Application note

General conditions for liquid handling

Information concerning the operation of components and the setup of systems for liquid handling

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1 About this document

This document provides information on key issues concerning liquid handling for the setup and operation of systems comprised of components.

Information

This document does not replace the operating instructions for the installed components/products.

1.1 Target group

These operating instructions are intended for:

- System developers of the individual components
- Users of the system

1.2 Applicable documents

All available documents regarding the components/products installed within the system (www.festo.com/sp).

2 Notes on proper use of our products

2.1 General

Before using the product, determine whether or not your application complies with use for intended purpose. Read the information in the operating instructions for the product before use, and comply with it during use.

Observe and comply with the following points:

- Only use Festo products in their original condition. This means that unauthorised changes or modifications are impermissible.
- Before use, make sure that the product is in flawless technical condition.
- Work on the product may only be carried out by qualified personnel.
- Only use original Festo accessories.

2.2 Medium

The products are normally designed for aqueous media and are tested with water and/or filtered compressed air. If use of another medium is intended, verify suitability/functionality in the respective application. Other media can have a significant influence on the product's technical characteristics (e.g. switching times, service life).

2.2.1 Media resistance

Make sure that all materials which come into contact with the medium are resistant to it. Refer to the media resistance list in the appendix in order to assess media resistance.

Information

Only those media may be used which do not result in dangerous reactions when mixed.

In the event of any uncertainties, consult with your regional Festo contact person.

2.2.2 Protection against harmful media

Wear appropriate personal protective equipment when using automation solutions for liquid handling. The recommendations for the media to be used and their by-products are decisive in this regard.

- Comply with the safety data sheets of the utilised media.
- Before dismantling each individual component, make sure that no hazardous substances can escape in an uncontrolled manner or, ideally, that no hazardous substance remains in the system.

Wherever possible, inert materials are used for components that come into contact with the media. Parts that are not wetted during normal operation consist of less chemically stable materials and are thus less resistant to reactive substances, i.e. they can be damaged if they come into contact with media.

2.2.3 Media viscosity

The products are normally designed for aqueous media and are tested with water.

Information

Flow characteristics change at higher or lower viscosities, which can lead to undesired system reactions.

2.2.4 Media crystallisation

Crystallisation of media within the products must be avoided because this can cause damage to individual components. Thoroughly rinse out media which tend to crystallise as quickly as possible.

2.2.5 Media containing solid particles

The products are normally tested by Festo with filtered compressed air (filter size: 0.1 µm) and/or particle-free water. Any information concerning maximum permissible particle sizes refers to the presence of individual particles in the medium. Operation with liquids or gases containing solid particles in larger quantities is not intended – unless otherwise specified.

Information

The presence of particles may have a negative effect on the function and service life of the products.

2.3 Warming of valves and media

2.3.1 Warming of valves during operation

The instructions in the documentation, in particular in the operating instructions, must be observed in order to avoid impermissibly high temperatures on accessible surfaces.

In the case of solenoid valves or products containing solenoid valves, maximum switching frequency and permissible duty cycle must be taken into consideration. These parameters can be found in the operating instructions. Some valves may not be operated without external electronics.

In order to avoid burns, it may be necessary to provide protection against contact, e.g. a cover – observe the operating instruction in this regard.

Observe and comply with the following points where hot surfaces are involved:

- Do not use any media which could ignite on contact with hot surfaces!
- Do not operate products with hot surfaces near flammable substances!
- Determine the ignition temperatures of the media and conduct a risk assessment. Note that non-accessible surfaces may be hotter than accessible surfaces.
- Make sure that temperatures are always within the permitted limits.
- Select an installation location for the products which ensures adequate heat dissipation. Use fans, for example, to improve heat dissipation.

2.3.2 Warming of the media during operation

Solenoid valves may cause warming of the medium in and flowing through the valve due to solenoid heat loss.

In the case of temperature-sensitive media, make sure that the medium's dwell time in the valve is as short as possible. This applies in particular if the valve is closed, or if the medium cannot flow out of the valve for other reasons, after a lengthy duty cycle.

In applications in which valves are open for long periods of time, the use of a normally open valve may be an alternative, or the use of holding current reduction may be appropriate ➔ 4 Terminology.

Valves operated with holding current reduction warm up less during long duty cycles. However, warming increases during operation close to maximum switching frequency ➔ 4 Terminology.

Other factors which have a considerable influence on warming of the media include:

– Block/individual mounting ➔ 4 Terminology.
– Static/flowing medium
– Valve covers

2.4 Pressure peaks

In particular in applications with non-compressible media, pressure peaks may occur when the valve closes. Pressure peaks must be taken into consideration when assessing the system's resilience.

Cushioning elements or pressure relief valves can be used to compensate for pressure peaks and to protect the components.

In liquid handling systems it must be ensured that:

- Maximum permissible media pressure of the component with the lowest pressure resistance is not exceeded – not even briefly
- Measures are implemented for the dissipation of pressure peaks (e.g. pressure relief valves), or
- Pressure peaks are reduced to a permissible level by suitable design/arrangement of the individual components in the system

2.5 Mounting valves

Always tighten components to the torque specified in the operating instructions. Too little torque may result in leakage at valves and fittings. Excessive torque can damage the components.

Use the included retaining screws, if provided. These are matched to the respective components and accessories.

2.5.1 Mounting valves on plastic manifolds

The use of metal female threads is recommended for secure fastening of valves on plastic manifolds. Threaded inserts can be inserted into the plastic manifold to this end.

Mounting is also possible by means of a through-hole in the plastic manifold in combination with a nut and a lock nut.

Note

When inserting threaded inserts into plastics, avoid any resultant bulging of the material which would prevent the valve from lying flat on the surface.

Note

Only in exceptional cases should valves be mounted directly to the plastic material with the included screws. The joint must lastingly withstand prevailing ambient conditions.

2.5.2 Mechanical load

Ensure that the products are not subjected to any inadmissible mechanical stress such as impact loads. Implement suitable protective measures.

Never install electric or fluid lines under tension.

Provide strain relief, in particular when mounting on handling systems.

2.6 Rinsability / dead volume

Insofar as possible, the components are designed for optimised cleanability and rinsability.

Expel liquids from the system with compressed air (or inert gas), or remove them by alternative means.

When setting up systems or during in-house design engineering, make sure that no blind holes or undercuts impede the exchange of media.

2.7 Leakage test

After installation, check products within the system for leakage with the help of suitable tools. It's advisable to use non-hazardous/non-toxic liquids or gases when testing the system for leaks.

- Check all products within the system for leakage at regular intervals during operation.
- Immediately replace leaky products.

Observe and adhere to the following points in the event of leakage:

- Make sure that no danger to people prevails and that no damage to the system [product] occurs. Implement appropriate safety measures.
- Immediately stop/discontinue operation of the product.

When handling media in the open (e.g. free-jet dispensing), make sure that no danger exists for people and/or the product.

Note

In the event that media should escape, suitable safety measures must be implemented in advance – also in the event that hot medium should escape.

2.8 Avoidance of product failure due to contamination

Always mount components in a clean working environment. Any particles of dirt on or in the components may cause leakage.

Avoid the ingress of particles during operation. Install a filter upstream from the critical component if necessary.

- Always maintain a clean working environment.
- Observe information included in the operating instructions for the components.

2.9 Electrical actuation

Observe information concerning the power supply in the operating instructions.

- Make sure that all EMC requirements are fulfilled. Observe notes in the operating instructions.

2.10 Fluid connection

Push-in fittings, fittings with hose nipples or clamp connections ("flangeless fittings") – which demonstrate best rinsability – can be used for the fluid connections of systems and components.

2.11 Returns in the event of complaints

Hazardous substances can endanger the health and safety of persons and cause damage to the environment. In order to prevent possible hazards, only return a product if expressly requested to do so by Festo.

- Consult your regional Festo contact person.
- Complete the contamination declaration and attach it to the outside of the package.
- Comply with all legal requirements for handling hazardous substances and transporting hazardous goods.

3 Design tips for setting up and optimising systems

- The diameter of the supply lines must be sufficiently dimensioned (smaller pressure drop in the system).
- Consider “communicating lines” in multi-channel systems.
- On the one hand, air pockets have a damping effect on pressure fluctuations, but on the other hand they increase susceptibility to vibration, especially where fast pressure regulators are used.
- Avoid diameter steps in media-carrying structures (outgassing of liquids). If necessary, degas liquids before use and protect from contact with the pressure medium.
- The structure with the largest pressure drop dictates overall flow. Fluidic dimensioning must be laid out in consideration of the requirements and component tolerances of the utilised fluid-conducting elements.
- When determining overall flow, observe valve switching times and the minimum volumes to be dispensed in order to obtain a robust dosing system.
- The speed at which the medium is discharged from the needle has a significant influence on the reproducibility of droplet breakaway, satellite formation and unwanted wetting of the tip of the needle. This must be taken into account when determining the working point.
- Viscosity is temperature-dependent, influences the above-mentioned parameters and must be taken into consideration when laying out the system. If necessary, define various viscosity ranges that require different working points.
- If vacuum is used for aspiration, consider the vapour pressures of the media in order to avoid increased leakage and the formation of bubbles. The point of lowest pressure is decisive for avoiding the formation of bubbles and outgassing (Bernoulli).
- Avoid unused dead volume within the system ➔ 4 Terminology. This saves medium, avoids air pockets and prevents static medium. Cleaning and rinsing of the system is simplified as well.

4 Terminology

- **Individual mounting (of valves)**
  Valve arrangement in which, due to the distances between the individual valves, they don't influence each other with regard to temperature.

- **Manifold mounting (of valves)**
  A row of several valves with minimal distance from one to the other.
  Poorer heat dissipation than with individual mounting can be expected with this arrangement.

- **Holding current reduction**
  An electronic system operated in conjunction with a solenoid valve. The electronics ensure that after high inrush current, so-called holding current settles in after a given period of time. This serves to reduce electrical power consumption and thus to minimise warming of the solenoid. Holding current reduction can be integrated either externally or in the valve.

- **Internal volume**
  The zone in a medium-carrying system or component which comes into contact with the medium, e.g. a valve. Internal volume ≠ dead volume

- **Dead Volume**
  The zone in a medium-carrying system which is poorly flushed or not flushed at all due to its geometry, e.g. blind holes.

5 Further documents

Title	Doc. no.	Description	Link EN	Link DE
Application note: VTOE-8... in combination with VAEM-VS8...	100298	How the VTOE-8... is used in combination with the VAEM-V-S8...	link	link

6 Final comments

Before marketing our products (as components within a system), the currently valid requirements for the application must be known and conformity of our products with them must be verified.

A Appendix

A.1 Media resistance list

Key		
	+	Resistant
	o	Conditionally resistant
	-	Not resistant

Compound	Chem. formula	Conc. %	Temp. °C	FKM	FFKM	EPDM	PC	PP	PPS	PEEK
Acetone	CH3COCH3	100	20	-	+	+	-	+	+	+
Aluminium oxide	Al2O3	100	20	+	+	+	+	+	+	+
Formic acid	HCOOH	10	20	-	+	+	o	+	+	+
Formic acid	HCOOH	10	100	-	+	+	-	o	+	+
Formic acid	HCOOH	100	20	-	+	-	-	+	+	o
Ammonia	NH3	10	20	-	+	+	-	+	+	+
Aniline	C6H5NH2		20	-	+	+	-	+	+	+
Benzaldehyde	C6H5CHO		20	-	+	+	-	+	+	+
Petrol			20	+	+	-	+	o	+	+
Benzol	C6H6		20	o	+	-	-	o	+	+
Benzophenone	C6H5COC6H5		20	+	+	o	-	o	+	+
Beer			20	+	+	+	+	+	+	+
Boric acid	B(OH)3	10	20	+	+	+	+	+	+	+
Boric acid	B(OH)3	4	20	+	+	+	+	+	+	+
Brake fluid (DOT4)			20	-	+	+	-	+	+	+
Butyric acid	CH3CH2CH2COOH		20	+	+	o	-	+	+	+
Butyl acetate	CH3COOC4H9		20	-	+	+	-	o	+	+
Calcium chloride	CaCl2		20	+	+	+	+	+	+	+
Calcium hydroxide	Ca(OH)2		20	+	+	+	-	+	+	+
Calcium sulphate	CaSO4		20	+	+	+	+	+	+	+
Chloroacetic acid	ClCH2COOH		20	-	+	+	-	+	+	+
Chlorine gas, dry	Cl2		20	+	+	+	o	-	o	+
Chloroform	CHCl3		20	+	+	-	-	o	+	+
Hydrogen chloride, gaseous	HCl		20	+	+	+	-	+	o	+
Chromic acid	H2CrO4	10	20	+	+	+	o	o	o	+
Chromic acid	H2CrO4	20	20	+	+	+	o	+	o	+
Cyclohexane	C6H12		20	+	+	-	-	+	+	+
Diesel oil			20	+	+	-	o	o	+	+
Diethylenglycol	(HOCH2CH2)2O		20	+	+	+	+	+	+	+
Diisooctylsebacate	C10H16O4(C8H17)2		20	+	+	-	-	+	+	+
Dioxane	C4H8O2		20	-	+	+	-	o	+	+

Compound	Chem. formula	Conc. %	Temp. °C	FKM	FFKM	EPDM	PC	PP	PPS	PEEK
Iron(III) chloride	FeCl3		20	+	+	+	+	+	+	+
Glacial acetic acid	CH3COOH	100	20	-	+	+	-	+	+	+
Epoxy resins			20	+	+	+	o	+	+	+
Acetic acid	CH3COOH	10	20	-	+	+	+	+	+	+
Acetic acid	CH3COOH	100	20	-	+	+	o	+	+	+
Acetic acid	CH3COOH	25	40	-	+	+	+	+	+	+
Acetic acid	CH3COOH	80	40	-	+	+	+	+	+	+
Ethanol	C2H5OH	96	20	o	+	+	+	+	+	+
Ethyl acetate	CH3COOC2H5		20	-	+	+	-	+	+	+
Ethylbenzene	C6H5C2H5		20	o	+	-	-	o	+	+
Ethylene chloride	Cl-CH2-CH2-Cl		20	+	+	-	-	-	o	+
Fatty acid			20	+	+	o	o	+	+	+
Hydrofluoric acid	HF	5	20	+	+	+	-	+	+	-
Formaldehyde	HCHO	40	20	o	+	+	+	+	o	+
Glycol	HO-CH2-CH2-OH	commercial	20	+	+	+	o	+	+	+
Glycerin	(CH2OH)2CHOH		20	+	+	+	o	+	+	+
Glycerin	(CH2OH)2CHOH		100	+	+	+	-	+	+	+
Urea	(NH2)2CO	up to 33	20	+	+	+	+	+	+	+
Heptane	CH3(CH2)5CH3		20	+	+	-	+	o	+	+
Hexane	CH3(CH2)4CH3		20	+	+	-	+	+	+	+
Hydraulic oil, mineral based			20	+	+	-	+	+	+	+
Hydraulic oil, synthetic-ester-based			20	+	+	-	-	+	+	+
Isooctane	CH3C(CH3)2CH2CH(CH3)CH3		20	+	+	-	+	+	+	+
Isopropanol	C3H7OH		20	+	+	+	o	+	+	+
Coffee extract			20	+	+	+	+	+	+	+
Potassium acetate	CH3COOK		20	+	+	+	+	+	+	+
Potassium carbonate	K2CO3	any	20	+	+	+	+	+	+	+
Potassium chlorate	KClO3	any	20	+	+	+	o	+	+	+
Potassium dichromate	K2Cr2O7	saturated	20	+	+	+	+	+	+	+
Potassium hydrogen tartrate	C4H5KO6		20	+	+	+	+	+	+	+
Potash	KOH	10	20	-	+	+	-	+	+	+
Potash	KOH	10	90	-	+	+	-	+	+	+
Potash	KOH	conc.	20	-	+	+	-	+	+	+
Potash	KOH	conc.	90	-	+	+	-	+	o	+
Potassium nitrate	KNO3		20	+	+	+	+	+	+	+

Compound	Chem. formula	Conc. %	Temp. °C	FKM	FFKM	EPDM	PC	PP	PPS	PEEK
Potassium permanganate	KMnO4		20	+	+	+	+	+	+	+
Slaked lime	Ca(OH)2		20	-	+	+	o	+	+	+
Cresol	C7H8O	100	20	+	+	-	-	+	+	-
Copper sulphate, aqueous	CuSO4	any	20	+	+	+	+	+	+	+
Air, dry			20	+	+	+	+	+	+	+
Magnesium sulphate	MgSO4		20	+	+	+	+	+	+	+
Sea water			20	+	+	+	+	+	+	+
Methanol	CH3OH		20	-	+	+	-	+	+	+
Methylene chloride	CH2Cl2		20	-	+	-	-	o	+	+
Methylethylketone MEK	CH3COC2H5		20	-	+	+	-	+	+	+
Methylethylketone MEK	CH3COC2H5		60	-	+	+	-	o	+	+
Sodium acetate	CH3COONa		20	+	+	+	+	+	+	+
Sodium carbonate	Na2CO3	10	20	o	+	+	+	+	+	+
Sodium hydroxide	NaOH	10	90	-	+	+	-	+	+	+
Sodium hydroxide	NaOH	conc.	20	-	+	+	-	+	+	+
Sodium hydroxide	NaOH	conc.	90	-	+	+	-	+	o	+
Sodium hypochlorite	NaOCl	13	20	-	+	+	o	o	-	+
Sodium sulphate	Na2SO4		20	+	+	+	+	+	+	+
Oil, ASTM oil no. 1			20	+	+	-	+	+	+	+
Oil, ASTM oil no. 2			20	+	+	-	-	+	+	+
Oil, ASTM oil no. 3			20	+	+	-	o	+	+	+
Oil, ASTM oil no. 4			20	+	+	-	+	+	+	+
Oil, ester			20	+	+	o	-	+	+	+
Oil, glycol			20	+	+	+	-	+	+	+
Oil, mineral based			20	+	+	-	+	+	+	+
Oil, perfluorinated			20	+	+	+	o	+	+	+
Oil, silicon			20	+	+	+	+	+	+	+
Oil, synthetic			20	+	+	-	+	+	+	+
Oleic acid			20	+	+	+	+	+	+	+
Oxalic acid	(COOH)2	10	20	+	+	+	+	+	+	+
Ozone	O3	20 ppm	20	+	+	+	+	+	+	+
Pentane	CH3(CH2)3CH3		20	+	+	+	+	o	+	+
Petroleum			20	+	+	-	o	+	+	+
Phenol	C6H5OH		20	+	+	-	-	+	+	o
}	H3PO4	10	20	+	+	+	+	+	+	+

Compound	Chem. formula	Conc. %	Temp. °C	FKM	FFKM	EPDM	PC	PP	PPS	PEEK
Phosphoric acid	H3PO4	80	20	+	+	+	+	+	+	+
Salicylic acid	HOC6H4COOH		20	+	+	+	+	+	+	+
Nitric acid	HNO3	10	20	+	+	+	-	o	o	+
Nitric acid	HNO3	conc.	20	+	+	-	-	-	-	-
Hydrochloric acid	HCl	10	20	+	+	+	+	+	+	+
Hydrochloric acid	HCl	conc.	20	+	+	+	-	+	o	+
Sulphur dioxide, gaseous	SO2		20	-	+	+	o	+	+	+
Sulphuric acid	H2SO4	10	20	+	+	+	+	+	+	+
Sulphuric acid	H2SO4	conc.	20	+	+	+	-	o	o	-
Hydrogen sulphide, gaseous, dry	H2S		60	-	+	+	o	+	+	+
Hydrogen sulphide, gaseous, damp	H2S		60	-	+	+	o	+	+	+
Soap solution		any	20	+	+	+	+	o	+	+
Starch solution		0.01	20	+	+	+	+	+	+	+
Stearic acid	C17H35COOH		20	+	+	o	+	+	+	+
Terpentine oil			20	+	+	-	o	-	+	+
Carbon tetrachloride	CCl4		20	+	+	-	-	-	+	+
Tetrahydrofuran (THF)	C4H8O		20	-	+	-	-	o	+	+
Toluene	C6H5CH3		20	o	+	-	-	o	+	+
Vaseline			20	+	+	-	+	+	+	+
Water	H2O		20	+	+	+	+	+	+	+
Water, demineralized	H2O		20	+	+	+	+	+	+	+
Hydrogen peroxide	H2O2	30	20	+	+	+	+	+	+	+
Tartaric acid	HOOCCH(OH)CH(OH)COOH	10	20	+	+	+	+	+	+	+
Xylene, isomeric mixture	C6H4(CH3)2		20	+	+	-	-	-	+	+
Citric acid	(HOOCCH2)2C(OH)COOH	10	20	+	+	+	+	+	+	+