Corrosion of buried LPG pipe work

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Industrial and domestic installations
Main points

- About LPG
- Explosions from fractured mains
- Industrial installation – ICL Plastics Explosion
- Domestic installation – house explosion
- Calor Survey
- Typical installations
- Metallic and non-metallic pipe work
- Fittings
- Mechanisms of deterioration
- Corrosion risk factors
- Duty of care
About LPG

- Primarily supplied as propane, butane or a mixture of the two
- Heavier than air so can settle and accumulate in low spots such as basements
- Can cause a suffocation hazard as well as fire and explosion hazard
- Pressures typically low (<75 mbar) or medium (75 mbar - 2 bar)
Explosions from fractured mains

- 1999 Larkhall, Scotland –
  - residential property destroyed, 3 fatalities
  - Ductile cast iron main leaking
  - plug corrosion
- 2001 Cavendish Mill, Oldham
  - old cotton mill converted to apartments, 1 fatality
  - 14” grey cast iron main found to be leaking
  - Fissure corrosion-crack due to bending moment on pipe and wet corrosive soil
ICL Plastics
ICL Plastics
ICL Plastics

Poorly consolidated soil

Rubble and voids

BASEMENT WALL

CONCRETE SLAB

GAS PIPELINE
ICL Plastics
ICL Plastics

Mirror placed underneath bend

Bridge of corrosion products across opening
ICL Plastics

Approx. 5°

Width of opening
1.5mm minimum
ICL Plastics

Outline of threaded end of pipe

Inner surface of bend – LPG side

Outer surface of bend – soil side

Six impressions from Vickers hardness testing

Main opening

Second opening
ICL Plastics
Findings

- Failure at the bend had characteristics of two forms of environmentally assisted cracking: fissure or graphitic corrosion and corrosion fatigue.
- Downwards force was due to concrete slabs in contact with the bend, and possible periodic higher loads caused by vehicle movements.
- Corrosion at the bend as a result of direct contact of the uncoated malleable cast iron with aggressive soil.
- The remainder of the pipe was very corroded with significant thinning.
Domestic pipework
Radiography of domestic pipework
Calor survey
Calor survey

sample 2 close-up view of perforation

ICL PUBLIC INQUIRY
Calor survey

perforation through pipe wall

elbow
Typical installation
Typical installation
Typical installation
Steel pipe for buried gas services

- Carbon steel
  Usually rolled strip, formed into a tube and continuously welded. Plain (red oxide primer or black lacquer) or galvanised.
- BS 1387: three weights – light, medium and heavy. Medium and heavy are most commonly used.
- Commonly used for mains gas and lpg
Steel pipe for buried gas services

<table>
<thead>
<tr>
<th>Nominal size, in</th>
<th>Wall thickness, in mm</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Light</td>
<td>Medium</td>
</tr>
<tr>
<td>3/4</td>
<td>2.30</td>
<td>2.60</td>
</tr>
<tr>
<td>1</td>
<td>2.60</td>
<td>3.20</td>
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*NB Galvanising produces a zinc layer 0.05mm to 0.1mm thick.
Steel pipe – plain and coated
Steel pipe connections

• Usually malleable cast iron to BS1256
• Female parallel threads / male taper threads
• Similar wall thickness to pipe
PE pipe for gas services

- GIS/PL2-2:2008- Specification for Polyethylene pipes and fittings for natural gas and suitable manufactured gas
  Part 2: Pipes for use at pressures up to 5.5 bar

- PE80 or possibly PE100

- OD 16mm, 20mm, or 25mm with 2.5mm thick wall
Corrosion basics

- Anode and cathode can be some distance apart.
- Movement of electrons, ions and molecules between the two.
Corrosion of ferrous pipes in soil

- Corrosion of steel and cast iron in soil normally needs oxygen and moisture.
- Other key factors are:
  - Soil type (gravel, sand, loam, clay, peat)
  - pH, chloride and sulphate
  - Organic matter
Typical corrosion rates

- Average rates for uniform corrosion would range from 0.01mm/year to 0.1mm/year.
- Corrosion is not usually uniform, most leaks will result from pitting.
- Pitting rates can be several times higher than uniform rates.
- Worst case pitting could perforate steel pipe with a wall thickness of 3.2mm in 10 years to 20 years.
Corrosion risk factors

- Type of ground
- Moisture content and variations
- Air – soil interface and depth of soil cover
- Temperature
- Protective coating
- Electric currents
Buried metallic LPG pipes – what to look out for (1)

- Age
- Pipe material and current condition
- Protective coating and condition
- Cathodic protection
Stages of deterioration
Buried metallic lpg pipes – what to look out for (2)

• Externally applied loading
• Knowledge of pipe route and ground type
• Position / layout relative to surface water
• Depth of pipe
Duty of care

• Issues arising from survey – who owns the pipes?
  – Industrial: LPG supplier owns the tank, pipework and valves usually responsibility of the company, even if installed by supplier.
  – Domestic: LPG supplier has responsibility for tank and pipe up to valve at the property.

BUT- differs according to contract

http://www.hse.gov.uk/gas/lpg/index.htm