PLASTIC PIPEWORK FOR GAS IN BUILDINGS AND THE CONSEQUENCES OF FIRE

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ABSTRACT

The application of plastic pipework for gas inside buildings is still restricted by national laws or local regulations in many countries, while other countries allow this application. The exclusion of plastics is in the main based on the supposed fear of the impact of a fire on the pipework and the escape of unburned gas with all its consequences.

Supporting data based on incident statistics will help to pave the road to more favourable legislation for plastic pipework inside buildings.

In many countries over the world gas incident data of gas installations have been collected for many years. In some of these countries incident data are confidential while in other they are published and may be used freely. The causes of incidents with pipework vary widely. Not only material failure and third party involvement are well known causes but also manipulation or suicide actions. It is obvious that the later two mentioned causes have to be removed from statistics because these are not material related. In view of statistical data, critical pipe failure due to fire impact are extremely seldom.

As a result a corrected overview of incidents will be presented and field experiences from The Netherlands will be reported. In this country the use of multilayer pipe in domestic pipework is very common for more than ten years.

The conclusion is that the incident rate (excluding manipulation and suicide) is very low and plastic pipework for gas in buildings does not contribute to an increase in failure statistics. The experiences with working with plastic installation pipework are excellent. Especially the tightness of the pipework has been mentioned as an advantage.

As soon as the road has been paved, the application of plastic pipework can be rolled out worldwide!

National and international regulations have to be modified in favour of Multilayer(ML) domestic gas pipework.

PROBLEM TO BE SOLVED

In many countries, legal obstacles are the major problem of the introduction of ML domestic gas pipework. This paper gives guidelines on basis of statistics and field experiences in order to change regulations in such a way that ML pipework can be installed.

DEVELOPMENT IN DOMESTIC PIPEWORK LAST 30 YEARS

The application of multilayer pipework is not a new phenomenon. Already 30 years ago plastics pipework was installed on a larger scale in New Zealand. The pipe material was PA 11 and pipes were quite thin walled. The application stopped because of rodent attacks on the pipework.

The revival of flexible pipework about 15 years ago resulted in many new pilot projects in which different flexible materials have been applied and tests have been carried out determining which materials might be suitable for safe and economic application in domestic gas installations. Many European countries participated in the European DIGBUILD project. Although the results of the pilot projects were quite positive, the commercial introduction was delayed by the relative high price of ML systems at that time and also due to required build-in safety devices, and the willingness to change installation practice and national regulations. With raising copper prices of last years the interest was growing again. Plastic pipework is nowadays very competitive with copper or steel pipework. The number of countries that would like to change to modern installation techniques is still growing.

ML GAS PIPEWORK AND STANDARDISATION

Quality aspects of ML gas pipes are described in ISO 17484 part 1 (ref 2) and part 2 (ref 3) is the code of practice. The European standard EN 1775 (ref 1) is a functional standard for domestic gas pipework installations. This standard is drafted in such a way as not to discriminate pipe materials. If a pipe material meets the functional requirements it is considered as a suitable installation material. ML pipes can fulfil the requirement of EN 1775. Most European countries have beside this standard their own much more detailed national regulation or standard (EN 1775 is not a harmonised standard based on a European Directive, so national standards are still allowed). In most detailed national standards only the traditional system has been described, implicating that ML pipework is excluded. Outside Europe there are also countries that allow ML pipes.

THE MAIN RISK OF ML PIPEWORK

The domestic gas installation consists of two parts, the pipework and the connected appliances including the flue gas system.

Domestic gas pipework

The main risks of domestic gas pipework (including ML pipework) are:

- The mixture of air and escaped gas exceeds the lower explosion limit (LEL). If an ignition source is present an explosion will take place. An explosion may be succeeded by a fire.

- Fire being fed by escaping gas

Asphyxiation is another potential risk but could be excluded for reasons of the maximal amount of escaping gas in a dwelling.

The escape of unburned gas is considered as the most dangerous, it could lead to an explosion. A gas fire is less dangerous because the capacity of domestic pipework is restricted by the pipe diameter and gas meter. Another important aspect is the location of the leakage; in a small unventilated space the explosion limit will be reached far quicker than in a well ventilated large room. Drilling or nailing in embedded pipework is unfortunately daily practice but does lead only in very exceptional cases to a dangerous situation. The escape of gas is quite limited generally and the smell of the gas is alarming the offender directly and measures can be taken directly.

Causes of pipework failure could be :

- Component or pipe failure (due to corrosion, aging, stress etcetera)

- Fire attack

- Manipulation

- DIY and inferior installation work

- Third party involvement (e.g. drilling, nailing etc)

Another type of cause of incidents is metal theft, especially copper theft. Due to the high copper prices this is an increasing problem.

Domestic gas appliances

The main risk of appliances is the production of carbon monoxide in case of malfunctioning of the appliance. Most gas boilers are room sealed nowadays but leaking flue gas pipes can be also the cause of CO-poisoning.

Note

Not all explosions in houses are related to the gas installation (pipework and appliances). Gas bottles, illegal firework storage, migrating gas from service of main pipes can also be a cause of an explosion.

DEFINITION OF FIRE RESISTANCE IN THE "GAS SECTOR"

The Gas Sector does not speak about *fire resistant* but about *high temperature resistant* (HTR). However both expression are used and mixed-up (e.g. in EN 1775 fire resistance is mentioned). The HTR requirement is not generally accepted, many countries negate this requirement for cost reasons, HTR are very costly generally. Gas pipework is classified as HTR when it withstands a temperature of 650 °C during a defined period. In real fires much higher temperatures will occur, even temperatures above 1400 °C will not be an exception. In many standards a simulation curve has been incorporated. A well known ISO standard for fires in building is ISO 834 (ref 5). Generally a temperature of 650 °C will be reached in a few minutes. The temperature of 650º C is related to the self-ignition temperature of natural gas. When the pipework fails at that temperature, escaped gas ignites immediately and an explosion will be prevented. ML pipework without additional safety devices may never fulfil the HTR requirement and neither do soldered copper pipes. Only welded steel and brazed copper pipes fulfil this requirement. Is this HTR requirement important? No! During the last 50 years millions of non-HTR gas pipework installations have been installed without problems. HTR is only useful if pipework is exposed to a temperature over 650 °C and no flame or other ignition source is present. In this case an explosion could be possible. The occurrence of such a situation is very seldom and may be perceived as an acceptable risk. In Table 1 a relation is presented between the leak size and amount of escaping gas at a pressure of about 20 mbar. Moreover is given the time that the LEL will be achieved in a space with a given volume. The ventilation factor is 1 (Once per hour the total air volume will be refreshed). The amount of escaping gas is dependent on many factors like flow limiters, type of gas meter, geometry of the leak etc. Therefore practical values have been given in table 1. The table is intended to give some feeling for explosion risk.

Leak size	**Escaped gas**	**10 m^3 Space**	**20 m^3 Space**	**40m^3 Space**
mm2	**m^3/h**	**Time lapse to LEL (min)**		
2,5 (nail)	0,5	300 min	∞ min	∞ min
150 (f.b). 1/2 inch	12	2,6 min	5,2 min	11 min
300 (f.b). 3/4/inch)	20	1,5 min	3,1 min	6,4 min
f.b. is full break of the pipe				

Table 1: Time lapse to explosion

Fire brigades consider burning gas generally as a controllable situation. In many cases not fire flames are the biggest problem for firemen but smoke.

ASPECT OF GAS PIPEWORK IN DOMESTIC BUILDING

In table 2 some aspects of a typical domestic gas installation have been given. These aspects are valid for at least 95% of all installed installations. In commercial and industrial buildings other values could be applicable.

Aspect		**Remarks**
Max. operating pressure (MOP)	15 - 30 mbar	For propane sometimes higher pressures
Pipe diameter	8 - 22 mm	
Amount of escaping gas at full failure	15 - 30 m3/h	The gas meter limits the capacity
Materials	Copper, steel, CSST, ML	
Joint methods	Soldering, brazing, welding fitting, press fitting, mechanical fitting	

Table 2: Some characteristics of a typical domestic installation

In recent decades gas pipework has been installed embedded in walls or floors increasingly. The advantage of this way of installation is that the pipework will be protected against damage and cleaning chemicals in an effective way. It is a customer's desire to have no open pipework. Aesthetic reasons and hygienic reasons are the major arguments. In almost all cases, all pipework and electricity cables are installed embedded in walls nowadays.

Domestic multilayer pipework is almost always embedded in walls or floors, or at least installed in a protected area.

ADDITIONAL SAFETY DEVICES

Are additional safety devices necessary? We know that domestic pipework is extremely safe. It is true that a safety device gives more safety; otherwise there is no reason to install them. The investment per customer (safety device and labour cost) is minimal $50,- . Suppose that a 75% reduction of casualties over a period of 40 years will be achieved by placing safety devices, the investment per casualty avoided will be at least several millions of dollars. Such an investment is only warranted for emotional reasons. In some special situations it could be wise to apply additional safety devices. The discussion on safety devices started with the introduction of ML pipes, but is now more or less a general item for all types domestic pipework.

The most popular safety system is the excess flow valve (EFV) which shuts-off the gas flow when a certain flow rate is exceeded. EFV's are often installed just behind the gas meter. Less popular are the thermal shut-off valves being placed at the vicinity of an appliance. When the temperature exceeds a defined value the valve closes.

Another reason for not applying safety devices is the maximum allowable pressure drop. Low pressure systems (almost 100% of the domestic installations) operate at a pressure of around 15 mbar up to 30 mbar. The permissible pressure drop is only a few mbar generally. A pressure which is too low may cause malfunctioning of the gas appliance. The pressure drop of safety devices is rather high in relation to the maximum permissible pressure drop of a few mbar. Therefore, safety devices may demand a larger size pipe diameter.

GAS INSTALLATION INCIDENT STATISTICS

Many countries have a system for gathering gas incident data. In some countries it is a governmental activity, while in other countries energy companies are collecting this data. Unfortunately no good international standardised guideline for registration exists with as consequence that registration varies from country to country. Due to privacy legislation it is sometimes difficult to retrieve the precise facts when victims are involved in an incident. Only the number of casualties is a clear factor for statistics. Often the number of injuries is well known too but not the seriousness, again due to privacy laws. Hospitals have these data at their disposal but these are not accessible for third parties in detail. Consequently, registration of incident data in a correct and uniform way is a very difficult job. Marcogaz has developed some guidelines in order to achieve some uniformity.

Within Europe a working group is active on collecting gas incident data in the whole gas chain. This working group is called ETPS (European third party safety) and has collected for more than twenty years European gas incident data. The working group now falls under the wings of Marcogaz.

Marcogaz supports safety in an active way. Marcogaz's opinion is that a reliable and safe gas supply is essential to modern societies. For this reason the Gas Industry has always been pro-active concerning safety issues by producing high level safety standards, developing appropriate Management Systems and promoting and financing improvement through R&D.

The result is that gas pipeline systems are by far the safest way to transport energy.

Detailed European statistics are not public for reason that incident data of the various European countries have been supplied under a confidentiality agreement. Nevertheless data on a more aggregated level (European level) is available.

In figure 1 the results of Europe and The Netherlands are compared. A first glance tells you that the rate in The Netherlands is better than Europe. However, the manner of gathering of incident data is quite different despite of registration agreements. In the Dutch statistics, manipulation and suicide indents are not included. Many European countries however include this data in the statistics. Considering this fact the Dutch statistics do not differ much from the European. The registration of the number of deaths is the most reliable statistic. Gathering data of injured people or material damage is for legal reasons often very difficult. **The number of fatalities on the gas installations over the last 16 years is quite low with an average ratio of about 1.4 fatalities per 1 million gas customers. Each customer represents about three persons, meaning that about three times more persons are exposed to the risk e.g. ca. 0,47 death/million habitants exposed. This number is related to all incidents with gas installations. Knowing that more than 90 % of the fatal incidents is related to CO poisoning, the incident rate for only the pipework is less than 0,047 death per million habitants exposed. Correcting this number for intentional acts, estimated to be at least 20 % of the cases, the number reduces to about 0,04 deaths per million. This is an extremely low number when taking into account that in this number also labour errors by installers and DIY work are included.**

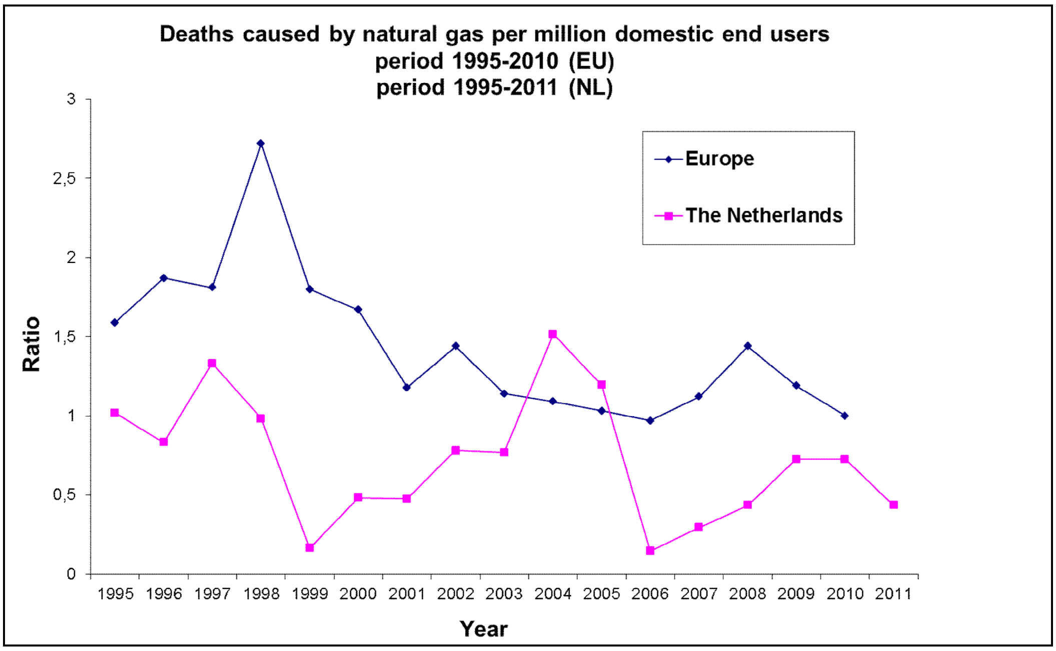

Figure 1: Ratio per million customers of gas installation incident. (ref 4)

FIELD EXPERIENCE IN THE NETHERLANDS

Experiences with the ML pipe systems are very positive. No complaints have been received related to joint or material failure except only once due to manipulation. No incidents have been reported. Press fittings are very reliable. Only in exceptional cases a leak is detected after installation. All domestic systems are tested at a highest pressure of 5 bar and a lowest pressure of about 100 mbar. A serious complaint of installer was that "never" a leakage is being found, resulting in reduced motivation of the testing personnel (they like to find a leak now and then). Testing personnel wonder why to carry out such a test. The new installation technique is now very common, because most installers already have had many years of experience with similar piping systems for water and floor heating. Nowadays installing ML is common practice; other (classic) materials are now the exception. It is obvious that the metal prices, especially that of copper has accelerated the introduction of ML pipework.

The Dutch installation guidelines for ML pipe are based on ISO 17484-2 (ref 2) and completed with national relevant requirements. All ML pipes were tested according to ISO 17484-1 (ref 3).

An improvement could be a standardisation of sizes in such a way that fitting are compatible. The range of wall thicknesses and pipe diameters is quite wide. If an installer uses more brands of ML pipes he is obliged to have a large stock of materials and mounting tools. It would be wise that at the next revision of ISO standards this will be an item. For repairing purposes universal replacement fittings have to be developed.

RECOMMENDATIONS

Change national standard in such a way that they will have a functional character. Consider new developments with an open mind. Be aware that rigid requirements could exclude good technical solutions.

Make sure which safety level is desired. A slightly higher safety level may lead to high costs.

Carry out a risk analysis of the pipework and take into account incident statistics. Be critical on the source of the data.

ML pipework shall only be installed embedded or in protected area.

All commercially available ML systems should become more compatible.

CONCLUSIONS

New installation materials, such as multilayer and PEX pipes, are an attractive, competitive solution. Moreover, ML systems are very safe if installation rules and skills are respected. Incidents statistics are quite positive on domestic pipework even when manipulation and wrong human involvement have been taken into account. The ratio of fatal incident due to causes without human involvement are extremely low: less than 4 $*10^{-8}$ (number of death per million inhabitants exposed to the risk).

The consequences of fire on pipework systems are of minor importance. Incident Statistics do support this statement.

ML pipework does not form an extra risk. After a period of ten years installing this material on a large scale no increase of the number of incidents has been detected in the Netherlands. (National) standards and regulation could be modified in order to allow ML pipework.

REFERENCES

1 EN 1775:2007 Gas supply - Gas pipework for buildings - Maximum operating pressure less than or equal to 5 bar - Functional recommendations

2 ISO 17484-2:2009 Plastics piping systems - Multilayer pipe systems for indoor gas installations - Code of practice

3 ISO 17484-1:2006 Plastics piping systems - Multilayer pipe systems for indoor gas installations with a maximum operating pressure up to and including 5 bar (500 kPa) - Part 1: Specifications for systems

4 Marcogaz WG EGAS C-Report - Statistics 2010 (UTIL-GI-12-04,29/05/12)

5 ISO 834: Fire-resistance tests - Elements of building construction Fire-resistance tests - Elements of building construction