank you!

Questions?