GAS PIPEWORK INSTALLATION IN BUILDINGS: NEW PLASTICS OR TRADITIONAL COPPER?

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ABSTRACT

New installation materials are an attractive alternative to traditional steel and copper pipework. In most countries however, new materials may not be used due to national regulations or laws rejecting the use of these.

This paper presents experiences with the new installation materials in the Netherlands during the last eight years, starting from the introduction of these, with pilot projects, to complete introduction of new pipework systems. Special attention has been paid to the safety of the pipe works and to the necessity of having additional safety devices.

A particular point to note is the high temperature resistance of materials, a major issue in various national regulations.

This presentation also contains the latest developments in standardisation.

Furthermore, some recommendations are given for the procedure for introduction of new materials.

INTRODUCTION AND HISTORY

About eight years ago, plastic pipes were installed inside buildings for the first time in The Netherlands. Before that time only steel and copper pipes were permitted to be used for domestic gas installations.
At that time, the question was raised how it would be possible to reduce the installation cost for a domestic gas installation. The solution was explored in the application of other types of pipe materials which could be installed in an easier and quicker way. In general, the labour costs of an installation are much higher than the material costs. To achieve a maximum reduction in cost, labour time needs to be reduced.
The difficulty 8 years ago was that none of the Dutch regulations allowed the use of new materials. However, the Standards Committee was willing to allow new materials if the safety of the installed systems was proved to be at least of the same level as copper or steel pipe systems.
The project group who started this new project was able to explain that newly developed systems would have a similar safety level as the traditional systems. The introduction of

several safety devices was supportive in convincing people and improving acceptance, although there was some doubt of the function of these devices.
After approval, several pilot projects were started. It was very important that all interested parties were invited to follow or to participate in the project. Included amongst these parties were members of the fire brigade, local authorities, installers, gas suppliers, test institutions, manufacturers and last but not least the future inhabitants of the new build houses. The result of this was that the new system was readily accepted and that the pilot projects were positively reported in the press.
Over time, the installation practices have been reviewed. As a result of this reviewing almost all additional safety devices have been cancelled. Currently the new flexible pipe systems in the Netherlands are quite simple and easy to install. Many new pipe systems are approved (Kiwa GASTEC QA approval) and are now commercially available. The installer has a multitude of choice!

INSTALLATION PRACTICE

In the Netherlands two types of multilayer pipes are used; plastic pipes with an aluminium layer, e.g. PEX-Al-PEX and fully PEX pipe with a thin outer layer of EVOH. The function of the EVOH layer is to prevent odorant migration through the pipe wall. Odorant migration could lead to false gas alarm (see ref. 1).
Pipes are assembled with press fittings. One type of fitting for PEX pipes makes use of the memory effect of PEX. Other types of fittings such as fusion fittings and mechanical screw fittings have not been used yet. Furthermore, the number of fittings shall be limited as far as possible. Usually pipe will be laid without a casing pipe; only in a restricted number of situations will a casing pipe need to be installed.
A major restriction is that all pipework has to be concealed in walls or floors, or needs to be well protected. Only at the location of the gas meter and in the vicinity of the wall plate, is pipe work in sight allowed. For this reason, this kind of pipework is only installed in new build houses and in total renovation projects. Copper pipework is used for historical buildings and small renovation. This will not change in future.
Concealed pipework is reasonably protected from mechanical impact and fire. For this reason, no additional safety devices are required. For copper pipe work these provisions are not necessary either.
Some system suppliers demand that excess flow valves must be installed. In this case, the suppliers' instructions have to be followed.

DOMESTIC GAS PIPEWORK AND SAFETY

For almost fifty years, the data of all incidents involving gas installations has been collected systematically in the Netherlands. Most (fatal) incidents are due to CO-poisoning because of incomplete combustion, incidents due to failing pipework are quite rare. Indeed, there have been some severe explosions, but investigation has shown that in nearly all cases the incidents have been caused by manipulation of the pipework (main reasons: suicide and insurance fraud) and by modifications of the pipe work carried out by untrained people.
Other incidents, such as the spontaneous failure of fittings or pipes, have seldomly occurred.

The major risk of a pipe installation is the uncontrolled escape of gas. Pipe work must stay gas tight during its entire lifetime. A well designed and professionally installed pipe installation will fulfil this requirement.

An important question is; are additional safety devices necessary? It will be obvious that a safety device may never serve as an alibi for poor installation practice. A safety device has to provide more safety; otherwise there is no reason to install it.
As already mentioned, the number of incidents with installation pipes is very low. Multilayer pipes are more vulnerable to impact, sharp objects and heat load than traditional copper and steel pipe systems. However, when multilayer pipes are protected after installation, such as in cement or behind plating then the system is reasonably protected against these hazards. For this reason, in the Netherlands, no additional safety devices are required.
If plastics pipes are laid and are unprotected (visible), additional safety devices will be compulsory.

However, the application of excess flow valves (EFV) is the subject of discussion in many countries and is independent of the type of installation material (an excess flow valve shuts off the gas flow when a certain flow rate is exceeded). Manipulation of gas installations is a growing problem in the last few years. Failures caused by manipulation are resulting in large gas escapes. In such cases, an EFV will cut off the flow and an explosion will be prevented. The decision to install EFV's is not related to the material but to other risks.
Nailing and drilling through installation pipes occurs regularly, but does not lead to severe incidents. As soon as the odour of gas is detected, the main valve will be closed. The downside however, is that the repair of a leak in a concealed pipe is quite expensive. Multilayer pipe and copper pipe posses roughly the same resistance to nailing and drilling. Steel pipe has a much better resistance (however, this is not applicable to corrugated stainless steel pipes, CSST, see Ref. 2).
The detection of plastic pipework without a metallic layer is quite difficult. Standard pipe detectors do not work, but special detectors are currently available on the market.

Another type of safety device is the thermal shut-off valve. When the temperature exceeds a defined value the valve will close automatically. This device works locally. To protect the complete pipe system, many of these devices are needed. Generally, the thermal shut-off valve is considered superfluous.

It is only in very rare cases that over-pressure valves have been installed. Such a device reacts to an increase in pressure due to temperature elevation. These valves give little protection and could be considered superfluous.

A very important issue for domestic pipework is the permissible pressure drop in the system. Low pressure systems (almost 100% of the domestic installations) operate at a pressure of around 18 mbar up to 30 mbar. The permissible pressure drop is only a few mbars. A pressure which is too low may cause malfunction of gas appliances. The pressure drop of safety devices is rather high in relation to the maximum permissible pressure drop of a few mbars. Therefore, safety devices may demand a larger size pipe diameter.

FIELD EXPERIENCES WITH PLASTICS PIPES SYSTEMS

Experiences with the new flexible pipe systems are very positive. No complaints have been received and no incidents have been reported. Press fittings are generally very reliable. Only in exceptional cases is a leak detected after installation.

The new installation techniques are well accepted, because most installers already have many years experience with similar piping systems for water and under-floor heating. For these installers the switchover to a new gas system is relatively easy. An installation company chooses one system and remains loyal to that system. One of the main reasons for this is that each system requires its own special fitting tools, and these are very expensive.

Furthermore, there is still a group of installers who feel that the old manual craftsmanship will be lost. However, even this group is starting to see the advantages of this system. These advantages include cleaner installation and a higher safety factor (no naked flames for soldering etc.)

Practical training is very important for the successful introduction of a new installation technique. Even new systems are not 100 % fool proof and severe errors can be made.

INSTALLATION COSTS

In the last few years, prices of materials have changed dramatically. Copper prices have doubled, and other materials also increased in price became more expensive. Copper pipe systems have become relatively more expensive than other types of pipe systems, due to the fact that the material price has a strong effect on the finished pipe.
At the introduction of the new pipe materials, the price was barely competitive with copper systems. This high price was also caused by the obligation to install safety devices at that time. Times have changed and currently new systems are very competitive, even with safety devices.

Soldered or brazed copper systems are no longer competitive with new systems; only copper systems with press joint fittings are reasonably competitive.

INTERNATIONAL ACCEPTANCE

Installation of gas pipe-works with new materials is currently only allowed in a very restricted number of countries. Many countries have a statement in their national regulations or even in their national law that only steel and copper may be used for indoor gas installations.
Changing regulations and laws is a lengthy procedure.
National installation regulations are based on a long term experience with known materials and techniques but also on fear, market protection and incidents, instead of risk analyses and investigations.
Almost all national regulations give detailed information for the construction of systems. The philosophy behind this is that if each component of the construction is right, the complete system will function.
Functional requirements apply to the total system. The designer has far more freedom in the selection of materials and techniques.

A typical example of a non functional requirement is the requirement for fire resistance or high temperature resistance (HTR). This requirement states that all components of the pipe-work shall withstand a temperature of 650 °C during a defined period. Such a requirement does exclude all types of multilayer pipes. Only brazed copper pipes and steel pipes can meet this requirement. Other countries have a 450 °C requirement which allows soldered copper pipe. But also this temperature is problematic for multilayer pipes. The functional requirement is that the complete system shall still retain a certain fire resistance. The functional requirement for fire resistance of EN 1775 reads:
The Designer shall consider the possibility of an outbreak of fire at a building, where gas pipe work is in use, causing damage to the fabric of the building and consequently or separately to the gas pipe work.
Multilayer systems which have been installed, concealed in walls and floors, will fulfil this requirement. If a fire breaks out in such a way that it will attack concealed pipework, the complete building could be considered as lost anyway. Pipe work does not need to be stronger than the building construction elements.

INTERNATIONAL STANDARDISATION

In TC 138 SC 4, a standard for multilayer pipes for indoor gas installations has been developed. If the voting on the final FDIS is positive, this standard will be published in 2006. The standard ISO 17484 (see ref.3) covers multilayer pipes with a metallic layer as well as multilayer full plastic pipes. Also pipes with only an EVOH layer are covered by the standard. Together with this standard a code of practice will be developed (Probably as ISO 17484 part 2, see ref.4). This code of practice is planned for latest 2007. The code of practice is not a typical installation standard but mainly gives guidelines on how to handle pipeline components etc. For designing and construction of multilayer pipe systems, a reference has been made to a European standard EN 1775. EN 1775 is a typical functional standard that does not exclude any material on the forehand. This standard is the first step in harmonisation of European installation regulations. However, this standard only has the status of a recommendation document. European countries could maintain their own national regulations under the condition that they are not in conflict with the EN standard. Although EN 1775 does not exclude any material, the European countries are free to exclude materials.

HIGH TEMPERATURE RESISTANCE (HTR)

HTR materials are resistant to a temperature of 650 °C during a defined period. There are different tests to determine the HTR. The self ignition temperature of natural gas is around 630 °C depending on the composition of the natural gas. The philosophy behind this requirement is that gas escaping due to a failure in the pipe will ignite directly if the temperature is above 650 °C. When a material is not high temperature resistant, the pipe-work could fail at a lower temperature. A contamination of unburned gas is possible, and if an ignition source is present, the gas will explode. HTR protects pipework against heat loads without flame or other ignition source. In practice it could happen, but the risk is extremely low.
Tens of millions of installations within Europe have been soldered and are not HTR. Severe explosions due to fire have never been reported in the Netherlands during more than 40 years. Fire outbreak after an explosion is reported frequently. Detailed reports where HTR has played a role are not yet known.

Gas appliances are generally not HTR. Some components are made from Zn Al alloys. This material has a melting temperature of about 380 °C.

HTR pipework and components are quite expensive. The price is at least double that of a non-HTR installation.

RECOMMENDATION FOR THE INTRODUCTION OF NEW MATERIALS

For the introduction of new pipework materials the following steps are important:

- begin a project group for the start-up of a pilot project
- invite all interested parties to join the project (local authorities, fire brigade, energy company, installers, etc)
- perform risk analyses (each country has different risks, e.g. earthquakes, building structures, etc)
- ensure that installers are fully trained in the use of special connection tools
- monitor problems e.g. working with special tools.
- do not be too critical regarding the number of safety devices; in the beginning it gives security (and is good for the acceptance of the pilot project)
- try to change national regulation from constructive to functional standards

CONCLUSIONS

New installation materials, such as multilayer and PEX pipes, are an attractive, competitive alternative for traditional steel and copper pipe systems. Due to the increasing prices of metallic materials, plastic pipes will become even more attractive in the near future.

The new generation pipe work has been installed in the Netherlands for the past eight years. No negative experiences of leaks have yet been reported. The systems are very gas tight. Throughout the years the use of safety devices has dropped as customer confidence has increased. Currently the new systems are at the same safety level as, and are constructed similarly to, traditional copper and steel pipe systems.

New installation materials have been accepted by the alteration of national regulations from constructional to functional requirements.

Almost all countries allow only steel and copper for domestic pipework. Carrying out an adequate risk analysis and thinking in functional requirements could help the acceptance of these materials. Pilot projects could bring familiarity with the new materials.

The high temperature resistance requirement as maintained by different countries is discriminating against the introduction of new materials. This requirement needs to be reviewed.

Shortly there will be material standards available for new materials such as ISO 17484-1 for multilayer pipe systems (and part 2 later for the Code of Practice for these systems).

The standardisation of tools and pipe sizes (outside diameter) is also desirable.

REFERENCES

1. Opportunities for Plastics in Flexible Indoor Gas Pipe Systems, Dave Oesterholt, Frans Scholten and Hendrik Roebers (Plastics Pipe Symposium, 2002, Munich)

2. Reduction of the Installation Costs for Domestic Gas Appliances
   Ianina Mofid, Per Persson, Karsten V. Frederiksen (WGC Amsterdam 2006)

3. ISO FDIS 17484-1 Plastics Piping Systems - Multilayer Pipe Systems for Indoor Gas Installations with a Maximum Operating Pressure Up to and Including 5 Bar - Part 1: Specifications for Systems
4. ISO WD 17484-2 Plastics Piping Systems - Multilayer Pipe Systems for Indoor Gas Installations with a Maximum Operating Pressure Up to and Including 5 Bar - Part 1: Code of Practice

Pictures of Installation Practice

Figure 1: A yellow PEX pipe for gas amongst other PEX pipes. The pipes are now visible, but just hours later all pipes were covered by a layer of concrete. The time between laying and covering with concrete is as short as possible in order to prevent damage to the pipe work system.

Figure 2: PEX pipe is very flexible and does not show load yielding. Complicated situations could be solved easily without using fittings.

Figure 3: Even in difficult situations a press connection can be made in a few seconds

Figure 4: Short lengths of PEX pipe in the meter cupboard. The PEX pipes are protected by a corrugated plastic pipe. In this case a manifold has been applied. In the manifold, excess flow valves have been incorporated.