Fachverband der
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Plastic Pipes in the Industry: The right choice!

Juli 2024


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PLASTIC PIPES IN THE INDUSTRY:

THE RIGHT CHOICE!

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Plastic piping – sustainable and cost-efficient

MEGATRENDS LIKE DIGITALISATION, CLIMATE CHANGE AND URBANISATION ARE CHALLENGING SOCIETY AND INDUSTRY. THE PLAYERS IN THE KUNSTSTOFFROHR-VERBAND E.V. (KRV) ACCEPT THESE CHALLENGES AND ARE DEVELOPING INNOVATIVE AND SUSTAINABLE SOLUTIONS TO OVERCOME THEM.

Plastic piping systems are environmentally safe high-tech products that transport data, energy, cooling, heat, water of all types, and also the basic resources of the chemicals industry.

Plastics have shaped our everyday life for more than 70 years now. And plastics have an essential significance for the chemicals industry in the handling and transportation of solid, liquid and gaseous media. The use of plastic piping in the chemical industry at the former Hoechst company in Frankfurt goes back to the early 1950ies. Nowadays, plastic pipes play a indispensable role in practically every industrial process. The reason: The great versatility of solutions in plastic.

Depending on the applications involved, plastics provide atractive properties such as specific dielectric strength, thermal resistance, high chemical resistance and resistance to corrosion. Sophisticated joining technologies and a comprehensive framework of standardisation assure efficient, cost-effective and, above all, safe solutions.

Valves and fittings are integral components used for regulation, shut-off, monitoring and control of industrial piping systems. Industrial applications are nowadays inconceivable without automatic pneumatic and electrical valves.

Only in this way are plastic piping systems able to fulfil the diverse demands they are required to meet in, for instance, the semiconductor, pharmaceuticals and chemical process industry, as well as in foodstuffs production, mining and power-generating plants.

Photo: ©SIMONA AG

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Requirements specificly defined by the chemical process industry (CPI) on piping systems

"When it comes to the recycling of noble metals and in the course of the manufacture of products containing noble metals a great variety of chemicals, in particular, concentrated acids and caustic media are required. The use of plastic piping systems gives us the necessary flexibility in the planning and construction of our chemicals plants."

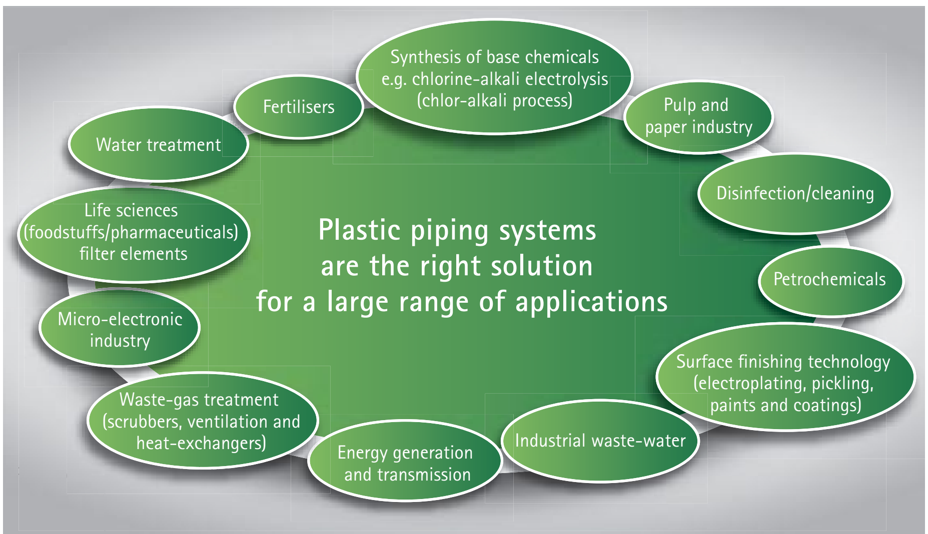
Hans-Joachim Alt; Heraeus Precious Metals-Engineering, Heraeus Holding GmbH, Hanau

The use of plastic piping systems for the transportation of chemicals and special grades of water other than drinking water results in very particular requirements on the piping components needed for this purpose. In addition to a most unusual broadness end depth of product range, the chemical resistance of the respective piping system is of utmost importance. For this reason, we encounter in no other sector of plastic-piping engineering such a great diversity of differing polymer materials can be found. The adjacent listing provides a short overview of the central customer requirements in this segment.

Compared to the size of the overall market for all applications of plastic piping systems, industrial piping accounts for only a relatively small percentage. But in view of the in many cases extremely individual and high requirement profile and precise specifications needed, it can rightly be designated as the "royal class" in plastic-piping engineering.

Requirements made on industrial piping systems:

- High safety level; leakage signalling and indication of cracking/fracture growth
- Functionality even in case of technical malfunction (e.g. in case of temporary overload)
- Resistance to chemical media; mini-mal leaching behaviour
- Legal conformity
- Long service lives
- Relevant pool of reference projects
- System solutions
- Simple maintenance, repair and installation
- High cost-efficiency



Plastic pipes – their chemical resistance

"Corrosion in polymers has been studied in detail in recent decades. The chemical resistance of plastic piping systems can now be effectively controlled by using a suitable polymer featuring a formulation well-suited to the specific environment and application."

Olivier Rod MSc, Vice President Material & Production, RISE Research Institutes of Sweden, Stockholm

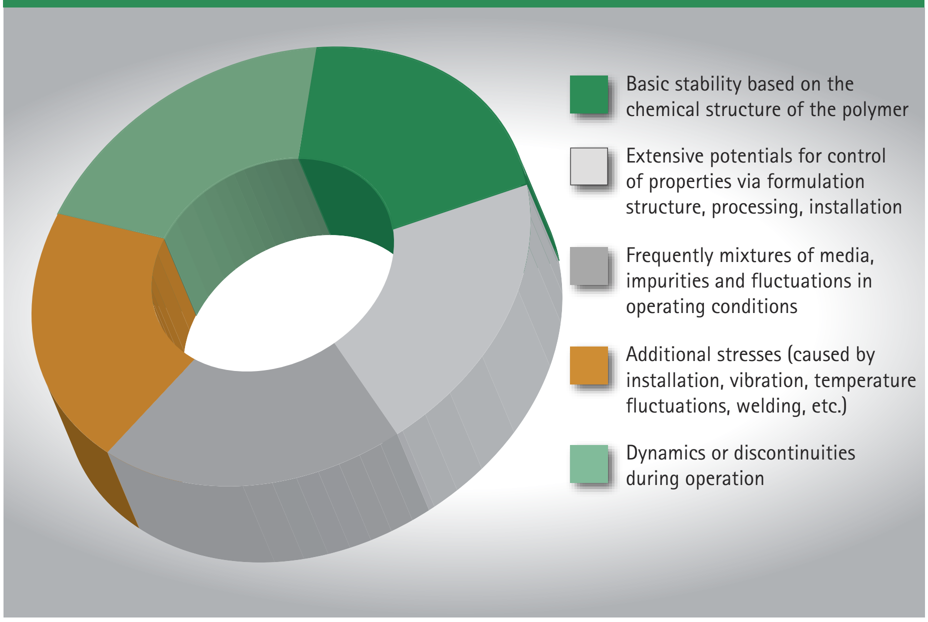
The great diversity of materials and exceptionally wide bandwidth of chemical resistance to numerous classes of media is the central element in the long-term success of plastic piping systems in the field of plant engineering.

It should be noted that a piping system's resistance to media is determined by a whole range of factors. The adjacent illustration shows the main influencing variables.

On the basis of nearly 70 years of practical experience and an already extremely sophisticated understanding of research of corrosion mechanisms, the material compatibility of the individual materials can be dependably described in the overwhelming majority of cases. In many instances, even extremely well quantified forecasts are now possible. Present-day knowledge shows that there is a polymer pipe-based solution for the conveyance of almost any chemical medium up to temperatures of 100 °C (and frequetly even beyond).

Great importance attaches to close cooperation between end-users and producers when it comes to the selection and specification of materials and systems; the frequently cited Chemical resistance tables should always be regarded merely as an initial aid to orientation.

Factors influencing the chemical resistance of plastic pipes



Standardisation – Quality Assurance – Certification – Approval

Product certification in the field of industrial plant engineering where liquid, gaseous and even solid media are conducted in piping systems assures the quality level expected by the user and thus makes an indispensable contribution to the safe operation of facilities fabricated from plastic piping systems.

Dr.-Ing. Jürgen Heinemann, Head of Piping Systems, DIN CERTCO Gesellschaft für Konformitätsbewertung mbH, Berlin

Formulation and processing essentially affect the properties of the components of plastic piping systems. Quality assurance of such products is assured by a highly developed range of standards and specifications which is also subject to continuous updating. The relevant basic German standards and European application-orientated standards are frequently also valid abroad and form the basis for internationally applicable specifications.

Certifications and approvals based on additional quality specifications and third-party monitoring by neutral and independent examiners and test institutions enjoy special ranking in the assurance of an extremely high quality standard. A prominent example of this in the case of the industrial pipe market is approval by the German Institute for Construction Technology (DIBt). This DIBt approval is also of supradisciplinary relevance in industrial plant engineering due to the extremely tightly meshed inspection and monitoring requirements required by building-supervision authorities and by the specifications for the materials used.

The resulting certification is the independent and impartial confirmation that a product conforms to all the specified quality and safety requirements.

Since 2004 the DIN CERTCO Gesellschaft für Konformitätsbewertung mbH has continued the fundamental tenents principles of quality policy for plastic piping systems, acting as the successor to the Gütegemeinschaft Kunststoffrohre e.V. (GKR) Certification programmes based on current standards and, in addition, defining outstanding quality characteristics, are developed in cooperation with the KRV, the raw-material and pipe manufacturers, end-users, test laboratories and all interested persons for the most diverse range of applications. DIN CERTCO thus supports, with great competence and transparency, independent and voluntary quality assurance for plastic piping systems with the so-called DINplus certification system.

Voluntary testing and certification enables manufacturers to test and certify their products voluntarily for standards such as compliance to technical requirements. In addition to DIN CERTCO Gesellschaft für Konformitätsbewertung mbH, other independent accredited bodies for product certification include, TÜV SÜD AG, Kiwa Deutschland GmbH and MPA Darmstadt, for example.

At international level, German and European standards are supplemented by international standards (e.g. ISO, ASTM, BS, JS).

The standardisation of the welding, adhesive bonding and jonting technology for plastic piping has for many years been governed extremely reliably – even at global level – by the codes and standards of the German Welding Society (DVS). Harmonisation with corresponding foreign standards is a constantly topical subject.

These codes and standards are rounded off by a large range of company standards and by numerous customers and special approvals which have evolved in the course of decades.

Pipe components are building products in accordance with the Construction Products Regulations. However, due to the fact that we a are still lacking the availability of harmonized standards in this field, no CE-marking for polymer pipes is possible at this stage.

Valves/fittings as from a nominal diameter of > DN 25, on the other hand, are subject to the Pressure Equipment Directive/Machinery Directive and are marked with a CE symbol on this basis.

Sustainability

Plastic piping systems play an indispensable role in plant engineering. They are not only themselves a high-tech product, they also assist other technologies to succeed. In plant engineering, not only technical and economic aspects are relevant in the fulfilment of the requirements made on piping systems. In addition to the "here and now", the needs of subsequent generations are also vital. Tomorrow's requirements concerning the protection of the environment and the climate, and thus the demands of energy and resources efficiency, form the basis for sustainable development.

The universal demand and the wish for the sustainability of plastics is increasingly connected with the question of the future acceptance of plastics as such. At the same time, the market is rising his demand on requirements on thermomechanical properties, purity and constant quality of polymers and polymer products.

This applies most particularly in the context of industrial use of plastic piping, since the requirement profile here is further expanded by the demand for the highest possible chemical resistance. In the past 70 years, a remarkable evolution in formulations, materials, processing, use and end products has taken place in the industrial plastic piping segment.

Nowadays, all systems on this market are based on very detailed specifications and making use of defined additive combinations, unequivocal specifications for the characteristics of base polymers, processing parameters as well as methods of installation and operation.

Sustainable sources of monomers

Plastics are nowadays produced predominantly on the basis of (limited) fossile feedstock, whereas the plastic of the future will, increasingly, be produced from biologically

Photo: ©Georg Fischer DEKA GmbH

Bioreactors consisting of plastic pipes for the cultivation of algae as a feed material for the cosmetics industry, foodstuffs production and the production of bio-fuels

Photo: ©Borealis AG

Production of phenol for polycarbonates from hydrocarbons using 100 % renewable feed materials

based and regenerative raw materials, products of chemical or materials-route recycling, and also from the conversion of CO_2. The technologies needed for this are already undergoing development. The use of ecologically degradable plastics is already a possibility for implementation of the circular economy in numerous consumer-sector applications. However, due to their quite limited chemical resistance properties, such biodegradable polymers do not play a role as material-basis for polymer piping systems for industrial use.

Long service lives

Unlike the situation in piping systems used in the public supply sectors, in which service-lives of up to 100 years are nowadays targeted, industrial plants are operated for an average of around 25 years. Such operating-life targets can be attained with certainty using the products of the plastic piping industry.

Circular economy

Traditional materials-route recycling, in which products, once their service life has expired, are shredded and reprocessed to make new products using standard plastics-processing methods, is generally not possible in the case of industrial piping systems. The reasons for this can be found in the gradual deterioration in thermomechanical properties ("down-cycling") of a given compound under repeated processing as a consequence of modification of chain length (→ molecular weight) caused by cross-linking or scission, and also the gradual consumption of additives (e.g. stabilisers, processing aids). The influence of chemicals on the piping system components during their period of use can in many cases have similar effects on the properties of the plastic material.

Chemical recycling

The handling of plastic waste and, in particular, packaging waste, currently confronts society with enormous challenges. Processed plastic waste is used, for example, in cement production, as a fuel-substitute, thus economising on the use of fossil materials.

It is increasingly being recognised that plastic waste is itself a valuable ressource. Not, indeed, for materials-route recycling, but as a starting material for the production of new plastics.

A route currently of great interest for the return of used plastics and plastic waste to the industrial cycle opens up via so-called "chemical recycling" (synonymous with "molecular recycling"), in which polymers/ plastic mixtures are split into low-molecular-weight organic components at high temperatures under the exclusion of oxygen using special catalysts in a thermochemical treatment process (pyrolysis).

Using this so-called pyrolysis-oil as a feedstock enables the access to (sustainable) well-defined organic basic components (e.g. Ethylene) that can then again fed into a conventional process to e.g. polymer-production.

This process, chemical recycling, is already in practice in plants for the production of plastics. In this way, new products at the quality levels demanded in plant engineering, among other sectors, are generated from life-expired disposable products. Even today, pyrolysis oil obtained from life-expired tyres and tall oil (a wood-based waste product from the production of paper) are used commercially for the synthesis of ethylene and thus for the production of sustainable PVC or PE.

Already started in 2015 in a scale of various metric tons capacity a novel process named "Fluorpolymer-upcycling plant" uses life-expired pipes and liners based on fully fluorinated polymers (PTFE, M-PTFE, FEP and PFA) to produce the monomer Tetrafluoroethylene (TFE) by means of pyrolysis. After purification, this monomer is again used for polymerisation. The properties of pipes produced using this process in no way differ from "original product" and in fact have superior properties compared to those of used, "end-of-life" products.

Sources for sustainable plastic

- Materials-route recycling
- Chemical/molecular recycling
- Ecologically degradable plastics

Sources of sustainable monomers

- Products from chemical/molecular recycling
- Bio-monomers
- Formed from conversion of CO_2

Energy-efficiency

The companies of the plastic piping industry are making multiple efforts to continuously raise the energy-efficiency of their production. On the user side, plastic pipe systems used, for example, in geothermal applications or as components in heat-exchanger systems increase energy-efficiency and reduce CO_2 emissions both within and outside of buildings.

Decarbonisation

The global trend toward decarbonisation of the energy industry, involving the gradual transition from fossil energy sources to hydrogen and the already developed scalable technologies for electrolytic splitting of water and the reduction of CO_2 to carbon monoxide, are resulting in an altered understanding of CO_2 emissions. In combination

1.4 Megawatt fuel cell (MCFC) supplying energy to the production location with the now very highly developed and established scrubber and filter technologies for the removal of sulphur- and chlorine-containing pollutants in flue and waste gas, the thermal utilisation of plastic waste begins to enjoy greater appreciation. The combustion of plastic thus becomes a new link in the carbon cycle; in this way, low-molecular base materials can be systematically synthesised from liberated CO_2 by means of electrolysis technology/electrocatalytic conversion with the use of suitable catalysts. Processes are currently being established that can be used to hydrogenate CO2 from exhaust gas or the atmosphere into methanol using sustainably produced hydrogen. Such technologies also open up access to sustainable synthetic fuels for use in conventional internal combustion engines.

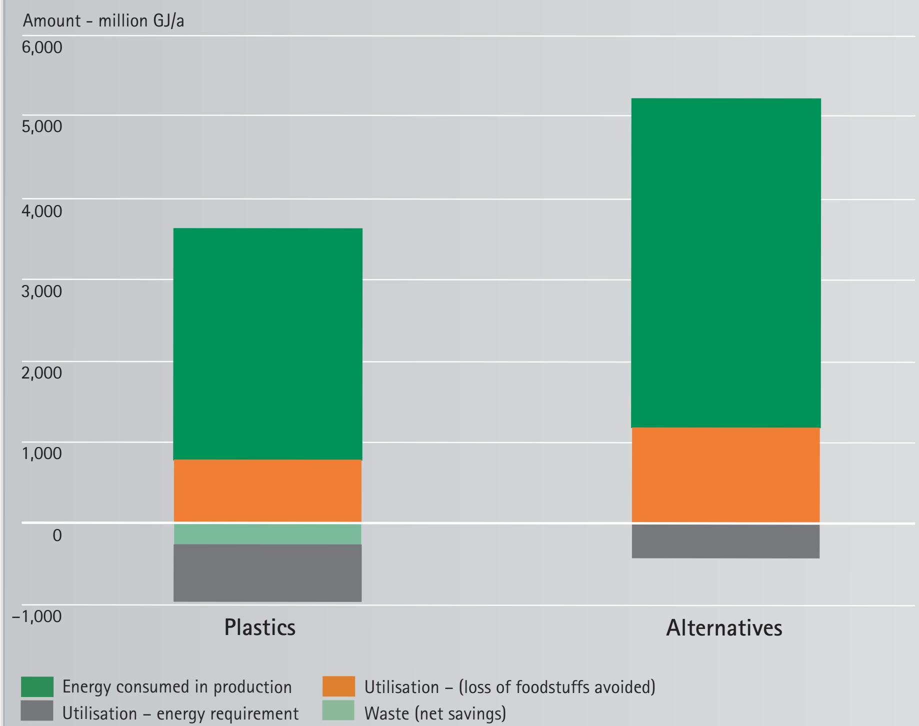
Around the world, intensive research is going on into scalable processes for closure of carbon cycles and for "smart" coupling of processes making use of "green" hydrogen, too. All of these processes should also lead to a situation in the plastic product life cycle where the carbon bound in the plastic will increasingly come from sustainable sources in future and fossil carbon sources will no longer be necessary for the production of polymers in the medium to long term - without any restrictions on the functionality and quality of the plastics in question, which are so valued by the market.

The preparation processes involved in the circular economy naturally give rise to extra costs. Boundary conditions which make sustainable plastics produced in accordance with the above-described model competitive with their counterparts produced on a fossil basis must therefore be created in an economic region. This is an essential aim of CO_2 certificate trading, which financially cushions the return of the CO_2 generated in the use of fossil carbon sources into the production cycle.

Plastic products consume less energy than their alternatives

- The energy requirement for the production, utilisation, recycling and disposal of plastics amounts in Europe to 4,300 million GJ/a (EU27+2).
- Total emissions of greenhouse gases amount to 200 million t/a.
- It can be demonstrated that the replacement of plastic products by alternative materials, wherever this is possible, would require around 57% more energy

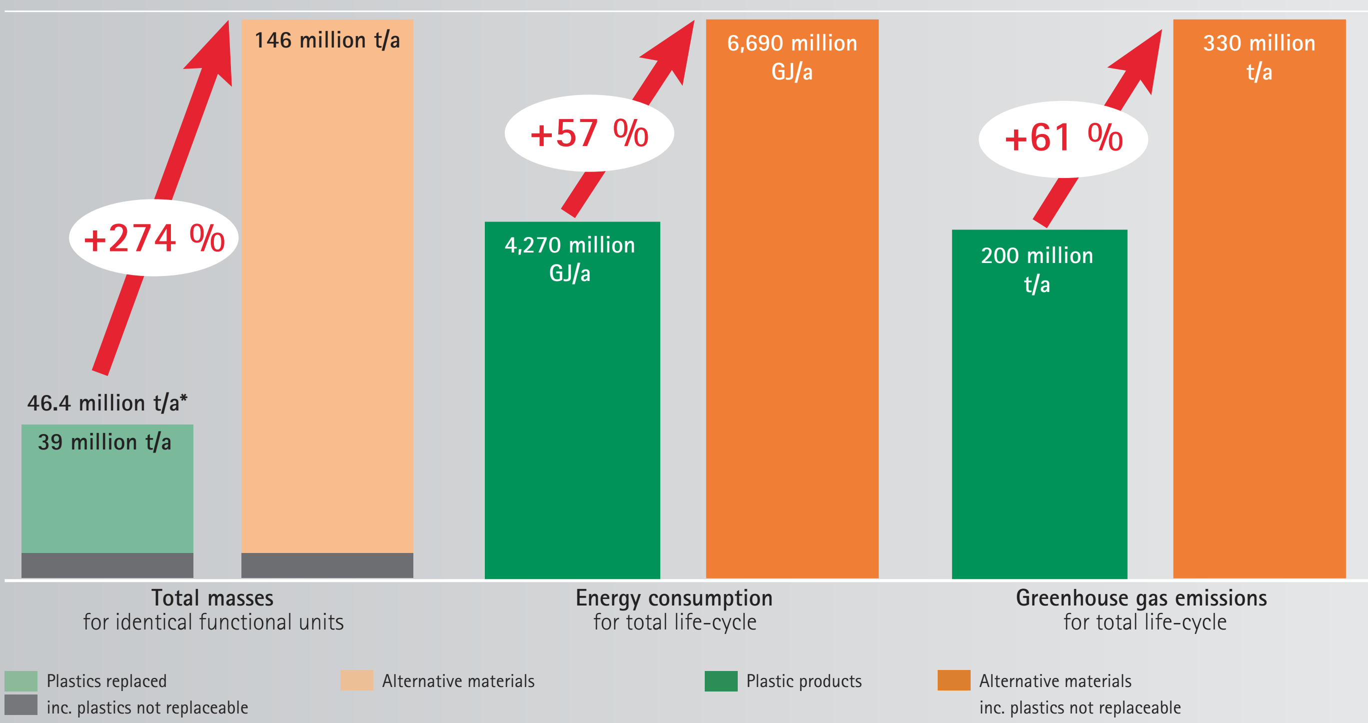
Total energy – consumption and energy savings



Energy consumption of plastic products in the course of their life-cycle (case studies covering 63% of total market) and their potential substitute materials, broken down by the life-cycle phases of Production, Utilisation and Waste Management. Positive figures indicate energy consumption, negative figures energy savings for avoidable losses on foodstuffs, primary production avoided (thanks to recycling) and generation of electricity and heat avoided (thanks to thermal route valorisation).

Source: The effects of plastics on energy consumption and greenhouse gas emissions in Europe, DENKSTATT GmbH, June 2010

Plastic products have made possible energy savings of 2,400 million GJ p.a.



Changes in product mass, energy consumption and greenhouse gas emissions if plastic products had theoretically been replaced with alternative materials

Source: The effects of plastics on energy consumption and greenhouse gas emissions in Europe, DENKSTATT GmbH, June 2010

(1,500-3,300 million GJ/a) than is consumed nowadays during the entire life-cycle of all plastic products.

- Plastic products permit significant savings of energy and greenhouse-gas emissions (production and utilisation being the most important phases in the savings mentioned).
- The study mentioned above examined the effects of various materials on the total energy consumption of products throughout their life-cycle.
- The study assumes a quantity of 46.4 million t/a of plastics which were used in plastics-processing companies in Europe in 2007 (EU27+2).
- Around 16 % of the total usage of plastics cannot realistically be replaced by alternative materials.
- The results here demonstrate that plastics make possible resources-efficient solutions.
- The replacement of plastic products by other materials in most cases increases both energy consumption and emissions of greenhouse gases.
- From the viewpoint of their overall life-cycle, plastics are thus among the most energy-efficient materials.
- In many cases, plastics permit a reduction in the overall consumption of material.

See internet for further information

www.krv.de/umwelt

Photo: ©raeva/stock.adobe.com

Materials and materials properties

> **Innovative polyolefin solutions have the potential to revolutionise the industrial piping sector even more. In addition to outstanding properties, such as unparalleled efficiency, highest performance standards and safety, durable and dependable pipe solutions in plastic also contribute to the sustainability of piping systems by permitting significant energy savings. We still need the innovative energy of our industry to overcome global challenges together.**
>
> *Alfred Stern, CEO Borealis AG, Vienna*

Plastics for every application

Plastics are subdivided into three main groups of polymers. One can differentiate here, depending on the degree of cross-linking, between thermoplastics, thermosets and elastomers. Thermoplastics and thermosets can be found in a large and diverse range of applications in pipe engineering, while elastomers are used in sealing systems.

Thermoplastics

Among the thermoplastics, the polymers polyethylene, polypropylene, polyvinyl chloride and polyamide are notable for their durability, great resistance to corrosion and low weight. They thus occupy an important ranking in chemical engineering. These plastics can be outstandingly adjusted to their particular application. Optimum modification of materials with respect to their morphology and formulation permits a broad bandwidth of applications. The foreground is in all cases taken by the considerations of safety and durability. These products can be joined cohesively either by means of adhesive bonding or welding and assure even by this alone a high level of safety and reliability in chemical and piping engineering.

Extremely smooth surfaces in pipes and fittings minimise hydraulic resistance and reduce the energy required for operation of the system as a whole.

The continuously rising demands made on plastic piping systems in chemical engineering result in the continuous further development and refinement of the base polymers.

In view of their extremely good long-term properties at elevated service temperatures and their high resistance to chemicals, they provide the user with great benefits while remaining at rational cost levels.

Fluoroplastics

Fluoroplastics are notable for their excellent resistance to both chemicals and elevated temperatures. Chemical resistance is explained by the high bonding energy of the carbon/fluorine bond and the corresponding screening of the carbon chain by the fluorine atoms. The fluoroplastics are differentiated between the partially fluorinated (PVDF, ECTFE) and fully fluorinated (FEP, PFA, PTFE-M, PTFE) types with respect to the degree of screening against chemical attack.

In the case of PVDF, these are used as self-supporting piping systems at ambient temperature for supply of ultra-pure water. In most other applications, the fluoropolymers are used as liners.

Liner materials are used in the form of loose linings or are permanently bonded with the steel substrate or fibre-reinforced resin structures after equipping with a rear layer of fabric. Despite the comparatively low modulus of elasticity at generally higher service temperatures, high-strength piping systems, tank facilities, distillation columns and many other chemicals-industry plant components can thus be produced.

Thermosets

Thermosets are plastics which can no longer be deformed after curing. They are thermally stable polymer materials which are permanently cross-linked in three dimensions via chemical primary valence bonds. This spatial cross-linking is the basis of thermoset reactive resin systems' extremely high level of temperature resistance, strength and stiffness. The thermosets most important for GRP piping systems include the polyester resins, epoxy resins, and also other cross-linked polymers, such as polyurethanes, for example.

Elastomers

Elastomers are wide-meshed cross-linked, rigid but elastically deformable plastics. The elastomeric plastics (e.g. sealing rings, rubber buffers for pressure and longitudinal expansion compensation) can be elastically deformed if subjected to tensile or compressive loads but then return to their original, non-deformed shape. The best known elastomers are natural rubber (NR), silicone rubber (VMQ), isoprene-rubber (IR) and fluoropolymer rubber (FKM, FPM).

Plastic piping systems have proven their worth in industry. They are the ideal conveying system for safety-relevant applications under exposure to extremely aggressive conditions. The diversity of the various plastics in all cases pursues the single objective of providing the most cost-effective solution for every challenge.

The following list shows purely by way of example a number of the available materials and their properties. Information on further materials and their properties can be obtained from the companies shown on page 41.

Polyethylene (PE)

PE is a thermoplastic material produced via the polymerisation of ethene. Various types of PE (PE80, PE100, PE100-RC or PE-RT), depending on the degree of branching of the polyethylene macromolecules and the distribution of the chain lengths, are supplied for different applications. PE is especially noted for its excellent processability combined with high flexibility and, thanks to the use of appropriate additives, for its extremely good resistance to ultraviolet irradiation. The material's good chemical resistance, combined with its toughness and stiffness, permits a large and diverse range of applications.

Polyethylene (PE)

Polypropylene (PP)

PP is a thermoplastic produced by the polymerisation of propene. Its properties can be improved through nucleation. The resulting very fine polymer structure leads to a higher strength with good impact strength at the same time, which naturally has a positive effect on resistance to chemicals. The various types of PP (PP-H, PP-B, PP-R and PP-RCT) are available for a large bandwidth of applications, depending on the degree of branch-

PP-H crystal microstructure under the microscope (linearly polarised light); left without, right with nucleation

One result of nucleation is a reduced surface roughness and thus a smoother interior pipe surface – with benefits for hydraulic flow

ing and of the molar mass of the polypropylene macromolecules and the use of copolymers.


Polypropylene (PP)
Photo: ©SIMONA AG

PP possesses elevated stiffness particularly in the upper service-temperature range – an ideal material, therefore, for installation of pipes above ground. High chemical resistance and good long-term properties under exposure to a range of fluids and media even at high temperatures complete the spectrum.

Polyvinyl chloride (PVC)

PVC is a thermoplastic produced by polymerisation of vinyl chloride.

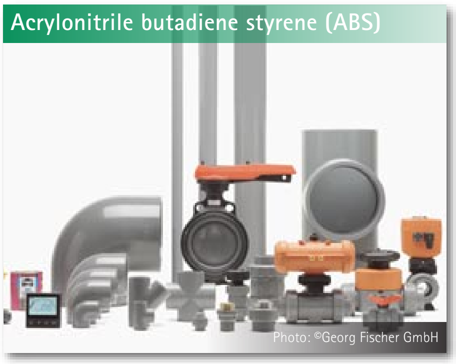
In the case of PVC, one differentiates between PVC-U and PVC-C. Both materials are noted for their flame retardancy. PVC-U (U = unplasticized) is one of the oldest mass produced plastics and is characterised as a universal material for its good cost-efficiency and simple thermomechanical workability.

PVC-C is produced via the post-chlorination of PVC. This results in a greater resistance to temperature compared to PVC-U and also, in certain cases, in improved chemical resistance.


Polyvinyl chloride (PVC)
Photo: ©Aliaxis Deutschland GmbH

Acrylonitrile butadiene styrene (ABS)

ABS is an amorphous thermoplastic which is joined using adhesive-bonding technology. Due to its mechanical properties, its good chemical resistance and its high impact toughness even in lower temperature ranges, this material is suitable for a large number of applications, particularly in the field of refrigeration and air-conditioning systems.


Acrylonitrile butadiene styrene (ABS)
Photo: ©Georg Fischer GmbH

Polyamide 12 (PA-U12)

PA-U12 is a plasticizer-free (U = unplasticized), partially crystalline high-performance thermoplastic, the high mechanical strength of which is based on hydrogen bonds between its macromolecules.

PA-U12 is characterised beyond the typical service-temperature range for its extremely high resistance to internal pressure, which enables it to replace the use of steel in the field of gas transmission between 10 and 16 bar operating pressure.

The chemical resistance of PA-U12 is outstanding not only to aqueous salt solutions, solvents and liquid and gaseous hydrocarbons, but also to weak acidic and basic media and mixtures of these, such as can occur, for example, in industrial wastewater.


Polyamide 12 (PA-U12)
Photo: ©Evonik Industries AG

In addition, long-chained semi-crystalline polyamides absorb only little water and exhibit great resistance to swelling caused by migrating media. This plastic's permeability is comparatively low – in fact, extremely low, depending on the particular fluid. In addition, PA-U12 has only a slight susceptibility to creep and a high impact toughness and can be used within a broad temperature range. Also worthy of emphasis is this material's extraordinarily high resistance to slow crack propagation.

In the case of many fluids, the relatively high resistance to pressure and temperature of PA-U12 piping systems are retained even when reduced by operating and design parameters.

Glass-fibre Reinforced Plastic (GRP)

GRP is a high-strength composite material consisting of reactive resin, glass fibres and pure, non-swelling filler materials and is used, in particular, in piping systems highly exposed to severe mechanical, thermal and/or chemical attack. The production process permits the combination of the most diverse input materials (glass fibre, reactive resin, additives) to make the ultimate end product. GRP pipes can thus be manufactured individually to conform to the requirements of the particular application.

The glass fibres, which posses good resistance to corrosion, provide the necessary flexibility of the composite material within an otherwise extremely high-strength stiff plastic. GRP is especially known for its very high stiffness and mechanical strength, particularly at high temperatures and when subjected to chemical attack. This material has decisive benefits in combination with its low weight, especially in large nominal diameters. Its chemical resistance can be further increased by pairing it with thermoplastic linings (e.g. PP or PVDF).

Glass-fibre Reinforced Plastic (GRP)

Photo: ©Amiblu Germany GmbH

GRP pipes featuring an inner pipe (inliner) consisting of thermoplastics, such as PE, PP, PVC-U, PVC-C, PA or PVDF, are referred to, for example, as composite-liner pipes. The inliner provides the required chemical resistance, while the GRP composite supplies the necessary mechanical-strength properties. Composite designs have achieved ever greater importance in recent years in chemical and piping engineering.

Polyvinylidene fluoride (PVDF)

PVDF is one of the highly crystalline high-performance thermoplastics. It also exhibits high stiffness, even in the elevated temperature range. The material is flame retardant and provides excellent resistance to a large number of organic and inorganic fluids. PVDF shows outstanding resistance to leaching out of formulation constituents (particularly in contact with ultra-pure fluids).

Polyvinylidene fluoride (PVDF)

Photo: ©SIMONA AG

Ethylene chlorotrifluoroethylene (E-CTFE)

E-CTFE is a tough thermoplastic. It is abrasion resistant and extraordinarily resistant to chemicals. It provides excellent suitability for the lining of pipes in systems for the conveyance of bioactive solutions or liquid media in the pharmaceuticals and foodstuffs industry as well as for ultra-pure gas and ultra-pure water piping in the medical-device and semiconductor industry.

Ethylene chlorotrifluoroethylene (E-CTFE)

Photo: ©Georg Fischer GmbH

Polytetrafluroethylene (PTFE)

PTFE is a semi crystalline thermoplastic, and is commonly referred to by the Teflon® trademark. Its virtually universal resistance to chemicals is explained by the high bonding energy of the carbon/fluorine bond and its excellent steric shielding of the carbon chain by the fluorine atoms.

There are practically no materials which stick to PTFE, as a result of its extremely low coefficient of friction.

PTFE cannot be welded and is, for this reason, generally used loosely clamped between the flanges of steel piping components.

Modified PTFE (PTFE-M)

PTFE-M, as compared to standard PTFE, in practice provides the following additional benefits: it can be joined using heating-element butt welding without any further weld filler materials, or using hot-gas string bead welding with PFA welding rods. PTFE's virtually universal resistance to chemicals is even further improved by the greater barrier effect against chemical penetration. This material's low permeation rate is of value particularly at high service temperatures of up to approx. 200 °C. It can be processed using the methods customary for PTFE.

Perfluoroalkoxy alkane (PFA)

PFA is a thermoplastic variant of PTFE. It possesses excellent non-stick properties, high resistance to permeation, particularly in the service temperature range of approx. 120 °C, virtually universal chemical resistance and an extremely high resistance to temperature. Its scratch resistance is lower, however. PFA is suitable for injection moulding, transfer moulding and extrusion. This material can be welded.

In addition to use as hoses and as a fitting material for aggressive chemicals, PFA is also employed as a corrosion-proof lining in chemical engineering.

Fluorinated ethylene propylene (FEP)

FEP, similarly to PFA, is a fully fluorinated material with thermoplastic processable properties, excellent non-stick performance and high resistance to permeation. Its resistance to chemicals is equivalent to that of PFA and PTFE-M.

It is well suited to welding and extremely resistant to outdoor weathering. Components consisting of FEP are used in the chemical processing, pharmaceuticals and semiconductor industries. FEP is used in exhaust gas purification and as media-resistant liners for lining steel tanks.

Polyether ether ketone (PEEK)

PEEK is a high-temperature-resistant semi crystalline thermoplastic. It is resistant to practically all organic and inorganic chemicals, possesses high resistance to gamma radiation and also has high mechanical strength.

Components consisting of PEEK are used in the chemicals industry, the oil and gas industry, the pharmaceuticals industry and in the medical-device and foodstuffs industry.

The tables show guideline figures for the particular material and can be used as aids to planning. Such technical characteristics data can vary depending on the particular processing method and on the method used for preparation of test objects. The suitability of any material for a specific application must be verified by the processor or user. No legal obligation and no liability may be derived from the information and/or data shown here nor, in particular, shall such information and/or data be construed as promised properties.

Table 1: Guideline figures for various materials as a possible aid to planning

Material		PE	PP	PVC		ABS
Material type		PE100	PP-H, PP-B, PP-R, PP-RCT	PVC-U	PVC-C	
Material morphology		Partially crystalline thermoplastic	Partially crystalline thermoplastic	Amorphous thermoplastic	Amorphous thermoplastic	Amorphous thermoplastic
Melting point range	°C	130–135	140–150 und 160–165 (PP-H, PP-B)	100–150	100–150	Not used
Glass transition range	˚C			73–83 (T_g)	100–120 (T_g)	
Young's modulus[1)]	MPa	900–1,000	750–2,000	2,500–3,000	2,500	1,900–2,700
Impact energy		+	+	0/+ (depends on formulation)	+	++
Longitudinal expansion	K^{-1}	$170–200 \cdot 10^{-6}$	$100–200 \cdot 10^{-6}$	$70–80 \cdot 10^{-6}$	$60–70 \cdot 10^{-6}$	$60–80 \cdot 10^{-6}$
Chemical resistance		Good safety against aqueous solutions of salt, acids, alkalis.	Good safety against aqueous solutions of salt, acids, alkalis, solvents.	Very universal chemical resistance to acids, alkalis, aqueous solutions, oxidising substances and many organic classes of substance. Caution in case of certain organic fluids.	Similar resistance profile to PVC U in many cases – but with certain additions (e.g. very good resistance to moist chlorine); but extremely restricted suitability in contact alkaline fluids.	Good safety against aqueous solutions of salt, acids, alkalis.
Service temperature range in form of full-walled self-supporting pipe	˚C	–40 bis +60	–20 bis +95	0 bis +60	0 bis +80	–40 bis +70
Maximum temperature in form of GRP liner	°C	+70	+90	+60	+90	Not used

Table 1 (continued): Guideline figures for various materials as a possible aid to planning

Material		PA	GRP	PVDF	E-CTFE/ECTFE	FEP
Material type		PA-U12	UP-GF, VE-GF, EP-GF			
Material morphology		Partially crystalline thermoplastic	Thermoset.	Partially crystalline, partially fluorinated thermoplastic.	Partially crystall-ine, partially fluorinated thermoplastic.	Partially crystalline, fully fluorinated thermoplastic.
Melting point range	°C	172	Not used	175	225	250–260
Glass transition range	°C					
Young's modulus[1)]	MPa	1,300–1,500	900–1,500	2,000–2,500	1,400–1,700	500–550
Impact energy		++	0	++	++ (no fracture)	+++ (no fracture)
Longitudinal expansion	K^{-1}	80 to 10^{-6}	10–50 to 10^{-6}	120–140[3)] to 10^{-6}	70–80[3)] to 10^{-6}	120[3)] to 10^{-6}
Chemical resistance		Good safety against aqueous solutions of salt, weak acid and alkaline fluids; very good safety against hydrocarbons and hydraulic fluid; slight tendency to swell; low permeability.	High resistance to chemicals, fuels and oils. The binder resin can be selected as suitable for use.	Very broad resistance to chemicals; restrictions in the case of alkalis, in contact with certain oxidising, very highly concentrated mineral acids and various organic fluids.	Also very good safety in alkaline fluids.	Virtually universal resistance to chemicals.
Service temperature range in form of full-walled self-supporting pipe	°C	–50 to +110	–60 to +120 (or +150[4)])	–30 to +110	–40 to +100	Not used
Maximum temperature in form of GRP liner	°C	Not used	–	110	120	130

Material		PFA	PTFE	PEEK
Material type			PTFE-M[2)]	
Material morphology		Partially crystalline, fully fluorinated thermoplastic.	Partially crystalline, fully fluorinated thermoplastic.	Partially crystalline thermoplastic.
Melting point range	°C	308 (melt)	330 (gel)	350
Glass transition range	°C	110 (T_g)	142 (T_g)	
Young's modulus[1)]	MPa	550–600	620–650	3,700
Impact energy		+++ (no fracture)	+++ (no fracture)	+++ (no fracture)
Longitudinal expansion	K^{-1}	140[3)] to 10^{-6}	120[3)] to 10^{-6}	40–50 to 10^{-6}
Chemical resistance		Practically universal chemical resistance	Practically universal chemical resistance	Practically universal chemical resistance
Service temperature range in form of full-walled self-supporting pipe	°C	Not used	Not used	Depends on application
Maximum temperature in form of GRP liner	°C	130 (or 150[4)])	130 (or 150[4)])	Not used

+++ = Insensitive to impact stress
++ = Very high resistance to impact stress
+ = High resistance to impact stress
0 = Sensitive to impact stress under certain conditions
– = Sensitive to impact stress

1) Short-term tensile young's modulus at 20 °C
2) PTFE-M can be butt-welded with no weld fillers. Use PFA welding rods for hot-gas string-bead welding
3) up to 100 °C application temperature
4) In combination with GRP with special high-temperature hybrid-resin matrix

Modified to meet your needs

Unlike traditional materials, plastics also offer potentials for innovation and individualisation in the long term.

Applications in the chemical processing industry frequently demand individual modifications, and "customising" here means systematically developing solutions to problems.

In areas in which there is a danger of explosion, plastics, with their anyway good electrical insulating properties, can be adjusted using special additives to be antistatic or electrically conductive. The electrical surface resistance is lowered by the addition of carbon blacks. (The results of this are shown in Figure 2).

Proven flame resistance protects in case of fire and is vital in ventilation systems. The special PP and PP-EL types feature self-extinguishing properties thanks to their high limiting oxygen index, which PVC and PVDF also generally assure. In the case of GRP pipes, this feature is achieved via the addition of a hypereutectic alloy consisting of approx. 78 % aluminium and 17 % silicon.

Fig. 2: Classification of materials by specific resistance

in acc. with BGR 132 / DIN IEC 60093

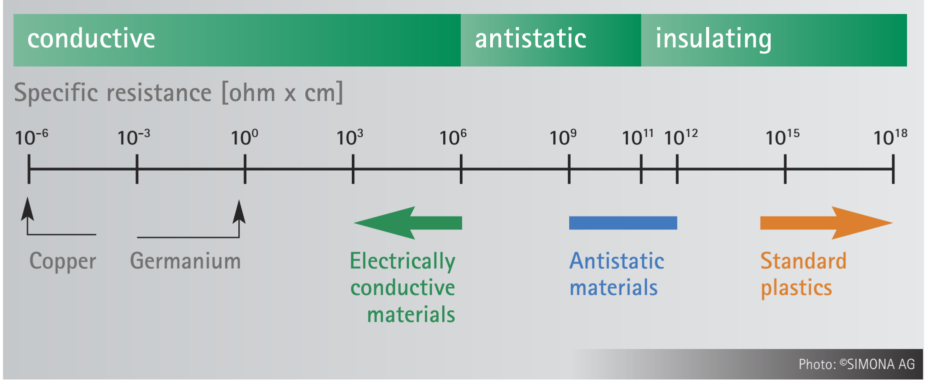


Photo: ©SIMONA AG

Pipelines are in many cases required to follow prescribed and highly ramified courses, avoiding, bridging or passing under obstructions. Material flows are, for example, combined or separated in manhole shaft structures and routed to specified transfer points. Where the combination of standardised pipes and fittings approaches its limits for the meeting of individual design requirements, the variability of the shape and design of plastics permits the implementation of special tailor-made solutions. Individual components or special structures, such as manholes or pipe bridges, for example, can then be created to conform with planning requirements.

Special solutions:

- Double-pipe systems using suitable fittings
- Pipes featuring special modifications, such as special dimensions and colours, for example, or material modifications
- Individually designed special fittings as system components
- Complex designs, including manhole shaft structures and distributor systems, for instance

Fire test on a plastic pipe in accordance with the IMO 753 standard

Photo: ©Georg Fischer DEKA GmbH

Busbars consisting of electrically conductive polyethylene

Photo: ©SIMONA AG

Joining methods

Plastic piping systems are able to achieve service lives of more than 100 years because joining and connecting systems that are durable (even under extreme conditions) are possible. This high level of quality is the result of materials specially developed for this purpose, tried and proven processing and welding technologies (based, for example on acknowledged DVS specifications in the case of joining) and of established and successful installation methods.

Dr. rer. nat. Benjamin Baudrit; Deputy Managing Director,
SKZ – KFE gGmbH, Würzburg

The methods for joining plastic piping components are diverse and are also, initially, dependent on the choice of material. For this reason, it is vital, when designing a plastic piping system, to obtain information concerning possible joining methods and their applicability as early as the initial planning phase. The selection of the most suitable joining method will depend on a large range of factors. Ultimately, a decision concerning the most suitable joining method will be influenced by cost-efficiency, component design, internal and external effects on the system, means of transport and local conditions and circumstances. The list shown below provides a rough overview of the most widely used joining methods in plastic piping engineering.

Photo: ©Georg Fischer GmbH

Socket fusion

Photo: ©Georg Fischer GmbH

- Easy handling during welding
- Easy weld preparation
- Straightforward operation of welding equipment
- Consistent weld quality
- Weld bead in the interior of the joint
- Non-tear-out connection
- ast, cost-efficient, strong
- Suitable for sizes up to 160 mm

Photo: ©WIDOS Wilhelm Dommer Söhne GmbH

Butt fusion

Photo: ©Georg Fischer GmbH

- Easy handling during welding
- Easy weld preparation
- Straightforward operation of welding equipment
- Consistent weld quality
- Weld bead in the interior and exterior of the joint
- Non-tear-out connection
- Fast, cost-efficient, strong

Photo: ©Georg Fischer GmbH

Electro-fusion

Photo: ©Georg Fischer GmbH

- Easy handling during welding
- Easy weld preparation
- Straightforward operation of welding equipment, integrated process monitoring
- Consistent weld quality
- No off-set or weld bead in interior
- Welding possible in poorly accessible places and positions
- Non-tear-out connection
- Fast, cost-efficient, strong

Photo: ©Aliaxis Deutschland GmbH

IR-butt fusion

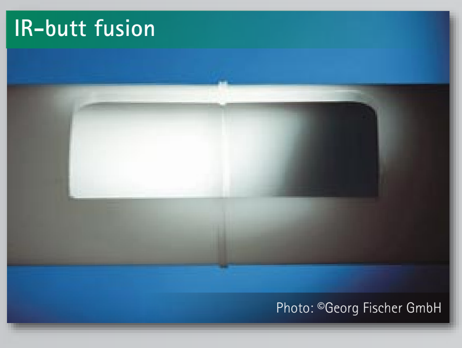


Photo: ©Georg Fischer GmbH

- Fast and automatable
- Significantly smaller bead
- No direct contact between the emitter and the work
- Non-tear-out joint

Photo: ©Georg Fischer GmbH

Hot-gas string bead welding (WF/WZ)

Photo: ©Georg Fischer GmbH

- Manual, high level of experience necessary
- Universal, suitable for any component geometry
- Standard method in composite piping engineering, equipment engineering (manholes and vessels), pipe engineering (jacket pipes)
- Non-tear-out joint

Photo: ©SKZ – KFE gGmbH

Extruder welding

Photo: ©Georg Fischer DEKA GmbH

- Extruder welding is a partially mechanised hot-gas welding process
- Groove and fillet are filled in a single working step
- Fast and cheap

Photo: ©MUNSCH Kunststoff-Schweißtechnik GmbH

BCF fusion joining

Photo: ©Georg Fischer GmbH

- Bead-free, maximum welding factors
- Restricted to certain wall thicknesses
- Restricted up to now to polyolefins/PVDF

Photo: ©Georg Fischer GmbH

Solvent cement joining

Photo: ©Georg Fischer GmbH

- Simple, fast, no machine needed
- Restricted to certain maximum dimensions
- Manual, depending on fluid exposure
- Selection of correct adhesive important
- Non-tear-out joint

Photo: ©MUNSCH Kunststoff-Schweißtechnik GmbH

Laminate connection

Photo: ©Amiblu Germany GmbH

- Quick replacement, adaptability
- Joining to other materials
- Layered structure in thickness and area

Photo: ©Amiblu Germany GmbH

Flanged joint


Photo: ©Georg Fischer DEKA GmbH

- Quick replacement, adaptability
- Fixed and floating flange variants possible
- Useful for pre-assembly installation
- Welding collar, gaskets and bolts needed
- Not an axially force-locked joint (detachable)


Photo: ©Amiblu Germany GmbH

Coupled joint


Photo: ©Amiblu Germany GmbH

- Simple on-site installation
- Quick installation thanks to couplings installed on one end at manufacturer's works
- Suitable for socketless pipes
- Types also available for axially force-locked and non-friction locked joints


Photo: ©Amiblu Germany GmbH

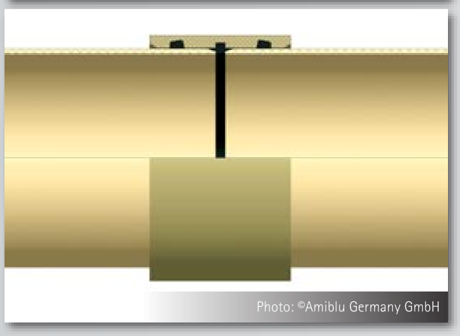


Photo: ©Amiblu Germany GmbH

Threaded joints, clamping, slip-in and press fittings


Photo: ©PLASSON GmbH

- Quick-connecting potential
- Simple installation, dismantling and reinstallation
- Non-tear-out joint (detachable)


Photo: ©PLASSON GmbH

Digital piping-system documentation

Modern system documentation is not restricted to the provision of electronic welding records in conformity to the common requirements, but can, instead, justifiably claim to reflect the entire life-cycle of all components of a pipe, from production via installation, up to and including operation. The use of new technologies will assure that data records are safely kept at a central storage point and can be consulted from anywhere at any time.

Information, such as site-designations, order numbers, welder ID, welding records and GPS coordinates, the results of hydrostatic testing and the records of non-destructive material testing, along with illustrations and videos, can be saved and archived on-line in data-bases. Maintenance cycles for valves and fittings can be stored in the system and thus facilitate the servicing and maintenance of the plant or system.

Training and qualifications in the field of joining systems

"The qualification provisions developed by the IKV in cooperation with the educational and training institutions over a period of more than 70 years are a guarantee of high-quality installation of plastic piping in Germany and also enjoy high international acclaim."

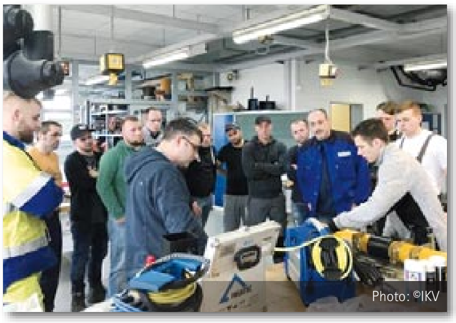
Dipl.-Ing. Leo Wolters, Head of the Basic and Further Training department,
Institute for Plastics Processing (IKV) in Industry and Craft at the RWTH Aachen University

The increasing use of plastic piping in both the industrial sector and in the field of wastewater and drinking water during the 1950s rapidly resulted in the IKV developing, only shortly after its founding, a qualification course in "Installation of fresh-water piping consisting of thermoplastics", which was attended with success for the first time by numerous apprentices in 1955 and was subsequently adopted into the IKV's range of courses. Only a short time later, the development of even more qualification provisions followed, including courses in plastic-pipe installation inside buildings.

Together with the specialist associations (DVS, DVGW, KRV, ZVSHK, RBV), the qualification provisions developed by the IKV have been incorporated into DVS directives, DVGW codes and framework curricula for manual trades. The development of plastics courses is certified in accordance with ISO 9001:2015.

The IKV functions as a Germany-wide information centre for the qualification provisions conducted by the training centres operated by the regional chambers of craft trades, the SKZ, the guilds and the construction industry. In the plastic-pipe installation sector, the portfolio is implemented at more than twenty of the currently existing forty-two training institutions by more than forty of the current 100 trainers technically qualified and supervised by the IKV.

Training since the 1950s



Present-day training

The qualification courses for installation of plastic pipes are attended by around 15,000 participants annually. The number of industrial plastic-pipe installation practitioners is around 20 %. All the joining methods (butt fusion, socket fusion, electro-fusion, mechanical joining, solvent cement joining, laminating) are taught, depending on the particular application. The courses are designed in such a way that all approved pipe and fitting manufacturers and all welding-machine makers are presented impartially alongside each other and in such a way that every course participant becomes practically familiar with the use and handling of all systems. Training as plastics welders, adhesive bonders and laminators is rounded off with training of skilled welding personnel in accordance with DVS 2213.

The following qualification provisions are at present available for the plastic-pipe installation sector:

- DVS 2212-1, "Qualification Testing of plastics welders, Test Groups I and II"
- DVS 2212-4, "Qualification Test Groups I and II of plastics welders; Welding of PE jacket pipes – Pipes and piping parts"
- DVS 2213, "Skilled plastics welding specialist"
- DVS 2220, "Qualification Testing of plastics laminators and adhesive bonders – Laminates and laminate and adhesive bonding joints consisting of GRP (UP-GF and EP-GF)"
- DVS 2221, "Qualification Testing of adhesive bonders for plastics – Pipe joints consisting of PVC-U, PVC-C and ABS using detachable adhesives"

Training and educational institutes in the field of plastic piping installation

Photo: ©IKV

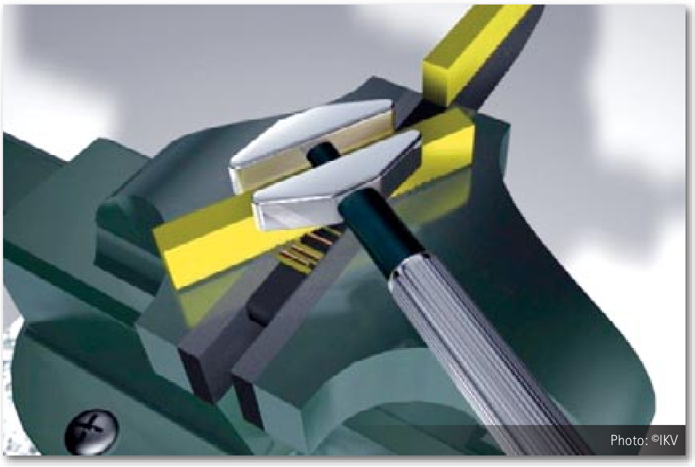
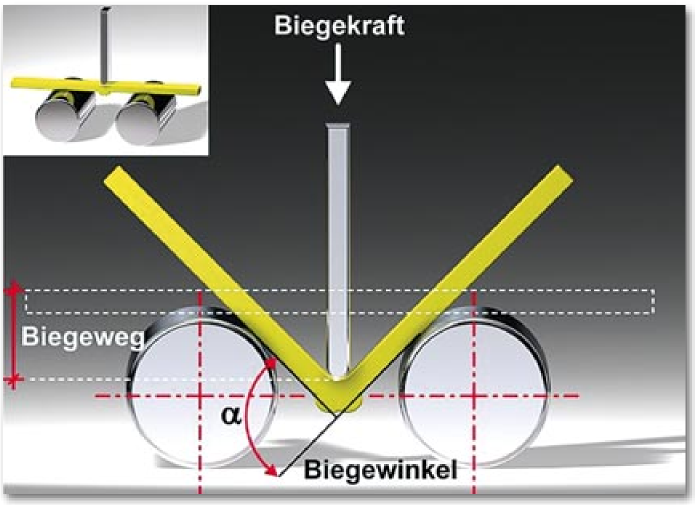


Photo: ©IKV

Torsion-shear test for characterisation of mechanical properties of electro-fusion and socket fusion welds



Technological bending test for verification of cold deformability of a weld

See internet for further information

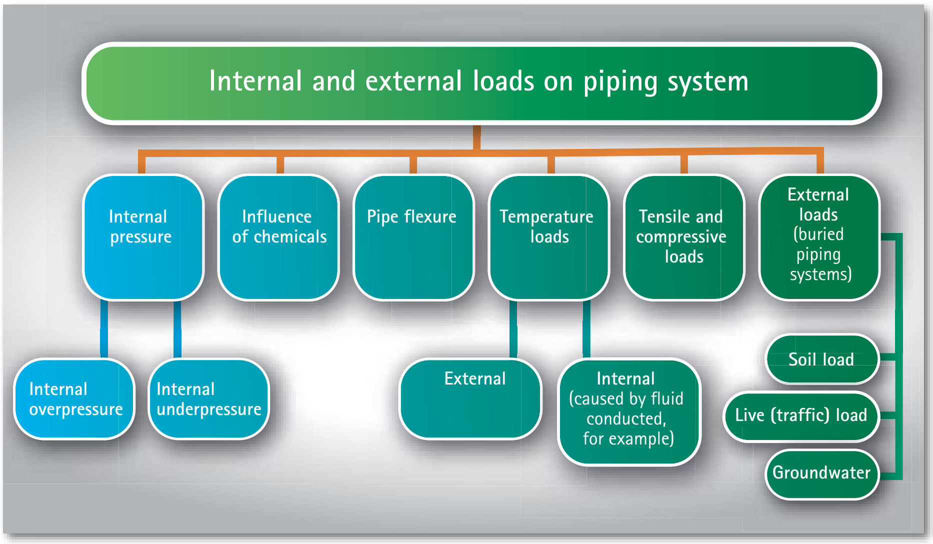
www.kunststoffausbildung.de

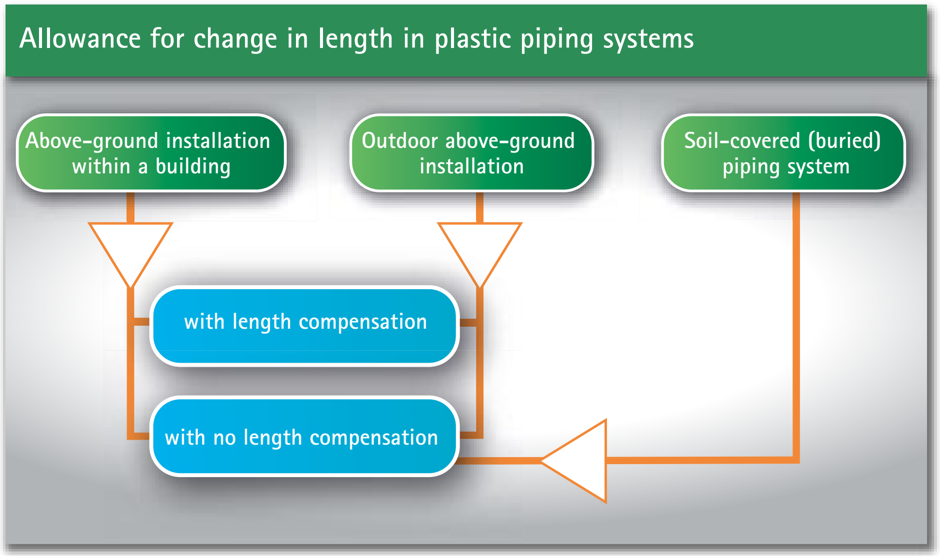
Notes on installation

Plastic pipes exhibit a significantly more time-dependent and temperature-dependent material behaviour than metal pipe materials. There are a number of external and/or internal loads and stresses which can in principle act on a piping system. These stresses apply most particularly in the case of soil-buried piping systems The possible loads and stresses are indicated in the graphics shown on the right.

The basic preconditions for a professionally designed piping system are good technical knowledge backed up with experience in the particular application and process engineering. In this field, plastics assure the use of highly durable, environmentally safe, low-maintenance, cost-efficient piping systems.

In the planning and installation of thermoplastic piping systems it is, nonetheless, necessary to keep in mind the characteristic materials properties (such as a high coefficient of expansion, for example). Modern calculation programs are nowadays available for this purpose.





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Legal provisions concerning plastic pipes for handling of water-hazardous substances

The protection and preservation of our environment and water are one of the most important obligations, particularly in plant engineering. The transportation of water-hazardous substances in plastic pipes is an elegant solution which assists in achieving this high target.

Dipl.-Ing. Matthias Doll, Expert Inspector in accordance with Article 53 AwSV, TÜV SÜD Industrie Service GmbH, Munich

In the EU directives, Brussels exercises a great influence on the shaping of environmental protection (soil, water and air) in Germany. EU requirements can be found, for example, in the:

- Water Framework Directive (WFD) and the subsidiary directives for protection of the groundwater
- Waste Framework Directive (WFD)
- Industrial Emissions Directive or in the
- Chemicals Regulations (REACH).

These requirements are implemented largely in the German Water Management Act (WHG), in German building law and in the Federal Immission Control Act (BImSchG).

The legal requirements for facilities and systems for handling and use of water-hazardous substances can essentially be found in Article 62 and Article 63 of the WHG, the Ordinance on facilities for handling substances that are hazardous to water (AwSV) and the generally acknowledged rules of technology in accordance with Article 62 of WHG. These would be (on the basis of the current status of building-law regulations):

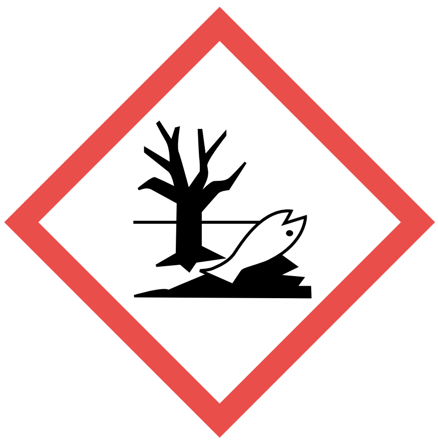

Photo: ©T. Michel/stock.adobe.com

- Technical Rules for the Handling of Water-hazardous Substances of the German Association for Water, Wastewater and Waste (DWA)
- Technical rules which are stated in the Specimen Model Administrative Provisions – Technical Building Rules (MVV TB), published in the "Proceedings of the German Institute for Construction Technology", and concerning the protection of bodies of water
- DIN and EN standards concerning the protection of bodies of water and not included in the Schedule of Building Regulations of the DIBt.

In accordance with Article 62 WHG, the requirements of the equipment-related protection of bodies of water apply to:

- Facilities for the storage, decanting and transshipping of water-hazardous substances ("LAU" facilities)
- Facilities for the production, treatment and use of water-hazardous substances ("HBV" facilities)
- Piping systems for the handling of water-polluting substances

Every operator of such facilities must be aware that the leaking of water-hazardous substances can cause harm and permanently contaminate the soil, water and groundwater, causing serious environmental damage. The concern addressed in Article 62 WHG is to be interpreted in such a way that not even the tiniest possibility of harm to water properties may be tolerated from the construction of such a facility, via its utilisation, up to and including its closure.

Article 63 WHG – Qualification Examination – was amended in 2017 and came into effect in January 2018. This amendment was necessary, on the one hand, to take account of the amended Building Code Law with respect to the European provisions on building products and their suitability. And, on the other hand, the legislative process was also used to improve the systematics and comprehensibility of the provisions.

It must be particularly noted that the Qualification Examination is to be ascertained by the authority only for the totality of the LAU facilities. In Article 63 Para. 4 WHG supplementary provisions for the (possible) suitability of plant components are then made.

Via Article 63 Para. 4 WHG, therefore, the suitability criteria of the following plant components for LAU facilities are set by the legislator:

- Building products which have been produced and brought into circulation (i.e. traded and marketed) under the provisions of European building-product law where certain requirements are fulfilled (including CE marking with a declaration of performance concerning significant features of the harmonised standard which serve the purpose of protection of water)
- Building products or building types for which a general building-supervision approval or building-type approval has been issued by the DIBt taking due account of the water-law requirements
- Pressure equipment in the sense of the European Pressure Equipment Directive

Photo: ©Borealis AG

Photo: ©Amiblu Germany GmbH

(PED) with corresponding CE marking where such has also been put into operation in accordance with PED.
- Machinery in the sense of the European Machinery Directive (MD) with corresponding CE marking where such has been put into operation in accordance with the MD.

Upon the introduction of the Ordinance on facilities for handling substances that are hazardous to water (AwSV) in August 2017, a uniform federal law was introduced after years of preparation and the overcoming of numerous hurdles. The regulations replaced not only the sixteen federal-state regulations (Ordinance on facilities for handling substances that are hazardous to water and on Specialist Companies [VAwS]), but also the Administrative Regulations for substances that are hazardous to water (VwVwS). The regulations for classification of water-hazardous substances into water hazard classes (WGK) were incorporated entirely into the AwSV – Annex 1. And, in addition, not only biogas plants, but also liquid manure, solid manure, and dung water plants were included in the AwSV.

The AwSV redrafts the organisational requirements on operation of facilities, such as, for example, requirements for notification and approval, expert inspection, in some instances. The provisions requiring expert inspection of such facilities were broken down into greater detail, resulting in the new regulations being more stringent compared to the previous provisions in the case of exceptional risks, such as facility location in, for example, areas endangered by flooding. The necessity of technically correct planning of such facilities was also emphasised. This was a reaction to the errors frequently made in the past which could have been avoided given correct planning. An obligation to documentation by the operator for his or her facilities was also introduced (Article 43). The Mandatory Commissioning of a Certified Specialist Organisation (Article 45) was expanded, and the requirements made on the personnel of a specialist organisation in accordance with WHG were made more stringent, with respect to obligations to further training, in particular.

With regard to the technical requirements, § 21 AwSV contains the requirements for the retention of pipelines for the transport of substances hazardous to water. In accordance with AwSV, too, retention provisions can under certain preconditions still be dispensed with partially or entirely in the case of non-buried piping systems, on the basis of a hazard estimate (Application of Technical Rules for Water-Hazardous Substances TRwS 780). In the context of TRwS 780, it should be noted that both parts are available in the current May 2018 edition. Irrespective of this, adherence to other provisions for the safety and protection of staff (including the need for splash protection measures) for double-walled pipes in accordance with the Industrial Health and Safety Act (ArbSchG) and the Ordinance on Industrial Health and Safety (BetrSichV) is, of course, mandatory.

In the draft of the new edition of the German Technical Instruction for maintaining clean air ("TA Luft") (first General Administrative Regulation for the Federal Immission Control Act) dated July 2018, new requirements were made, in addition, with respect to flanged joints. The previous requirement of "highly effective sealing" is no longer sufficient to meet the German Clean Air Act.

In this new draft edition of the German Clean Air Act, transition occurs from the individual observation of "Sealing with German Clean Air Act Certificate" to a system-related observation of the total "Flanged joint with German Clean Air Act Certificate". The tightness class of plastic flanged joints must be demonstrated for the entire flanged joint with a harmonised component test with reference to the Technical Rule VDI 2200, "Tight Flange Connections – Selection, Calculation, Design and Assembly of Bolted Flange Connections".
The maximum permissible leakage rate is L= 0.01 mg/s · m.


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Mai 2018

Wide range of pipe and pipe-system concepts

Plastic piping systems used in electrolysis technology have improved significantly in the past five years. Profound understanding of the material under operating conditions has enabled us to optimise these components for their specific use in the chemicals industry.

Dr. Sami Pelkonen, Chief Executive Officer, ThyssenKrupp Industrial Solutions BU Chemical and Process Technologies, Dortmund

No other class of pipes is capable of filling a greater bandwidth of different pipe and pipe-system concepts than plastic piping. This applies especially in the field of plant engineering.

Bandwidth of pipe concepts for plastic piping systems used in plant engineering

Concept	Joining methods	Typical diameter range [mm]	Characteristics
Double pipe (pipe-in-pipe)	Solvent cement joining, welding	20–225 (inner pipe)	Greater safety achieved thanks to pipe-in-pipe concept. Leakage monitoring thanks to underpressure system. Visual inspection using sensors (outer pipe in the form of transparent PVC) or underpressure measurement.
GRP piping	Socket joint, solvent cement joining, laminated joint, flanged joint	25–4,000	Great safety thanks to pipe-in-pipe joint. Various types of resin permit appropriate solutions in terms of temperature and fluid.
Ventilation pipes	Socket joint in combination with solvent cement joining and hot-gas string bead or butt welding	< 800	Frequently the most cost-effective alternative to convey corrosive waste-air/fumes.
Tubes	Socket joint, threaded joint and special solutions	< 2 inch	Often available as rolls; hoses in fully fluorinated plastics are frequently used as the inner pipe in double-pipe systems in the semiconductor industry.
Customized piping	Extremely versatile and individual in material and application	generally < 2,500	Pipes in the form of “semi-finished product”; generally no system concept needed.
Thermoplastic piping systems	Welding, solvent cement joining, flanged joint	16–4,000	Standard in industrial sector.
Composite liner pipe	Hot-gas string bead or butt welding, flanged joint	16–2,000	Boosted safety thanks to pipe-in-pipe concept; frequently significant increase in application temperatures, because inliner acts only as a corrosion barrier, while the mechanical load is borne by the GRP jacket.

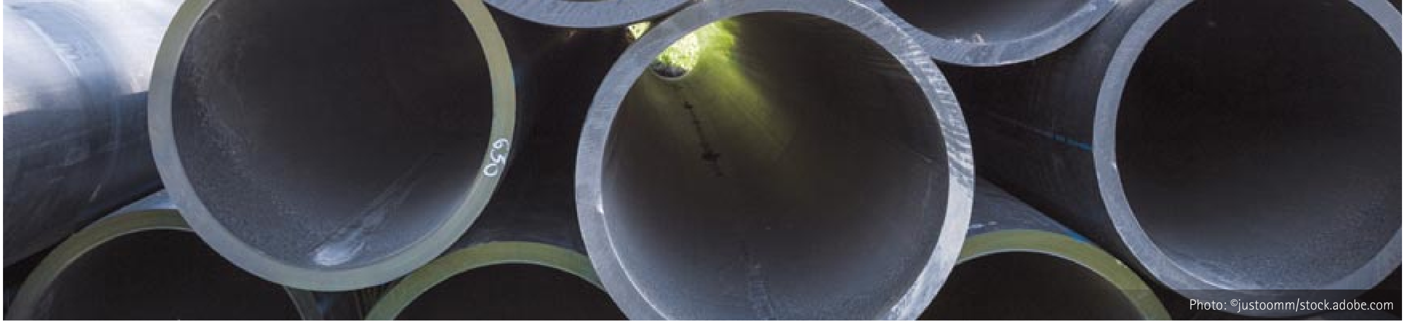


Photo: ©justoomm/stock.adobe.com

Typical applications

> **A modern chlorine plant cannot be designed to be sustainable without plastic piping systems.**
>
> *Bernhard Rijpkema, Manager Materials Technology, Nouryon Industrial Chemicals, Arnhem, Netherlands*

Chemicals process industry

Piping systems for cooling water in the process industry

PE, PP and PVC piping systems are used when conducting a mixture of water with a sulphuric acid content (36 %) at 40 °C.

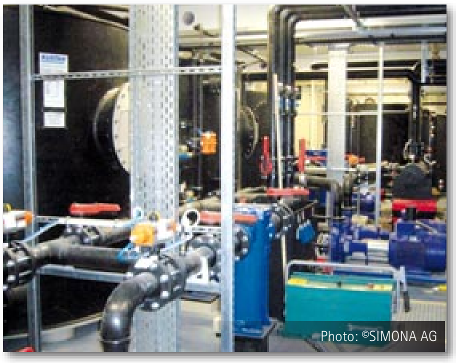


Photo: ©SIMONA AG

Photo: ©SIMONA AG

Durable all-in solution for pickling systems

Plastic pipe systems are the right solution, one that meets a whole range of chemical requirements:

- Nitric acid and hydrofluoric acid at 70 °C: PP-H
- Distilled water at 80 °C: PP-H
- Aqueous sulphuric acid at 90 °C: PVDF
- Sulphuric acid (95%): PVC-C, PVC-U
- Sodium sulphate at 85 °C: PVC-C

Photo: ©SIMONA AG

Energy-savings of up to 25 % in industrial chlorine production

Electrolytic production of chlorine and alkaline solution from rock salt or potassium chloride is a fundamental chemical process which has been in global use on the megatonne scale for many decades. But this process incurs an extremely high energy consumption. In a highly innovative further refinement of the membrane process currently used by all relevant suppliers of this technology, electrolysis is operated on the cathode side (lye production) under an oxygen atmosphere at temperatures in the 85 to 90 °C range (the so-called ODC process). This operation greatly modifies the cell reaction and new conditions arise, under which chlorine recovery can be accomplished with savings of electrical energy of up to 25 % compared to the standard membrane process. This technology employs composite liner pipes consisting of a specially modified PVC-U material on the alkaline solution side. Chlorine electrolysis is in principle a reference technology in which very many plastic pipes have long been used under exceptionally demanding operating conditions in the immediate environment of the electrolysis cell and in its peripherals, and also in the further processing of the chlorine and alkaline solution recovered. Yet another proof of the efficiency, performance and corrosion resistance of this class of materials.

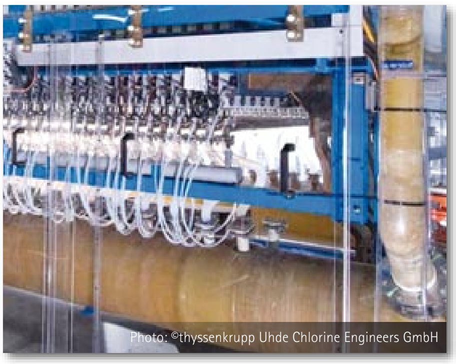


Photo: ©thyssenkrupp Uhde Chlorine Engineers GmbH

Carbon Capture and Utilisation (CCU) uses PA-U12 relining for rehabilitation of CO_2-conducting lines

In Veracruz (Mexico), 880,000 t of carbon dioxide yielded in the petrochemicals industry are used each year for the production of urea. The original steel piping, of internal diameters of 305 mm (12") and 460 mm (18") exhibited after 20 years of operation a drastic reduction of their wall thickness, indicating the presence of moisture in the CO_2. When the residual wall thickness had reached 20 %, plastic liners were then drawn into the steel pipes.

Tiny holes, and also the permeation of CO_2 through conventional liners, can result in the formation of carbonic acid, a substance which, even in very small amounts, accelerates the oxidation of steel. The pipes in Veracruz run for 700 m across a river on a scarcely accessible pipe gantry. The liner material selected was PA-U12, because permeation of CO_2 through a PA-U12 pipe wall is negligible. In addition, the stiffness of PA-U12 in CO_2 -saturated state, and also the material's creep resistance, are so high that the probability, at an operating pressure of 27.5 bar (400 psi), of reliably bridging the holes for the twenty-five year remaining service-life of the steel pipes, which are likely suffering somewhat larger perforations as a result of rust, can be dependably regarded as high.

To permit the pulling-in of the liner pipes into the now refurbished steel pipes, the liner-pipes' diameter was reduced by drawing them through a roller rack. Once in the steel pipes, the liners relaxed and thus contacted with the inner diameter of the steel pipes. The longitudinal grooves made in the PE-U12 liners form between the liner and the steel pipe an air-flushed space to which a leakage-protection monitoring system is connected at regular intervals.

The liner pipe is thus the safest selection and assures lifelong zero-maintenance for the crossing of water.

Photo: ©Evonik Industries AG

PA-U12 liner pipe

High chemical resistance

Piping systems consisting of PP-H assure trouble-free operation in the recovery process for acid pickling liquor (nitric acid 20 % and hydrofluoric acid 5 %) for the treatment of metal surfaces.

Photo: ©SIMONA AG

Severely polluted industrial wastewater from peroxide production

Heavily contaminated wastewater occurs in peroxide production at a chemicals park in Gibbons, Canada. A pressure pipe reached the end of its useful life, probably due to insufficient attention to its exposure to chemicals. For this reason, a Polyamide 12 pipe (external diameter 114 mm SDR 13.5) was drawn loose into the embrittled original pipe (external diameter 219).

At operating temperatures of above 50 °C, very high resistance to hydrocarbons, hydrogen sulphide and carbon dioxide in aqueous solution has been demonstrated for Polyamide 12 on the basis of experience in offshore applications. In case of reduction of the pipe diameter, it was possible to assure the necessary flow rate by a corresponding increase in operating pressure. The PA-U12 pressure pipe had been designed at SDR 13.5 for an operating pressure of 10 bar (150 psi). The PA-U12 liner has been in operation with no difficulties since 2015.

Photo: ©Evonik Industries AG

PA-U12 liner pipe

Water preparation


Photo: ©SIMONA AG

Distribution system showing PP-H piping and fittings in a water-preparation plant


Photo: ©SIMONA AG

Desalination plant showing PE100 pipes and fittings


Photo: ©Aliaxis Deutschland GmbH


Photo: ©SIMONA AG

Modern materials for water-preparation plants

Corrosion-resistant plastic pipes are the ideal conducting and handling system for water. They fulfil all hygiene requirements dependably and guarantee long service-lives and high operational reliability. Plastic piping systems are used in preparation plants for industrial and commercial wastewater, in swimming-pool technology and in desalination plants. Standardised system components combined with special individual fittings permit flexible adaptation to structural requirements.

Ultra-pure water plants

PVFD and PP-H materials; ultra-pure water (up to 18 megaohm); IR welding; polishing stage in a semiconductor plant; use of diaphragm valves/shut-off valves.


Photo: ©Georg Fischer GmbH

Ventilation and air-conditioning systems


Photo: ©SIMONA AG


Photo: ©SIMONA AG

Safe discharge of chemically contaminated waste-air

Plastics used in ventilation and air-conditioning systems convince with their low weight and simple installation. They are particularly noted for their resistance to chemicals and high temperatures.

Self-extinguishing fire behaviour is a fundamental precondition for use in buildings. These are the materials especially suited for such applications: PPS and PP-EL-s, PE-EL, PVC and PVDF.

Energy and heat transmission

Corrosion-free transmission of biomethane contaminated with hydrogen sulphide

In Fortaleza, Brazil, organic waste is collected municipally in large bio-bins. From this, a biogas plant recovers biomethane, which is then supplied by the local utility to a ceramics producer, which had previously used biomass as the fuel for firing of ceramic products. In 2017, a 24 km gas-conducting pressure line of dimensions external diameter 160, SDR 11 and consisting of polyamide (PA-U12) was installed, horizontal directional drilling being used for a number of sections of the pipe.

The line was to be designed for 18 bar and would be operated at 16 bar. In addition to withstanding the operating pressure, chemical resistance was also decisive in the use of Polyamide 12. The high level of hydrogen sulphide (H_2S) in the biomethane would have subjected the steel piping to excessive corrosive attack. The chemical resistance of Polyamide 12 for transmission of biomethane with a hydrogen sulphide content had been established during the planning phase and is responsible for the up to now trouble-free operation of this line.


Photo: ©Evonik Industries AG

Plant for conversion of biogas from domestic waste into biomethane


Photo: ©Evonik Industries AG

Polyamide (PA-U12) pressure lines, dimensions: external diameter 160, SDR 11

Refrigeration systems

Pre-insulated PE100 piping with a PE100 outer pipe and fittings as a non-condensing and corrosion-free solution for secondary cooling, used as a conducting line for cold water, brine and glycol in large residential and commercial buildings, computing centres, process cooling systems and foodstuffs refrigeration (fruit and vegetable processors, abattoirs, breweries and supermarkets). Polyamide is ideally suitable for the -50 to 60 °C temperature range. The 3-in-1 design reduces installation time to a minimum.


Photo: ©Georg Fischer GmbH

Energy-efficient system solutions

Geothermal heat-exchangers located under storehouses, roads and car park surfaces cool process water between 20 and 50 °C using the outdoor temperature.

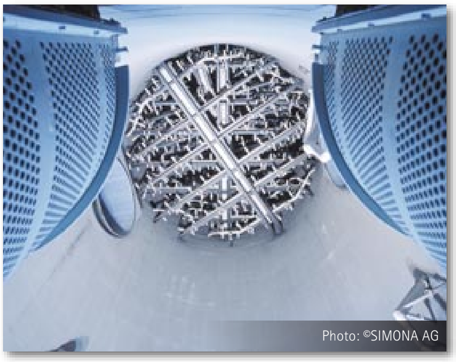
Depending on the process and cooling-water temperature, the annual period of use is up to 4,000 hours at full load. Energy-efficiency can be boosted using a simple pump control system and exploiting the cold of the environment. Coefficients of performance >100 have been achieved.

Keeping roads, bridges, parking and storage areas free of snow and ice. A highly efficient and resources-conserving refrigeration arrangement consisting of a plastic-pipe heat exchanger system is created in combination with the cooling of water used in production.


Photo: ©Gerodur MPM Kunststoffverarbeitung GmbH & Co. KG

Installation of the heat-exchanger

Power-plant technology



PP-H blast lances and strainer baskets in the flue-gas desulphurisation system of a coal-fired power plant

GRP cooling-water line in a gas-fired power plant

Longer service-lives in energy generation plants

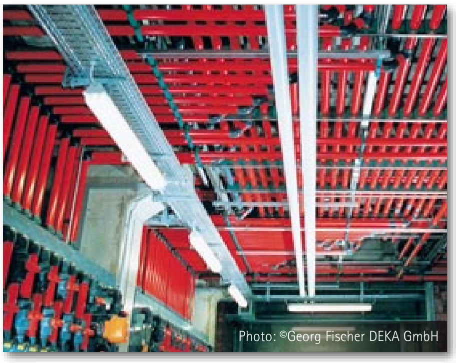
Plastic pipes can look back on a long and successful tradition in power-plant technology. They assure both long operational times and high operational reliability and thus reductions in ongoing costs.

Polypropylene is used in flue-gas desulphurisation plants. The excellent resistance of this material to chemical and abrasive media makes additional protective systems unnecessary.

GRP and PE are frequently used in cooling-water systems. Their low weight even at large nominal diameters and their long-term mechanical behaviour are significant advantages over traditional materials.

Foodstuffs industry

Valid law specifies that plastic pipes coming into contact with foodstuffs constitute so-called food-contact materials for which a legally specified approval regulated throughout the European Union is required. Additional conditions in this analysis define the status of "physiological acceptability". The approval of system components is therefore conducted on the basis of special and complex finished-part inspections for clearly defined classes of media. The use of plastic pipes therefore sets extremely demanding and individual requirements on the material itself, on joining methods and on system components. A number of the known plastics have already become established on this market as lower-cost and sustainable alternatives to stainless steel.



Use of foodstuffs-approved PVC piping systems in the vinegar and tinned goods industry (here: 25% acetic acid [glacial acetic acid] at T = 15 °C)

Prospects

Plastic pipes are among the oldest examples of the success of plastics in fields that require reliability, must perform their function for many decades and can be exactly tailored to the particular application, as in demanding industrial pipe engineering. Systematic further development of the relevant technologies, materials and formulations is set to continue plastic piping's success story into the future, enabling even exceptional needs for strength, resistance and safety to be met. The circular economy and plastics produced from regenerable raw materials are further options for a new approach to products and for entirely new concepts.

Prof. Dr. Rudolf Pfaendner, Head of Division Plastics
Fraunhofer Institute for Structural Durability and System Reliability LBF, Darmstadt

In industrial pipework construction, plastic pipe systems stand for maximum reliability even under extreme conditions. These pipes are corrosion-resistant and also high resistance to a large range of chemicals and aggressive fluids. Continuous further development of the standard grades of plastic – PE, PP and PVC – the increasing use of commercial plastics, such as PA12, for instance, and of the high-temperature plastics PTFE and PVDF, are expanding the range of applications. The trend toward the use of more pressure-resistant plastic pipes is continuing. Engineering plastics, the use of drawn winding layers, innovative copolymers or fillers and multilayer pipe designs make all this possible. The topics of "functional coating" and "nanotechnology" are set to bring about new uses and new products, including important applications in industry.

Application-dependent requirements for temperature and chemical resistance as well as mechanical properties require customised solutions. The technical application advice helps with the selection of suitable materials for specific requirements.

In order to transport aggressive media and fluids that are hazardous to the environment in a particularly safe manner, double pipes are installed in industrial plants. Permeation-tight plastic pipe systems with a barrier layer are used to prevent gaseous substances from escaping.

The federal government has created, in the National Hydrogen Strategy (NWS), a coherent framework for action for the future generation, transmission, utilisation and further use of hydrogen and, accordingly, for corresponding innovations and investment. Here, too, plastic piping systems will assist in attaining the targeted aims.

The technology for joining individual pipe components needs, like the components themselves, to be matched precisely to the particular application. Only in this way can the durability of the system as a whole be assured. In addition to the continuous development and refinement of materials, the technology for joining them also plays a key role in plant engineering.

In addition to conventional cohesive adhesive bonding, the butt-welding processes have thus also become established for PVC-U and PVC-C. The weldability of new, bio based plastics must also be guaranteed, in order to exploit more efficiently the potential presented by these bio-plastics for the manufacture of new and innovative products.

The industrial Internet of Things, also known as Industry 4.0, is modifying certain parts of trading and production chains and is generating innovative potentials in the relations between customer and supplier. Computers are now increasingly being phased out as separate devices, and are being replaced by "smart objects" (things). The industrial Internet of Things makes it possible to more easily collect and control data from multiple production processes. Use can therefore be made of information for plant maintenance or in case of repair, thus helping to assure efficient plant management.

Additive manufacturing, i.e. the use of 3D printing, is steadily developing into an established production process. Thanks to the enormous degrees of freedom in design, coupled with fast development and production processes, additive manufacturing is capable of complementing toolmaking, shortening production times and optimising process chains in manufacturing. Additive end products can also be generated from CAD data in small series and incorporating geometries otherwise achievable only with difficulty, if at all, using conventional methods.

The conservation of resources and recycling are topics of significance for all plastic piping systems, irrespective of the particular application. "Cradle-to-cradle", i.e. by analogy, "from origin to origin," is the concept for an all-encompassing and consistent circular economy. Smart product-design concepts based on renewable energy sources will assist in implementing this aim for all sectors, including plant engineering.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Kunststoffrohrverband e.V. (KRV)

YOUR CONTACT FOR DIALOGUE IN THE FIELD OF PLASTIC PIPING SYSTEMS

For more than 60 years, the Kunststoffrohrverband e.V. has been the voice of the plastic piping industry in Germany. The relevant codes and standards, combined with quality assurance of pipes and fittings, were initially the essence of the association's activities, later to be accompanied, however, with the additional tasks of public-relations work and therefore the imparting of knowledge on the potential applications and performance of plastic piping systems.

The membership of the association includes renowned and, in many cases, globally active producers of plastic piping systems and plastics. Our member companies are active in bodies working on technical regulations and promote in this field the quality, safety, ecology and consumer protection of the products they manufacture. The KRV central office is the venue for the exchange of information and opinion between science, economics, politics and industry. The association supports and coordinates knowledge transfer and provides know-how on plastic piping systems and their potentials for use. In the field of opinion-making on and around plastic piping systems, the KRV acts as an impartial contact point for all players, with no ties and no obligations to any individual companies or to particular products.

Plastic piping has proven its value in gas and drinking-water supply systems, in wastewater discharge, in cable conduits, in building and domestic systems and in the plant engineering industry. Whether for safe transmission of water or gas, as a jacket pipe for energy and telecommunications cables, installed in open trenches or by trenchless methods, and operated by pressure or by gravity: modern industrial society cannot exist without plastic pipes. These products are being continuously further developed, to ensure that they satisfy the very highest technical, ecological and economic standards.

So we can no longer conceive of our modern and highly complex society without plastic pipes. Plastic pipes assure significant economic and social benefits. They help in overcoming modern challenges presented by such megatrends such as digitalisation, climate change and urbanisation, and ensure a better quality of life everywhere in the world.

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Member companies

INDUSTRIAL PIPING TECHNICAL GROUP

Aliaxis Deutschland GmbH
www.aliaxis.de

Evonik Industries AG
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www.lyondellbasell.com

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www.wkt-online.de

Fachverband der
Kunststoffrohr-Industrie

FACTS | FIGURES | BACKGROUND

Plastic Pipes in the industry:
The right choice!

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The Kunststoffrohrverband e.V. (KRV) is the central representative body for the twenty-six member companies, who are active in the production of plastics and of plastic piping systems, in many cases as world market leader.

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