A COMPLETE SET OF SPECIFICATIONS FOR ALL KINDS OF PLASTICS PIPELINE MATERIALS USED IN GAS DISTRIBUTION SYSTEMS

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Abstract
The use of plastic pipeline materials in gas distribution systems is still increasing. Presently PE and high impact PVC are the dominating materials in gas distribution networks up to 4 bar. Most of these networks operate at these pressures, only a limited part of the network operates at higher pressures, up to 10 to 20 bar. The performance of the plastic gas distribution systems is excellent, also caused by the availability of (ISO) specifications for these systems.Within ISO TC 138/SC4, which is responsible for defining requirements for plastics used in gas supply systems, many organizations from all over the world are involved. In this paper an overview is given of the status of all specifications in this area.For PE pipeline systems a full set of specs is available, covering all aspects from requirements on resins, pipes, fittings up to the jointing methods and code of practice. These specifications are regularly updated. Recently, also a full set of specifications has become available for high impact PVC pipes aimed to be used at lower pressures (<0.1 bar).For higher demanding applications (higher pressures, higher and lower temperatures, rocky soils, etc.) tailor-made plastic pipeline systems have or are being developed. For crosslinked PE (PEX) now a complete set of ISO specifications is available. For higher pressure applications, up to 16 to 20 bar, polyamide (PA) and fibre-reinforced thermoplastic pipeline (RTP) systems have been developed. For these materials ISO TC 138/SC4 has also defined specifications or is drafting specs. For multilayer pipes this is also in progress.Altogether this means that in due time a complete set of specifications will be available for all plastics to be used in gas supply systems, defining requirements to resins, pipes, fittings and jointing techniques. This will certainly contribute to the successful, safe and reliable use of plastics in gas distribution systems.

Introduction

The length of the gas distribution networks (mains, excluding service lines) all over the world exceeds 5 million km. Only in the USA more than 1,500,000 miles of gas distribution mains are in operation. In these systems various materials have been used and are still in use. In the town gas period mainly cast iron pipes were installed. Some of these pipes are still in operation after times exceeding more than 125 years. Later on steel pipeline systems were used as well. And from about 1950 the first plastics pipe materials

were introduced in gas distribution systems, like rigid PVC. In the sixties of the previous century PE was installed, which is now the most widely used material for gas distribution systems. Other plastics pipe materials have been introduced as well or are under development, like crosslinked polyethylene (PEX), high-impact polyvinylchloride (PVC-HI), polyamid (PA) and multi-layer and fibre-reinforced plastics (RTP).

Use of various materials in gas distribution systems

In Table 1 an overview is given of the various pipeline materials used in gas distribution networks. Here, gas distribution is defined as transport of natural gas up to 16 bar. The upper limit of 16 bar is also used in the European specifications for gas supply systems (e.g. EN 12007-series).

Usually the gas distribution system is divided in a number of pressure stages. Often a low pressure class up to about 0.1 bar is used, a middle-class pressure up to about 4 bar, and a higher pressure class up to about 10 or 16 bar. This division in pressure classes has been used to summarize which materials are allowed/suitable for the different pressure stages, see Table I.

Table I. Suitability of various pipeline materials for use at different pressures in gas distribution networks.

		Pressure (bar)			
Materials	**In use from**	**0.1**	**4**	**10**	**16**
Cast Iron	1880	+	-	-	-
Steel	1930	+	+	+	+
PVC	1955	+	-	-	-
Ductile Iron	1970	+	+	-	-
PE80	1975	+	+	-	-
PE100	1995	+	+	+	-
PEX	2000	+	+	-	-
PA	2005	+	+	+	(+)
RTP	2005	+	+	+	+
Multi-layer	2005	+	+	+	-

+: suitable
- : unsuitable

From this table it can be seen that a variety of plastics pipeline systems are now available for gas distribution systems. Plastics are often preferred because of the ease of handling and installation of these pipelines compared to that of metal pipelines, and the reduced maintenance costs (no corrosion problems, no cathodic protection necessary).

Gas distribution is mainly done at lower pressures (?0.1 bar) and middle pressures (?4 bar). In these pressure regions plastic pipe materials are presently by far the preferred material.
PE100 has now filled up the gap up to 10 bar. What is still missing however, is the availability of plastic pipe systems in the pressure range between 10 and 16 bar. A number of plastic pipe materials will be introduced for this segment, like PA and RTP. Besides this development plastic pipe materials have been developed or are under development for special niche applications, like relining, use at higher and lower temperatures, no-dig applications etc.
For market introduction of plastics pipeline materials for gas distribution systems it is necessary to have a good set of product requirements to guarantee a long-term safe and reliable use. Safety is a key feature for the operation of gas distribution networks, and society expects that the materials used in these systems fulfil all relevant safety requirements.

Standardization on plastics pipe systems for gas supply

In the previous decades many specifications for plastics to be used in gas distribution systems have already been issued. At first these requirements were set up by national committees in various countries, often lead by national gas distributing companies. From the sixties of the previous century however, a technical committee (TC) is active in the International Organisation for Standardization (ISO) for setting up specifications for plastics pipe, fittings and valves for the transport of fluids, ISO/TC138. ISO is a global network that identifies what International Standards are required by business, government and society, develops them in partnership with the sectors that will put them to use, adops them by transparant procedures based on national input and delivers them to be implemented worldwide. More information about ISO can be found on www.iso.org.
In sub-committee 4 (SC4) of ISO/TC138, standards, specifications and guides are developed for plastics pipes and fittings for the supply of gaseous fuels. For many years SC4 mainly issued specifications for PE pipe systems. In the last years however, ISO/TC138/SC4 deals with a variety of plastics pipe materials to be used in gas supply systems.
Moreover, in Europe standards for plastic pipeline systems for gas distribution have been set up by a committee (TC155 WG 19) within CEN (European standardization organisation). There is a strong link between the standardization activities within CEN and ISO.
In this paper only the status of the standardization activities within ISO/TC138/SC4 will be reviewed. This is an update of a paper given on the 17th Plastic Fuel Gas Pipe Symposium in 2002 (ref. 1).

Structure and working programme of ISO/TC138/SC4

Presently 24 countries are active as participating (P) members within subcommittee 4 of ISO/TC138, whereas 14 countries are observer (O). This committee usually meets once a year and this meeting is attended by about 50 members from gas companies,

manufacturers, and testing institutes based in Africa, America, Asia, Australia and Europe. The secretariat is lead by Kiwa Gastec Technology in the Netherlands on behalf of the Dutch Standardization Institute (NEN). Within SC4 a number of working groups are active, see Table II. These working groups meet regularly (usually a number of times a year) to draft the various specifications and to deal with the comments received.

Table II. Working groups of ISO/TC138/SC4

WG1	Fittings for PE Pipe Systems
WG2	Welding of PE Pipe Systems
WG4	PE-X systems
WG5	Multilayer Pipe Systems
WG6	Butt-fusion Procedures
WG7	Polyamid Pipe Systems
AHG1	Review ISO 4437
AHG2	Reinforced Thermoplastics Pipes
AHG3	PVC-HI

At the moment 34 specifications for plastic pipeline systems for gas supply are the responsibility of ISO/TC138/SC4, see Appendix 1, of which 23 are published as an International Standard (IS), Technical Specification (TS) or a Technical Report (TR).

Status of the specifications for plastics pipelines for gas supply within ISO/TC138/SC4

1. Polyethylene (PE) pipe systems

As mentioned before, PE is presently the most widely used plastic pipe material in gas distribution systems. This is mainly originating from the fact that the largest part of gas distribution systems operate at pressures up to 4 bar. Up to these pressures PE has a good performance/cost ratio. Polyethylene pipeline systems have a good track record in gas distribution operations. There are hardly any failures and the leakages in these systems are low (see e.g. ref.2). The availability of a good set of specifications for these PE pipeline systems will certainly contribute to that. At the moment there is already a full set of ISO specifications available for the resins, pipes and fittings made from PE. For jointing of these pipes, specifications for welding are available as well. Presently a number of the specifications for PE pipeline systems for gas distribution are updated based on recent technological developments.

2. PVC-HI pipeline systems

In many countries gas distribution is mainly done at pressures not exceeding 0.1 bar. For instance, already more than 40 years ago, the gas utilities in The Netherlands have chosen for a low-pressure gas distribution system operating at 0.1 bar. For such a gas distribution network, high-impact PVC proved to be an excellent choice (ref. 5). Jointing is done by using push-in fittings with rubberring sealing. A complete system is available.

Experience with this system is very good. Failure rate is very low and the leakage rate is about equal to that of PE gas distribution systems. In The Netherlands, requirements for these systems are already in use for many years. Recently (June 2006) a complete set of ISO specifications is now available as well.

3. Other plastic pipeline systems

Mainly for higher demanding situations in gas distribution, like higher pressures, lower and higher temperatures and no-dig applications, special plastic pipeline systems are introduced.

One of these new plastic pipeline systems is **crosslinked PE (PEX),** which has an improved temperature resistance (at lower and higher temperatures) and an excellent resistance to notches. Therefore this material is aimed to be used in situations where these properties are important, e.g. in no-dig applications in rocky soils. For these PEX pipeline systems a full set of ISO specifications has recently (2006) become available.

Some parts of gas distribution systems operate at higher pressures exceeding 10 bar. Polyethylene is not suitable anymore for these situations. For these applications a number of plastic pipeline materials has been developed, like PA and RTP.

Reinforced thermoplastic pipeline systems (RTP) have been developed for high demanding situations (high pressures up to more than 100 bar, and high temperatures up to 120 ºC) in e.g. oil exploration and transport. But these pipeline systems are "overdesigned" for gas distribution. Recently a "light" version of RTP has been developed, tailor-made for gas distribution up to about 20 bar (ref. 3). A special jointing technique, based on electrofusion of PE pipe systems, has been developed as well. The pipes can be coiled up to lengths of a few hundreds of meters. Unfortunately the RTP pipes are only available up to now to diameters of 5"(125 mm). For this class of pipeline systems an ISO TS will be issued soon. (Requirements for pipes and joints).

Polyamide pipeline systems (PA11 and PA12) is another possibility for higher pressure gas distribution systems (ref.4). The pipes can be jointed by welding. At the moment a workgroup within ISO TC138/SC4 is drafting a full set of specifications for this material in gas distribution applications. It will cover PA11 as well as PA12. Two sets of requirements will be drafted, one for systems operating at pressures up to 4 bar, and one for operation up to 20 bar.

Finally, the development of **multilayer plastic pipeline systems** can be mentioned. A workgroup within ISO TC138/SC4 has already drafted a specification for multilayer pipes to be installed indoor, but this group will also draft specifications for multilayer pipes in outdoor gas distribution systems. By using multilayer systems, a special set of properties can be tailor-made for special applications in gas distribution.

Conclusions

Nowadays plastics pipeline systems are predominantly installed in gas distribution systems. These gas networks mainly operate at lower (<0.1 bar) or middle pressure (< 4 bar). PE, and in some countries like The Netherlands high-impact PVC, are specially suitable for such systems and show an excellent track record. The availability of a full set of (ISO) specifications certainly contributes to that. These ISO specifications are regularly updated to reflect the technological developments. For higher demanding applications, e.g. higher pressures, higher and lower temperatures, and increased resistance to notches, new plastic pipeline systems have entered the market. In this respect, PEX, PA, RTP and multilayer pipeline systems can be mentioned. Nowadays, for all these plastic pipeline systems ISO specifications are already available or being drafted.
The availability of such (ISO) specifications is generally considered as a prerequisite for a successful, safe and reliable operation in gas distribution networks.

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Appendix 1

Table A.1. Overview of the status of specifications within ISO /TC 138/SC4

WG	ISO number	Title	Current stage
SC4	TR 10837:1991	Determination of the thermal stability of polyethylene (PE) for use in gas pipes and fittings	Published
WG1	10838-1:2000	Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels -- Part 1: Metal fittings for pipes of nominal outside diameter less than or equal to 63 mm	Updating stage
WG1	10838-2:2000	Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels -- Part 2: Metal fittings for pipes of nominal outside diameter greater than 63 mm	Updating stage
WG1	10838-3:2001	Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels -- Part 3: Thermoplastics fittings for pipes of nominal outside diameter less than or equal to 63 mm	Under review
WG1	8085-1:2001	Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels -- Metric series -- Specifications -- Part 1: Fittings for socket fusion using heated tools	Under review
WG1	8085-2:2001	Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels -- Metric series -- Specifications -- Part 2: Spigot fittings for butt fusion, for socket fusion using heated tools and for use with electrofusion fittings	Under review
WG1	8085-3:2001	Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels -- Metric series -- Specifications -- Part 3: Electrofusion fittings	Under review
WG2	10839:2000	Polyethylene pipes and fittings for the supply of gaseous fuels -- Code of practice for design, handling and installation	Published
WG2	12176-1:1998	Equipment for fusion jointing polyethylene systems -- Part 1: Butt fusion	Updating stage
WG2	12176-2:2000	Plastics pipes and fittings -- Equipment for fusion jointing polyethylene systems -- Part 2: Electrofusion	Updating stage
WG2	12176-3:2006	Plastics pipes and fittings -- Equipment for fusion jointing polyethylene systems -- Part 3: Operator's badge	Published
WG2	12176-4:2003	Plastics pipes and fittings -- Equipment for fusion jointing polyethylene systems -- Part 4: Traceability coding	Published
WG2	19480:2005	Polyethylene pipes and fittings for the supply of gaseous fuels or water -- Training and assessment of fusion operators	Published
WG2	TR 13950:1997	Plastics pipes and fittings -- Automatic recognition systems for electrofusion	Updating stage
WG4	14531-1:2002	Plastics pipes and fittings -- Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels -- Metric series -- Specifications -- Part 1: Pipes	Published
WG4	14531-2:2004	Plastics pipes and fittings -- Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels -- Metric series -- Specifications -- Part 2: Fittings for heat-fusion jointing	Published
WG4	14531-3:2006	Plastics pipes and fittings -- Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels -- Metric series -- Specifications -- Part 3: Fittings for mechanical jointing (including PE-X/metal transitions)	Published

WG4	14531-4:2006	Plastics pipes and fittings -- Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels -- Metric series -- Specifications -- Part 4: System design and installation guidelines	Published
WG5	17484-1	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	Drafting stage
WG5	17484-2	Plastics piping systems -- Multilayer pipe systems for indoor gas installations with a maximum operating pressure up to and including 5 bar (500 kPa) -- Part 2: Code of Practice	Drafting stage
WG5	18225	Plastics piping systems - Multilayer piping systems for outdoor gas installations - Specifications for systems	Drafting stage
WG6	21307	Plastics pipes and fittings -- Butt fusion jointing procedures for polyethylene (PE) pipes and fittings used in the construction of gas and water distribution systems	Drafting stage
WG7	15439-1	Plastics piping systems for the supply of gaseous fuels for maximum operating up to and including 0,4 MPa (4 bar) -- Polyamide (PA) -- Part 1: General	Drafting stage
WG7	15439-2	Plastics piping systems for the supply of gaseous fuels for maximum operating up to and including 0,4 MPa (4 bar) -- Polyamide (PA) -- Part 2: Pipes	Drafting stage
WG7	15439-3	Plastics piping systems for the supply of gaseous fuels for maximum operating up to and including 0,4 MPa (4 bar) -- Polyamide (PA) -- Part 3: Fittings	Drafting stage
WG7	22621-1	Plastics piping systems for the supply of gaseous fuels for maximum operating up to and including 2 MPa (20 bar) -- Polyamide (PA) -- Part 1: General	Drafting stage
WG7	22621-2	Plastics piping systems for the supply of gaseous fuels for maximum operating up to and including 2 MPa (20 bar) -- Polyamide (PA) -- Part 2: Pipes	Drafting stage
WG7	22621-3	Plastics piping systems for the supply of gaseous fuels for maximum operating up to and including 2 MPa (20 bar) -- Part 3: Fittings	Drafting stage
AHG1	4437:1997	Buried polyethylene (PE) pipes for the supply of gaseous fuels -- Metric series -- Specifications	Updating stage
AHG2	TS 18226	Plastics pipes and fittings -- Reinforced thermoplastics pipe systems for the supply of gaseous fuels for pressures up to 40 bar	Drafting stage
AHG3	6993-1:2006	Buried, high-impact poly(vinyl chloride) (PVC-HI) piping systems for the supply of gaseous fuels -- Part 1: Pipes for a maximum operating pressure of 1 bar (100 kPa)	Published
AHG3	6993-2:2006	Buried, high-impact poly(vinyl chloride) (PVC-HI) piping systems for the supply of gaseous fuels -- Part 2: Fittings for a maximum operating pressure of 200 mbar (20 kPa)	Published
AHG3	6993-3:2006	Buried, high-impact poly(vinyl chloride) (PVC-HI) piping systems for the supply of gaseous fuels -- Part 3: Fittings and saddles for a maximum operating pressure of 1 bar (100 kPa)	Published
AHG3	6993-4:2006	Buried, high-impact poly(vinyl chloride) (PVC-HI) piping systems for the supply of gaseous fuels -- Part 4: Code of practice for design, handling and installation	Published