

## Leak on grey cast

## iron pipe

26/12/2004

## Mulhouse (HAUT-RHIN)

## France

Piping / Distribution systems  
Explosion  
Victims  
Urban environment  
Property damage

### THE FACILITIES INVOLVED

#### The site:

The accident happened at 12 rue de la Martre, in Mulhouse, France. The 4-storey building at this address had 6 subscribers connected to the district's natural gas network. The network at this location consisted of multiple heterogeneous piping sections: polyethylene, steel, grey cast iron, and spheroidal graphite iron.

The gas service was tasked with gradually removing the grey cast iron pipes when the network was extended in 1993 (in conjunction with the installation of a pressure regulating station in rue de la Martre), then again in 1995 and 1996 (during the installation of piping on the network and supply of a boiler room). However, a 105 m long section (shown in green in the diagram below), dating from 1957, was still in operation along Rue de la Martre, and located a distance of about 6 m from the façade of that building at No. 12.

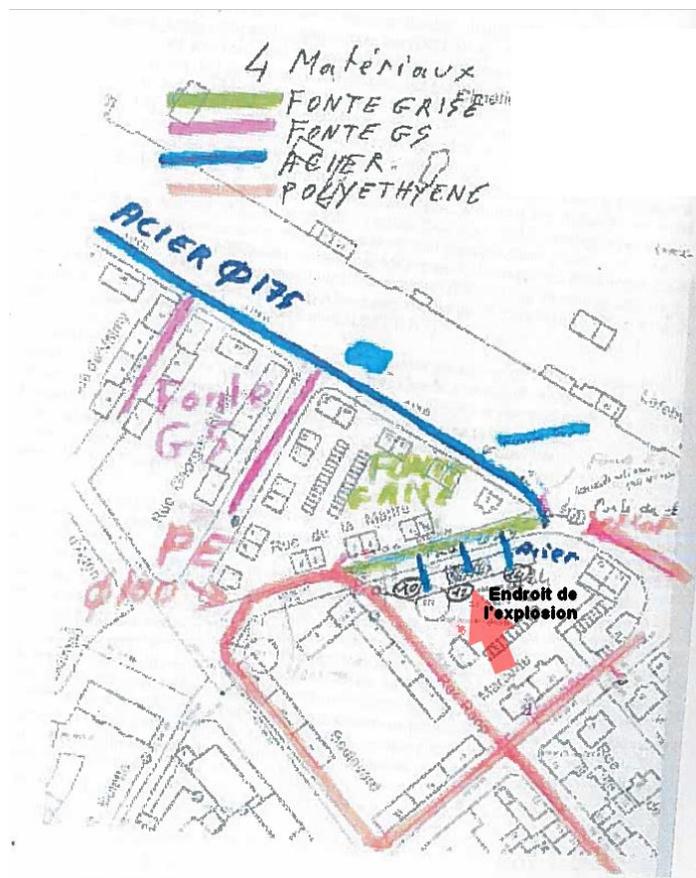


Diagram of the natural gas distribution network on rue de la Martre in Mulhouse

## THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

### Chronology:

An explosion occurred at 5:03 p.m. on Sunday, 26 December 2004, during the school holiday period. The blast destroyed the 4-storey building at 12 rue de la Martre and damaged the neighbouring buildings (Nos. 10 and 14). The resulting damage caused the building to collapse. The ground floor and the 1<sup>st</sup> floor were crushed down to the basement level, with the upper floors collapsing down from above.



The building after the explosion of 26 December, 2014 (© rights reserved)

The emergency services quickly arrived at the scene, along with a gas service operator who was informed of the explosion at 5:12 p.m., arriving to the scene at 5:31 p.m. The low-pressure supply line in the street was shut off at around 6:00 p.m.

An investigation into "involuntary homicide and injury" was initiated by the Deputy Public Prosecutor and an investigating judge was appointed on 27 December. The Minister of Industry also asked the *Conseil Général des Mines* to draw up a report to supplement the administrative investigation carried out by the DRIRE Alsace.

### Consequences of this accident:

The human consequences of the accident were significant: 15 slightly injured persons and 17 bodies were removed from the rubble, the last having been found nearly 24 hours after the explosion.

Following the event, the supply of gas was shut off to part of the neighbourhood affecting 274 customers. The gas service attempted to re-establish the network in the afternoon of 27 December, but a strong smell of gas was detected coming from the excavation trench which had been dug to disconnect the branch connections at Nos. 10, 12 and 14. A gas supply system was thus established from the neighbouring polyethylene network.

Finally, about sixty people had to be relocated, including the ten or so survivors of the explosion at No. 12 and the inhabitants of the two adjoining buildings.

### European industrial accident scale:

By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States' Competent Authority Committee for implementing the "SEVESO" Directive for hazardous substances and in light of available information, this accident can be characterised by the following four indices:

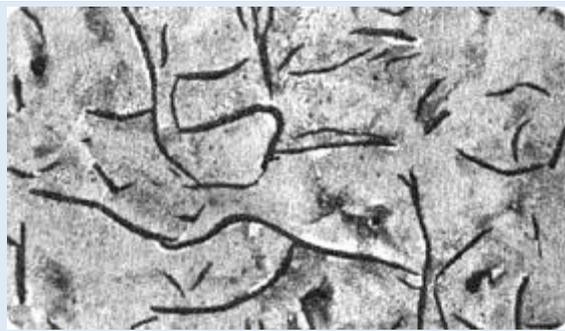
Dangerous materials released	 <input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Human and social consequences	 <input checked="" type="checkbox"/>
Environmental consequences	 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Economic consequences	 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

The parameters associated with these indices and their corresponding rating protocol are available at the following website: <http://www.aria.developpement-durable.gouv.fr>.

## THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THIS ACCIDENT

Several hypotheses were proposed by the experts following the explosion:

- A gas leak from a butane cylinder (LPG) found with its valve partially open in the rubble of the cellar;
- A natural gas leakage from the interior installations of an apartment;
- A natural gas leakage from the building's collective installations;
- And finally, a natural gas leak from the grey cast iron pipeline on the distribution network.



Microstructure of a grey cast iron (© DR)



Accident in Dijon (ARIA 21551). A 4-storey building suffered damage following an explosion caused by a natural gas leak on a grey cast iron distribution pipeline. The explosion left 11 persons dead and 3 injured.

### A closer look at grey cast iron or brittle cast iron...

Grey cast iron is an alloy of iron and carbon that crystallises into long, narrow formations. Most steel grades contain less than 1.2% carbon while cast iron generally contains 2.5% to 4%. A high carbon content lowers the melting point of the metal and makes it more fluid.

The properties of grey cast iron are as follows:

- Good compression resistance;
- Mouldability;
- Resistance to abrasion;
- Easily machinable;
- Fatigue resistance.

Nevertheless, it is considered fragile or brittle as attested by the accidentology:

- Rupture of a natural gas distribution pipeline made of grey cast iron in Dijon on 04/12/1999 (ARIA 21551);
- Explosion involving a grey cast iron network in Toulouse on 29/11/2002 (ARIA 23630)...

The various expert judicial and administrative assessments confirm the latter assumption: there was a natural gas leak from a crack on a grey cast iron distribution pipeline on a public roadway. The natural gas then spread under the sidewalk (consisting of coarse fill covered with asphalt) which then formed a pocket of gas in a confined environment (basement cellar). The ignition source is unknown. However, someone probably went down to the basement around 5 p.m. and switched on the light (2 bodies were found in the cellar). The leak was estimated at 32 m<sup>3</sup>/h, based on a distribution pressure of 20 mbar. The power of the blast blew out the basement's load-bearing walls, causing the first two floors of the building to collapse.

The non-ductile grey cast iron pipe responsible for the accident had not been replaced during the various works conducted between 1993-1996. The section along the Rue de la Martre was also deemed to be "low risk" according to the *gas service's* criteria: distance of the structure from the façade of the building slightly greater than 5 m. The programme to remove the grey cast iron, currently underway in Mulhouse, nevertheless had scheduled the removal of the section around 2006-2007.

The following factual elements were observed during the accident investigation, which may explain the damage to the grey cast iron section or the failure to detect the gas leak:

- Penetrometer measurements showed that natural gas easily passes through coarse fill used for the sidewalk, and the uneven surface of the materials used did not provide regular support for the grey cast iron piping;
- The street lamp's foundation block had created a hard spot on the pipe;
- During the night of 25 to 26 December, a gas odourisation system malfunction occurred on one of the sector's main gas sources. The gas extracted from the Cerville storage facility was thus under-odourised due to a problem on the odourant THT (tetrahydrothiophene) injection pumps.



View of the cellar after the rubble had been cleared away – © rights reserved

## ACTIONS TAKEN

### Judicial follow-up:

After a 3-week trial in March 2009, the gas service was sentenced in June of the same year. About 120 people, including those injured in the blast or persons close to the victims, filed civil actions.

Following the verdict, the gas service was ordered to pay two fines totalling 232,500 euros. The court found the gas service guilty of involuntary homicide, injury and property damage through negligence, reckless behaviour and various non-compliances. In 2006, the gas service had already been convicted on appeal for the Dijon accident and fined 204,500 euros for its part in an explosion that was also caused by a rupture on a grey cast iron pipe.

The gas group must publish the verdict on its website for a period of one month. During the trial, the distributor did not contest "collective violations" and had stressed that it had had to make choices, particularly concerning an ambitious programme to replace 1,200 km of grey cast iron per year.

### Administrative follow-up:

After the Mulhouse accident, the Order of 1 December 2005 prohibits the use of distribution pipes made of grey cast iron. The 1<sup>st</sup> article of this Order notably states that distribution networks or elements (connections) made of lamellar graphite cast iron, also known as grey iron cast or brittle cast iron, must be taken out of service, replaced or removed by 31 December 2007 at the latest.

To implement the order, network operators are required to create programmes to decommission, replace or remove the sections concerned. These programmes are sent to the administration for review and follow-up.

The latest figures provided by the gas service show the gradual decrease in grey cast iron sections and connections on its network, but a few linear lines remain or were still being discovered in 2017:

Discoveries	2012	2013	2014	2015	2016	16/09/2017
Network length (Km)	6,3	2	1,6	0,6	0,7	0,39
Number of network sections	283	103	38	39	50	39
Number of connections	180	64	71	62	55	22

Source: gas service

At the time of the accident (late 2004), the gas network in the city of Mulhouse consisted of 24 km of piping, 11.1 km of which was in high-risk areas.

## LESSONS LEARNT

As part of the accident investigation, all assumptions must be studied:

- Origin of the gas leak (individual/collective installations, distribution network);
- Was the damage to a distribution pipe a cause or a consequence of the explosion?
- Is the gas leak rate compatible with the dangerous phenomenon observed? In the case of the explosion that occurred in rue de la Martre, the energy released corresponded approximately to the combustion of 15 m<sup>3</sup> of methane, i.e. 600 MJ or 170 kWh;
- Gas odourisation problems preventing a hazardous situation to be quickly detected;
- The issues of gas diffusion in the ground that are often questioned.

On this last point, the Mulhouse accident illustrates that horizontal propagation of gas escaping from a ruptured gas pipeline is possible, as well as its passage through defects in walls (as evidenced by the traces of combustion on the cellar's wall: see photo, page 3). Emergency personnel (fire brigade or gas service) must therefore intervene with the greatest degree of vigilance, taking into account the risk of explosion in a confined environment.

Finally, the accidentology shows that many explosions involve grey cast iron pipes. However, the latter were included at one point, or even several times, in general programmes (national or regional) which provided for their elimination before the accidents occurred. It is therefore clear that the removal of these sections and connections must be rigorously monitored over time. The detection of any section made of unsuitable material must be subject to appropriate measures to ensure the safety of property and persons.

	<h3>Gas leak in a building pipe made of grey cast iron in 2017</h3> <p>ARIA 50632 - 20-07-2017 - 43 - LE PUY-EN-VELAY</p>
<p>A natural gas leak was detected at around 10 a.m. on a buried pipe at the junction of a 3 m long (DN 80) grey cast iron and steel pipe. The leak resulted in a pocket of gas which formed in a confined environment. The emergency services established a security perimeter: 10 building occupants were evacuated. Traffic was interrupted while the gas service replaced the pipe with a steel section.</p> <p><b>Causes</b></p> <p>The gas service's last inspection of the building pipe in April 2014 did not reveal any specific anomalies. However, the procedure used within the scope of these checks does not provide for precise identification of the material of indoor piping, except for lead. Incidentally, the grey cast iron pipe was identified as being made of steel in the computerised maintenance management system software (CMMS).</p> <p><b>Measures taken</b></p> <p>Following the incident, the administration asked the gas service to detail its methodology for determining the material of the pipes inside buildings and particularly when searching for grey cast iron pipes. The gas service undertakes to inspect similar installations in the city of Le Puy-en-Velay (buried indoor pipe, DN&gt;40, commissioned prior to 1971). Of the twenty or so works identified, none are made of grey cast iron.</p> <p>Depending on the distributor's commitments, the following provisions will apply in the event of a similar situation and uncertainty about the materials:</p> <ul style="list-style-type: none"> <li>• analysis and inspection of the connections on low-pressure islands;</li> <li>• reinforced monitoring actions on pipes inside buildings;</li> <li>• appropriate safety measures in the event that grey cast iron is detected.</li> </ul> <p>In its operating report concerning the former Auvergne region, the distributor must also report the abovementioned measures to the administration. The national procedure concerning the maintenance of the collective connections will also be modified.</p>	