



ILC Cryogenic Plants Large Helium Refrigeration Plant Operating Experience

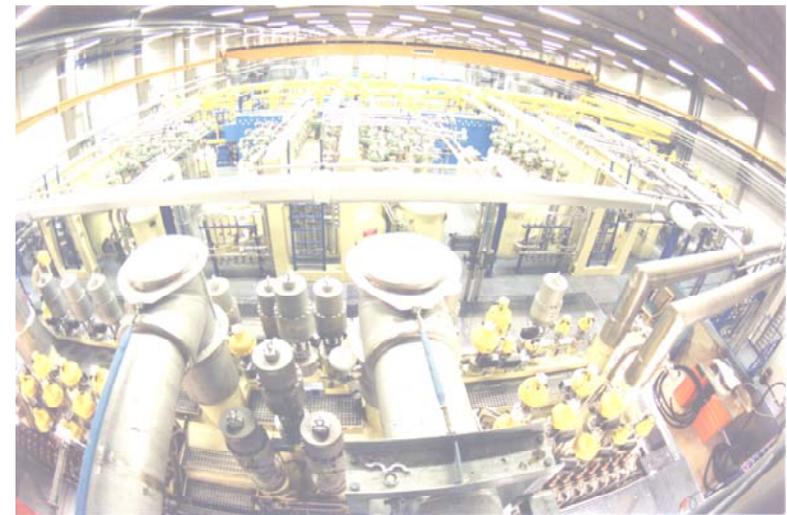
ILC--International Industrial Forums

Particle Accelerator Conference 2007
Albuquerque, NM

Richard Nolte, Jr.
June 28, 2007

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LARGE SCALE CRYOGENIC SYSTEM: HERA at DESY

AP/Linde Team Formed to Offer Cryogenics Own/Operate to ILC

- **AP/Linde team provides refrigeration services**
 - Distinct from sale of cryogenic equipment
 - Proven industrial way to lower cost and increase reliability
- **Air Products as the prime contractor brings helium supply and refrigeration system operation**
- **Linde as the subcontractor brings refrigerator/liquefier equipment**



ILC Cryogenic Team Fast Facts



Air Products

- **\$10 B global gases, chemicals, equipment and services provider**
- **Serving technology, energy, healthcare and industrial markets**
- **Large global helium supplier**
- **Operations in more than 30 countries**
- **>20,000 employees worldwide**
- **Known for our innovative culture and operational excellence**
- **Corporate safety, environmental and quality commitment to all stakeholders**

Linde Group

- **\$17 B global gases, process plants, equipment, and services provider**
- **Serving technology, energy, healthcare and industrial markets**
- **Large global helium supplier**
- **Operations in more than 70 countries**
- **>53,000 employees worldwide**
- **Leading process technologies**
- **Corporate safety & quality commitment to customers and employees**

Linde - Equipment Capabilities

Main activities

Helium Solutions

Purifiers, Liquefiers, Reliquefiers, Refrigeration System

Hydrogen Solutions

Purifiers, Liquefiers

Storage & Distribution Solutions

Distribution Systems, Storage Tanks, Dewars

Special Solutions

Special Cryogenic Plant Engineering

Customer Service Solutions

Installation, Maintenance, System Operation, Spare Parts

Air Products Brings Complementary Operating Capabilities

- Operates a third of world's liquefiers associated with helium production
- Designed and installed majority of crude helium extraction plants
 - e.g., Cliffside, TX (USBLM)
- CERN particle accelerator liquefier operating and management experience
 - Liquid helium and nitrogen supply
 - 20 people assigned to manage cryogenic services
- Currently managing GE's Florence, SC MRI manufacturing product supply and helium recovery
 - Liquid helium
 - Dewar helium
- Gardner Cryogenics (an APCI division) is the world's leading developer, designer and manufacturer of liquid helium storage and related equipment
- Built and operated the refrigeration system for General Dynamics' Hammond, LA facility for the SSC project



Air Products Worldwide Helium Network



Linde - Fabrication Facilities



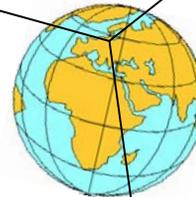
Fabrication Facility Tulsa, USA

- A total of approx. 97,000 m² of floor space
- Approx. 400 skilled craftsmen and engineers



Fabrication Facility Schalchen, Germany

- A total of approx. 80,000 m² of floor space
- More than 740 skilled craftsmen and engineers



Several Fabrication Facilities
by local suppliers

Linde Helium Solutions: USA

- **World's largest industrial helium liquefier at Liberal, Kansas (Air Products)**

Capacity:

- **3,500 l/h @ 4.4 K, with LIN pre-cooling**

Power input:

- **~2,600 kW**



APCI designs,
constructs and
operates our own
helium production
facilities in U.S. and
Algeria



Linde Helium Solutions: CERN

Large Scale Helium Refrigerator 18 kW for CERN - LHC

Cooling of superconducting
magnets and cavities

Installed Operating Mode

- 4,400W @ 4.5 K isothermal
- 20,700W @ 4.5-20 K cold compr.
- 55,400W @ 20-280 K current leads
- 33,000W @ 50-75 K radiation shield

Power input:

4,100 kW, approx.

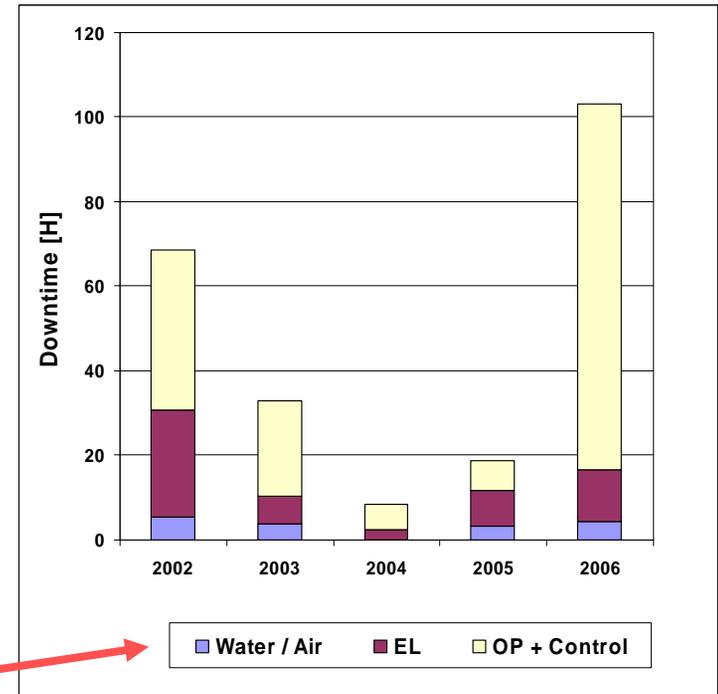
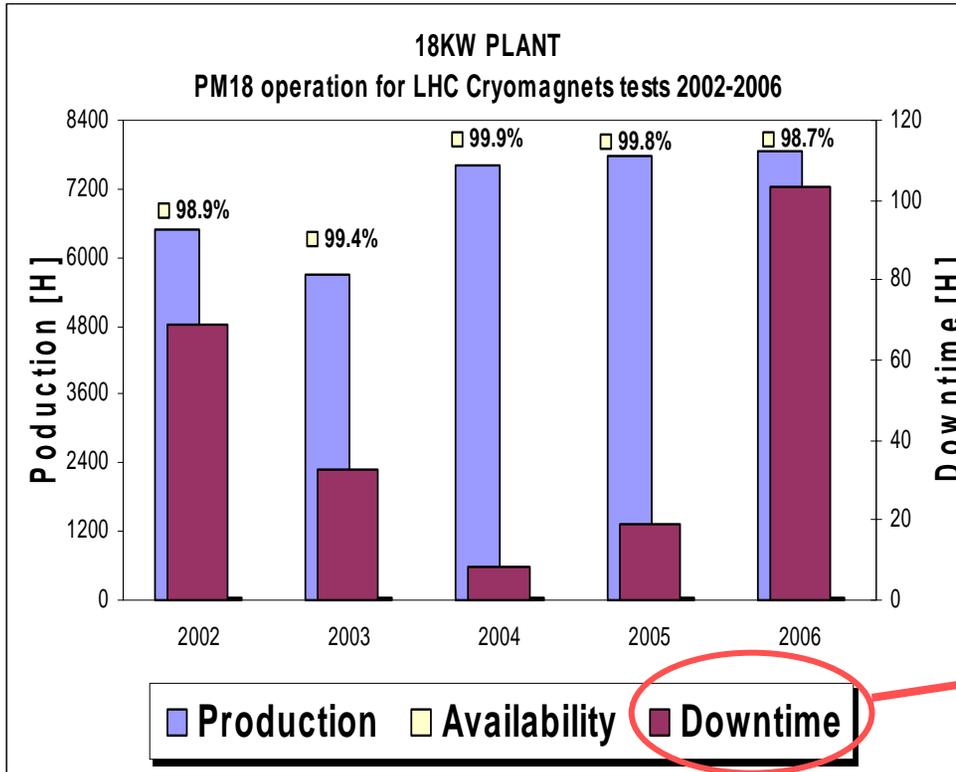
Expected He-Liquefaction
with LN₂-support is 5,800 l/h



Linde CERN Reliability

C169/LHC SERVICE CONTRACT

- Routine Operation
- Preventive / Corrective maintenance
- New Plants Commissioning



APCI equipment helps
safely deliver our products
to the point of use . . .

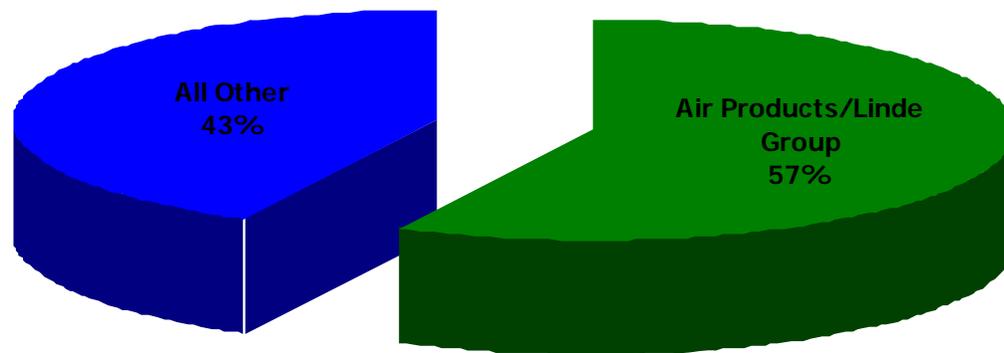


Gardner Cryogenics Container



Air Products and Linde: The Global Leaders in Helium

- **#1 production capacity share**
 - least dependent on 3rd party purchases
- **#1 manufacturer of helium production equipment**
 - APCI and Linde
- **#1 manufacturer of LHe containers**
 - Gardner Cryogenics
- **#1 manufacturer of LNG heat exchangers**
 - allows early insight into future helium availability



Production Capacity Shares

Remote monitoring with Air Products



Conceptual Approach for Supplying Refrigeration Services (Own/Operate)



- **Extension of our operating philosophy used at our own facilities**
- **Applications of these principles at our own plants has earned AP one of the best overall on-stream performance and safety records in the industry**
- **Applied at customer-owned facility with same results**

APCI Plant Reliability is 99+%

Statistical Data from Air Products owned and operated plants

	Lost Production (days/year)	Outages Frequency (# / year)
Scheduled Outages	4.3 (1.2%)	1
Unscheduled Outages		
0-6 hours	0.5	4
24-72 hours	1.5	3
24-72 hours	1	0.8
Total Unscheduled	3.0 (0.8%)	7.8
Total Outages	7.3 (2%)	8.8

APCI Helium Equipment Experience

<u>CUSTOMER</u>	<u>LOCATION</u>	<u>DESCRIPTION</u>	<u>YEAR</u>
RAS GAS/QATAR GAS	QATAR	HELIUM RECOVERY FROM LNG	2006
CLIFFSIDE REFINERS, L.P.	AMARILLO, TX	HELIUM ENRICHMENT UNIT	2001
BROOKHAVEN NL (RHIC)	BROOKHAVEN, NY	TRANSFER LINES	2000
DUKE ENERGY	BORGER, TX	CRUDE PLANT	2000
AIR PRODUCTS	LIBERAL, KS	LIQUID PLANT	1999
PIONEER NATURAL RESOURCES	FAIN, TX	CRUDE PLANT	1997
HELIOS	ARZEW, ALGERIA	LIQUID PLANT	1995
CRYOR	ORENBURG, RUSSIA	LIQUID STORAGE	1994
AIR PRODUCTS	LIBERAL, KS	LIQUID PLANT	1992
DUKE ENERGY	LIBERAL, KS	CRUDE UPGRADE	1990
AIR PRODUCTS	SHERMAN, TX	LIQUID PLANT	1985
AIR PRODUCTS	SHERMAN, TX	GAS/LIQUID PLANT	1982
INTERNATIONAL	RED ROCK, AZ	GAS/LIQUID PLANT	1980
CITIES SERVICE	ULYSSES, KS	GAS/LIQUID PLANT	1968
USBLM	EXELL, TX	CRUDE PLANT	1967
PHILLIPS PETROLEUM	SHERMAN, TX	CRUDE PROCESS ONLY	1963
KERR McGEE	NAVAJO, AZ	GASEOUS PLANT	1962
PHILLIPS PETROLEUM	DUMAS, TX	CRUDE PLANT	1962
NORTHERN NATURAL GAS	BUSHTON, KS	CRUDE PLANT	1962
CITIES SERVICE	ULYSSES, KS	CRUDE PLANT	1962
USBLM	KEYES, OK	GASEOUS PLANT	1959

Major APCI Service Agreements

<u>Plant</u>	<u>Location</u>	<u>Type of Agreement</u>
560 TPD O2 plant	AZ, USA	Technical Services Package
75 TPD O2 plant	Orange County Ca, USA	Operate and Maintain
Helium	Algeria	Operations and Maintenance assistance
Helium Purifier	Amarillo, TX	Technical Services Package
Helium liquefiers	CERN Switzerland	Operate and Maintain
N2 generator	UK	Maintain
220 TPD O2 / 100 TPD N2	NV, USA	Operate and Maintain
N2 Generator	UK	Preventative Maintenance
1100 TPD O2	NV, USA	Operate and Maintain
1400 TPD O2	NV, USA	Operate and Maintain
4 x Nitrogen Generators	Netherlands	Agreed rates
160 TPD O2	Houston TX, USA	Operate and Maintain
180,000 SCFH N2	CO, USA	Operate and Maintain
2800 TPD O2	Trinidad	Operate and Maintain + Admin services
Nitrogen generator	UK	Quarterly Audit
2100 TPD Oxygen Generator	Republic of South Africa	Operate and Maintain
1200 TPD Oxygen Generation	Malaysia	Technical Services Package
650 TPD Oxygen plant	AZ, USA	Operations and Maintenance Assistance
Oxygen generator	Shipboard generator	Operations and Maintenance Assistance
1600 TPD O2 Plant	Punta Arenas, Chile	Technical Services
3 N2 generators	NY, USA	Operate and Maintain

Own/Operate Approach

- **Remote Monitoring**
- **Operate/maintain facility at minimum cost with maximum reliability**
- **Continuously improve overall plant performance**
- **Capital improvements to increase efficiency and/or production**
- **Safety is our 1st priority**



Need for an Industrial ILC R&D Program

DOE/NSF Review: May 2007

Goal of this review... was to evaluate the R&D plan, milestones and resource needs for FY2007 and beyond, and to plan for U.S. activities relating to development of test infrastructure and industrial partnerships...

Gerry Dugan
GDE Americas Regional Director

Report of the ICR Committee: June 14, 2007

...essentially no funds have been available so far for industrial R&D...which will be a very important input for validating the costs assumed for a significant fraction of the ILC components. Also, industrialization can lead to competition and further cost savings....

International Cost Review Committee
ILC

Suggested Plan of Action for ILC Cryogenics



- **Begin early dialog (funded R&D engineering) with the industrial gas industry**
- **Utilize industry's experience/resources to move from reference design to engineering design**
- **Engage industry to refine current cost estimate**

APCI - Linde Value Added Summary: Our Team Brings Unique Capabilities

- **Linde Turbines and Cold Compression Equipment, Fabrication and Helium Solutions**
- **APCI Global Operations Organization**
- **Remote monitoring improves up-time**
 - 12 year management experience with 6000 assets
 - Fully staffed 24/7 real time data collection center
- **Best operating practices**
 - Helium conservation measures
 - Power conservation
 - Optimize manpower requirements
 - Maximize on-stream
- **Safety best practices**
- **Helium supply backup**
- **Financing expansions or upgrades**
 - Engineering, design and build skills



To Conclude

- **The Own/Operate industrial gas model:**
 - **A proven way to lower**
 - **capital costs**
 - **operation and maintenance costs**
 - **A proven way to increase**
 - **plant reliability and backup supply**
 - **safety best practices**



Thank you

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