Reducing Methane Emissions from Wet Seal Centrifugal Compressors,
Replication of Projects Identified by Methane to Markets:
The Case of Compressor Dry Seals in PEMEX

Pemex Gas and Basic Petrochemicals
Division of Production

March 2010
THE CASE OF COMPRESSOR DRY SEALS IN PEMEX

CONTENIDO

1. - PEMEX Positioning
2. - Environmental Performance
3. - M2M - PGPB Collaboration
4. - Success Case
5. - Leak Detection and Measurement
6. - Migration from M2M to CDM Project
7. - Conclusions
Petróleos Mexicanos (Pemex) is a decentralized government agency that is solely responsible for carrying out strategic activities in the field of hydrocarbons which are reserved in the Mexican Constitution. Based on the guidelines set forth by the Secretary of Energy, Pemex performs its activities for the purpose of maximizing the economic value of hydrocarbons for the country in harmony with both the community and the environment.

- **Pemex is the largest company in Mexico and Latin America and the country's largest taxpayer**
- **Total production of liquid hydrocarbons was 3,486 Mbd (including crude oil and liquefied natural gas) and 6,058 MMpcd of natural gas**
- **Exports for 2007 were 1,686 Mbd of crude oil, 139 MMpcd of natural gas, 176 Mbd of petroleum products and 746 Mt of petrochemicals**
- **The amount of total sales increased 2.9% in respect to 2006, to approximately $1,136 billion pesos ($104.5 billion USD)**

**Pemex promotes development in Mexico**
Pemex is one of the main generators of economic value for Mexicans. The company creates and distributes the value generated during its production chain in its different forms. During 2007, total sales increased 2.9% in relation to 2006, reaching $1,136 billion pesos ($104.5 billion USD). Sales in the country rose 4.4% and exports rose 1.2% compared with 2006.
**PGPB Positioning inside Pemex**

**Pemex - Gas and Basic Petrochemical (PGPB):** processes natural gas and develops basic petrochemical products and liquefied gas in its nine Gas Processing Centers (CPG) in the states of Tamaulipas, Veracruz, Tabasco and Chiapas, and is responsible for transporting and marketing these products.

**PGPB Facilities**

**Positioning inside Pemex Group**

Pemex Gas has generated 18% of total profits in the Pemex Group.

- Pemex Gas: 18%
- Pemex Petrochemical: 2%
- Pemex Refining: 27%
- Pemex Exploration & Production: 53%
In 2008, Pemex Gas registered income of 20 billion USD, reaching 11th place in Latin America, and 5th place in México.

PGPB generated nearly 18% of the total profits of Petróleos Mexicanos.

With these numbers, the per capita income of PGPB reached 1.9 million USD.

http://www.gas.pemex.com/PGPB/Conozca+Pemex+Gas/Semblanza/Posicionamiento/
2.- ENVIRONMENTAL PERFORMANCE

One of the challenges Pemex faces consists of making compatible the production of oil resources with the natural environment's conservation and restoration processes, and with the resources found in the communities that surround its operation centers. Pemex expects to invest approximately $7 billion USD between 2007 and 2012 on its environmental development strategy.

Climate change
Pemex generates close to 6% of the nation's greenhouse gas (GHG) emissions. The strategy to reduce GHG gas emissions is focused on improving energy efficiency, co-generation and use of methane, and to register Clean Development Mechanism (CDM) projects.

Petróleos Mexicanos Sustainable Development Report
This annual report provides useful, objective and straightforward information on Pemex's activities. It was produced with the participation of an independent group of citizens with experience in the issues covered by this report. This citizen group formulated questions on the report and queried Petróleos Mexicanos on its activities. This publication complies with the indicators set forth in the Global Reporting Initiative (GRI). It is with great satisfaction that Pemex presents the first Mexican GRI Application Level A+ report, the highest level possible awarded by this initiative. Moreover, the Report meets the guidelines of the United Nations Organization Global Compact for communication in progress.
### Main initiatives and organizations that involve Pemex participation

<table>
<thead>
<tr>
<th>Initiatives</th>
<th>Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>UN Global Compact</td>
<td>Comisión de Estudios del Sector Privado para el Desarrollo Sustentable (CESPEDES).</td>
</tr>
<tr>
<td>Extractive Industries Transparency Initiative (EITI) - Board Member</td>
<td>Association of Petroleum and Gas Companies of Latin America and the Caribbean (ARPEL)</td>
</tr>
<tr>
<td>Methane to Markets (M2M)</td>
<td>International Maritime Organization (OMI)</td>
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<td>GHG emission Program in Mexico</td>
<td>The International Fuel Quality Center (IFQC)</td>
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<tr>
<td>Kyoto Protocol (CMD)</td>
<td>Chemical Distribution Institute (CDI)</td>
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<td></td>
<td>Oil Companies International Marine Forum (OCIMF)</td>
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<td></td>
<td>European Barge Inspection Scheme (EBIS)</td>
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<tr>
<td></td>
<td>International Association of Independent Tanker Owners (Intertanko)</td>
</tr>
<tr>
<td></td>
<td>International Tanker Owners Pollution Federation (ITOPF)</td>
</tr>
</tbody>
</table>
3. M2M – PEMEX GAS COLLABORATION

List of projects performed to date under the M2M – PEMEX Gas collaboration:

- **August 2006** – Cactus, Ciudad PEMEX and Nuevo PEMEX GPCs. Fugitive emissions identification and quantification measurements.
- **October 2007** – Cactus, Ciudad PEMEX y Nuevo PEMEX GPCs. Post-repair/rehabilitation measurements from valves, etc.
- **August 2006** – Ciudad PEMEX GPC. Fugitive emissions measurement from compressors with wet seals (can be used as a baseline for a CDM project)
- **October 2007** – Ciudad PEMEX GPC. Post-implementation measurement from dry seals on compressors
- **October 2007** – Nuevo PEMEX GPC. Integrated methane emissions and energy diagnostic.
- **February 2008** – Poza Rica GPC. Integrated methane emissions and energy diagnostic.
- **December 2008** – Burgos GPC. Integrated methane emissions and energy diagnostic
M2M has supported PGPB in the evaluation of the benefits of converting wet seals to dry seals in centrifugal compressors in south Mexico facilities (Ciudad Pemex CPG).

The prefeasibility study included:

- Preliminary estimations of benefits
- Methane emissions reductions in wet seals
- Adjustment of preliminary estimates
- Project economic evaluation
- Final measurements

**Decision Making**

**Step 1:** Identify Best Practices
- Identify prospects for wet seals replacement

**Step 2:** Estimate dry seal conversion savings

**Step 3:** Determine dry seal conversion cost

**Step 4:** Savings vs. Costs Comparison
Based on industry’s information* it has been identified that typically 80% of methane emissions in natural gas compression stations originate at the compressor, particularly when equipped with wet seals.

In this wet seal compressors, buffer oil degassing may vent 40 to 200 SCFM of gas to the atmosphere.*

Dry seal technology offers, within certain application limits, a technically and economically feasible alternative to reduce these emissions.

70% of PGPB’s Production Subdivision compressors are equipped with wet seals.

* Source: “Replacing wet Seals with Dry Seals in Centrifugal Compressors” (EPA430-B-03-012)
Comparison between Wet Seals and Dry Seals on Compressors

The verification of the results indicated a Emissions Factor Reduction of 43.09 SCFM

Emission Factor by compressor: Before

<table>
<thead>
<tr>
<th>Component category</th>
<th>Emission factor (SCFM)</th>
<th>Emission factor (Mcf/yr)</th>
<th>Emission Factors by cost $/yr@US$6/Mcf</th>
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</thead>
<tbody>
<tr>
<td>Seals</td>
<td>43.11</td>
<td>22,654</td>
<td>US $135,924</td>
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</table>

After

<table>
<thead>
<tr>
<th>Component category</th>
<th>Emission factor (SCFM)</th>
<th>Emission factor (Mcf/yr)</th>
<th>Emission Factors by cost $/yr@US$6/Mcf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seals</td>
<td>0.02</td>
<td>10.15</td>
<td>US $63</td>
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</table>
The leak detection was carried out according to Method 21 of United States EPA (1997) that permits using infrared chambers, VOC chambers or hand-held gas detectors of gas hydrogen (Bascom-Turner Gas Sentry CGI-201, CGI-211 o GMI Gas Surveyor3).

UNFCCC approved technologies to detect and measure leak flow rates*

**To Detect**
- Electronic Screening
- Acoustic Leak Detection
- Organic Vapor Analyzers (OVAs) and Toxic Vapor Analyzers (TVAs)

**To Quantify**
- High volume or hi-flow samplers
- Bagging techniques
- Rotameters
- Ultrasonic flow meters

* Leak reduction from natural gas pipeline compressor or gate stations, CDM – Executive Board AM0023 / Version 02

Leak measurement provided by M2M is consistent with the requirements of the Kyoto Protocol.
The success of the Dry Seals Project of Ciudad Pemex, permitted his replicability to others PGPB facilities.

The measurement results of October 2007 carried out by M2M, were taken as Base Line of a new Dry Seals Project for 15 aditional compressors at Nuevo Pemex and Poza Rica CPG’s. According to the CDM Methodology, PGPB has developed the required steps for the new Project:

<table>
<thead>
<tr>
<th>Description</th>
<th>Dates</th>
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<tbody>
<tr>
<td>PIN</td>
<td>October 07</td>
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<tr>
<td>No Objection Letter</td>
<td>November 07</td>
</tr>
<tr>
<td>Letter of Intention</td>
<td>January 08</td>
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<tr>
<td>Stakeholders consult</td>
<td>November 08</td>
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<td>PDD</td>
<td>January 09</td>
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<td>CICC Approbation</td>
<td>March 09</td>
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<td>ERPA signature</td>
<td>April 09</td>
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<td>PDD Validation on site</td>
<td>May 09</td>
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<td>PDD Validation doc.</td>
<td></td>
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<tr>
<td>Monitory Plan</td>
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</tbody>
</table>

**Documentation**

- PIN Elaboration
- PDD Validation (a third party authorized)
- PDD Elaboration
- PIN Validation by Comité de Cambio Climático del Sector Energía (CICC): Adicionality and Sustainable Development
- PIN Approbation by CICC: No objection Letter about PIN
- Letter of intention signature: PGPB with a third party

**Certification**

- Register in Executive Board (UNO)
- Verification of emission reductions (a third party authorized)
- Expedition of certificates of emission reductions by Executive Board (UNO)

**Bonds Comercialization**

- PIN: Project Idea Note
- PDD: Project Detailed Document
- CICC: Comisión Intersecretarial de Cambio Climático presidida por la SEMARNAT (SE, SEDESOL, SENER, SCT, SAGARPA y SER)
Migrating from M2M Project to CDM Project?

M2M Project

- Identify Best Practices M2M
- Use Approved Methodology
- Make previous measurement
- Project Implementation

CDM Project

- UNFCC Approved Methodology
- Subject Project: Emission Reductions

CDM Guidelines
7.- CONCLUSIONS

One of the top strategic priorities of PEMEX Gas and Basic Petrochemicals Production Subdivision is the technological modernization of its installations in compliance with Quality, Safety, Health, Environmental Protection, Sustainable Development and Added Value (AVA) policies, therefore, this project meets all established premises.

Methane to Markets support has been and will prove fundamental to ratify the project’s potential, verify real life situations and assess its replication at all PEMEX gas compression facilities.

Based on our findings, these activities have also a high replication potential in all Gas Processing Complexes, with the added feature that only a fraction of the potential was estimated, so the real, global potential could be significantly higher.

In this particular case of compressor seals, the potential for project replication in other PEMEX divisions must be affordable, so the final benefits from the program to the Corporation could be more than attractive.

PGPB reiterates its commitment to sustainable development by carrying out these important initiatives: M2M and CDM Projects contribute to the efforts to prevent climate change.
Pemex Gas and Basic Petrochemicals

Production Subdivision

¡Thank-You!

Ing. Martha Palomino Ramírez mpalomino@gas.pemex.com Tel. +52(993)3103500 Ex. 30242