QUANTIFYING LOSSES FROM CAST IRON NETWORK
AND ALTERNATIVES FOR THE RENEWAL

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Comgas is the **largest natural gas distribution company** in Brazil.

Its concession region concentrates **27%** of Brazilian GDP, **35%** of energy demand nationwide, **29 million** people, **8 million** homes and **9 million** vehicles.

Comgas distributes **30% of natural gas volumes** nationwide with **13 million m³ / day** in **67 cities**.

**6,700 km** of natural gas network.
Its controlling shareholders are **BG Group and Shell**

**Workforce with 5,000 people** as direct employees and contractors

**930,000 customers**

**100,000 new customers** to be connected every year.

**Focus on residential customer connection** in existing gas network areas and peripheral areas.
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**COMGAS NATURAL GAS DISTRIBUTION NETWORK**

OLD MAINS. Comgas doesn’t expand the cast iron any more.

<table>
<thead>
<tr>
<th>Network Material</th>
<th>Network extension [km]</th>
<th>% of Total</th>
</tr>
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<tbody>
<tr>
<td>CAST IRON</td>
<td>627.0</td>
<td>10.5%</td>
</tr>
<tr>
<td>STEEL</td>
<td>1,978.1</td>
<td>33.1%</td>
</tr>
<tr>
<td>POLYETHYLENE</td>
<td>3,379.3</td>
<td>56.5%</td>
</tr>
<tr>
<td><strong>TOTAL MAINS</strong></td>
<td><strong>5,984.4</strong></td>
<td><strong>100.0%</strong></td>
</tr>
<tr>
<td><strong>TOTAL SERVICE LINES</strong></td>
<td><strong>724.1</strong></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL SERVICE LINES</strong></td>
<td><strong>6,708.5</strong></td>
<td></td>
</tr>
</tbody>
</table>
COMGAS CAST IRON NETWORK HISTORY

• It is about **50 years** old.

• Mainly located in the **old downtown of Sao Paulo** city

• During the 90’s, the **process of conversion** from town (naphtha) gas to natural gas was started

• From this period, the level of **escapes** in the cast iron network **increased**

• These escapes are related to **dehydration of the joints** due to the higher dryness levels of natural gas, when compared to town gas

• Another sources of escapes in cast iron network is related to **fractures** and also **higher pressure** of natural gas compared to town gas.
1) Field data collection by renewal department – before the renewal

- Blocking of the gas pipeline before the renewal operation (including all the valves)
- Manometers installation
- Pressure and period data collection (every 2 minutes for at least 12 minutes)
2 - Filling out the form and sending to Comgas Control Room

<table>
<thead>
<tr>
<th>Period</th>
<th>Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_0$</td>
<td>$P_0$</td>
</tr>
<tr>
<td>$T_1$</td>
<td>$P_1$</td>
</tr>
<tr>
<td>$T_2$</td>
<td>$P_2$</td>
</tr>
<tr>
<td>$T_3$</td>
<td>$P_3$</td>
</tr>
<tr>
<td>$T_n$</td>
<td>$P_n$</td>
</tr>
</tbody>
</table>

Gas pipeline data
- Operation pressure
- Diameter
- Pipeline length
3 - Pipeline volume calculation (V1)

- Just one pipe diameter:

\[ V_1 = \frac{\pi \cdot D^2 \cdot L}{4} \]

- Two pipes diameters:

\[ V_1 = V_A + V_B = \frac{\pi \cdot D_A^2 \cdot L_A}{4} + \frac{\pi \cdot D_B^2 \cdot L_B}{4} \]

EXAMPLE

<table>
<thead>
<tr>
<th>Extensão</th>
<th>99.8 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diâmetro</td>
<td>6 pol</td>
</tr>
<tr>
<td>Volume da Tubulação</td>
<td>1,8205 m³</td>
</tr>
</tbody>
</table>

Pipeline volume
4 - Escaped volume calculation related to the period - Balanced volume (V0):

\[ V_0 = \frac{P_1 \cdot V_1}{P_0} \]

- \( V_0 \) data tabulation related to the period \( t_0, t_1, t_2, \ldots, t_n \);
- \( \Delta V_0 \) calculation \( (V_0 \ t_{n+1} - V_0 \ t_n) \);
- Escaped volume = \( \Sigma \Delta V_0 \).
5 - ) Plot the escaped volume $X$ period

6 - ) Derivative – to obtain the gas flow formula

\[
\frac{dV}{dt} = \frac{d}{dt} \left( -0.0001 \cdot t^2 + 0.0029 \cdot t + 0.0002 \right) = -0.0001 \cdot t + 0.0029
\]
7 - ) For $t = 0$ ➔ Maximum gas flow

When the pressure is the operational pipe pressure

$$\frac{dV}{dt} \bigg|_{t=0} = Q' = 0,0029 \, \text{m}^3 / \text{min}$$

In a regular operation, the internal pipe pressure is invariable, so $Q'$ can be considered in the study.

8 - ) Average escape rate

$$Q = \frac{Q'}{\text{Pipe length}} \, [\, \text{l} / \text{m}^*\text{h} \, ] \Rightarrow Q = \frac{0,0029 \bullet 60 \bullet 1000}{99,8} = 1,7435 \, \frac{\text{l}}{\text{m} \bullet \text{h}}$$

• The more measurements are made, the more the database will be !!

• The database of all measurements made can be extrapolated to all the cast iron network, excluding “the points outside the curve”
These values average are used by Comgas to quantify the losses from cast iron network.

Today:

\[ Q = 1,625 \frac{l}{m \cdot h} \]

or

\[ Q = 809,216.8 \frac{scf}{mile \cdot year} \]

Database: 950 values

LUAG Estimation = Q * Network length
The primary component of natural gas, the metane, is a powerful greenhouse gas.

Natural Gas is over 20 times more powerful than the carbon dioxide (CO₂) !!

Alternatives to mitigate risks of escapes include joints treatment and network replacement.

Comgas has chosen the network replacement, also reinforced by the regulatory body.
THE RENEWAL OF THE OLD CAST IRON NETWORK

• Since 2000, Comgas has already renovated around 330 km of the cast iron network.

• The main method used for the renewal until 2009 had been the Insertion.

• Through these actions, Comgas has already avoided the emission of around 55 million m³ of natural gas to the atmosphere, which corresponds to about 900,000 ton of CO₂ equivalent.
THE RENEWAL OF THE OLD CAST IRON NETWORK

Insertion of polyethylene pipe in the old cast iron network

Advantages:

Complete elimination of escapes;

Less risks during operations;

Lower level of excavated trenches;

Lower cost with improved productivity;

New polyethylene pipe is protected by old cast iron pipe, with possible use of pipe locator;

Higher operating pressure and stabilization during peak demands
THE RENEWAL OF THE OLD CAST IRON NETWORK

Operation of Insertion

Local of the Renewal: Risk-based approach according to area profile and historical information of escapes.

First day:
• Digging of trenches (main and service lines)

Second day
• Interruption of supply to customers
• Network isolation and purge of natural gas
• Insertion of polyethylene pipes in cast iron
• Connecting the new polyethylene pipeline into the existing network
• Commissioning of network and service line
• Re-connecting the customers

Third day
• Compacting and concreting of trenches (48 hours)
• Asphalt cover
Sidewalk Pipeline – A New Method of Renewal

- **Construction** of a new polyethylene pipeline under the sidewalk by directional drilling and connection with a high pressure pipeline
- **Connection to the service lines**
- **Abandon** the old cast iron

Comgas intends to use this method for the next renewal plans!
THE RENEWAL OF THE OLD CAST IRON NETWORK

Sidewalk Pipeline – A New Method of Renewal

Advantages compared to insertion:

Lower cost (about 50% less)

Less asphalt recover

Less steel plates

Less risk during operations

Less impact on traffic

High productivity (about 50% more)
THE RENEWAL OF THE OLD CAST IRON NETWORK

Comgas intends to renovate 282 km in the next 5 years.

This way, there will be a reduction of 50% of the present length.

As a consequence, the emissions will be reduced too.

There is not a definition to renewal after 2015, but the renewal probably will be extended towards zero of emissions!