Air Liquide acquires Lurgi: Integrating Technologies for the Gasification Industry

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Agenda

- The Air Liquide Group
- Why Air Liquide bought Lurgi
- Air Liquide Engineering today including Lurgi
- Air Liquide / Lurgi Technology portfolio for the Gasification market
  - Air separation
  - Gasification
  - Syngas purification
  - Final processing
- Conclusion: Integrated solutions adding value to gasification projects
The Air Liquide Group

- Founded in 1902,
- Present in 72 countries,
- 37,000 employees,
- 7 R&D centers: each year 200 patents registered,
- 1 million customers across various industries and healthcare activities
Focus on Technology

Integrated solutions: gas, associated products, and high value added services which are all centered on technological innovation

- Continuous investment in research:
  - Dedicated facilities in USA, France, Germany & Japan
  - close to 900 people

- Test facilities, pilot plants and collaborations
  - New inventions & process optimizations
  - 200 partnerships with industry, universities & research facilities

- Inventions, patents & processes
  - Air Liquide > 8800 patents
  - Lurgi > 80 innovative processes
Large Industries: an integrated industrial model for the supply of industrial gases

Operations

Project Development

Engineering & Manufacturing

Project Management

Gas supply to the Customer over-the-fence

Operational feedback leading to continuous improvement

Large Industries

AL Engineering

- Chemicals
- Metals
- Oil & gas
- Energy conversion

Customer gas needs and requirements

Lurgi
... world leading producer of air gases

- Facilities in operation, 2006
  - > 350 Air Separation Units
  - > 50 Hydrogen, CO and Syngas Units
  - > 20 Industrial Cogeneration Trains
  - > 5000 miles of pipelines
Air Liquide Strategic Goals in Acquiring Lurgi

- Support new growth ambitions of Large Industries World Business Line

- Widen and diversify our technology & product portfolio

- Enhance project execution capabilities
Air Liquide / Lurgi Technology portfolio for the Gasification market: Air Separation

Natural Gas
- Off gases
  - Sulfur Removal

Naphtha
- Preparation
  - Autothermal Catalytic Reforming

Heavy Residues
- Preparation
  - Air Separation
  - CO Shift Conversion

Coal
- Preparation
  - Gasification
  - Sulfur Removal
  - CO Cold Box
  - PSA

Biomass
- Pyrolysis
  - Sulfur Removal

Feedstock
- Preparation
- Syngas Generation
- Syngas Purification
- Final Processing
- Market

H2 Refineries
- Turbine

Power
- CO2

SNG
- Methanation

Fertilizers
- Nitrogen Ammonia

Synfuels
- Fischer Tropsch

Chemicals
- Methanol Synthesis

Sulfur
Leadership in Mega Air Separation Units

- Increase in scale is the result of 30 years of continuous R&D and Engineering work on:
  - Internal compression process
  - Radial bed front end purification
  - Proprietary distillation packing
  - Process control and integration

- World record: 4300 MT/D for SASOL (total of 15 ASUs for 40,000 tpd)

- World’s Largest Main Air Compressor

- World’s Largest Air Separation Unit: SASOL T15

- 3,900 MT/D O2 ASU for gasification of asphaltenes (Long Lake project)
### Select ASU for Gasification Reference List

<table>
<thead>
<tr>
<th>Project</th>
<th>Type</th>
<th>Oxygen (MT/D)</th>
<th>Contract Type</th>
<th>Gasifier</th>
<th>Start-up</th>
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Beyond innovating & optimized solutions, Air Liquide has a proven history of reliably supplying oxygen to gasification projects.
Air Liquide / Lurgi Technology portfolio for the Gasification market: Gasification

**Feedstock Preparation**
- Natural Gas
  - Off gases: Sulfur Removal
  - Heavy Residues: Preparation
  - Naphtha: Preparation, Autothermal Catalytic Reforming
  - Coal: Preparation, Gasification
  - Biomass: Pyrolysis

**Syngas Generation**
- Steam Catalytic Reforming
- Air Separation
- Gasification

**Syngas Purification**
- CO Shift Conversion
- CO2 Removal
- CO Cold Box
- PSA
- Sulfur Recovery

**Final Processing**
- PSA
- Turbine
- CO2
- Methanation
- Nitrogen Ammonia
- Fischer Tropsch
- Methanol Synthesis
- Sulfur

**Market**
- H2 Refineries
- Power
- SNG
- Fertilizers
- Synfuels
- Chemicals

World leader in industrial and medical gases
Gasification: Sasol- Lurgi FBDB references

2.2 S-L FBDB Gasification – Worldwide Deployments Update

USA
- Dakota Gasification Plant
  Beulah, North Dakota
  14 x FBDB Units, 22 years in Operation: 1985 – 2007
  Coal: Low Rank, Lignite
  Products: Substitute Natural Gas (SNG), Ammonium Sulphate, Phenols, CO₂ for Enhanced Oil Recovery

South Africa
- Sasol Sentech
  Secunda
  20 x FBDB Units
  Operation: 20 years, 1979 - 2000
  Coal: Low Rank, Sub-Bituminous
  Products: Syngas to FT Fuels, NH₃, Phenols, Anode Coke, Sulphur

China
- Shanxi-Tianji Coal Chemical Company
  Province: Shanxi
  5 x FBDB Units
  Coal: Anthracite
  Products: NH₃

China
- Yima Coal Gasification
  Province: Henan
  2 x FBDB Units
  Coal: Low rank, Sub-bituminous
  Products: MeOH

India
- Jindal Steel
  Coal Gasification
  350,000 Nm³/h of raw Syngas
  Products: DRI

Successful Deployment and Operation of 101 Sasol-Lurgi FBDB Gasifiers over 50 years, >20 million gasifier operating hours

Copyright©, Copyright Reserved, Sasol-Lurgi Technology Company (Pty) Ltd, 10 September 2007
Gasification: Multi Purpose Gasification (MPG®)

- **Client:** NorthWest Upgrader
- **Location:** Alberta, Canada
- **Plant:** MPG® and Rectisol®
Air Liquide / Lurgi Technology portfolio for the Gasification market: Syngas purification

**Natural Gas**
- Sulfur Removal

**Off gases**
- PSA

**Naphtha**
- Preparation
- Air Separation
- Autothermal Catalytic Reforming

**Heavy Residues**
- Preparation
- Gasification

**Coal**
- Preparation
- Gasification
- Sulfur Removal
- CO Shift Conversion
- CO2 Removal
- CO Cold Box
- PSA
- Sulfur Recovery
- PSA
- CO2 Removal
- CO2 Removal
- Sulfur Recovery
- PSA

**Biomass**
- Pyrolysis
- Sulfur Recovery
- PSA

**Feedstock**
- Preparation
- Syngas Generation
- Syngas Purification
- Final Processing
- Market

**Market**
- H2 Refineries
- Power
- CO2
- SNG
- Fertilizers
- Synfuels
- Chemicals
- Sulfur

**GTC Conference Oct/2007**

World leader in industrial and medical gases
Syngas purification: CO-Shift experience

- 133 CO-Shift Units built
- 18 Clean CO-Shift Units downstream of Oil Gasification
  - Total capacity 1.7 Mio Nm³/h syngas (=1 500 MMSCFD) (equivalent to 1.6 Mio Nm³/h hydrogen = 1 430 MMSCFD)
  - Largest train 190 000 Nm³/h syngas (= 170 MMSCFD) (equivalent to 173 000 Nm³/h hydrogen = 155 MMSCFD)
- 9 Raw Gas Shift units
  - Total capacity 1.9 Mio Nm³/h syngas (= 1 740 MMSCFD) (equivalent to 0.8 Mio Nm³/h hydrogen = 710 MMSCFD)
  - Largest train 470 000 Nm³/h syngas (= 420 MMSCFD) (equivalent to 160 000 Nm³/h hydrogen = 140 MMSCFD)
Client: Sasol S.A.
Location: Secunda, South Africa
Process: Rectisol
Licensor: Lurgi
Plant Capacity: 643,000 m³/h Feed Gas
Scope of Work: Extended Basic Engineering for new Absorber
Start-Up Year: 1995
Highlights: The largest absorber of the world
Diameter: 5.4 m
Height: 62 m
Syngas Purification: CO Coldbox

- Client: SIPCHEM Jubail Acetyls
- Location: Al Jubail, KSA
- Plant Capacity: 33,600 Nm³/h CO, 100,000 Nm³/h H₂
- Scope of Work: SMR + aMDEA® Membrane + CO Coldbox
- Start-Up Year: 2008
- Highlights: The largest CO coldbox in the world
## Syngas Purification: OxyClaus® Burner

- **Client:** Shell
- **Location:** Houston/TX, USA
- **Process:** Claus / Oxy Claus
- **Licensor:** Lurgi + TPC
- **Plant Capacity:** 200,000 t/a
- **Feedstock:** Sour Refinery Gas + Sour Water Stripper Gas
- **Scope of Work:** Basic and detailed Engineering and Supply
- **Start-Up Year:** 1995
- **Highlights:** First Oxy Claus® Burner in USA
Air Liquide / Lurgi Technology portfolio for the Gasification market: Final Processing

- **Natural Gas**
  - Off gases
    - Sulfur Removal
  - Steam Catalytic Reforming

- **Naphtha**
  - Preparation
  - Autothermal Catalytic Reforming

- **Heavy Residues**
  - Preparation
  - Air Separation

- **Coal**
  - Preparation
  - Gasification
  - Sulfur Removal

- **Biomass**
  - Pyrolysis

- **Feedstock Preparation**
  - Syngas Generation
  - Syngas Purification
  - Final Processing

- **Market**

**Final Processing**
- **PSA**
  - CO2 Removal
  - CO Shift Conversion

**Syngas Purification**
- **PSA**
  - Sulfur Recovery

**Syngas Generation**
- **Steam Catalytic Reforming**
  - Sulfur Removal

**Feedstock**
- H2 Refineries
  - Power
  - CO2
  - SNG
  - Fertilizers
  - Synfuels
  - Chemicals
  - Sulfur
Final Processing: Coal to Chemicals

- Clients: Shenhua Ningxia Coal Industry Group, Datang International Power Generation
- Location: China
- Lurgi’s 3-in-1 solution: Rectisol® / OxyClaus®, MegaMethanol®, MTP®
- Start-Up Year: 2008 & 2009

Datang, China 450,000 tpy (Poly) Propylene
Conclusion

- Integrated solutions for gasification projects
- Value recognized through collaborative development process
- Multiple processes engineered to work together
- Single contract with single-line responsibility
- The combined expertise, technology and operating experience of Air Liquide and Lurgi.

<table>
<thead>
<tr>
<th>Product Supply: over-the-fence</th>
<th>Equipment Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen, Nitrogen, Argon &amp; Rare Gases</td>
<td>✓</td>
</tr>
<tr>
<td>Hydrogen &amp; Carbon Monoxide</td>
<td>✓</td>
</tr>
<tr>
<td>Steam &amp; Electricity</td>
<td>✓</td>
</tr>
</tbody>
</table>

- Air Separation
- Syngas to Chemicals
- Gas Processing and Purification
- Cogeneration
- Petrochemical Processes
- Biodiesel and Bioethanol Production
Thank You

www.airliquide.com

www.lurgi.com