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KRV Technical Information

Chemical Resistance and Permeation Behaviour of Plastic Pipes to Be Used in Industrial Facilities

Introduction

Due to their specific characteristics, plastic piping systems have a great importance in industrial plant engineering and make a significant contribution to the operational reliability of the facilities.

To guarantee work, consumer, and environmental protection, it needs to be ensured that the piping systems are chemically resistant and feature defined permeation behaviour. Standardised verifications such as the internal pressure creep rupture test or special analyses of the mechanical behaviour when impacted by aggressive fluids and gases that are harmful to both environment and health, provide the technical and scientific evidence of the operational readiness.

The further development of materials constantly enhances the areas of application of plastic piping systems. For specific fields of application, the plastic piping industry offers specialised raw materials and tailored pipe constructions.

Areas of Application and Limits of Use

Due to their manifold range of applications, plastic piping systems often outmatch other pipe materials in technical and economic terms also in applications cases beyond the areas defined in the product norms. Significant arguments in favour of plastic piping systems include:

- Resilience towards aggressive fluid and gases
- Resistance to corrosion
- Low risk of incrustations
- Leak tightness
- Form-fit welded joints
- Mechanical resilience
- Abrasion resistance
- Low weight
- Mechanical and thermal workability

Especially the high chemical resistance offers an application spectrum for which less suitable materials have been available so far.

Here, the selection of the relevant plastic and the dimensioning of the pipe require a thorough verification and application technology-related advice and qualification approval by the pipe manufacturer.

The consulting service of the pipe producer needs to be rendered on the basis of the application parameters known to him. Hence it is necessary that the client defines the basic conditions of use as detailed as possible. Special questionnaires and checklists by the pipe producer provide useful support.

In spite of the excellent characteristics of plastics, there are also material-related and application-based limits of use. These constraints are shown by temperature ranges, flow media, system pressures, or other peripheral general operating conditions. In this case, the pipe manufacturer should provide a clear statement concerning the suitability. Requirements with regard to the chemical resistance, corrosion resistance, leak tightness, permeation behaviour, or resistance to stress cracking which cannot be fulfilled simultaneously by the plastic alone, must be met by using combinations of materials or compound materials.

Chemical Resistance and Permeation Behaviour

For the layout of plastic piping systems in the industrial plant engineering, especially in the chemical industry, basic knowledge of the chemical resistance and permeation behaviour of the raw materials is absolutely required.

- **Chemical resistance**

As a pure substance or mixture of substances, chemicals have – in combination with pressure and thermal conditions – a substantial impact on the serviceability and durability of plastic pipes.

The chemical resistance is a requirement that describes the behaviour of a pipe towards a flow medium. It can be put only conditionally on a level with leak tightness. Materials can very well permeate the pipe wall without damaging it with a swelling, stress crack causing, or oxidising effect. This specifically applies to gases, volatile hydrocarbons, or chlorinated hydrocarbons.

Evaluation criteria are used to classify polyolefins in resistant, partly resistant, or not resistant, in accordance with ISO 4433. The evaluation criteria for the chemical resistance include the change of relative mass as well as quotients for elasticity modulus, yield stress, breaking elongation, elongation at yield, and cracking elongation of a test piece compared to a reference basis.

Partly resistant towards a flow medium with a specific temperature means that the pipe can be used for applications without inside pressure or any other mechanic stress, but with a certain, yet limited expected strain on the pipe wall. For application, the permeation of specific fluids through the pipe wall needs to be considered. In case of limited resistance, the suitability of the pipe wall material for the relevant application case needs to be verified.

- **Permeation behaviour**

Permeation denotes the movement of low-molecular gases, vapour, or fluids through the pore-free and crack-free molecular structure of a solid material. In piping systems, permeation is caused by the concentration difference of the permeant within and outside the pipe.

Permeation takes place in the single steps adsorption, absorption, diffusion, and desorption. The volume moving through a solid body with known surface and thickness at a given partial pressure difference and with a certain period of time is described by the permeation coefficient.

By realising special multilayered composite pipe constructions with a barrier coat, for example, the plastic pipe manufacturers can influence the permeation behaviour of the pipe wall in a way that security technology-based, economic, and environmental requirements are fulfilled.

Regulation and Scientific Background

Engineering standardisation in Germany helps the industry and society to strengthen, shape, and open up regional and global markets. Based on a decision made by the German Federal Court of Justice, BGH, on May 14, 1998 – VII ZR 184/97 – DIN standards represent private technical regulations with recommendatory nature.

Based on the proven findings of science, technology, and experience, the state of the art denotes a developed state of technical possibilities at a certain point in time. Technical determinations deemed by a majority of representative experts to reflect the latest state of technology, correspond to the generally recognised codes of practice.

The verification of the chemical resistance of plastics is described in ISO 4433, parts 1 and 2, as well as DIN EN ISO 175. DIN 16888 describes the appraisal of the chemical resistance of pipes made of thermoplastics. Part 1 of the regulation deals with pipes made of polyolefins, while part 2 focuses on unplasticised polyvinyl chloride. Supplementary sheet 1 to DIN 8061 includes information on the chemical resistance of pipes and pipeline components made of PVC-U. Supplementary sheet 1 to DIN 8075 and ISO/TR 10358 contains information on the chemical resistance of pipes and pipeline components made of PE-HD.

The media lists e.g. of the German Institute of Building Technique, DIBt (Deutsches Institut für Bautechnik) or the German Association for Welding and Similar Processes, DVS (Deutscher Verband für Schweißen und verwandte Verfahren e.V.), provide reference values for possible applications. The ‘Medienlisten 40’ of DIBt and the ‘Technische Regel DVS 2205-1’ provide reduction factors – depending on the concentration and temperature – by which an expected useful life must be reduced, if a lasting contact with the relevant material occurs. Relevant information can also be obtained from the raw material and pipe producers.

Reduction factors, so-called chemical resistance factors are also included in DIN 16889, part 1. This chemical resistance factor f_{CR} is a reduction factor used for a flow material with a specific temperature when calculating the resistance to internal pressure that pipes made of polyolefins have towards water – an uncritical medium without impact on the material – with the same temperature as the flow material.

Innovative Plastic Piping Systems for Demanding Applications

Since the end of the 1950-ies, plastics have prevailed in the industrial plant manufacturing. With growing demands on the chemical resistance and mechanical resilience of the plastic piping systems, the materials have been constantly enhanced.

It is state of the art that pipes made of high-performance plastics with the relevant joining technologies are also used for aggressive composites in all concentration levels and under complex operational and installation conditions. For extreme applications, pipes with functional protective coating, two-pipe systems with continuous optical or electronic monitoring or compound systems are used. These developments allow employing plastic piping systems in industrial plant manufacturing in a way that is safe for humans and for the environment.

Standards and Regulations

DIN 8061 Supplementary Sheet 1	Pipes made of unplasticised polyvinyl chloride; chemical resistance of pipes and pipeline components made of PVC-U
DIN 8075 Supplementary Sheet 1	Pipes made of polyethylene with high density (PE-HD); chemical resistance of pipes and pipeline components
DIN 16888-1	Assessment of the chemical resistance of pipes made of thermoplastics; pipes made of polyolefins
DIN 16888-2	Assessment of the chemical resistance of pipes made of thermoplastics; pipes made of unplasticised polyvinyl chloride
DIN 16889-1	Determination of the chemical resistance factors at pipes made of thermoplastics; pipes made of polyolefins
DIN EN ISO 175	Plastics – test procedure for determining the behaviour towards liquid chemicals
ISO 4433-2	Thermoplastic pipes – resistance against chemical fluids – classification – part 2: polyolefin pipes
ISO 4433-3	Thermoplastic pipes – resistance against chemical fluids – classification – part 3: unplasticised polyvinyl chloride (PVC-U), high-impact polyvinyl chloride (PVC-HI) and chlorinated polyvinyl chloride (PVC-C) pipes
ISO/TR 10358	Plastic pipes and fittings; summarised classification table for chemical resistance
DVS 2205-1	Calculation of containers and devices made of thermoplastics – parameters
Media list 40	DIBt media lists for containers, retaining devices and pipes made of plastics

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