Mustang Engineering, L.P.
Presentation to
LNG Interagency Working Group
Hercules, California
7 December 2006

LNG
Smart®
Air
Vaporization
Who is Mustang?

- Founded 1987 in Houston, Texas
- Joined Wood Group in 2000
- Engineering & project management
- Services for oil & gas and chemical industries

Mustang can take your project from Concept to Operations Support

- 20 consecutive years of growth
- Resources 3500+ Strong
- 4500 projects
- 300 clients
- One of Top Oil & Gas Engineers in the World
- Top 5 Engineering Company in USA
Mustang is a leading engineering firm, providing complete Engineering, Design, and Project Management services and technology to the domestic and international petroleum, chemical, and pharmaceutical industries.
Wood Group: Parent of Mustang

A global market leader in:
- offshore engineering
- subsea pipeline design
- mature field enhancement
- artificial lift
- industrial gas turbine services

- $3.0 bn sales in 2005
- 16,000 employees worldwide
- Operating from bases in 40 countries
Biographies

Ned Baudat
Director of Projects

- 40 yrs. of LNG & gas processing experience
- Process design, start-up, fabrication, project engineering & project management
- LNG liquefaction & regasification, refinery, gas liquids recovery, onshore & offshore
- Mustang since December 2003: LNG tech. & projects
- 17 yrs with Bechtel Global Gas: Project Director, Darwin LNG; Project Mgr., Atlantic LNG Trinidad
- Chemical Engineering degree Rice University
- Registered professional engineer in Texas
- Numerous patents - most recently LNG Smart® products for LNG liquefaction, storage & regas

Brad Hubbard
Technology & Project Development

- 31 yrs. project engineering & management of offshore oil & gas facilities, LNG, methanol, GTL.
- Mustang since March 2000: Developing offshore LNG regas & liquefaction technology
- 25 yrs. Amoco: Project Engr. Atlantic LNG Train; offshore gas & production, FPSOs
- Ocean Engineering degree Texas A&M University
- Registered professional engineer in Texas
- Patent for Floating LNG Regas & Liquefaction
Submerged Combustion Vaporizer (SCV)

- **Advantages**
  - Commonly used in US
  - Efficient heat transfer from fired gas
  - Each SCV sized for approx. 150mmscfd; New design for 200mmscfd

- **Disadvantages**
  - Operating Cost = 1.3% of send out rate used for fuel gas
  - 140 gpm of acid water - requires chemical treatment
  - Air emissions (CO, CO2, NOx)
Open Rack Vaporizer (ORV)

- **Advantages**
  - Commonly used in Japan, Korea
  - Relatively small footprint
  - ORV unit capacity = 0.22 bscfd

- **Disadvantages**
  - Sodium hypochlorite injection, Chlorine residual
  - Permitting issues in the U.S.
  - Water temp sensitive
  - Seawater quality restrictions / requirements
  - Reapply coating of tubes to prevent mercury corrosion every 3-4 years
  - Tubes need to be cleaned every 3 months
  - Not suitable for offshore floating applications
LNG Smart® Air Vaporization (SAV)

- Environment & emissions friendly
- Economical
- Equipment industry proven
LNG Smart® Air Vaporization Process*
(with Supplemental Heat System)

- LNG
- Warm Air 21°C (70°F) 80% RH
- Cool Air 7°C (45°F)
- Fresh Water 4.5°C (40°F)
- LNG Vaporizer
- KF Surge Tank
- KF Pump
- KF / Glycol Exchanger
- Pipeline Gas 4.5°C (40°F)
- Supplemental Heat System ~ 15% in California

* Patent Pending
Rendering of SAV air heaters in an onshore application. Each 3 fan unit is 14’ wide by 60’ long & mounted on a structure 40’ high.
SAV - environment & emissions friendly

• Safe for people & marine life; no seawater used
• Environmentally friendly intermediate fluids
• By-product ... clean, “fresh water”
• Reduced air emissions over Submerged Combustion Vaporizers (SCV)
SAV Monthly Efficiency vs Annual Composite Efficiency

Basis: 1.0 bscfd Send-out Rate
600 mmBTU/hr Heat duty for LNG Vaporization

Example for 87% Annual Composite Efficiency

- Monthly Efficiency
- Time Weighted Composite Efficiency
- Fuel Gas
SAV vs. SCV Emissions Example

_Basis:_ 1.0 bscfd send-out rate – 600 m2 BTU/hr heating requirements
California Coast location

<table>
<thead>
<tr>
<th>Vaporization System</th>
<th>Combustion %</th>
<th>NOx tons/yr</th>
<th>CO Tons/yr</th>
<th>CO2 Tons/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCV</td>
<td>100</td>
<td>83.6</td>
<td>62.1</td>
<td>276,860</td>
</tr>
<tr>
<td>Smarts® Air Vaporization (SAV)</td>
<td>13</td>
<td>10.9</td>
<td>8.1</td>
<td>35,992</td>
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</tbody>
</table>

Example for 87% Annual Composite Efficiency
## SAV Emission Reduction vs. SCV

**Basis:** 1.0 bscfd Send-out Rate

600 mmBTU/hr Heat duty for LNG Vaporization

<table>
<thead>
<tr>
<th>LNG Smart® Efficiency %</th>
<th>SCV Emissions</th>
<th>NOx tons/yr</th>
<th>CO tons/yr</th>
<th>CO2 tons/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>83.6</td>
<td>62.1</td>
<td>276,860</td>
<td></td>
</tr>
<tr>
<td>95%</td>
<td>4.2</td>
<td>79.4</td>
<td>3.1</td>
<td>59.0</td>
</tr>
<tr>
<td>90%</td>
<td>8.3</td>
<td>75.3</td>
<td>6.2</td>
<td>55.9</td>
</tr>
<tr>
<td>85%</td>
<td>12.5</td>
<td>71.1</td>
<td>9.3</td>
<td>52.8</td>
</tr>
<tr>
<td>80%</td>
<td>16.7</td>
<td>66.9</td>
<td>12.4</td>
<td>49.7</td>
</tr>
<tr>
<td>75%</td>
<td>20.9</td>
<td>62.7</td>
<td>15.5</td>
<td>46.6</td>
</tr>
<tr>
<td>70%</td>
<td>25.1</td>
<td>58.5</td>
<td>18.6</td>
<td>43.5</td>
</tr>
<tr>
<td>65%</td>
<td>29.2</td>
<td>54.4</td>
<td>21.7</td>
<td>40.4</td>
</tr>
<tr>
<td>60%</td>
<td>33.4</td>
<td>50.2</td>
<td>24.8</td>
<td>37.3</td>
</tr>
</tbody>
</table>
SAV Efficiency vs. Location

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Temp.</th>
<th>Average Humidity</th>
<th>% Efficiency (Fuel Gas Savings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jamaica</td>
<td>81°F</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>Lake Charles, La.</td>
<td>68°F</td>
<td>68%</td>
<td>89%</td>
</tr>
<tr>
<td>Long Beach, Ca.</td>
<td>64°F</td>
<td>65%</td>
<td>87%</td>
</tr>
<tr>
<td>Boston, Maine</td>
<td>51°F</td>
<td>64%</td>
<td>60%</td>
</tr>
<tr>
<td>Portland, Oregon</td>
<td>51°F</td>
<td>80%</td>
<td>65%</td>
</tr>
</tbody>
</table>
SAV – economical

**Yearly Fuel Gas Savings In millions US $**

- **Colder Air**
- **Warmer Air**

**Basis:**
- 1.0 bcf/d send out
- 600 mmbtu/hr to vaporize LNG

**SAV**e $27 MM / Yr

- **Caribou, ME**
- **Boston, MA**
- **California**

**LNG Smart® Air Vaporizer Efficiency (%)**

* vs. Submerged Combustion Vaporization
FACTS

- $\Delta P$ across coils same for full scale
- Fin fan unit size scale factor = 1/23
- Uses Potassium Formate & water solution for intermediate fluid
- 100% proven equipment
- Same intermediate fluid flow rate per tube
- Same air flow per tube
- Same coil configuration / arrangement
- Same coil diameter and length
• Trunkline, Lake Charles Enhancement Project
• 2.1 bscfd natural gas send-out, Air Vaporization
• 80,000 bpd NGL recovery unit, Btu control
• Scheduled to start up 2nd quarter of 2008
SAV Application on FSRU

Standard pump motors and valves

Uniquely designed fin-fan air exchangers

Standard heat exchangers and shell & tube vaporizers

Recognized Class Society linked codes & standards
Mustang Smart Air Vaporization 0.8 bcf/d send-out arranged on disconnectable LNG Carrier with Reinforced Membrane Tanks with 150,000 m³ storage
LNG Smart® Air Vaporization Summary

- LNG Smart® Air Vaporization - minimum fuel gas
- Reduces air emissions significantly
- Uses no sea water
- Horsepower requirements – comparable to SCV and ORV
- Area requirements comparable to SCV
- Suitable for onshore or offshore installations
- Condenses moisture from air – dehumidifier, defogger
- Cost savings over fuel gas burning systems
- Ambient temperature sensitive – supplemental heat required
Mustang Engineering

LNG Smart® Air Vaporization

... providing offshore and onshore regasification solutions