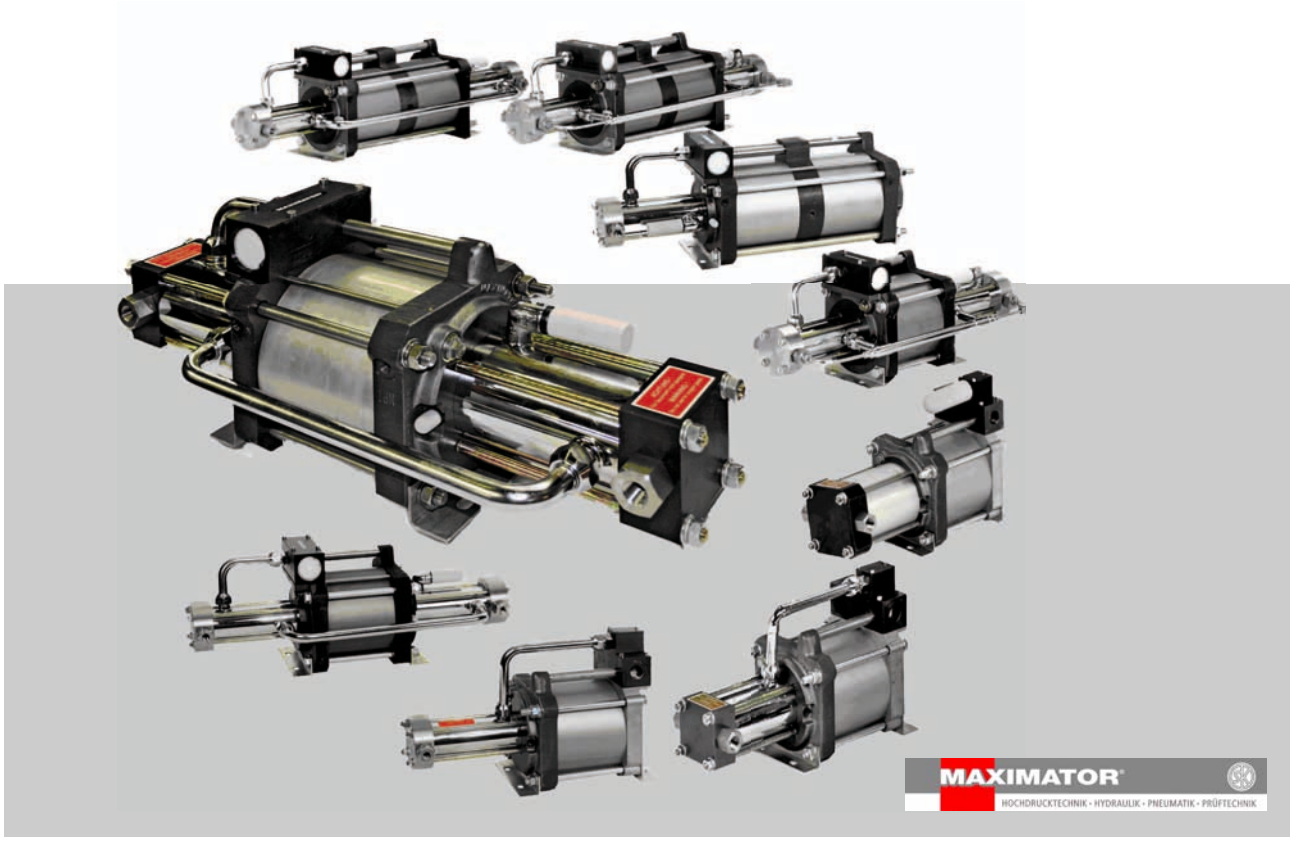
Operating instructions

Boosters

DLE 2 (-1, -2) – DLE 75 (-1, -2)



Read the instructions prior to performing any task!

Maximator GmbH
Lange Straße 6
D-99734 Nordhausen
Telephone: +49 (0) 3631/9533-0
Fax: +49 (0) 3631/9533-5065
email: info@maximator.de
Internet: www.maximator.de
Translation of the original operating instructions
Maxi-14315-DE, 1, en_US

This operating manual was created by:
Kothes!
Technische Kommunikation GmbH & Co. KG
Internet: www.kothes.de

⚠ This operating manual enables the safe and efficient handling of boosters DLE 2 (-1), (-2) – DLE 75 (-1), (-2). The operating manual is a component of the booster and must be kept in the immediate vicinity of the booster where it is available to personnel at all times. Personnel must have carefully read and understood this manual before performing any tasks. The basic prerequisite for safe work is compliance with all specified safety instructions and handling instructions. In addition, the applicable local accident prevention regulations and general safety regulations must be complied with for the booster's area of implementation. The illustrations in this manual are provided for purposes of basic understanding and can deviate from the actual version. No claims whatsoever may be derived from any deviations.

Copyright

Customer service

Our customer service organization is available for technical information and repairs:

Address	Maximator GmbH Ullrichstrasse 3 99734 Nordhausen
Telephone - customer service Mon - Fri: 7:00 AM - 5:00 PM CET	+49 (0) 3631-9533-5026 (Service Manager)
Telephone - customer hotline Mon - Fri: 8:00 AM - 10:00 PM CET Sat - Sun and holidays: 8:00 AM - 8:00 PM CET	+49 (0) 1805-629 462 867
Fax	+49 (0) 3631 / 9533-5065
email	service@maximator.de
Internet	www.maximator.de

In addition, we are always interested in new information and experiences associated with the application which could prove valuable in improving our products.

Table of contents

1 Overview

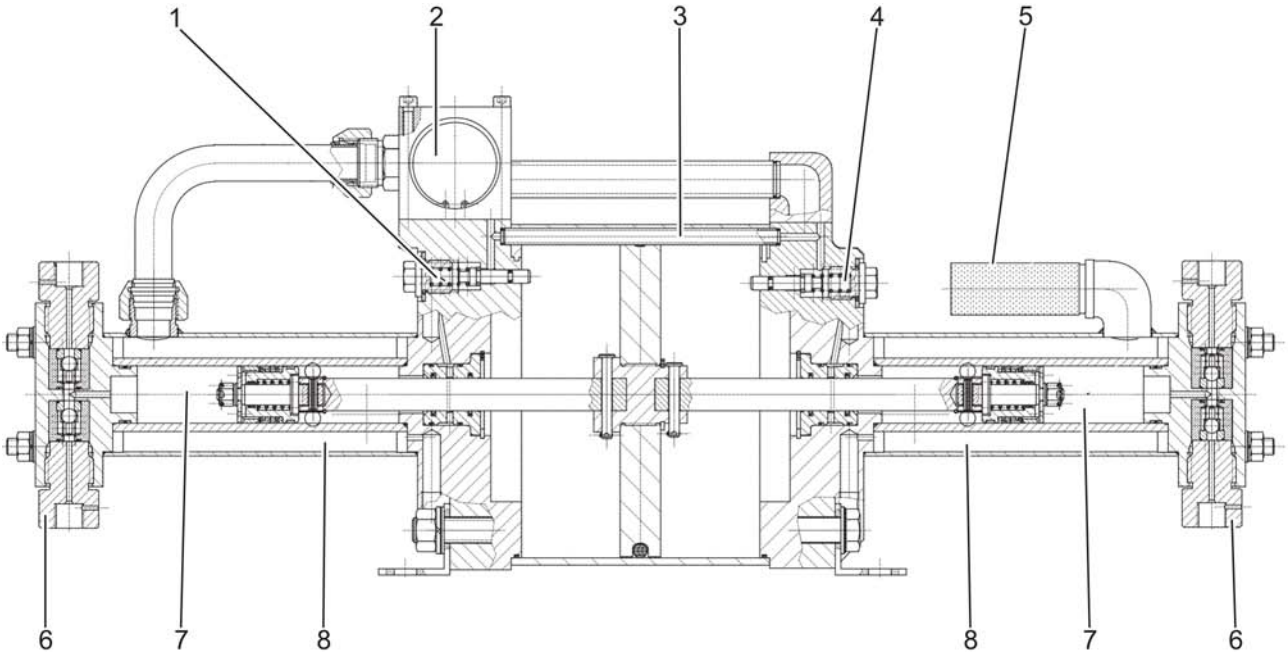


Fig. 1: Booster Overview

1 Pilot valve 1
2 Spool valve (4/2 directional control valve)
3 Air cylinder
4 Pilot valve 2
5 Exhaust air silencer
6 Booster head with suction and pressure valve
7 Pressure cylinder
8 Cooling cylinder

1.1 Brief description

The compressed air-driven boosters of model series DLE 2 (-1, -2) – DLE 75 (-1, -2) are incomplete machines and designed to be installed in plants or systems. The boosters are used exclusively for the oil-free compression of combustible, non-combustible, toxic and non-toxic gases, and compressed air.

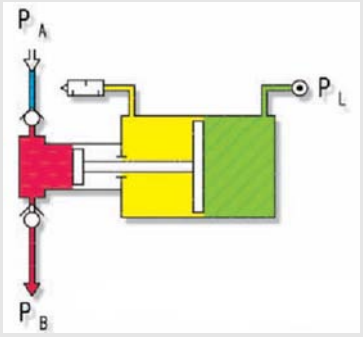
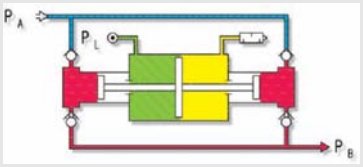
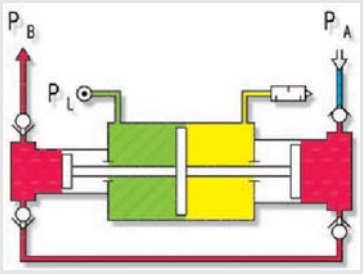
1.2 Versions

The individual booster type versions are listed in the following.

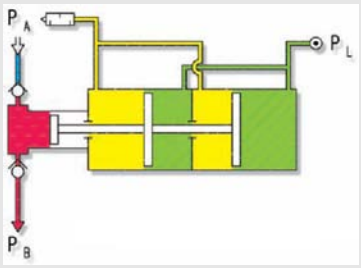
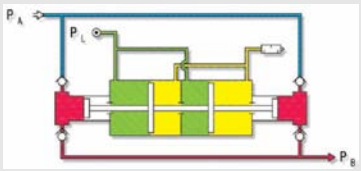
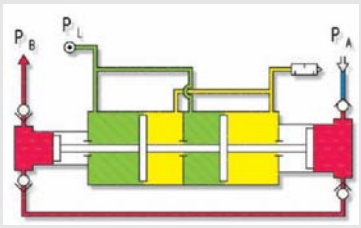
Boosters with one drive piston

Legend:

- P_L = Air drive
- P_A = Gas admission pressure
- P_B = Operating pressure
- = outlet air

Version	Graphic representation
Single-stage, single-acting Types: ■ DLE 2–1 ■ DLE 5–1 ■ DLE 15–1 ■ DLE 30–1 ■ DLE 75–1	
Single-stage, dual-acting Types: ■ DLE 2 ■ DLE 5 ■ DLE15 ■ DLE 30 ■ DLE 75	
Dual-stage, dual-acting Types: ■ DLE 2-5 ■ DLE 5-15 ■ DLE 5-30 ■ DLE 15-30 ■ DLE 15-75 ■ DLE 30-75	

Boosters with two drive pistons

Version	Graphic representation
Single-stage, single-acting with two air pistons Types: ■ DLE 2–1–2 ■ DLE 5–1–2 ■ DLE 15–1–2 ■ DLE 30–1–2 ■ DLE 75–1–2	
Single-stage, dual-acting with two air pistons Types: ■ DLE 2-2 ■ DLE 5-2 ■ DLE 15-2 ■ DLE 30-2 ■ DLE 75-2	
Dual-stage, dual-acting with two air pistons Types: ■ DLE 2-5–2 ■ DLE 5-15–2 ■ DLE 5-30–2 ■ DLE 15-30–2 ■ DLE 15-75–2 ■ DLE 30-75–2	

2 Safety

This section provides an overview of all important aspects that are essential for the protection of personnel as well as safe and trouble-free operation. Additional task-specific safety instructions will be provided in the sections that refer to the individual life stages of the plant.

2.1 Intended use

The compressed air-driven boosters of model series DLE 2 (-1, -2) – DLE 75 (-1, -2) are incomplete machines and designed to be installed in plants or systems. The boosters are used exclusively for the oil-free compression of combustible, toxic and non-toxic gases, and compressed air. Only displacement media that is permitted for use in boosters may be compressed (↪ *Chapter 2.2 “Permissible displacement media (gases)” on page 15*). The boosters are driven by compressed air with a maximum driving pressure of 145 psi.

The boosters can be used, if they are marked accordingly, in explosion-protected areas.

Intended use also includes compliance with all the instructions in this manual.

Any use that extends beyond the intended use, or any other use of the system is considered to be misuse.

Foreseeable misuse

⚠ WARNING

Danger in the event of misuse!

- **Never use any displacement media other than those listed in *Chapter 2.2 "Permissible displacement media (gases)" on page 15*.**
- **Never operate the boosters in closed containers.**
- **Never make unauthorized conversions or modifications to the boosters.**
- **Compressed air must never be used for respiration purposes.**
- **Never use the boosters in any manner other than that described in this operating manual.**
- **Never exceed the technical limits or pressures specified in this operating manual.**
- **Only operate the booster if it is in faultless technical condition.**
- **The boosters must not be used directly for pharmaceutical or sanitary purposes involving food.**
- **Always comply with all instructions concerning installation, maintenance, and fault correction specified in this manual.**

Misuse of the boosters of model series DLE 2 (-1, -2) – DLE 75 (-1, -2) can lead to dangerous situations.

Compression of hydrogen

To prevent potentially explosive atmospheres in areas around hydrogen systems from developing, always observe the following:

- Always set up hydrogen systems in a well ventilated room.
- Always keep hydrogen systems leak-tight.
- Blow-out lines of safety valves and leakage lines must always be routed outside into the open.
- Blow-out lines must not be installed under eaves, openings in buildings, or in the vicinity of air intake openings.
- For hydrogen systems in rooms or buildings, it must be possible to safely and quickly shut off the gas supply coming from the outside at a safe point.
- Pipe connections on hydrogen systems must always be created ensuring that the connection will be tight for a long time.

2.2 Permissible displacement media (gases)

Displacement media (gases)

Displacement media that is permitted for compression with the boosters is listed in the following.

⚠ WARNING

Risk of accident if the permissible displacement media is not observed!

- **Only compress displacement media permissible for the particular booster models. For this purpose, compare the type information on the type plate with those from the following table.**
- **Always observe the special instructions for the particular displacement media.**

If the permissible displacement media and the special instructions are not observed, this can lead to severe accidents.

Displacement medium (gases)	Symbol	Booster types	Special instructions for the compression of the displacement media
Argon	Ar	All models	
N-butane	C_4H_{10}	All models	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.
Compressed air		All models	
Carbon monoxide	CO	DLE xxx-C	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.
Carbon dioxide	CO_2	DLE xxx-C	
Ethane	C_2H_6	All models	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.
Ethylene	C_2H_4	All models	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.
Freon (F-12)	CCL_2F_2	DLE xx-CR	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.

Displacement medium (gases)	Symbol	Booster types	Special instructions for the compression of the displacement media
Helium	He	All models	
Hydrogen	H_2	DLExxx-(H2)	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.
Methane	CH_4	All models	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.
Acid gas (natural gas with portions of hydrogen sulfide)		DLE xxx-NACE	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.
Propane	C_3H_8	All models	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.
Nitrogen	N_2	All models	
Laughing gas	N_2O	All models	
Oxygen	O_2	DLE xxx-S	Lay pipes for leak bores, lubrication with halocarbon grease (oxygen scavenging), max. compression ratio 1:6 Max. pressure 5076.33 psi
Sulfur hexafluoride	SF_6	DLExxx-CR	Lay pipes and rinse SFP (special flushing port) and leak bores; high pressure seal not 100% leak-tight.
Xenon	XE	All models	

Contact the manufacturer for special instructions on the use of further media. See the contact information on Page 2 of these operating instructions.

Remove plug on SFP (special flushing port) for hazardous gases and lay pipes. To do this, see ↳ Appendix A “Hydrogen compression with Maximator boosters” on page 117 in these operating instructions.

2.3 Basic dangers

The following section lists remaining risks from boosters that exist even if they are used as intended.

To reduce the risk of personal injury and property damage and to avoid dangerous situations, observe the safety messages listed here as well as the safety instructions in the additional sections of this operating manual.

2.3.1 General dangers at the workstation

Noise

⚠ WARNING

Risk of injury caused by noise!

- **Always wear personal protective equipment when working on running boosters.**
- **Only be in the danger zone to the extent required.**

The noise level that occurs in the work area can cause severe hearing loss depending on the type of installation and expanding air.

2.3.2 Dangers due to gases under pressure

Pressurized components

⚠ WARNING

Danger of injury due to pressurized components!

- **Always establish de-pressurized status before mounting or dismounting hoses, lines, threaded unions, or quick-release couplings. Completely de-pressurize the pressure accumulator.**
- **Always wear personal protective equipment.**
- **Have defective components that are pressurized in operation replaced immediately by qualified personnel (mechanical and plant engineer).**

Compressed air or gas can escape from compressed air lines, threaded unions, or pressurized components if these components are not handled properly. This compressed air or gases can harm the eyes, whirl up dust, can cause uncontrolled movements of the lines, and can cause severe injuries. Defective pressurized components can also cause uncontrolled movements that can result in severe injuries.

2.3.3 Dangers due to low temperatures

Cold surfaces

⚠ CAUTION

Risk of injury due to cold and iced up surfaces!

- **Always wear protective clothing and protective gloves during all work in the vicinity of cold or iced up surfaces.**
- **Make sure prior to all work that all surfaces have warmed up to ambient temperature.**

Components such as the exhaust air silencer can cool down severely and ice up due to expanding air or gas. Skin contact with cold surfaces can cause skin irritations.

Flying ice crystals and accumulated liquids

⚠ WARNING

Risk of injury caused by flying ice crystals and accumulated fluids!

- **Always wear protective eye wear during all work.**
- **Immediately pick up any accumulated fluid using appropriate means.**
- **Always wear non-slip safety shoes.**
- **Place warnings and mandatory action signs on or near the area where liquids can collect on the floor or where there can be flying ice crystals.**

Icing can develop on the exhaust air silencer of the booster during operation that is freed up by expanding outlet air and tossed around. The pushed off ice crystals can lead to eye injury and accumulated fluids on the floor.

2.3.4 Dangers due to fire

Fire control

⚠ WARNING

Risk of injury from insufficient or improper fire suppression!

- **Ensure that fire extinguishers suitable for the corresponding class of fire are readily available.**
- **Check fire extinguishers for proper operation every 2 years.**
- **Refill fire extinguishers after each use.**
- **Use only fire-extinguishing propellants and spare parts that correspond to the approved design specified on the fire extinguisher.**
- **Follow the safety and operating instructions specified on the fire extinguisher when deploying it.**
- **Observe its functional temperature range when deploying the fire extinguisher.**

Using a fire extinguisher in the event of fire that is not ready for operation or unsuitable for the corresponding class of fire may lead to severe injuries, including death, and significant material damage.

2.3.5 Dangers due to explosion

Explosion protection

⚠ WARNING

Risk of explosion!

- **Prior to starting work in the Ex area, obtain a written work approval.**
- **Perform tasks only when a potentially explosive atmosphere can be ruled out.**
- **Prior to all fault elimination work, flush booster with nitrogen to prevent oxyhydrogen gas from developing from previously compressed toxic or combustible gases.**
- **Use only those tools that are permissible for use in the Ex area.**
- **Never smoke in the explosive area.**

Bringing in ignition sources such as sparks, open flames, and hot surfaces can lead to explosion in the Ex area. Non-compliance with these instructions will lead to loss of explosion protection.

2.3.6 Dangers due to chemical substances

Displacement media

⚠ WARNING

Risk of injury due to improper handling of displacement media!

- **Always observe the manufacturer's safety data sheet.**
- **When working with gas, always ensure adequate ventilation.**
- **Do not smoke within the danger zone and in the immediate vicinity. Do not use open flames, fire, and ignition sources of any kind.**
- **Keep a breathing apparatus that does not depend on circulating air on hand for emergencies.**
- **If there are signs of suffocation, immediately provide the affected person with the breathing apparatus that does not depend on circulating air, move to fresh air into recovery position, and keep warm. If no longer breathing, provide first aid measures and start artificial respiration. Seek medial attention immediately.**

Improper handling of displacement media can lead to severe poisoning or even death by suffocation.

Occurring vapors

⚠ WARNING

Risk of injury due to occurring vapors!

- **Do not stay in the immediate vicinity while the boosters are operated.**
- **Do not eat or drink in the vicinity of the boosters.**
- **In case of doubt, wear light respiratory protection.**

During the work process, exhaust gas of the drive air can develop on the drive component of the booster that can lead to poisoning when inhaled or upon contact with skin.

2.4 Responsibility of the owner

Owner

The owner is the person who is personally operating the boosters for industrial or commercial purposes or who is leaving the use/application to a third party and who has the legal product responsibility during the operation for the protection of the user, the personnel, or third parties.

Owner's obligations

The booster is used commercially. The owner of the booster is therefore subject to legal occupational health and safety obligations.

In addition to the safety instructions in this operating manual, general occupational health and safety, accident prevention, and environmental protection regulations must be complied with for the area of implementation of the booster.

In this regard the following particularly applies:

- The owner must inform himself of applicable occupational health and safety regulations, and in a hazard analysis identify additional hazards that may exist at the installation site of the booster due to the special work conditions. The owner must convert this information into operating instructions for operation of the booster.
- The owner must ensure during the entire implementation period of the booster that the operating instructions drawn up by the owner correspond to the current state of legislation, and if necessary the owner must adapt these operating instructions.
- The owner must clearly regulate and specify responsibilities for installation, operation, fault correction, maintenance and cleaning.
- The owner must ensure that all personnel who handle the booster have read and understood this operating manual. In addition, the owner must train personnel and inform them of hazards at regular intervals.
- The owner must provide the required protective equipment for personnel and instruct personnel that the wearing of the required protective equipment is a binding obligation.

The owner is also responsible for keeping the booster in faultless technical condition at all times. For this reason the following applies:

- The owner must ensure that the booster is integrated in the emergency stop devices or in the safety chain of the system in which the booster will be installed.
- When aggressive displacement media and/or toxic gases are used, the owner must ensure that lines will be installed that will capture the leaking aggressive media and/or toxic gases in corresponding containers and that the aggressive and toxic media will be disposed of properly.

- When aggressive, combustible, dangerous, or toxic gases are compressed, the owner must ensure that the booster is flushed with nitrogen before any fault elimination work is performed.
- The owner must ensure that only permissible displacement media (↯ *Chapter 2.2 “Permissible displacement media (gases)” on page 15*) will be compressed with the booster.
- The owner must ensure that the operating media (compressed air, gases) are pre-installed and stored as prescribed.
- The owner must ensure that all pressure hoses, pressure lines, couplings, and threaded unions are configured and dimensioned for the pressure ranges of the booster.
- The owner must ensure that suitable media connections are present and that these connections can be safeguarded via a separate shut-off valve.
- The owner must ensure that the connections of the operating media (compressed air, gases) function properly.
- The owner must ensure that the booster is kept and operated exclusively in technically faultless condition.
- The owner must ensure adequate lighting is always provided in the work area of the booster.
- The owner must ensure that all fault correction and repair tasks are executed exclusively by specialized personnel, who have the qualifications cited in the fault table.
- The owner must ensure that all warnings, instructions and safety signs attached on the booster are always complete and maintained in legible condition.
- The owner must ensure that the system is checked for damage and proper condition prior to each booster start up.

Obligations of the mechanical engineer and plant engineer

The mechanical engineer and plant engineer must has additional obligations resulting from the installation of the booster into a plant or system:

- The mechanical engineer and system engineer must ensure that, when installing the boosters in a plant or in a system, that an overall risk assessment is produced and that required steps to minimize hazards are initiated.
- The mechanical engineer and plant engineer must ensure that the boosters are integrated in the emergency stop concept of the plant/system.
- The mechanical engineer and plant engineer must ensure that all pressure hoses, pressure lines, couplings, and threaded unions are configured and dimensioned for the pressure ranges of the boosters.

Additional explosion protection obligations of the owner

The owner has additional obligations according to the EU directive to improve the health protection and safety of employees who may be endangered by explosive atmospheres.

They include the following organizational steps:

- Marking of Ex areas
- Placing clear signs of all prohibitions
- Preparing explosion protection documentation for every zone
- Prohibiting access to unauthorized persons

2.5 Personnel requirements

2.5.1 Qualifications

⚠ WARNING

Risk of injury in the event of inadequate qualification of the personnel!

- **Always have all work performed by personnel qualified for the particular work only.**
- **Keep unqualified personnel away from the danger zone.**

If unqualified work performs work on the booster or stays in the danger zone of the boosters, dangers arise that can cause severe injury and considerable property damage.

The qualifications of the personnel for the various areas of activity are listed in the following in this operating manual:

Mechanical and plant engineers
Mechanical and plant engineers are personnel, who due to their specialized training, skills, and experience, as well as knowledge of the applicable regulations, are capable of executing the tasks assigned to them. In addition mechanical and plant engineers are familiar with the installation, assembly, and the bringing together of machines and are capable of recognizing and avoiding possible hazards on their own.

Operator
The operator has been trained in a training session by the owner about the tasks conferred upon him and possible dangers in case of improper behavior. The operator may only perform tasks that exceed operation in normal mode if this is specified in the instructions and if the owner has expressly permitted him to do this.

Specialist for potentially explosive areas
The specialists for potentially explosive areas, due to their specialized training, skills, and experience, as well as knowledge of the applicable standards and regulations, are able to perform tasks on systems or sub-components in potentially explosive areas. The specialists for potentially explosive areas can independently recognize potential hazards and prevent dangers.

Only those persons of whom it can be expected that they will perform their work reliably are permissible as personnel. Persons with a reduced ability to respond, e.g., due to drugs, alcohol, or mediation, are not permissible.

When selecting personnel, observe the age and job-specific regulations that apply to the work site.

2.5.2 Instruction

The operator must instruct the personnel regularly. To improve tracking measures, an instruction protocol must be created with the following minimum information:

- Date of instruction
- Name of the instructed person
- Content of instruction

- Name of the instructor
- Signatures of the instructed person and the instructor

2.6 Personal protective equipment

Personal protective equipment is used to protect personnel from impairments to occupational health and safety.

During the various tasks performed on and with the booster, personnel must wear personal protective equipment, to which special reference is made in the individual sections of this manual.

Description of the personal protective equipment

The personal protective equipment is explained below:

Protective gloves
Protective gloves are used to protect the hands from friction, abrasions, puncture wounds or deeper wounds as well as coming into contact with hot surfaces.

Protective work clothing
Protective work clothing is close-fitting work clothing with low tear resistance, with close sleeves and without protruding parts.

Safety goggles
Safety goggles are intended to protect your eyes from flying components and splashes of liquid.

Safety shoes
Safety shoes protect the feet against being crushed, falling objects and slipping on slippery surfaces.

2.7 Safety devices

Integration into an emergency stop concept is required

The boosters are incomplete machines and have no own control and no autonomous emergency stop function.

Before the boosters are started up, emergency stop equipment to the machine must be installed and integrated into the plant control safety chain.

Connect the emergency stop equipment such as to rule out dangerous situations for persons and damage to property when the power supply is interrupted or reactivated after an interruption.

The emergency stop equipment must always bee freely accessible.

2.8 Signage

The following symbols and information signs are located in the work area. They relate to the direct environment where they have been put up.

⚠ WARNING

Risk in conjunction with illegible signage!

- **Always keep safety, warning and operating notices in good legible condition.**
- **Immediately replace damaged signs or stickers.**

Over time, stickers and signs can get dirty or become illegible for other reasons, so that risks can no longer be recognized and necessary operating instructions can no longer be adhered to. This presents a risk of injury.

Signage at the booster

The signs attached on the booster are presented and explained in the following illustrations.

Depending on the version of the booster, the information on the signs can vary.

Fig. 2: Signage

Illustration	Description
	CAUTION! Not suitable for oxygen.
	CAUTION! Keep grease-free, suitable for OPERATION WITH OXYGEN.

2.9 Behavior in case of fire and accidents

Preventative measures

- Always be prepared for fire and accidents!
- Keep first aid equipment (bandage boxes, covers, etc.) and fire extinguishers so that they are functional and close at hand.
- Familiarize personnel with accident reporting, first aid, and rescue equipment.
- Keep access routes free for rescue vehicles.

Measures in case of fire and accidents

- Trigger an emergency off with the emergency off equipment right away.
- If there is no danger to your own health, rescue people in the danger zone.
- If required, initiate first aid measures.
- Call the fire department and/or ambulance.
- In case of fire: if there is no danger to your health, fight the fire with fire extinguishing equipment and continue firefighting until the fire department arrives.
- Inform the responsible person in the affected area.
- Free access routes free for rescue vehicles.
- Inform rescue vehicles.

2.10 Spare parts

Explosion protection

⚠ WARNING

Danger of explosion if the wrong spare parts are used!

- **Only use the manufacturer's genuine spare parts or spare parts that are expressly approved by the manufacturer.**
- **Always contact with the manufacturer if there are questions.**

Using incorrect or faulty spares can lead to explosion in the Ex area. This can lead to sever injury or even death as well as considerable property damage. Non-compliance with these instructions will lead to loss of explosion protection.

2.11 Environmental protection

NOTICE

Danger to the environment due to incorrect handling of materials that can harm the environment!

- **Always heed the notes below about the handling of materials that can harm the environment and their disposal.**
- **If materials that can harm the environment accidentally escape into the environment, take suitable measures immediately. In case of doubt, inform the responsible local authority about the damage and ask what suitable measures to take might be.**

In case of incorrect handling of materials that can harm the environment, especially improper disposal, there can be significant damage to the environment.

The following materials that might harm the environment are used:

Cleaning products

Cleaning products that contain solvents contain poisonous substances. They may not be allowed to escape into the environment. Disposal must be handled by a professional disposal company.

Lubricants

Lubricants may contain poisonous and environmentally hazardous substances. They are water polluting and must not be released into the environment. Disposal must only be performed by licensed specialists. Always follow the instructions of the Material Safety Data Sheet (MSDS). The operating company should make sure that personnel is regularly instructed how to safely handle and dispose of lubricants.

Displacement media

Displacement media such as gases can contain toxic substances. They must not be released into the environment. Potentially leaking displacement media must be disposed of by a specialized company.

3 Structure and function

3.1 Overview

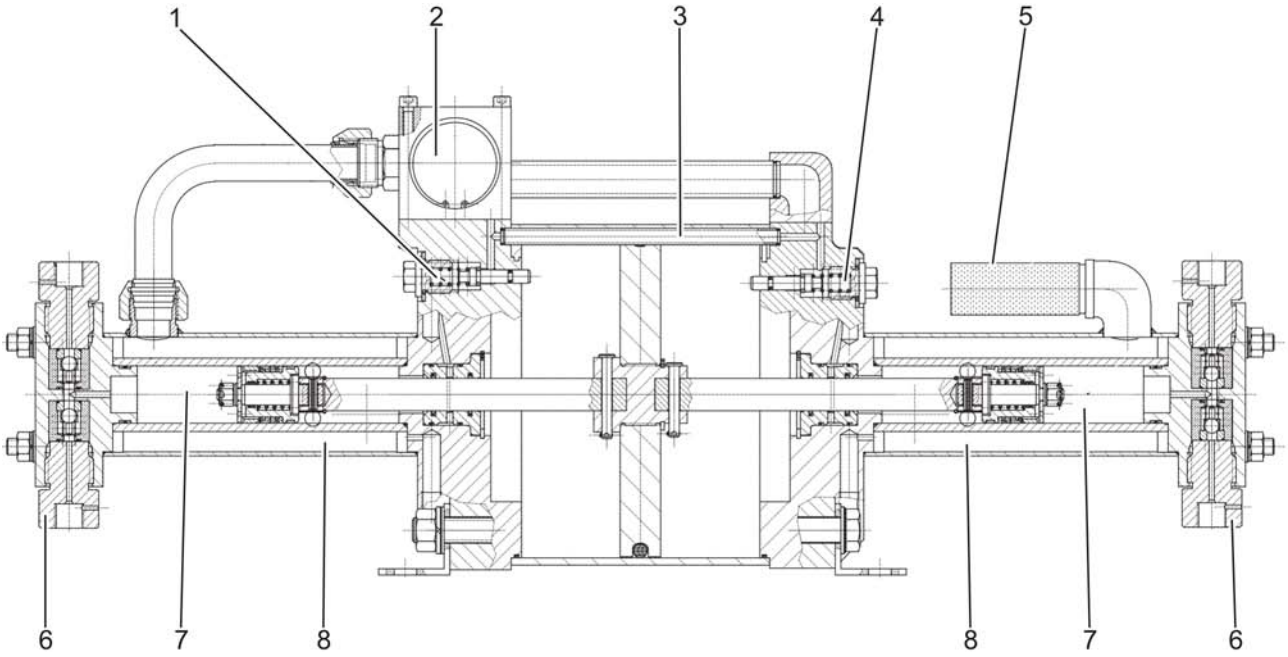


Fig. 3: Overview

1 Pilot valve 1
2 Spool valve (4/2 directional control valve)
3 Air cylinder
4 Pilot valve 2
5 Exhaust air silencer
6 Booster head with suction and pressure valve
7 Pressure cylinder
8 Cooling cylinder

3.2 Brief description

The boosters work on the principle of a pressure intensifier. They are used to compress gas and compressed air to a higher pressure; they are operated with a pneumatic admission pressure of a maximum of 10 bar compressed air. This admission pressure is required to compress the particular delivery medium to a higher operating pressure. In the process, large areas are driven by means of low pressure by the air piston thus generating a high pressure level on small areas of the booster via the high pressure piston.

The following are fields of application for the boosters:

- Pressure test with gas
- Transferring gases from transport containers with a low pressure level to a high pressure level
- Filling pressure accumulators with nitrogen

- Gas recovery
- Nitrogen reservoir filling
- Supply of seal gas plants
- Gas assisted injection molding
- CO_2 foaming
- Filling clean air cylinders
- Leakage tests

3.3 Assembly description

3.3.1 Booster head with intake and outlet valve

The booster head closes the compression chamber and separates it spatially from the surrounding pressure. The booster head contains the intake and outlet valves. The displacement medium flows into the compression chamber through these intake and outlet valves and back out again.

3.3.2 High pressure component

The high pressure component is used to compress the particular displacement medium. The high pressure component consists of the pressure cylinder, booster head with intake and outlet valves, and the high pressure piston with the sealing and guide elements.

3.3.3 Pilot valve

The pilot valves are used by the air piston as a limit switch. The pilot valves are actuated by the air piston in the end positions, they forward air pulses to the control valve. As a result, the pilot valves ventilate the actuation chamber of the control valve. This moves the control valve from one end position to the other.

3.3.4 Control valve

The control valve is used to alternately apply compressed air to the upper and underside of the air piston. The control valve is actuated via the pilot valves; it ensures that the drive air is directed to the left and/or right side of the air piston.

3.3.5 Drive component

The drive component is used to accommodate the drive air (compressed air); it actuates the high pressure component of the booster via a piston rod thus compressing the particular displacement medium to a higher pressure.

3.3.6 Exhaust air silencer

The exhaust air silencer is used to discharge expanding air from the booster with reduced noise. The drive air escapes from the booster after the operation has been performed via the exhaust air silencer. The exhaust air silencer is made of plastic or aluminum depending on the booster model.

3.3.7 Cooling cylinder

The cooling cylinder is used for insulating and cooling the high pressure component of the booster. The cooling cylinder encloses the high pressure cylinder. The expanding (very cold) drive air is directed into the space between the two cylinders in order to cool the high pressure cylinder during operation.

3.3.8 Compressed air control unit

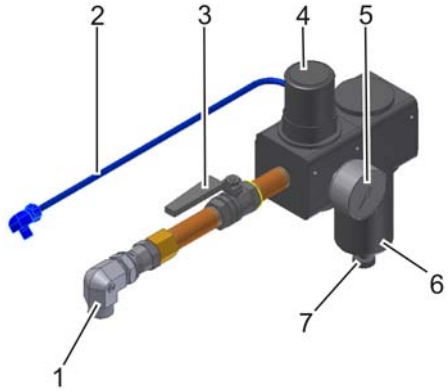


Fig. 4: Compressed air control unit

The compressed air control unit (Fig. 4) is a frequently installed sub-assembly; however, it is not part of the standard equipment. The manufacturer recommends the use of a compressed air control unit.

The compressed air control unit is used to manually adjust and control the operating pressure directly at the booster. It is pre-assembled at the drive air connection of the control valve (Fig. 4/1). Via the pressure regulator (Fig. 4/4), the particular operating pressure can be adjusted and controlled on the pressure gage (Fig. 4/5). Furthermore, the drive air can be warmed up via the water trap (Fig. 4/6) and the bleeder valve (Fig. 4/7). The ball valve (Fig. 4/3) manually shuts off the drive air from the compressed air network to the booster. The control line (Fig. 4/2) supplies the pilot valve air connection with direct pilot valve air.

3.4 Mode of operation of the boosters

The piping and instrumentation (P + I) flow chart of the boosters is illustrated in the graphic below.

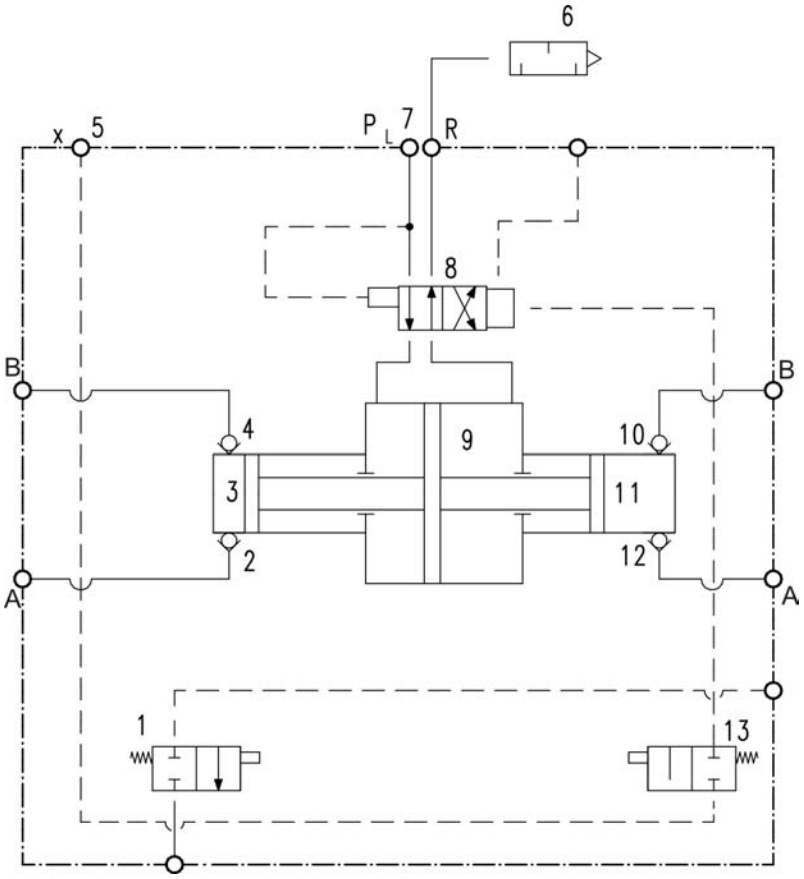


Fig. 5: P + I flow chart of the boosters

1 Pilot valve lower cap
2 Intake valve
3 High pressure piston
4 Outlet valve
5 Pilot valve air connection (X)
6 Exhaust air silencer
7 Air connection (P_L)
8 Control valve
9 Air piston
10 Outlet valve (B)
11 High pressure piston
12 Intake valve (A)
13 Pilot valve upper cap

Explanation of the mode of operation

The drive air flows from the air connection (Fig. 5/7) through the control valve (Fig. 5/8) to the underside of the air piston (Fig. 5/9). The air piston moves to the right in the drive component thus performing a suction cycle on the left side of the high pressure component. The intake valve (Fig. 5/2) opens up and the gas to be compressed flows through the connection (Fig. 5/A) into the compression chamber of the high pressure component. A pressure cycle is performed on the right side of the high pressure component.

The intake valve (Fig. 5/12) closes, the outlet valve (Fig. 5/10) opens up, and the compressed gas flows out of the connection (Fig. 5/B). When the air piston (Fig. 5/9) has moved to the right end position of the drive component, it opens up the pilot valve (Fig. 5/13). The control air flows from the connection through the open pilot valve (Fig. 5/13) to the large control valve side of the booster.

The control valve (Fig. 5/8) switches to the other switch position and the drive air flows to the right side of the air piston (Fig. 5/9). The air piston moves to the left side of the drive component. As a result, a pressure cycle is generated on the left side of the high pressure component and a suction cycle on the right side. The expanding drive air now escapes from the working chamber via the exhaust air silencer (Fig. 5/6).

In the booster variants with a transmission ratio of > 5, the air is directed through the cooling cylinder and therefore used to cool down the high pressure components.

3.5 Connections

The booster is delivered without any piping or threaded unions. The connected load information (↳ "Connected loads, mechanical" on page 105) must be observed for all interface connections. A connection drawing of all connections to be installed can be found in ↳ Appendix B "Connection drawing" on page 127.

The boosters have the following interfaces:

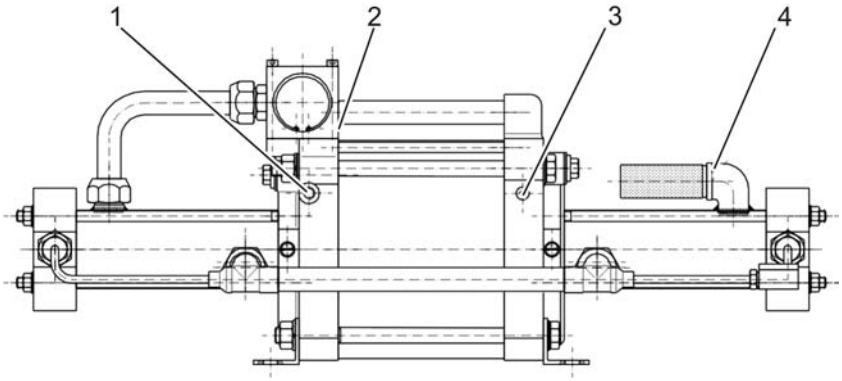


Fig. 6: Interfaces (side view)

Item no.	Designation	Connec-tion	Function
1	Control air connec-tion"X"	G 1/8"	Connection for direct pilot valve air (uncontrolled and filtered) control air ≥ drive air
2	Ventilation connection for spool valve "Y"	Bore	Ventilation and bleeding of the spool valve (pulse-type air discharge)
3	Air connection for pilot valve "X"	M5	Bleeding of the pilot valve. This connec-tion can be used to connect a stroke counter. The air escapes in pulses here. The connection must therefore not be closed.
4	Exhaust air silencer connection	G1/2"	Outlet of the expanding drive air

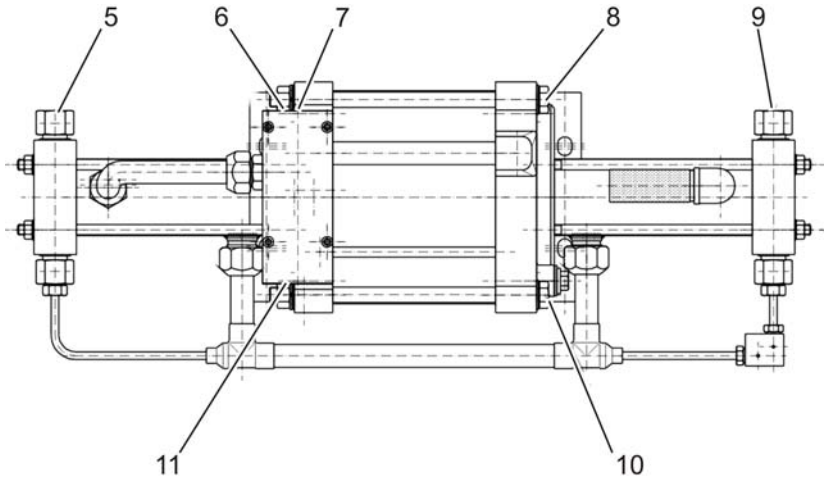


Fig. 7: Interfaces (top view)

Item no.	Designation	Connection	Function
5	Outlet connection "B"	Depends on model	Outlet for operating pressure
6	Leakage connection for high pressure sides "Z_1" and "Z_3"	G 1/8"	Ventilation of the high pressure cylinder behind the piston. Alternate admission and expulsion (alternately fitted with silencer).
7	Operation connection "PL"	G 1/8"	Inlet for the compressed drive air
8	Leakage connection for high pressure sides "Z_1" and "Z_3"	G 1/8"	Ventilation of the high pressure cylinder behind the piston. Alternate admission and expulsion (alternately fitted with silencer).
9	Inlet connection "A"	Depends on model	Inlet for the admission pressure
10	Leakage connection for air sides "Z_2" and "Z_4"	G 1/8"	Deduction of the leakage at the drive component
11	Leakage connection for air sides "Z_2" and "Z_4"	G 1/8"	Deduction of the leakage at the drive component

3.6 Working areas and danger zones

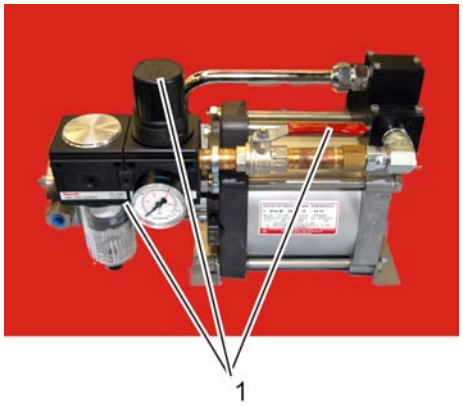


Fig. 8: Working areas and danger zones

The danger zone (Fig. 8/marked in red) is the entire zone surrounding the entire booster. If the booster has an optional compressed air control unit (Fig. 8/1), the working area is located within the danger zone.

3.7 Scope of delivery

The booster is delivered without piping or threaded unions.

The following components are part of the scope of delivery:

Designation	Quantity
Booster	1
Retaining bracket for mounting	2
Operating instructions for boosters DLE 2 (-1, -2) – DLE 75 (-1, -2)	1
Installation explanations	1
Conformity declaration according to ATEX Category IIB and/or IIC	1

3.8 Accessories

The following accessories are available for the boosters.

Compressed air control unit

The compressed air control unit is used to manually adjust the drive air directly at the booster. The compressed air control unit consists of a pressure filter, a water separator, a shut-off valve, a pressure regulator, a hose line, and a manometer. A safety valve for the compressed air control unit is available additionally.

Air lubricator

The air lubricator is used to increase the oil content in the drive air. The manufacturer recommends the use of an air lubricator if the drive air is extremely dry.

Gasket sets

The individual gasket sets of the booster components are available from the manufacturer as complete sealing kits. These sealing kits are used during all fault correction work. See ↬ *Appendix D “Cross-sectional drawings and bills of materials” on page 131*.

4 Transport, packaging, and storage

4.1 Safety instructions for transport

Improper transport

NOTICE

Material damage due to improper transport!

- **When unloading transport items at delivery, as well as for inner-company transport, proceed carefully and pay attention to the symbols and instructions on the packaging.**
- **Only remove the packaging just before installation.**

Transport items can fall or tip over if transported improperly. This can cause considerable material damage.

4.2 Transport inspection

Check the delivery immediately upon receipt to ensure that it is complete, and to identify any transport damage.

Proceed as follows if there is apparent external damage:

- Do not accept the delivery, or only accept it with reservation.
- Note the extent of transport damage on the transport documents or on the transport company's delivery ticket.
- Submit a complaint.

Report any defect as soon as it is detected. Claims for damage compensation can only be enforced during the applicable periods for giving notice of lack of conformity.

4.3 Packaging

Information concerning packaging

The individual packaged pieces have been packaged appropriately according to the expected transport conditions. Only environmentally-friendly materials were used for the packaging.

The packaging is supposed to protect the individual components from transport damage, corrosion and other damage prior to installation. Therefore, do not destroy the packaging and only remove it shortly prior to the installation.

Handling packaging materials

Dispose of packaging materials in accordance with the respectively valid statutory regulations and local guidelines.

NOTICE

Improper disposal poses an environmental hazard!

- **Dispose of packaging materials in an environmentally responsible manner.**
- **Comply with locally applicable disposal guidelines. If necessary commission a specialized company to dispose of packaging.**

Packaging materials are valuable raw materials and in many cases they can be reused, or they can be effectively treated and recycled. Improper disposal of packaging materials causes environmental hazards.

4.4 Storage

Storage of packages

Only store packages under the following conditions:

- Do not store outdoors.
- Store in a dry and dust-free environment.
- Do not expose to any aggressive media.
- Protect from direct sunlight.
- Avoid mechanical vibration.
- Storage temperature: - 4 to 140 °F.
- Relative humidity: Max. 60%.
- When storing for longer than three months, check the general condition of all parts and the packaging on a regular basis. Touch up or reapply anti-corrosion agents as needed.

It may be the case that storage instructions are affixed to the packages that extend beyond the requirements cited here. Comply with these instructions accordingly.

5 Installation and commissioning

5.1 Safety instructions for installation and commissioning

Improper installation and commissioning

⚠ WARNING

There is an injury hazard if the device is not installed and commissioned properly!

- **Allow only mechanical engineers and plant engineers to install and commission the device.**
- **Ensure order and cleanliness at the installation location! Parts and tools that are lying loose or on top of each other are accident hazards.**
- **Properly mount lines and hoses. Maintain the prescribed bolt-tightening torque.**
- **Only remove sealing plugs directly prior to mounting the connecting lines.**
- **Comply with the following before commissioning:**
  - **Ensure that all installation tasks have been properly executed and concluded in accordance with the instructions in this manual.**
  - **Ensure that a leak test of all line connections has been executed.**
  - **Ensure that no one is in the danger zone.**

Improper installation and commissioning can cause serious injury or material damage.

Explosion protection

⚠ WARNING

Danger of explosion during installation!

- **Prior to installation, obtain a written work approval.**
- **Perform installation only when a potentially explosive atmosphere can be ruled out.**
- **Use only those tools that are permissible for use in the Ex area.**

Bringing in ignition sources such as sparks, open flames, and hot surfaces can lead to explosion in the Ex area. Non-compliance with these instructions will lead to loss of explosion protection.

5.2 Prerequisites for installation

The prerequisites that must be in place for installation of the booster are described below.

The booster is an incomplete machine and is designed to be installed in a plant or system.

Set up the booster in such a manner that the following conditions are satisfied:

- The installation site must be level.
- The booster must be stable and secure, or firmly and securely seated.
- The booster must not be exposed to any vibration or oscillation.
- The booster must be easily accessible from all sides.
- The booster must be installed in such a manner that it is not exposed to any external heat sources.
- The booster must be installed in a dust-free environment.

Installation specifications

⚠ WARNING

Danger of explosion if the installation specifications are not observed!

- **Always set up boosters in a well ventilated room.**
- **Always keep hydrogen systems leak-tight.**
- **Blow-out lines of safety valves and leakage lines must always be routed outside into the open.**
- **Blow-out lines must not be installed under eaves, openings in buildings, or in the vicinity of air intake openings.**
- **For hydrogen systems in rooms or buildings, it must be possible to safely and quickly shut off the gas supply coming from the outside at a safe point.**
- **Pipe connections on hydrogen systems must always be created ensuring that the connection will be tight for a long time.**

If the installation specifications for boosters designed for the compression of toxic and combustible gases are not observed, this can lead to the development of a potentially explosive atmosphere.

5.3 Mounting the booster

⚠ CAUTION

Danger of material damage!

- **Keep all connections sealed with sealing plugs during installation.**
- **Only remove the sealing plugs directly prior to mounting the connection piping.**

Fouling or drilling dust that gets into the connections of the booster during installation can result in booster damage.

Personnel:	■ Mechanical and plant engineers
Protective equipment:	■ Protective work clothing ■ Safety goggles ■ Safety shoes
Special tool:	■ Power drill ■ Vacuum cleaner

1. Set up booster with pre-assemble angle brackets at installation site.

   i To do this, observe the installation plan
   ↳ Appendix C “Installation plan” on page 129.

2. Set up booster, draw bore holes, and remove booster again.
3. Drill installation holes.
4. Vacuum up drilling dust.
5. Set up booster and use attachment screws and spring washers with a torque of 85 Nm to fasten to foundation.

5.4 Installing the connecting lines

A description of how the booster is connected to the compressed air network and to a transport gas container is provided below.

The booster is delivered without any threaded unions or piping. Please observe the corresponding information in
↳ “Connected loads, mechanical” on page 105 and
↳ Appendix B “Connection drawing” on page 127.

Personnel:	■ Mechanical and plant engineers
Protective equipment:	■ Protective work clothing ■ Safety shoes ■ Safety goggles
Special tool:	■ Wrench

Unforeseeable movements

⚠ WARNING

Danger of injury due to unforeseeable movements of compressed air lines!

- **De-pressurize the connecting line prior to all mounting tasks.**
- **All piping must be securely anchored to the floor or to walls.**
- **All piping must be routed in such a manner that they will not cause any tripping hazard.**
- **Always wear personal protective equipment.**

Lines of the in-house compressed air network can move in an unforeseeable manner and can cause injuries if there is a load change.

Use of incorrect connecting lines

⚠ CAUTION

Danger of material damage if the wrong connecting lines are used!

- **The piping and lines must be matched to the maximum output pressure of the booster.**
- **The tightening torque of the respective threaded unions must be complied with.**
- **The cross-section of the high-pressure pipes and lines may not be less than the cross-section of the connections.**

The use of incorrectly dimensioned piping in threaded unions can cause malfunctions and material damage to the booster.

The prerequisites that must be in place for proper installation is the presence of a professionally planned, installed, and maintained compressed air network and a shut-off valve additionally installed on the inlet of the compressed air network.

5.4.1 Connecting the drive air

Depending on the version, the connection of the drive air on the booster must be either installed on the air drive connection (PL) of the spool valve housing or, if a compressed air control unit is available, at the air drive connection of the compressed air control unit. Please observe the information in ↳ "Connected loads, mechanical" on page 105 and ↳ Appendix B "Connection drawing" on page 127 on how to use drive air lines, hose connections, or threaded unions.

A description of how the drive air is installed on the compressed air control unit is provided below.

Fig. 9: Unscrewing sealing plug

1. Unscrew sealing plug from drive air connection (Fig. 9/1) of spool valve housing or from compressed air control unit (Fig. 9/2).

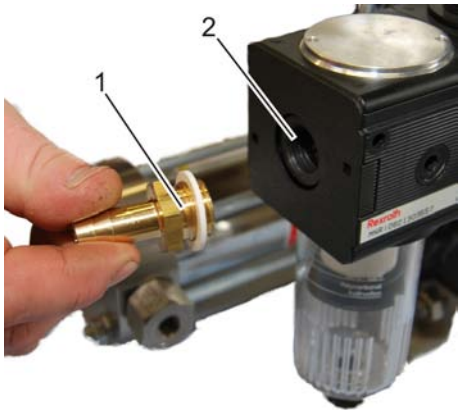


Fig. 10: Drive air connection (compressed air control unit)

2. Insert connecting piece (G 3/4 ") (Fig. 10/1) into drive air connection (PL) of compressed air control unit (Fig. 10/2) together with seal and tighten using a torque of 440 lbf in.

5.4.2 Connecting the inlet line for admission pressure and outlet line for operating pressure

Please observe the information in ↳ "Connected loads, mechanical" on page 105 and ↳ Appendix B "Connection drawing" on page 127 on how to use drive air lines, hose connections, or threaded unions.

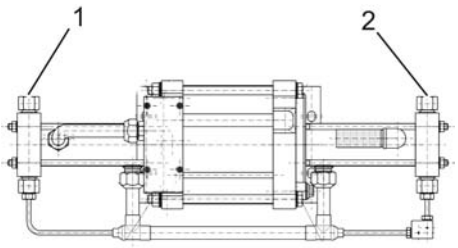


Fig. 11: Connecting inlet and outlet connections

1. Detach sealing plugs from inlet and outlet connections (Fig. 11/1 and 2).
2. Install piping for inlet and outlet lines according to *Appendix B "Connection drawing" on page 127*.

5.4.3 Installing a separate leakage line

When compressing combustible or toxic gases, an additional leakage line must be installed on the booster.

Fig. 12: Removing breather silencer

1. Unscrew the breather silencer (Fig. 12/1) out of leakage connections Z1 and Z3.

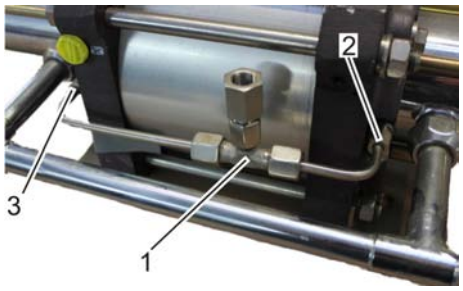


Fig. 13: Piping for leakage line

2. Connect leakage piping (Fig. 13/1) to leakage connections Z1 (Fig. 13/2) and Z3 (Fig. 13/3).
3. Install separate leakage line according to (*Appendix B "Connection drawing" on page 127*) on leakage piping.

5.5 Installing exhaust air silencer

A description of how the exhaust air silencer is installed is provided below.

Depending on the booster version, the exhaust air silencer can be made of plastic or aluminum. The installation of the Die exhaust air silencer is always identical.

Personnel:
- Mechanical and plant engineers

Protective equipment:
- Protective work clothing
- Safety shoes
- Safety goggles

Fig. 14: Exhaust air silencer

1. Keep exhaust air silencer ready.

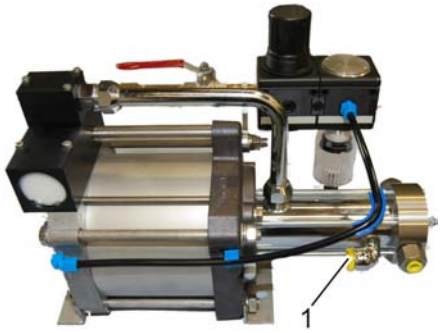


Fig. 15: Sealing plug

2. Unscrew sealing plug from exhaust air connection.

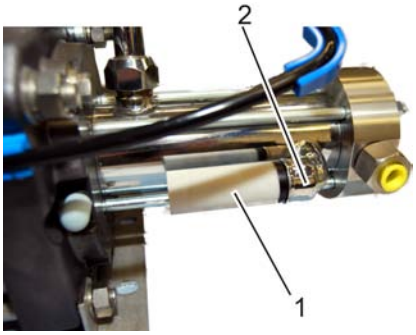


Fig. 16: Installing exhaust air silencer

3. Position exhaust air silencer (Fig. 16/1) at exhaust air connection (Fig. 16/2) and tighten hand-tight.

5.6 Commissioning

A description of how the booster is commissioned is provided below.

Personnel:	■ Mechanical and plant engineers
Protective equipment:	■ Protective work clothing ■ Safety goggles ■ Safety shoes
Special tool:	■ Leak detector spray

Checks prior to commissioning

1. Check all media connections for correct installation.
2. Check all piping and threaded unions for mechanical damage.
3. Open displacement medium (gases) on transport gas container.
   ⇨ The displacement medium flows in.
4. Open compressed air line of compressed air network to booster.
   ⇨ The booster starts delivering.

   When a compressed air control unit is used, the drive air is connected to the manometer of the compressed air control unit when the compressed air network is opened. In this case, the manometer must be additionally checked for function (“Checking the manometer for function” on page 50).
5. Perform a leak test with leak detector spray on all connections.

Checking the manometer for function

During the commissioning process the manometer of the compressed air control unit must be checked for function. Proceed as follows to do this:

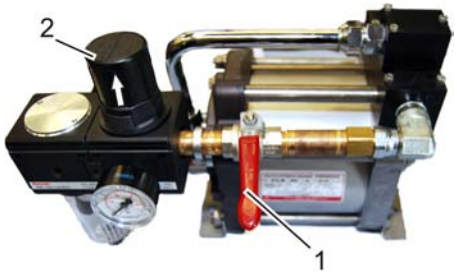


Fig. 17: Compressed air control unit

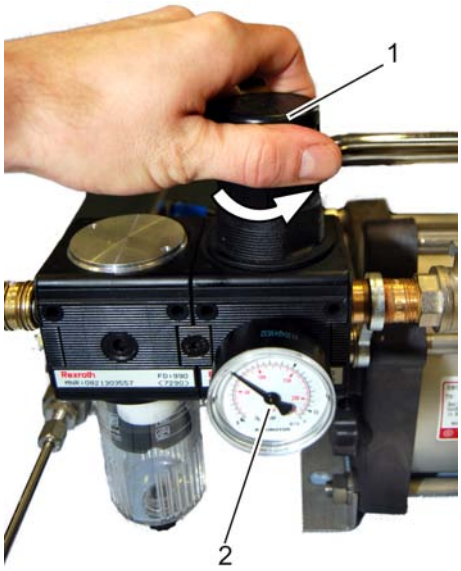


Fig. 18: Opening pressure regulator

1. Keep the ball valve of the compressed air control unit (Fig. 17/1) closed.

   i The ball valve is closed, if its position is perpendicular (Fig. 17/1) to the center axis.

2. Pull the pressure regulator (Fig. 17/2) of the manometer upward.

   ⇨ The pressure regulator will audibly detach from the arrest.

3. Open the pressure regulator (Fig. 18/1) by turning it to the right.

   ⇨ The drive air is applied.

4. On the manometer (Fig. 18/2), check whether the applied pressure is displayed.

Fig. 19: Bleeding

5. Open the vent screw (Fig. 19/1) of the water separator (Fig. 19/2) and dissipate the pressure.
   ⇨ Pressure escapes from the vent valve and the pressure drop is displayed on the manometer.
6. Close the vent screw (Fig. 19/1).
7. Close the pressure regulator through left rotation.
8. Press the pressure regulator downward.
   ⇨ The pressure regulator audibly clicks into place.
9. Perform a leak test with leak detector spray on all connections.

6 Operation

6.1 Safety instructions for operation

Improper operation

⚠ WARNING

Danger of injury due to improper operation!

- **Execute all operating steps in accordance with the information and the instructions in this manual.**
- **Comply with the following prior to starting the tasks:**
  - **Ensure that all piping, threaded unions, displacement media and safety devices are installed correctly and that they function properly.**
  - **Ensure that no one is in the danger zone.**
- **Never render safety devices inoperable during operation or bypass them.**

Improper operation can cause severe injury and significant material damage.

6.2 Daily inspections

The inspections listed below must be performed daily prior to and during operation.

Personnel:
- Operator

Protective equipment:
- Protective work clothing
- Safety shoes
- Safety goggles

Execute the following inspections prior to operation:

- Check all threaded unions and piping for damage.
- If no compressed air control unit is used, check the quality of the compressed air ↳ *"Pneumatic" on page 104*.
- If a compressed air control unit is used, check the function of the manometers ↳ *"Checking the manometer for function" on page 50*.

Execute the following inspections prior to operation:

- Drain condensation via the vent screw of the compressed air control unit (↳ *Chapter 6.5 "Draining the condensate on the water separator" on page 58*).

6.3 Calculating the operating pressure

Before the booster is commissioned, the operating pressure must be calculated. The static end pressure of the booster is calculated for the particular booster type using the following formulas.

A list of booster types can be found in Chapter 1.2 “Versions” on page 9.

A legend for the calculation of the operating pressure can be found below the table.

Booster type	Calculation of the static operating pressure
Single-stage, single-acting	PB = PL * i
Single-stage, dual-acting	PB = i * PL + PA
Dual-stage	PB = i2 * PL + i2 / i1 * PA
Single-stage, single-acting with two drive components	PB = PL * i
Single-stage, dual-acting with two drive components	PB = i * PL + PA
Dual-stage with two drive components	PB = i2 * PL + i2 / i1 * PA

Legend:

PL = Drive pressure

PB = Operating pressure

PA = Gas admission pressure

i = Transmission ratio

i1 = Transmission ratio stage 1

i2 = Transmission ratio stage 2

6.4 Switching on

A description of how the booster is installed is provided below.

The boosters have no main switch. The booster starts to operate as soon as the displacement medium is present and the drive air is applied at the booster. The switch-in process using the compressed air control unit differs from the switch-in process without the use of the compressed air control unit. The two processes are described below.

Personnel:
- Operator

Protective equipment:
- Protective work clothing
- Safety shoes
- Safety goggles

Switching the booster on

In a booster without compressed air control unit, the booster starts delivering as soon as the displacement medium is present and the drive air of the in-house compressed air network is applied.

1. Calculate the required operating pressure (*Chapter 6.3 “Calculating the operating pressure” on page 54*).
2. Adjust drive pressure on pressure regulator of in-house compressed air network and check pressure on manometer.
3. Open displacement medium (gas) on transport gas container.
   ⇨ The displacement medium flows in.
4. Open compressed air line of compressed air network to booster.
   ⇨ The booster starts delivering as soon as the drive air pressure is applied.

Switching the booster on with a compressed air control unit present

1. Calculate the required operating pressure (*Chapter 6.3 “Calculating the operating pressure” on page 54*).
2. Make sure that the ball valve (Fig. 20/1) of the compressed air control unit is closed.

Fig. 20: Ball valve of the compressed air control unit

3. Make sure that the vent valve (Fig. 21/1) of the compressed air control unit is closed.
4. Open valve of displacement medium (gas) on transport gas container.
   ⇨ The displacement medium flows in.
5. Open compressed air line of compressed air network to booster.
   ⇨ Drive air is applied to the compressed air control unit.

Fig. 21: Vent valve

Fig. 22: Releasing pressure regulator from arrest

6. Pull the pressure regulator (Fig. 22/1) upward.

⇨ The pressure regulator will audibly detach from the arrest.

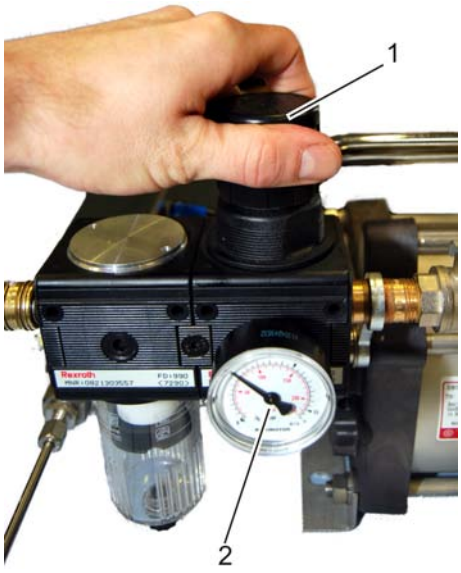


Fig. 23: Adjusting the operating pressure

7. Slowly adjust the previously calculated drive pressure by turning the pressure regulator (Fig. 23/1) and check required drive pressure on manometer (Fig. 23/2).

⇨ Turning it to the right will increase the drive pressure; turning it to the left reduces the driver pressure.

8. Once the drive pressure has been adjusted, press the pressure regulator downward.

⇨ The pressure regulator audibly clicks into place.

Fig. 24: Opening the ball valve

9. Open the ball valve (Fig. 24/1) of the compressed air control unit (Fig. 24/arrow).

⇨ The booster starts delivering as soon as the operating pressure is released via the ball valve.

6.5 Draining the condensate on the water separator

A description of how the condensation is drained on the vent valve of the water separator is provided below.

The booster must be checked daily during operation for the presence of condensation. If condensate is present in the water separator, it must be drained.

Personnel:
- Operator

Protective equipment:
- Protective work clothing
- Safety shoes
- Safety goggles

Special tool:
- Accumulator

1. Check water separator of compressed air control unit (Fig. 25/2) for the presence of condensate.
   ⇨ If condensate is present, it must be drained.
2. Position accumulator under vent screw.
3. **⚠ CAUTION! Danger from condensate splashing out!**
   Slowly open vent screw (Fig. 25/1) and let condensate drain.
4. Close the vent screw (Fig. 25/1).

Fig. 25: Checking the water separator

6.6 Switching off

A description of how the booster is switched off is provided below.

The boosters have no main switch. The booster stops operating as soon as the drive air is shut off. The switch-off process using the compressed air control unit differs from the switch-off process without the use of the compressed air control unit. The two processes are described below.

Personnel:
- Operator

Protective equipment:
- Protective work clothing
- Safety shoes
- Safety goggles

Switching the booster off

In a booster without compressed air control unit, the booster stops as soon as the drive air from the in-house compressed air network is shut off.

1. Shut off compressed air line of in-house compressed air network.
2. Shut off displacement medium on valve of gas transport container.
   ⇨ The booster stops delivering.

To this end, see the operating instructions for the in-house compressed air network.

Switching the booster off with a compressed air control unit present

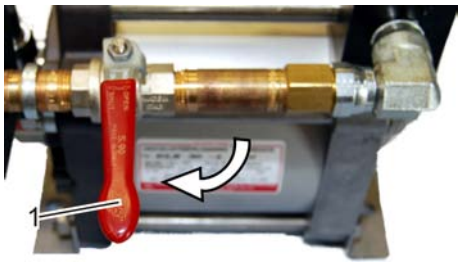


Fig. 26: Close ball valve

1. Close the ball valve (Fig. 26/1) of the compressed air control unit (Fig. 26/arrow).
2. Shut off displacement medium on valve of gas transport container.
3. Shut off compressed air line of in-house compressed air network.
   ⇨ The booster stops delivering.

6.7 Shut-down in an emergency situation

In dangerous situations, movements of components must be stopped as quickly as possible and the energy supply must be switched off.

Shut-down in an emergency situation

Proceed as follows in an emergency:

1. Immediately trigger an emergency stop with the emergency stop device.
2. Immediately shut off the displacement medium and compressed air lines.
3. If there is no danger for your own health, get people out of the danger zone.
4. If required initiate first-aid measures.
5. Alert the fire department and/or rescue service.
6. Inform the responsible parties at the implementation site.
7. Switch off the booster and safeguard it from being switched on again.

7 Faults

Possible causes for faults and fault correction tasks are described in the following chapter.

In the events of faults that cannot be corrected with the help of the notes below, contact the manufacturer; see contact information in Chapter 1.4 of these operating instructions.

7.1 Safety instructions for fault correction

Nitrogen

⚠ WARNING

Danger of suffocation due to improper handling of nitrogen!

- **Always observe the manufacturer's safety data sheet.**
- **Always ensure adequate ventilation.**
- **Keep a breathing apparatus that does not depend on circulating air on hand for emergencies.**
- **If there are signs of suffocation, immediately provide the affected person with the breathing apparatus that does not depend on circulating air, move to fresh air into recovery position, and keep warm. If no longer breathing, provide first aid measures and start artificial respiration. Seek medial attention immediately.**

Improper handling of nitrogen while purging the booster can lead to poisoning or even death by suffocation.

Safeguarding against restart

⚠ WARNING

Life-threatening danger due to unauthorized restart!

- **Prior to starting the tasks, shut off all media, depressurize the booster, and safeguard it from being switched on again.**

Through unauthorized restart or opening of the compressed air supply, or the displacement media, during troubleshooting and fault correction there is danger of severe or fatal injuries for persons in the danger zone.

Improperly executed fault correction tasks

⚠ WARNING

Danger of injury due to improper fault correction!

- **Before starting the tasks purge the compressor with nitrogen.**
- **Ensure order and cleanliness at the installation location! Parts and tools that are lying loose or on top of each other are accident hazards.**
- **If components have been removed, ensure that they are properly reinstalled, that all fastening elements are reinstalled, and that all threaded connections are tightened with the specified screw-tightening torque.**
- **Comply with the following before restarting the system:**
  - **Ensure that all fault correction tasks have been properly executed and concluded in accordance with the instructions in this manual.**
  - **Ensure that no one is in the danger zone.**

Improperly executed fault correction tasks can cause severe injury and significant material damage.

Compressed air and gases

⚠ WARNING

Danger of injury due to compressed air and gases!

- **Always establish de-pressurized status before mounting or dismounting hoses, lines, threaded unions, or quick-release couplings. Completely de-pressurize the pressure accumulator.**
- **Always wear personal protective equipment.**
- **Have defective components that are pressurized in operation replaced immediately by qualified personnel (mechanical and plant engineer).**

In the event of a fault or a defect, compressed air or gas can escape from compressed air lines, hoses, or pressurized components of the booster. This compressed air or gases can whirl up dust, can cause uncontrolled movements of the lines, and can cause severe injuries.

Cold surfaces

⚠ CAUTION

Risk of injury due to cold and iced up surfaces!

- **Always wear protective clothing and protective gloves during all work in the vicinity of cold or iced up surfaces.**
- **Make sure prior to all work that all surfaces have warmed up to ambient temperature.**

Components such as the exhaust air silencer can cool down severely and ice up due to expanding air or gas. Skin contact with cold surfaces can cause skin irritations.

Behavior if there is a fault

The following always applies:

1. For faults that pose an imminent danger to personnel or material assets, immediately trigger the emergency-stop function, shut off all lines, and depressurize the machine.
2. Determine the cause of the fault.
3. If correction of the fault requires work in the danger zone, switch off the machine and safeguard it against being restarted.

   Immediately inform the responsible parties at the installation site of the fault.
4. Depending on the type of fault have it corrected by the required personnel specified below.

The fault table provided below lists personnel who are authorized to correct the fault.

7.2 Fault table

Fault description	Cause	Remedy	Personnel
Booster does not work at low air pressure.	Excessive friction on the spool valve.	Replace and re-lubricate the O-rings on the spool valve (↬ *Chapter 7.3.2 “Replacing the O-rings on the spool valve” on page 66*).	Specialist for potentially explosive areas

Fault description	Cause	Remedy	Personnel
	O-rings of the spool valve swell when the wrong oil or lubricating grease is used.	Replace O-rings and use acid-free and silicone-free lubricant (↯ *Chapter 7.3.2 "Replacing the O-rings on the spool valve" on page 66*).	Specialist for potentially explosive areas
Booster does not work or it works too slowly.	Exhaust or spool valve iced up.	Dewater compressed air through water separator (↯ *Chapter 6.5 "Draining the condensate on the water separator" on page 58*).	Operator
	Formation of a residue in the exhaust air silencer .	Clean silencer; replace if necessary (↯ *Chapter 7.3.4 "Cleaning the exhaust air silencer and replacing it if necessary" on page 73*).	Operator
Booster does not work. Air escapes via the exhaust air silencer.	O-ring on spool valve is defective.	Replace and re-grease O-rings on spool valve (↯ *Chapter 7.3.2 "Replacing the O-rings on the spool valve" on page 66*).	Specialist for potentially explosive areas
	O-ring on the air piston is defective or worn.	Replace and re-grease O-ring on air piston (↯ *Chapter 7.3.6 "Replacing O-ring on air piston" on page 78*).	Specialist for potentially explosive areas
Booster does not work. Air escapes via a small bore on the spool valve housing.	Spool valve is blocked.	Clean sleeve of spool valve (↯ *Chapter 7.3.3 "Cleaning and greasing the sleeve of the spool valve" on page 71*).	Specialist for potentially explosive areas
	Spool valve is blocked.	Check O-rings on spool valve and sleeve and replace and grease if necessary (↯ *Chapter 7.3.3 "Cleaning and greasing the sleeve of the spool valve" on page 71* and ↯ *Chapter 7.3.2 "Replacing the O-rings on the spool valve" on page 66*).	Specialist for potentially explosive areas
Booster does not work. Air escapes via the plunger guide in the upper cap.	Pilot valve in the upper cap or lower cap is blocked.	Clean and grease the pilot valve (↯ *Chapter 7.3.5 "Cleaning and greasing the pilot valve" on page 75*).	Specialist for potentially explosive areas
	Pilot valve in the upper cap or lower cap is blocked.	Check pilot valve for wear and replace if necessary (↯ *Chapter 7.3.5 "Cleaning and greasing the pilot valve" on page 75*).	Specialist for potentially explosive areas

Fault description	Cause	Remedy	Personnel
Booster operates at high frequency and with short strokes.	Pilot valve in the upper cap or lower cap is defective.	Clean and grease the pilot valve or replace if necessary (↳ *Chapter 7.3.5 "Cleaning and greasing the pilot valve" on page 75*).	Specialist for potentially explosive areas
Leaks on silencers of bores Z1 and Z3.	High pressure seal or high pressure cylinder is worn.	Check high pressure seal or high pressure cylinder for wear and replace if necessary (↳ *Chapter 7.3.9 "Checking high pressure seals and high pressure cylinder for signs of damage" on page 94*).	Specialist for potentially explosive areas
Leaks on silencers of bores Z1 and Z3 (**only for DLE 15, 30, and 75**).	High pressure piston with pressure cylinder is worn.	Replace high pressure piston with pressure cylinder as a complete component (↳ *Chapter 7.3.8 "Replacing the high pressure cylinder with high pressure piston as a complete component" on page 93*).	Specialist for potentially explosive areas
Booster does not work, but exhaust air silencer blows out air.	O-ring on the air piston is worn.	Check O-ring on air piston for wear and replace if necessary (↳ *Chapter 7.3.6 "Replacing O-ring on air piston" on page 78*).	Specialist for potentially explosive areas
Leaks on inlet and/or outlet valve of booster head/booster does not reach operating pressure.	Inlet and/or outlet valve soiled or defective.	Check inlet and/or outlet valve of booster head; clean or replace if necessary (↳ *Chapter 7.3.7 "Cleaning the inlet and outlet valve of the booster head" on page 92*).	Specialist for potentially explosive areas

7.3 Fault correction tasks

7.3.1 Purging the high pressure component with nitrogen

Boosters that are used to compress combustible or toxic gases must be purged with nitrogen prior to starting the tasks for fault correction purposes in order to purge any remaining combustible or toxic gases and to thus prevent the development of oxyhydrogen gas

and toxic gas mixtures. In the following chapters on fault correction, references are made to Supplement "Hydrogen compression with Maximator boosters" in the Appendix. To purge the booster, proceed as described in the supplement.

⚠ DANGER

Danger of explosion caused by toxic and combustible gas residues on the inside of the booster!

– Purge the high pressure component of the booster with nitrogen before any fault correction task.

Failing to purge the booster with nitrogen following previously compressed toxic or combustible gases prior to starting fault correction tasks can lead to an explosion caused by the development of oxyhydrogen gas and to severe injury or even death.

Personnel:	■ Specialist for potentially explosive areas
Protective equipment:	■ Safety shoes ■ Safety goggles

1. Bring the booster to a standstill and let the stored pressure completely dissipate.
2. Purge the booster. Proceed as described in Appendix A "Hydrogen compression with Maximator boosters" to do this.

7.3.2 Replacing the O-rings on the spool valve

A description of how the O-rings on the spool valve are replaced is provided below.

Personnel:	■ Specialist for potentially explosive areas
Protective equipment:	■ Safety goggles ■ Protective work clothing ■ Safety shoes
Special tool:	■ Circlip pliers ■ Wrench ■ Lubricating grease ■ Screwdriver

The fault correction tasks below are described on a booster with an optionally installed compressed air control unit. The fault correction tasks for boosters without compressed air control unit are identical. In that case, steps 3 – 4 are merely eliminated. This will be pointed out at the appropriate point.

1. Bring the booster to a standstill, de-pressurize it, and let the stored pressure completely dissipate.

   Carry out steps 3 – 4 and 14 – 15 only if a compressed air control unit is present. If no compressed air control unit is installed, the drive air line must be removed from the spool valve housing instead of the elbow union.

2. Purge booster with nitrogen. Proceed as described in *Appendix A "Hydrogen compression with Maximator boosters" on page 117* to do this.

3. Release threaded union (Fig. 27/1) of compressed air control unit on spool valve housing (Fig. 27/2).

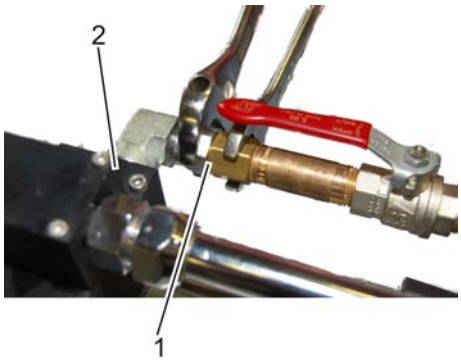


Fig. 27: Releasing the threaded union

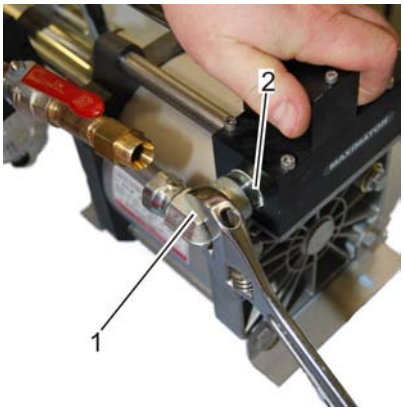


Fig. 28: Releasing the elbow union

4. Release and remove elbow union (Fig. 28/1) of compressed air control unit or on drive air connection of spool valve housing (Fig. 28/2).

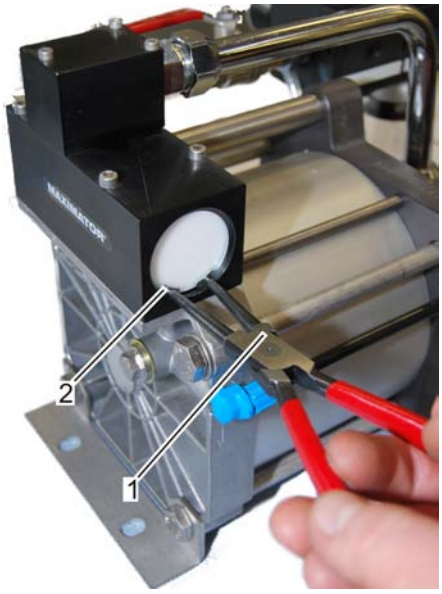


Fig. 29: Removing the circlip

5. Position circlip pliers (Fig. 29/1) on circlip of spool valve housing (Fig. 29/2) and carefully remove circlip and secure to prevent it from getting lost.

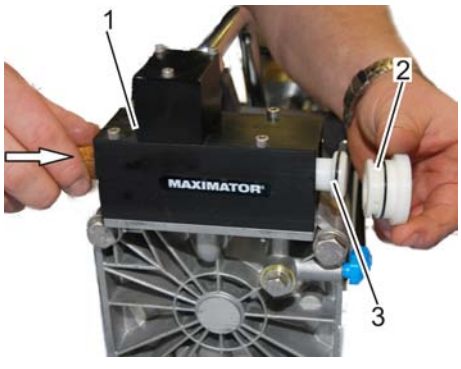


Fig. 30: Detaching spool valve and cap

6. Insert screwdriver into drive air connection (Fig. 30/ arrow) of spool valve housing (Fig. 30/1) and carefully press out cap (Fig. 30/2) and spool valve (Fig. 30/3).

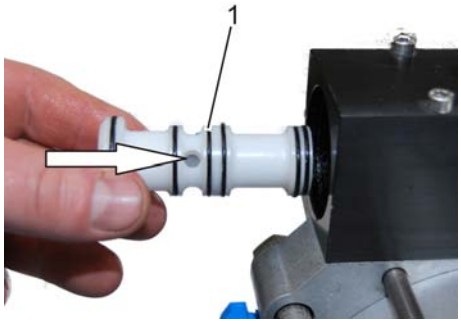
7. Remove all O-rings from spool valve and caps.

8. Grease new O-rings (Fig. 31).

Fig. 31: Greasing O-rings

9. Slide new O-rings (Fig. 32/1) onto spool valve and cap.
10. Lightly lubricate spool valve and cap with grease.

Fig. 32: Sliding on new O-rings



11. Insert spool valve (Fig. 33/1) into spool valve housing and push in up to the stop (Fig. 33/arrow).

Fig. 33: Inserting spool valve

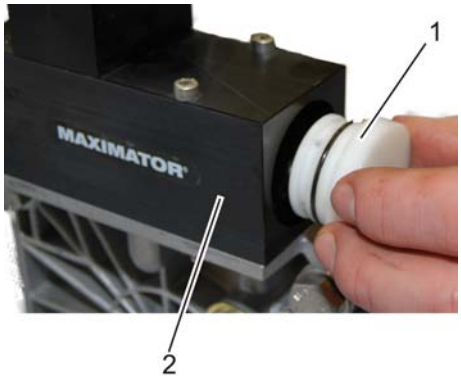


Fig. 34: Inserting the cap

12. Insert cap (Fig. 34/1) into spool valve housing (Fig. 34/2).

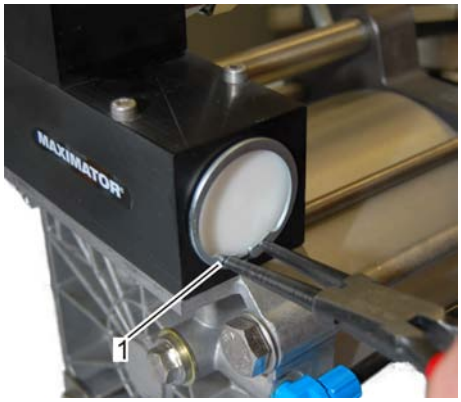


Fig. 35: Securing the cap

13. Secure cap in spool valve housing using circlip (Fig. 35/1).

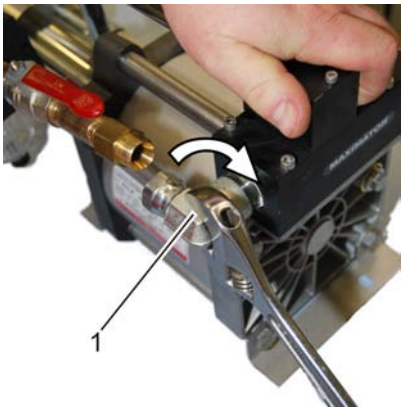


Fig. 36: Removing the elbow union

14. Position and fasten elbow union (Fig. 36/1) of compressed air control unit to drive air connection of spool valve housing.

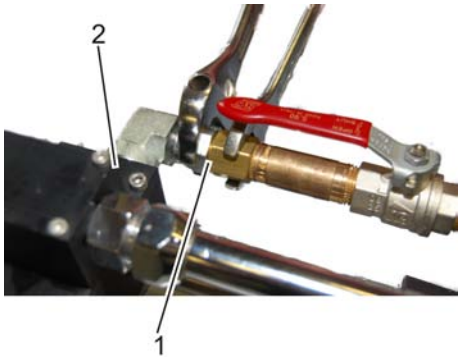


Fig. 37: Installing compressed air control unit

15. Fasten piping (Fig. 37/1) of compressed air control unit to elbow union (Fig. 37/2).

7.3.3 Cleaning and greasing the sleeve of the spool valve

A description of how the sleeve of the spool valve is cleaned and greased is provided below.

Personnel:	■ Specialist for potentially explosive areas
Protective equipment:	■ Safety goggles ■ Safety shoes ■ Protective work clothing
Special tool:	■ Circlip pliers ■ Wrench ■ Screwdriver ■ Lubricating grease ■ Punching drift ■ Hammer

Removing the sleeve of spool valve

To clean the sleeve of the spool valve, it must be removed.

1. Bring the booster to a standstill, de-pressurize it, and let the stored pressure completely dissipate.

   The sleeve of the spool valve is located in the spool valve housing. To remove the sleeve of the spool valve, the spool valve must first be removed. To do this, proceed as described in *Chapter 7.3.2 “Replacing the O-rings on the spool valve” on page 66, steps 3 – 6.*

2. Purge booster with nitrogen. Proceed as described in *Appendix A “Hydrogen compression with Maximator boosters” on page 117* to do this.

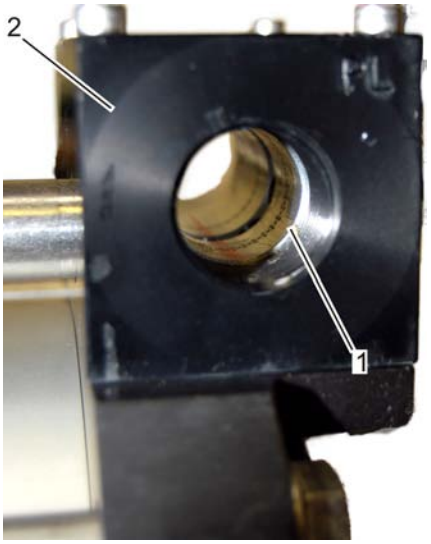


Fig. 38: Positioning the drift

3. Carefully position punching drift at edge of sleeve (Fig. 38/1) in spool valve housing (Fig. 38/2).

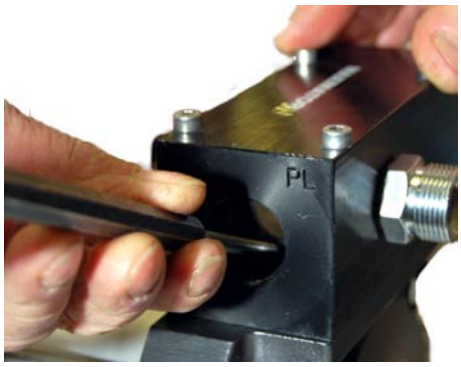


Fig. 39: Punching out the sleeve

4. ***NOTICE!*** **Risk of damaging the female thread!**

   Carefully punch out sleeve (Fig. 39) making sure that the female thread in the spool valve housing is not damaged.

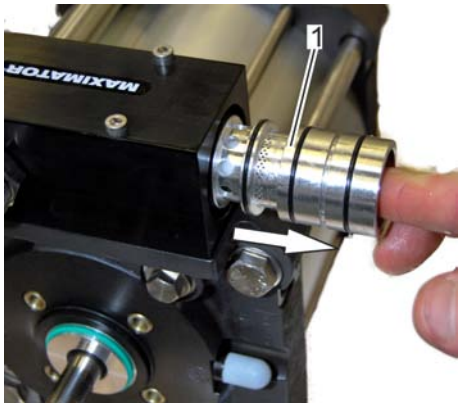


Fig. 40: Removing the sleeve

5. Remove sleeve (Fig. 40/1) out on other side of spool valve housing.

6. Check inside of sleeve for score marks and other signs of damage.

   If the sleeve is damaged, it must be replaced.

   Make sure not to slide any O-ring onto the groove (Fig. 41/3) of the control sleeve, since there is a cross bore in this groove.

Fig. 41: Detaching the O-rings

7. Detach O-rings (Fig. 41/1) from the sleeve (Fig. 41/2).
8. Clean inside and outside of sleeve with a paper towel.
9. Grease new O-rings and carefully slide onto sleeve.
10. Clean inside and outside of sleeve with a finger.
11. Grease the inside of the spool valve housing.

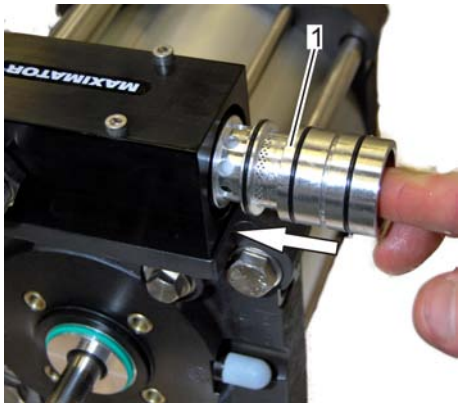


Fig. 42: Inserting the sleeve

12. Carefully insert sleeve into spool valve housing and push in up to the stop.
13. Insert spool valve. To do this, proceed as described in ↳ *Chapter 7.3.2 "Replacing the O-rings on the spool valve" on page 66*, steps 11 – 14.

7.3.4 Cleaning the exhaust air silencer and replacing it if necessary

A description of how the exhaust air silencer is cleaned and replaced if necessary is provided below.

Cold components

⚠ CAUTION

Danger of injury due to cold components!

- **Prior to starting the tasks, let the exhaust air silencer thaw adequately.**
- **Wipe off any dew that might be present.**

The exhaust air silencer cools down severely and ices up.

Personnel:
- Operator

Protective equipment:
- Safety goggles
- Protective work clothing
- Safety shoes
- Protective gloves

Depending on the version, the exhaust air silencers of the individual booster models can differ. However, the tasks described below are always identical.

1. Bring the booster to a standstill and let the stored pressure completely dissipate.
2. Let the iced up exhaust air silencer thaw adequately; wipe off any water that might have thawed.
3. Unscrew silencer (Fig. 43/1) from exhaust air connection (Fig. 43/2).
4. Adequately purge exhaust air residues in the exhaust air silencer with water and detergent.

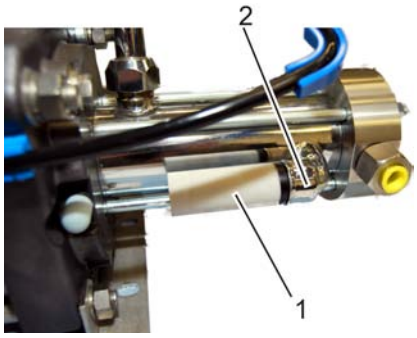


Fig. 43: Exhaust air silencer

Fig. 44: Blowing out the exhaust air silencer

5. Blow out exhaust air silencer with a compressed air gun in the opposite direction of the exhaust air (Fig. 44/arrow).

   If the deposits cannot be removed or if the booster does not reach the required stroke frequency or power after it has been cleaned, the exhaust air silencer must be replaced.
6. Screw exhaust air silencer into exhaust air connection and tighten hand-tight.

7.3.5 Cleaning and greasing the pilot valve

A description of how the pilot valves are cleaned and greased or - if necessary - replaced is provided below.

Personnel:
- Specialist for potentially explosive areas

Protective equipment:
- Safety goggles
- Safety shoes
- Protective work clothing

Special tool:
- Wrench, width across flats 13 mm/0.51 in
- Long nose pliers
- Lubricating grease

It is always necessary to clean, grease, or - if necessary - replace both pilot valves.

1. Bring the booster to a standstill and let the stored pressure completely dissipate.
2. Purge booster with nitrogen. Proceed as described in *Appendix A "Hydrogen compression with Maximator boosters" on page 117* to do this.
3. Position wrench (Fig. 45/1) at threaded union of pilot valve (Fig. 45/2).

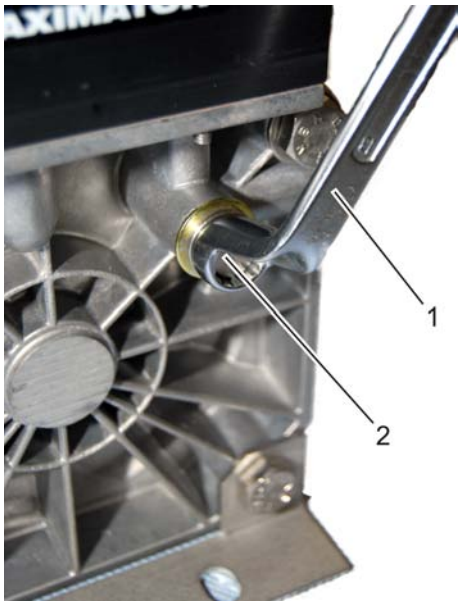


Fig. 45: Pilot valve

Fig. 46: Removing the threaded union

4. Remove threaded union with sealing ring (Fig. 46/1) and pilot valve spring (Fig. 46/2) and secure to prevent it from getting lost.

Fig. 47: Pilot valve tappet

⇨ The pilot valve tappet (Fig. 47/1) is located in the pilot valve opening.

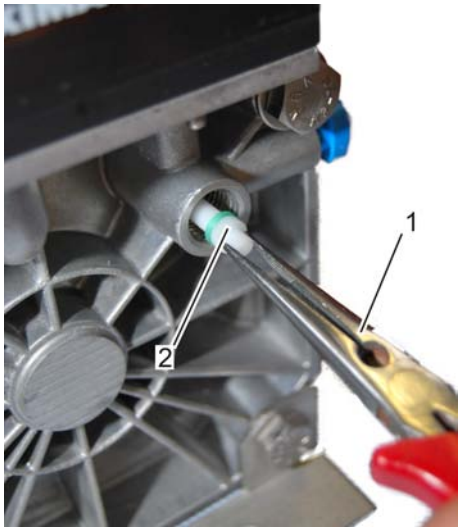


Fig. 48: Removing the pilot tappet

5. Carefully insert long nose pliers (Fig. 48/1) into pilot valve opening and pull out pilot valve tappet (Fig. 48/2).
6. Check pilot valve tappet and O-ring for signs of damage.

   i A damaged pilot valve plunger must be replaced.

Fig. 49: Pilot valve tappet

7. Clean and grease pilot valve tappet with a paper towel.

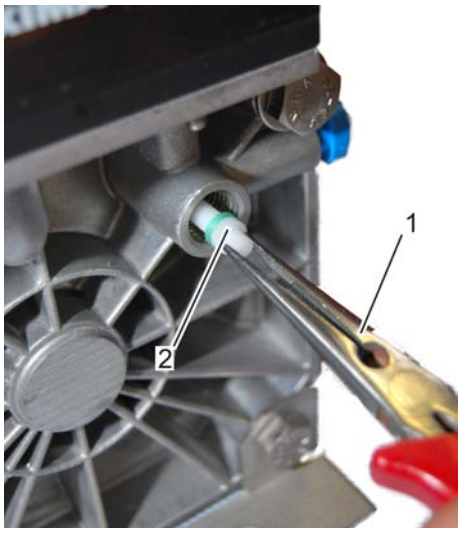


Fig. 50: Inserting the pilot valve tappet

8. Carefully insert pilot valve tappet (Fig. 50/2) with the long nose pliers (Fig. 50/1).

Fig. 51: Fastening the pilot valve

9. Position and tighten pilot valve spring (Fig. 51/2) and threaded union with sealing ring (Fig. 51/1).

To clean and grease the second pilot valve, proceed as described in steps 1 – 9.

7.3.6 Replacing O-ring on air piston

A description of how the O-ring on the air piston is replaced is provided below.

Many of the steps described below must be carried out in the exact same manner for other fault correction tasks. In the corresponding chapters, references are made to the respective steps in this chapter.

Personnel:	■ Specialist for potentially explosive areas
Protective equipment:	■ Safety goggles ■ Safety shoes ■ Protective work clothing
Special tool:	■ Wrench

7.3.6.1 Removing the high pressure component

1. Bring the booster to a standstill and let the stored pressure completely dissipate.
2. Purge booster with nitrogen. Proceed as described in *Appendix A "Hydrogen compression with Maximator boosters" on page 117* to do this.

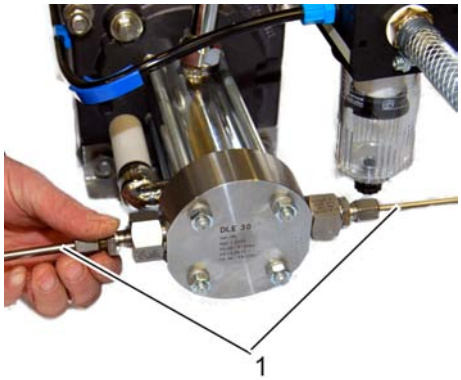


Fig. 52: Inlet and outlet line

3. Unscrew inlet and outlet line (Fig. 52/1) from inlet and outlet connection of booster head.
4. Close openings of removed inlet and outlet line with sealing plug to prevent it from soiling.
5. Release attachment screws of booster from foundation and secure to prevent them from getting lost.
6. Remove line from drive air connection.

   Depending on the version, drive air connection PL is connected to the compressed air control unit or to the spool valve housing.

In a dual-acting booster, the cooling pipe must be removed from the high pressure components and the inlet connections.

7. Release threaded union of cooling pipe from both high pressure components (Fig. 53/2) and from inlet connections (Fig. 53/1) and remove cooling pipe.

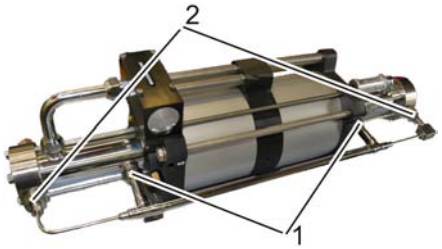


Fig. 53: Removing the cooling pipe

Fig. 54: Releasing the booster head

8. Release the four nuts of the stay bolts on the booster head (Fig. 54/marked in red) with a wrench. Secure nuts and square taper washer for U-sections to prevent them from getting lost.

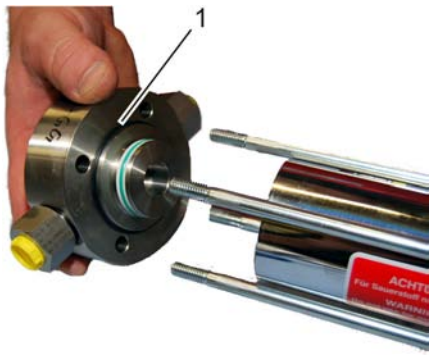


Fig. 55: Detaching the booster head

9. Carefully detach booster head (Fig. 55/1) from stay bolts.

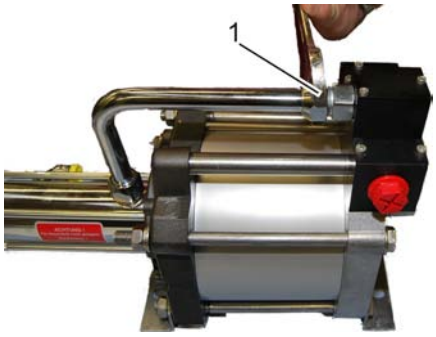


Fig. 56: Removing the cooling pipe

10. Release threaded union of cooling pipe from spool valve housing (Fig. 56/1).

Fig. 57: Removing the cooling pipe

11. Carefully pull off cooling pipe and cooling cylinder (Fig. 57/1) from pressure cylinder (Fig. 57/2).

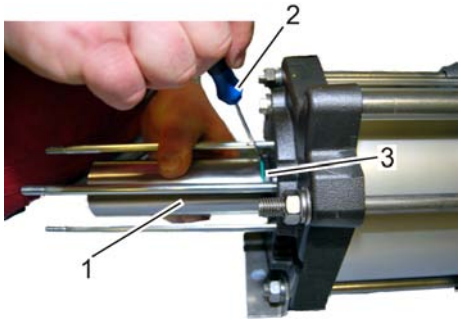


Fig. 58: Prying off the high pressure cylinder

12. ***NOTICE!*** **Danger of material damage!**

    Carefully pry off high pressure cylinder (Fig. 58/1) with a screwdriver (Fig. 58/2) from lower cap of drive component (Fig. 58/3).

13. Slowly pull back high pressure cylinder on piston rod.

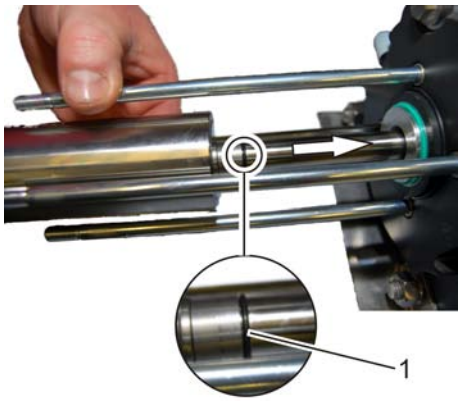


Fig. 59: O-ring

14. Release O-ring (Fig. 59/1) from groove of piston rod and slide in direction of drive component (Fig. 59/arrow).

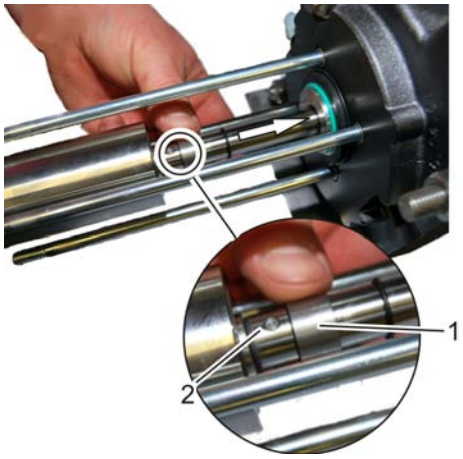


Fig. 60: Safety sleeve

15. Slide safety sleeve (Fig. 60/1) of piston rod in direction of drive component (Fig. 60/arrow).
    ⇨ A dowel pin (Fig. 60/2) is located below the safety sleeve, which connects the piston rod to the high pressure piston.
16. Push out dowel pin (Fig. 60/2) with a screwdriver and secure to prevent it from getting lost.

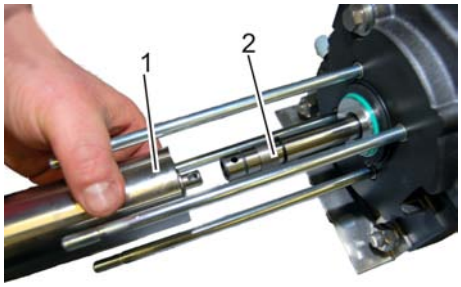


Fig. 61: Detaching the high pressure cylinder

17. Detach high pressure cylinder (Fig. 61/1) from piston rod (Fig. 61/2).

7.3.6.2 Removing drive component and replacing O-ring of air piston

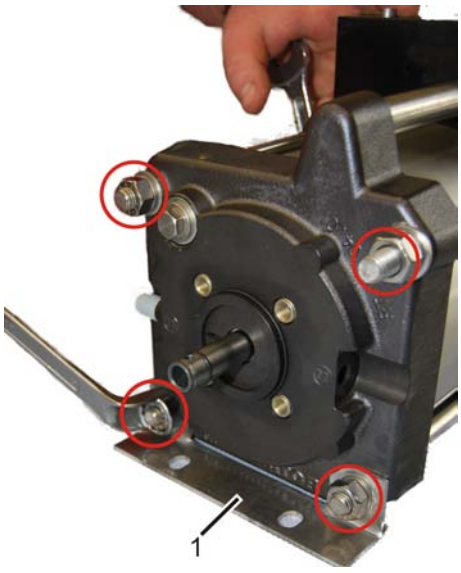


Fig. 62: Stay bolt

1. Release threaded union of 4 stay bolts (Fig. 62/ marked in red) and secure to prevent it from getting lost.

   i The upper stay bolts are mounted with a nut, a spring lock washer, and a square taper washer for U-sections. The lower stay bolts are merely mounted with a nut and a spring lock washer.
2. Pull out stay bolt.
3. Remove fastening angle (Fig. 62/1).

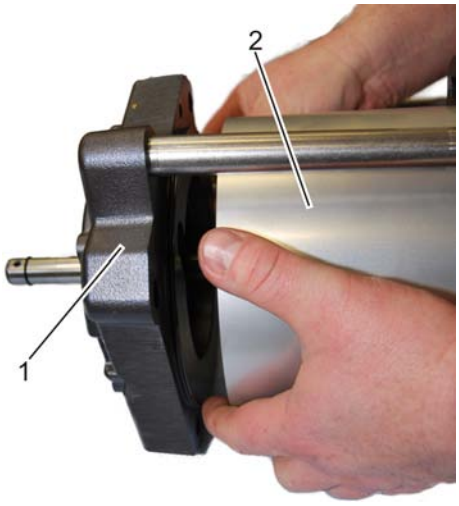


Fig. 63: Lower cap

4. Push lower cap (Fig. 63/1) of drive component from air cylinder (Fig. 63/2).

   ⇨ The 2 air pipes are now hanging free.

Fig. 64: Air pipes

5. Detach air pipes (Fig. 64/1).

Fig. 65: Control tube

6. Remove control tube (Fig. 65/1).

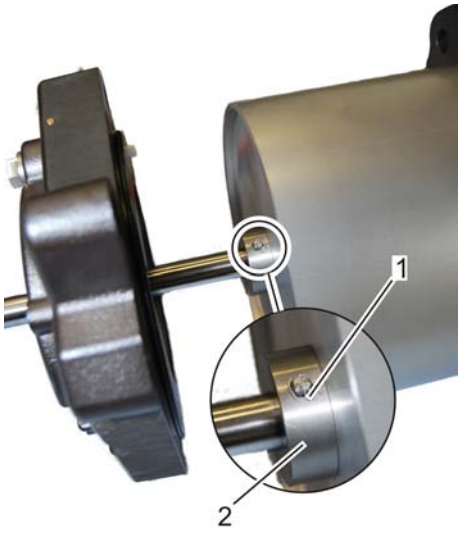


Fig. 66: Cotter pin

7. Remove cotter pin (Fig. 66/1) of socket pin from piston mount (Fig. 66/2).

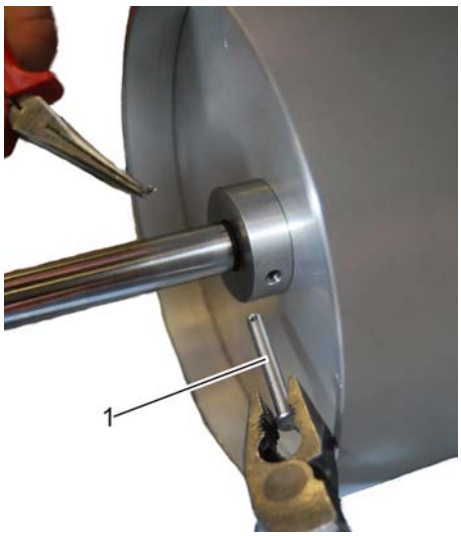


Fig. 67: Pulling out the socket pin

8. Pull out socket pin (Fig. 67/1) with pliers from the piston mount.
9. Detach lower cap of drive component and piston rod.

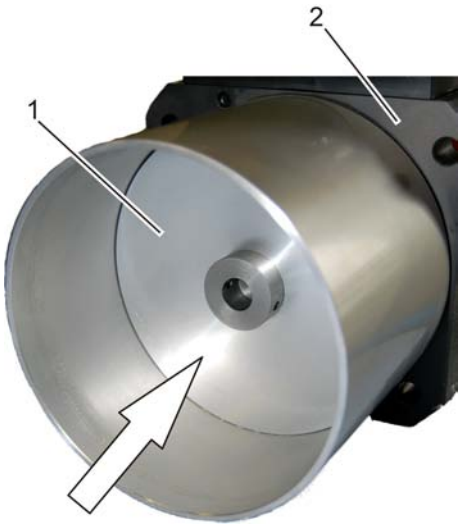


Fig. 68: Air piston

10. Push air piston (Fig. 68/1) in direction of upper cap (Fig. 68/2) of drive component.

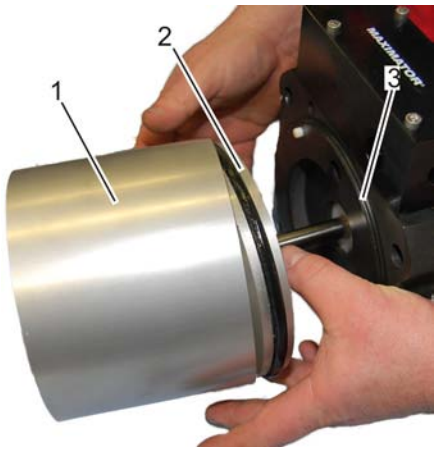


Fig. 69: Detaching the air cylinder

11. Carefully detach air cylinder (Fig. 69/1) from air piston (Fig. 69/2).

12. Check seal of upper cap (Fig. 69/3) and replace if necessary.

Fig. 70: Detaching the seal

13. Detach seal from air piston (Fig. 70).

14. Grease new seal and slide onto air piston.

i The seal on the air piston is a floating seal and appears to be too big for the air piston. However, that is done on purpose.

15. Push back air piston in direction of lower cap (Fig. 70/arrow).

Fig. 71: Putting on the air cylinder

16. ***NOTICE!*** **Risk of damaging the piston seal!**

Position air cylinder (Fig. 71/1) at an incline to the air piston (Fig. 71/2) and carefully slide over air piston.

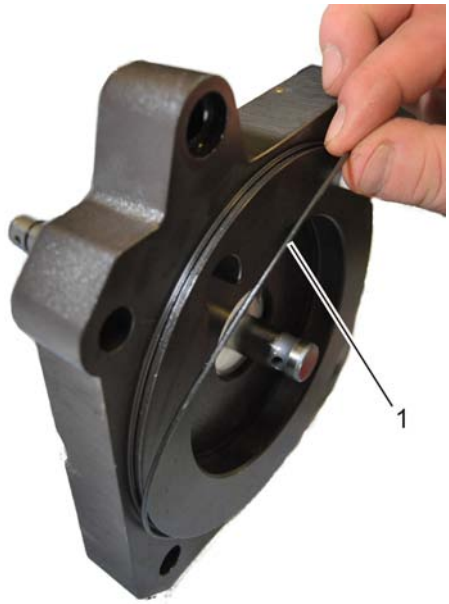


Fig. 72: Seal of lower cap

17. Check seals of lower cap (Fig. 72/1) and replace if necessary.

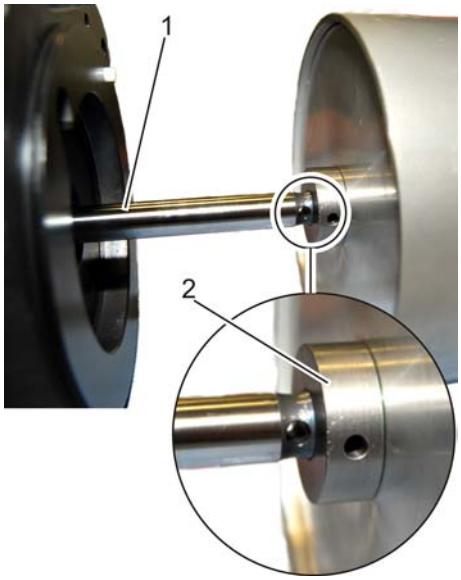


Fig. 73: Position piston rod

18. Position lower cap with piston rod (Fig. 73/1) on piston mount (Fig. 73/2) and make sure that holes are aligned.

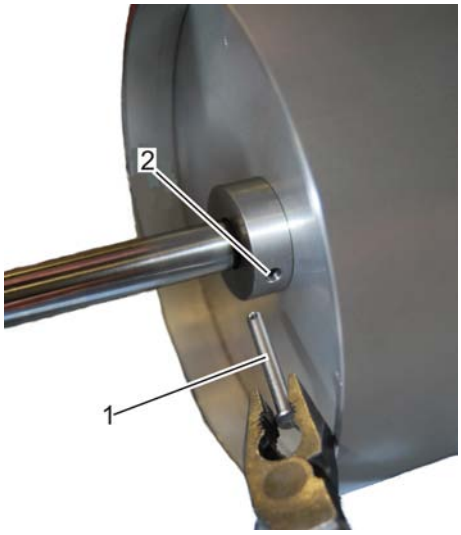


Fig. 74: Inserting the socket pin

19. Insert socket pin (Fig. 74/1) into piston mount (Fig. 74/2) and secure with cotter pin.

Fig. 75: Air pipe

20. Detach O-rings (Fig. 75/1) from air pipes.
21. Grease new O-rings and slide onto air pipes.

Fig. 76: O-rings of control tube

22. Remove O-rings (Fig. 76/1) from control bore (Fig. 76/2) of upper and lower cap with a sharp object (scriber).

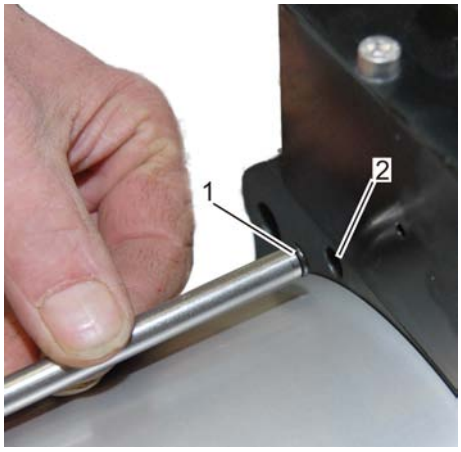


Fig. 77: Inserting the control tube

23. Place new greased O-rings onto ends of control tube (Fig. 77/1) and insert control tube into control bore (Fig. 77/2) of upper cap.

    ⇨ Because of the grease on the O-ring, the seal adheres to the control tube (Fig. 77).

24. Insert stay bolt through upper cap.

Fig. 78: Installing air pipes and lower cap

25. Insert two air pipes (Fig. 78/1) with new and greased O-rings into air pipe bores of upper cap.

26. Position lower cap (Fig. 78/2) on air cylinder and thread in air pipes (Fig. 78/1) and control tube.

27. *The upper stay bolts must be mounted with a nut, a spring lock washer, and a square taper washer for U-sections. The lower stay bolts must only be mounted with a nut, a spring lock washer, and the assembly brackets.*

    Position stay bolts with nuts, spring lock washers, and square taper washer for U-sections and tighten with a torque of 485 lbf in.

7.3.6.3 Installing the high pressure component

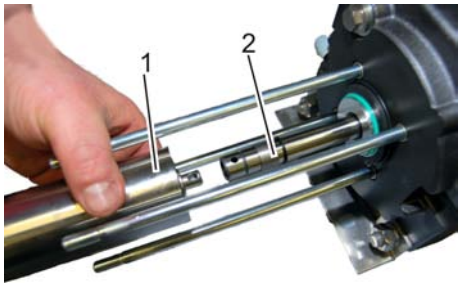


Fig. 79: Installing the high pressure cylinder

1. Position high pressure cylinder with high pressure piston (Fig. 79/1) on piston rod (Fig. 79/2) and make sure that holes are aligned.

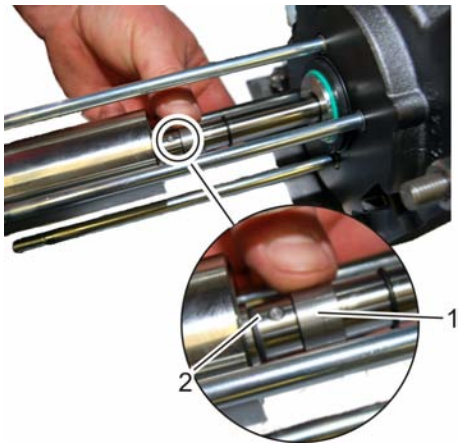


Fig. 80: Securing the dowel pin

2. Insert dowel pin (Fig. 80/2) into bore and slide safety sleeve (Fig. 80/1) over dowel pin connection.

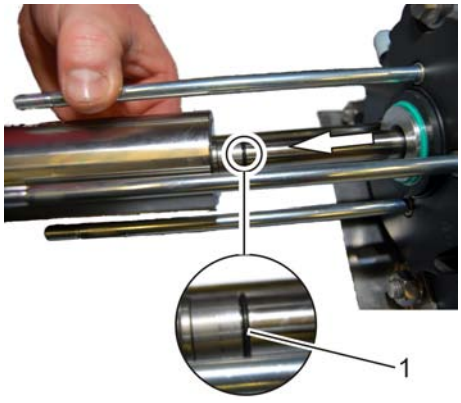


Fig. 81: O-ring

3. Slide O-ring (Fig. 81/1) on piston rod into groove in front of safety sleeve.
   ⇨ The safety sleeve is fixed in place by the O-ring.
4. Slide high pressure cylinder in direction of lower cap.

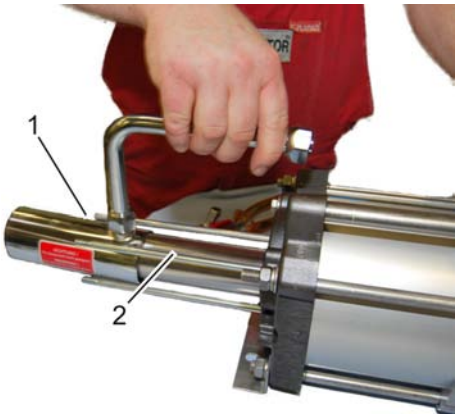


Fig. 82: Cooling pipe and high pressure pipe

5. Carefully slide cooling pipe and high pressure pipe (Fig. 82/1) over high pressure cylinder (Fig. 82/2).

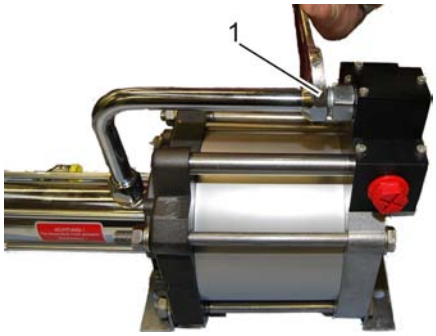


Fig. 83: Fastening the cooling pipe

6. Fasten cooling pipe (Fig. 83/1) to threaded piece of spool valve housing.

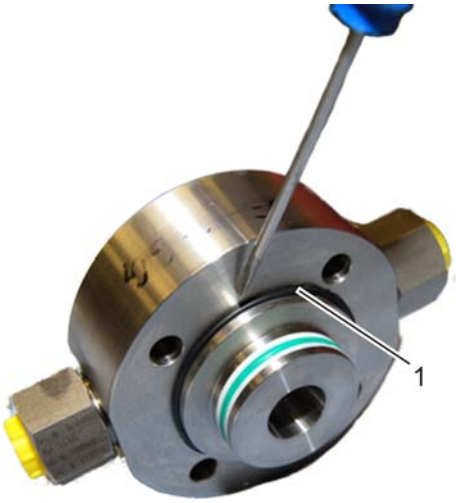


Fig. 84: Booster head seal

7. Detach seal from booster head (Fig. 84/1).
8. Grease new seal and carefully slide onto booster head.

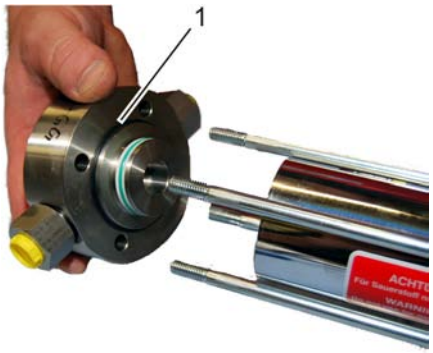


Fig. 85: Slipping on booster head

9. Carefully slip booster head (Fig. 85/1) onto stay bolts.
10. Fasten booster head with nuts, spring lock washers, and square taper washer for U-sections and tighten with a torque of 350 lbf in.
11. Install booster at installation location and tighten foundation screws with a torque of 750 lbf in.

7.3.7 Cleaning the inlet and outlet valve of the booster head

A description of how the inlet and outlet valve of the booster head is checked for soiling and cleaned is provided below.

Personnel:	■ Specialist for potentially explosive areas
Protective equipment:	■ Protective work clothing ■ Safety shoes ■ Safety goggles
Special tool:	■ Wrench ■ Torque wrench

In single-stage, dual-acting boosters, inlet and outlet valves must be removed and cleaned on both booster heads.

The inlet and outlet valves of booster models DLE 2 and DLE 5 differ in design from the one's described below. However, the fault correction procedure is identical.

1. Bring the booster to a standstill, de-pressurize it, and let the stored pressure completely dissipate.
2. Purge booster with nitrogen. Proceed as described in *Appendix A "Hydrogen compression with Maximator boosters" on page 117* to do this.
3. Remove inlet and outlet valves on the booster head and protect the open lines from soiling.
4. Release inlet and outlet connections (Fig. 86/1) on booster head with a wrench (Fig. 86/2).

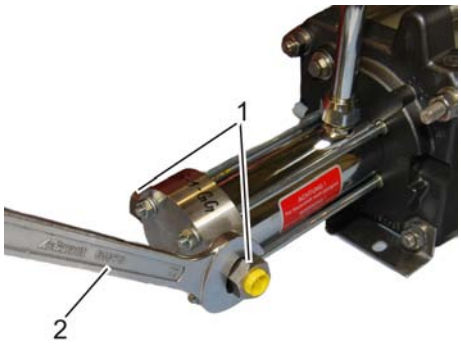


Fig. 86: Releasing the valves

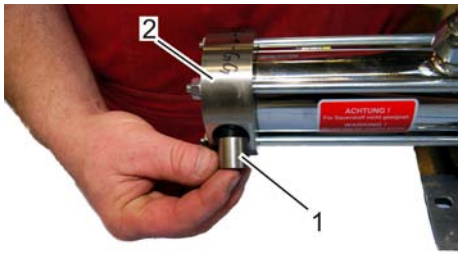


Fig. 87: Removing the valve

5. Remove inlet and outlet valve from booster head.

Fig. 88: Disassembled valve

6. Carefully disassemble valve on a clean working surface.

   The valves consist of two O-rings (Fig. 88/1), valve seat (Fig. 88/2), ball (Fig. 88/3), compression spring (Fig. 88/4), and valve body (Fig. 88/5).

7. Clean all components of the valve, check for signs of damage, and replace if necessary.

8. ***NOTICE!*** **Danger of material damage due to incorrect installation!**

   Install valve in identical sequence.

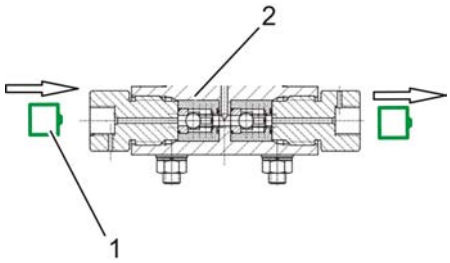


Fig. 89: Installation direction

9. Make sure when installing the valves that the conical valve seat (Fig. 89/1) of the valve is always inserted in the flow direction (Fig. 89/arrows) into the booster head (Fig. 89/2).

10. Fasten inlet and outlet connections and tighten with a torque of 1060 lbf in.

11. Install piping of inlet and outlet lines according to *Appendix B “Connection drawing” on page 127*.

7.3.8 Replacing the high pressure cylinder with high pressure piston as a complete component

A description of how the high pressure cylinder with the high pressure piston is replaced as a complete component is provided below. The high pressure piston is located on the inside of the high pressure cylinder.

These fault correction tasks only apply to booster models DLE 15, 30, and 75.

Personnel:	■ Specialist for potentially explosive areas
Protective equipment:	■ Protective work clothing ■ Safety shoes ■ Safety goggles
Special tool:	■ Wrench

7.3.8.1 Removing the high pressure cylinder with high pressure piston

To remove the high pressure cylinder with high pressure piston, proceed as described in ↳ Chapter 7.3.6.1 “Removing the high pressure component” on page 79.

7.3.8.2 Installing a new high pressure cylinder with high pressure piston

To install a new high pressure cylinder with high pressure piston, proceed as described in ↳ Chapter 7.3.6.3 “Installing the high pressure component” on page 89.

7.3.9 Checking high pressure seals and high pressure cylinder for signs of damage

An explanation of how the high pressure seal and the high pressure cylinder are checked for signs of damage and replaced if necessary is provided below.

Personnel:	■ Specialist for potentially explosive areas
Protective equipment:	■ Protective work clothing ■ Safety shoes ■ Safety goggles
Special tool:	■ Wrench

Checking the high pressure seals and replacing them if necessary

To check the high pressure seals for signs of damage, the high pressure component must be removed. Proceed as described in ↳ Chapter 7.3.6.1 “Removing the high pressure component” on page 79 to do this.

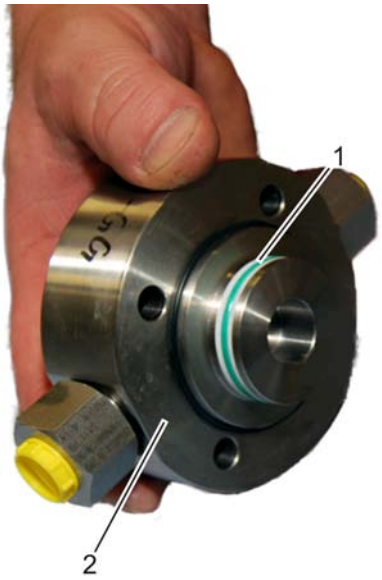


Fig. 90: High pressure seal (on high pressure side)

1. Check high pressure seal (Fig. 90/1) on booster head (Fig. 90/2) for signs of wear and replace if necessary.

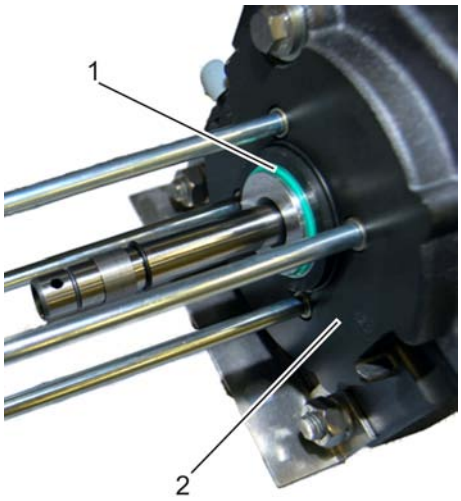


Fig. 91: High pressure seal (on air side)

2. Check high pressure seal (Fig. 91/1) on lower cap of drive component (Fig. 91/2) for signs of wear and replace if necessary.

Fig. 92: High pressure cylinder

3. Check inside of removed high pressure cylinder (Fig. 92) for score marks and other signs of damage.

If the high pressure cylinder is damaged, it must be replaced as a complete component.

In booster model DLE 15–30–75, the high pressure piston is located in the high pressure cylinder. In the event of damage, the high pressure cylinder with the integrated high pressure piston must be replaced as a complete component.

Reinstalling the high pressure component

To reinstall the high pressure components, proceed as described in Chapter 7.3.6.3 “Installing the high pressure component” on page 89.

7.4 Start up after a corrected fault

After correcting the fault execute the following steps to start up again:

1. Properly reconnect all high pressure lines.
2. Check connections for signs of leaks with a leak detection spray.
3. Ensure that no one is in the danger zone.
4. Start in accordance with the notes in Chapter "Operation".

8 Maintenance

No maintenance work is planned for the boosters.

9 Dismantling and disposal

After the end of the useful life has been reached, the booster must be dismantled and disposed of in an environmentally responsible manner.

9.1 Safety instructions for dismantling and disposal

Explosion protection

⚠ WARNING

Danger of explosion during dismantling!

- **Prior to dismantling, obtain a written work approval.**
- **Prior to dismantling, purge the booster with nitrogen to flush any remaining toxic and combustible gas out of the booster.**
- **Perform dismantling task only when a potentially explosive atmosphere can be ruled out.**
- **Use only those tools that are permissible for use in the Ex area.**

Bringing in ignition sources such as sparks, open flames, and hot surfaces can lead to explosion in the Ex area. Non-compliance with these instructions will lead to loss of explosion protection.

Improper dismantling

⚠ WARNING

Danger of injury due to improper dismantling!

- **Prior to starting the tasks ensure that there is adequate free space.**
- **Shut off all operating media of the machine.**
- **Ensure order and cleanliness at the workstation! Parts and tools that are lying loose or on top of each other are accident hazards.**
- **Consult with the manufacturer if there are questions.**

Stored residual energy, sharp-edged components, points and corners on or in the machine, or on the required tools can cause serious injury.

9.2 Dismantling

Personnel:	■ Specialist for potentially explosive areas
Protective equipment:	■ Protective work clothing ■ Safety shoes ■ Safety goggles

1. Bring the booster to a standstill and let the stored pressure completely dissipate.
2. Purge booster with nitrogen. Proceed as described in *Appendix A "Hydrogen compression with Maximator boosters" on page 117* to do this.
3. Dismount all piping and threaded unions.
4. Release foundation screws.

Then properly clean assemblies and components and take them apart in compliance with the applicable occupational health and safety and environmental protection regulations.

9.3 Disposal

If no there is no take-back or disposal agreement, submit disassembled components for recycling:

- Scrap metals.
- Give plastic elements to recycling.
- Dispose of other components sorted according to their material properties.

NOTICE

Danger to the environment due to incorrect disposal!

- **Have electrical scrap, electronic components, lubricants and other auxiliary materials disposed of by an approved operation.**
- **In case of doubt, obtain information about environmentally-friendly disposal from the local municipal authorities or a special disposal operation.**

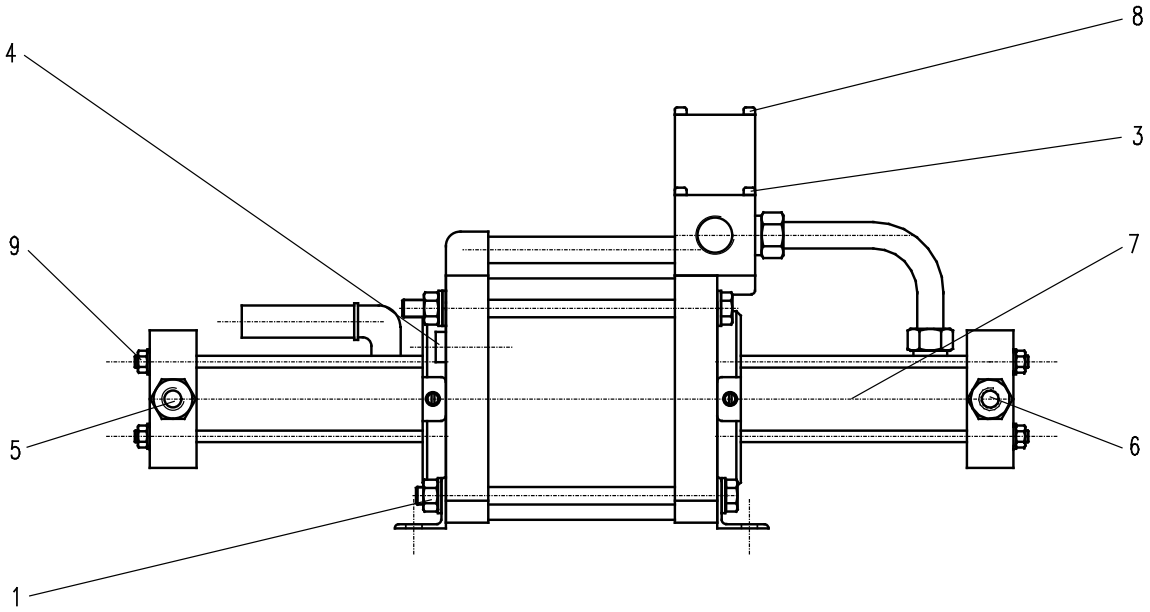
Improper disposal can present a danger to the environment.

9.4 Tightening torques

TMANZ4

MAXIMATOR®
HYDRAULIK PNEUMATIK HOCHDRUCKTECHNIK PRÜFSTÄNDE
Geschäftsbereich der Schmidt, Kranz & Co GmbH

Technical Information:
Torques for screw connections
Type: DLE - Booster



1: Tie rod air drive section
2: Union nut HP-seal
3: Spool valve housing
4: Pilot valve screw
5: Inlet gland
6: Outlet gland
7: Piston attachment
8: Exhaust-connection
9: Tie rod HP-section

Pumps Type	1 a)		2		3 b)		4 a)		5 a)		6 a)		7 a)		8 b)		9 a)	
	SW	Nm	SW	Nm	SW	Nm	SW	Nm	SW	Nm	SW	Nm	SW	Nm	SW	Nm	SW	Nm
DLE 2(-1), DLE 5(-1)	19	55	--	--	4	5	13	2	32	120	32	120	13	25	3	5	17	40
DLE 15/30/75(-1)	19	55	--	--	4	5	13	2	27	120	27	120	10	20	3	5	13	40

SW ... wrench opening

a) Open end- resp. box wrench
b) Hex key

10 Technical data

10.1 Dimensions and weights

The dimensions and weights of all booster types are listed below.

The values listed below are approximate values and can vary slightly.

Type	Width	Height	Depth	Weight
	inches	inches	inches	lbs
DLE 2–1	17.32	10.83	7.09	33.07
DLE 5–1	17.32	10.83	7.09	33.07
DLE 15–1	17.72	10.83	7.09	28.66
DLE 30–1	17.72	10.83	7.09	28.66
DLE 75–1	17.72	10.83	7.09	28.66
DLE 2	23.62	10.83	7.09	44.09
DLE 5	23.62	9.25	7.09	44.09
DLE 15	24.41	9.25	7.09	39.68
DLE 30	24.41	9.25	7.09	39.68
DLE 75	24.41	9.25	7.09	39.68
DLE 2-5	23.62	9.25	7.09	44.09
DLE 5-15	24.02	9.25	7.09	41.89
DLE 5-30	24.02	9.25	7.09	41.89
DLE 15-30	24.41	9.25	7.09	41.89
DLE 15-75	24.41	9.25	7.09	41.89
DLE 30-75	24.41	9.25	7.09	41.89
DLE 2–1–2	24.02	10.83	7.09	48.50
DLE 5–1–2	24.02	9.25	7.09	48.50
DLE 15–1–2	24.21	9.25	7.09	44.09
DLE 30–1–2	24.21	9.25	7.09	44.09
DLE 75–1–2	24.21	9.25	7.09	44.09
DLE 2-2	30.71	10.83	7.09	55.11
DLE 5-2	30.71	9.25	7.09	55.11

Type	Width	Height	Depth	Weight
	inches	inches	inches	lbs
DLE 15-2	31.50	9.25	7.09	50.71
DLE 30-2	31.50	9.25	7.09	50.71
DLE 75-2	31.50	9.25	7.09	50.71
DLE 2-5–2	30.71	9.25	7.09	55.11
DLE 5-15–2	31.10	9.25	7.09	52.91
DLE 5-30–2	31.10	9.25	7.09	52.91
DLE 15-30–2	31.50	9.25	7.09	52.91
DLE 15-75–2	31.50	9.25	7.09	52.91
DLE 30-75–2	31.50	9.25	7.09	52.91
8 DLE 3	38.98	13.78	8.66	121.25
8 DLE 6	38.98	13.78	8.66	121.25
8 DLE 1.65	31.89	13.78	8.66	88.18

10.2 Connected loads

Pneumatic

Data	Value	Unit
Compressed air quality	Oil-free possible	
Solids, max. particle size	5	µm
Solids, max. particle concentration	2.19 * 10^{-3}	grain/ft^3
Dew point up to + 10 °C water content	4.1	grain/ft^3
Dew point up to + 2 °C water content	2.5	grain/ft^3

* Once a lubricator has been used, the air must always be lubricated, since oil in air will wash out the pneumatic pump grease!

Connected loads, mechanical

Type	Inlet connection*	Outlet connection **	Recommended internal tube diameter in inches		
			Drive air	Admission pressure	Operating pressure
DLE 2–1	G 1/2	G 1/2	0.75	0.51	0.51
DLE 5–1	G 1/2	G 1/2	0.75	0.51	0.51
DLE 15–1	G 1/4	G 1/4	0.75	0.24	0.16
DLE 30–1	G 1/4	G 1/4	0.75	0.24	0.16
DLE 75–1	G 1/4	G 1/4	0.75	0.24	0.16
DLE 2	G 1/2	G 1/2	0.75	0.51	0.51
DLE 5	G 1/2	G 1/2	0.75	0.51	0.51
DLE 15	G 1/4	G 1/4	0.75	0.24	0.16
DLE 30	G 1/4	G 1/4	0.75	0.24	0.16
DLE 75	G 1/4	G 1/4	0.75	0.24	0.16
DLE 2-5	G 1/2	G 1/2	0.75	0.51	0.51
DLE 5-15	G 1/2	G 1/4	0.75	0.51	0.16
DLE 5-30	G 1/2	G 1/4	0.75	0.51	0.16
DLE 15-30	G 1/4	G 1/4	0.75	0.24	0.16
DLE 15-75	G 1/4	G 1/4	0.75	0.24	0.16
DLE 30-75	G 1/4	G 1/4	0.75	0.24	0.16
DLE 2–1–2	G 1/2	G 1/2	0.75	0.51	0.51
DLE 5–1–2	G 1/2	G 1/2	0.75	0.51	0.51
DLE 15–1–2	G 1/4	G 1/4	0.75	0.24	0.16
DLE 30–1–2	G 1/4	G 1/4	0.75	0.24	0.16
DLE 75–1–2	G 1/4	G 1/4	0.75	0.24	0.16
DLE 2-2	G 1/2	G 1/2	0.75	0.51	0.51
DLE 5-2	G 1/2	G 1/2	0.75	0.51	0.51
DLE 15-2	G 1/4	G 1/4	0.75	0.24	0.16
DLE 30-2	G 1/4	G 1/4	0.75	0.24	0.16
DLE 75-2	G 1/4	G 1/4	0.75	0.24	0.16
DLE 2-5–2	G 1/2	G 1/2	0.75	0.51	0.51

Type	Inlet connection*	Outlet connection **	Recommended internal tube diameter in inches		
			Drive air	Admission pressure	Operating pressure
DLE 5-15–2	G 1/2	G 1/4	0.75	0.51	0.16
DLE 5-30–2	G 1/2	G 1/4	0.75	0.51	0.16
DLE 15-30–2	G 1/4	G 1/4	0.75	0.24	0.16
DLE 15-75–2	G 1/4	G 1/4	0.75	0.24	0.16
DLE 30-75–2	G 1/4	G 1/4	0.75	0.24	0.16
8 DLE 3	G1/2	G 1/2	0.75	0.51	0.51
8 DLE 6	G1/2	G1/2	0.75	0.51	0.51
8 DLE 1.65	G1/2	G1/2	0.75	0.51	0.51

When the recommended internal tube diameters are observed, the boosters reach the maximum delivery output.

Additional connections

The above inlet and outlet connections are standard connections. Additional connections options for inlet and outlet are provided below. These additional connection options must correspond to the type key information on the type plate. To this end, see
Chapter 10.9 “Type key” on page 112 in these operating instructions.

* Inlet connection (Table "Connected loads, mechanical")

Connection designation of inlet connection	Dimension	Booster types
N	NPT G1/2"	DLE 2, DLE 5
	NPT G1/4"	DLE 15 – 75
U	9/16 – 18 UNF for G1/4" high pressure pipe, connection H4 downstream of Maximator	DLE 15 – 75

** Outlet connection (Table "Connected loads, mechanical")

Connection designation of outlet connection	Dimension	Booster types
N	NPT G1/2"	DLE 2, DLE 5
	NPT G1/4"	DLE 15 – 75
U	9/16 – 18 UNF for G1/4" high pressure pipe, connection H4 downstream of Maximator	DLE 15 – 75

*The following combinations of threaded inlet and outlet unions are possible **GG**, **GU**, **UU**, **NU**, and **NN**.*

10.3 Performance characteristics

Type	Displacement in cu.in.	Max. operating pressure pB (static) psi	Max. compression ratio	Transmission ratio (i1/i2)	Max. operating temperature in °F	Admission pressure	
						min. psi	max. psi *
DLE 2–1	56.26	290	1:10	1:2	140	0	230.1
DLE 5–1	22.76	725	1:15	1:5	140	29.0	725.2
DLE 15–1	7.45	2175	1:20	1:15	212	101.5	2175
DLE 30–1	3.66	4350	1:20	1:30	212	217.6	4350
DLE 75–1	1.53	10875	1:20	1:75	212	507.6	10875
DLE 2	112.53	580	1:10	1:2	140	0	580.1
DLE 5	45.52	1450	1:15	1:5	140	29.0	1450
DLE 15	14.89	4350	1:20	1:15	212	101.5	4350
DLE 30	7.32	8700	1:20	1:30	212	217.6	8700
DLE 75	3.05	21750	1:20	1:75	212	507.6	21750
DLE 2-5	56.26	1450	1:25	1:2/1:5	140	0	0.8 *PL
DLE 5-15	22.76	4350	1:45	1:5/1:15	212	29.0	6 *PL
DLE 5-30	22.76	8700	1:90	1:5/1:30	212	29.0	2 *PL
DLE 15-30	7.45	8700	1:40	1:15/1:30	212	101.5	15 *PL
DLE 15-75	7.45	21750	1:100	1:15/1:75	212	101.5	3.5 *PL
DLE 30-75	3.66	15225	1:50	1:30/1:75	212	217.6	20 *PL
DLE 2–1–2	56.26	580	1:10	1:4	140	0	580.1
DLE 5–1–2	22.76	1450	1:15	1:10	140	58.0	1450
DLE 15–1–2	7.45	4350	1:20	1:30	212	145.0	8700
DLE 30–1–2	3.66	8700	1:20	1:60	212	230.1	8700
DLE 75–1–2	1.53	21750	1:20	1:150	212	652.7	21750
DLE 2-2	112.53	580	1:10	1:4	140	0	580.1
DLE 5-2	45.52	1450	1:15	1:10	140	58.0	1450
DLE 15-2	14.89	4350	1:20	1:30	212	145.0	4350
DLE 30-2	7.32	8700	1:20	1:60	212	230.1	8700

Type	Displacement in cu.in.	Max. operating pressure pB (static) psi	Max. compression ratio	Transmission ratio (i1/i2)	Max. operating temperature in °F	Admission pressure	
						min. psi	max. psi *
DLE 75-2	3.05	21750	1:20	1:150	212	652.7	21750
DLE 2-5–2	56.26	1450	1:25	1:4/1:10	140	0	1.6 *PL
DLE 5-15–2	22.76	4350	1:45	1:10/1:30	212	29.0	12 *PL
DLE 5-30–2	22.76	8700	1:90	1:10/1:60	212	29.0	4 *PL
DLE 15-30–2	7.45	8700	1:40	1:30/1:60	212	101.5	30 *PL
DLE 15-75–2	7.45	21750	1:100	1:30/1:150	212	101.5	7 *PL
DLE 30-75–2	3.66	21750	1:50	1:60/1:150	212	217.6	40 *PL

** = Maximum permissible pressure load that may be used for the high pressure component of the booster. Compression ratio = operating pressure/admission pressure*

10.4 Operating conditions

Environment

Data	Value	Unit
Temperature range	- 4 – + 140	°F
Relative humidity, maximum	60	%
Ambient pressure range	min. 14.5 psi less than drive pressure, max. 145 psi	
Altitude, max.	unlimited	ft above sea level

Duration

Data	Value
Switch-on time	Switch-on time 50% with a stroke frequency of > 60 strokes per minute
Switch-on time	Switch-on time 100% with a stroke frequency of < 30 strokes per minute

10.5 Operating materials

Lubricant

Operating material	Manufac-turer	Designation
Lubricating grease	Klüber Lubri-cation	ISOFLEX TOPAS NB 52

10.6 Emissions

The noise emission measurement was executed at a height of 5 feet and at a distance of 3.3 feet to the test stand. The determined noise emission was measured during full-load operation with a counterpressure of 145 psi.

Data	Value	Unit
Noise emission	81	dB(A)

10.7 Ex marking

Fig. 93: Ex marking explosion group IIB

The Ex marking is located on the drive component of the boosters in immediate vicinity of the type plate.

Fig. 94: Ex marking explosion group IIC

Marking	Designation	Meaning
CE	CE sign	Conformity sign in accordance with Appendix X of directive 94/9/EC. The manufacturer attaches it before the device is put into circulation.
II	Device group	The booster may be used in potentially explosive areas with the exception of mining.
2GD	Device category	With device category 2GD, a potentially explosive atmosphere may develop occasionally involving gas (G) and dust (D). The device ensures a high level of safety and can be used in zone 1 and zone 2.
IIB	Explosion group	Can be used for substances with a Maximum Experimental Safe Gap of 0.02 inches ≤ MESG ≤ 0.04 inches (IEC 60079-1).
IIC	Explosion group	Can be used for substances with a Maximum Experimental Safe Gap of < 0.02 inches (IEC 60079-1).
c	Ignition protection type	Constructive safety for non-electronic devices in potentially explosive areas as per DIN EN 13463-5.
X	Additional marking	Indicates the necessity to observe special operating conditions, in this case environmental temperatures (↳ *"Environment" on page 109*).

10.8 Type plate

Fig. 95: Type plate

The type place is centrally located on the drive component of the booster and contains the following information:

- Manufacturer
- Type (information from type key)
- Year of manufacture
- Gas pressure, min. inlet
- Gas pressure, max. outlet
- Maximum air drive
- Transmission ratio
- Max. compression ratio

10.9 Type key

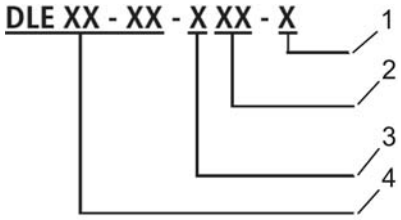


Fig. 96: Type key

The type key for the corresponding booster models is structured as follows:

1 Version for C = CO_2, S = oxygen
2 Thread of gas inlet and outlet G = pipe thread (standard), U = high pressure connection , N = NPT
3 1 = 1 high pressure piston, 2 = 2 drive piston
4 Design (e.g. DEL 15–75)

11 Index

Appendix

A Hydrogen compression with Maximator boosters

Achtung!

Wichtige Informationen für die MAXIMATOR Kompressoren der DLE - Baureihe. Werden die Kompressoren zur Verdichtung von aggressiven, brennbaren, gefährlichen oder giftigen Gasen eingesetzt, sind die Hinweise, wie im Fallbeispiel „Wasserstoff“ unbedingt zu beachten.

Weiterhin müssen natürlich die dem entsprechenden Gas geltenden Vorschriften und Richtlinien eingehallten werden. Für den sicheren Betrieb der Kompressoren, ist der Betreiber verantwortlich.

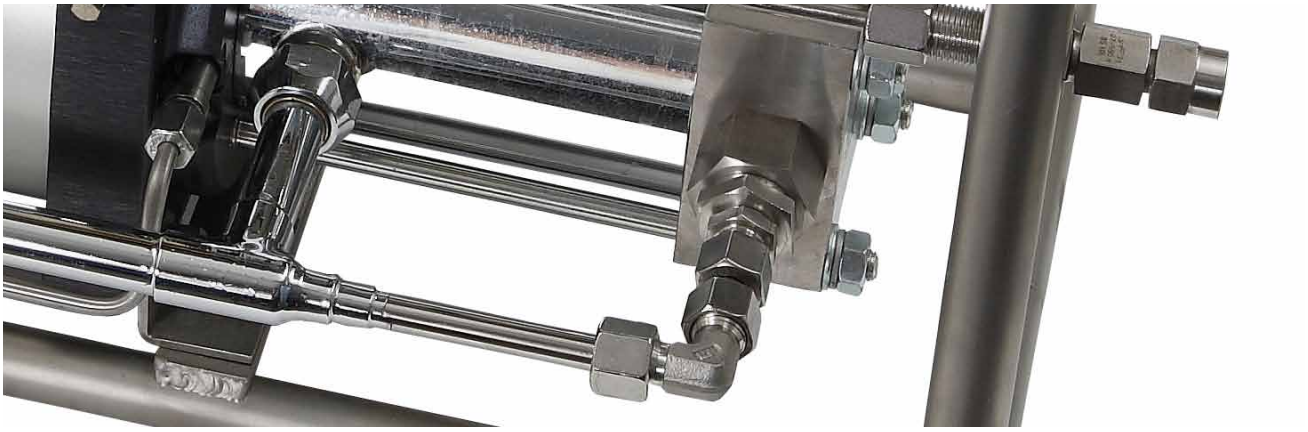
Caution!

Important information for MAXIMATOR DLE Series Booster:
If the boosters are used to compress aggressive, flammable, hazardous or toxic gases, the instructions as mentioned in the document: “Best Practice Hydrogen Compression” need to be observed.

Furthermore the current regulations and directives for the specific gas need to be complied. The operator is responsible for the safe operation of the booster.

MAXIMATOR GmbH
Walkenrieder Straße 15 • 37449 Zorge/Harz • Fon +49 (0) 55 86 / 8 03-0 • Fax +49 (0) 55 86 / 80 3-3040
eMail: info@maximator.de • www.maximator.de

MAXIMATOR®
GLOBAL PRESSURE SOLUTIONS



Best Practice
Hydrogen compression

Safety, explosion protection, systems engineering

What you need to know

Hydrogen is a colourless, odourless and flavourless gas and therefore cannot be detected with our human sensory organs.

Hydrogen burns with invisible flame and radiates only little heat in this process.

When mixing with air in a ratio of 4 to 76 percent by volume (vol. %) of hydrogen a detonating gas develops that already can be brought to explosion by a low-energy spark.

Oxygen-hydrogen mixtures with a fraction of below 10.5 percent by volume are heavier than air and sink to the floor.

Physical and chemical properties

Appearance:	colourless gas
Odour:	odourless
Molar mass:	30,8 grain/mol
Melting point:	-434 °F
Boiling point:	-423 °F
Critical temperature:	-400 °F
Ignition temperature:	1040 °F
Explosion limits (vol. % in air):	4 %(V) - 75 %(V)
Relative density, gaseous (air=1):	0,07
Solubility in water (mg/1):	0,699 grain/ft³

Safety during compression of hydrogen

Avoiding explosive atmospheres in confined spaces and outdoors

The formation of an explosive atmosphere in adjacent areas near the hydrogen equipment is prevented by observing the following requirements:

- Hydrogen equipment shall be installed in well-ventilated areas (if possible, outdoors).
- Hydrogen equipment has to be leak-proof and remain so.
- Venting lines from safety valves, leakage lines and similar lines shall be directed into the open.
- Discharge units must not terminate below eaves, openings in buildings or placed near air intake ports.
- In case hydrogen equipment is installed in confined spaces,the gas supply coming from the outside must be provided with a reliable shut-off device placed at a safe point.
- Pipe connections on hydrogen equipment shall be fitted such that they ensure a long-term tightness of the joint.

Explosive mixture

Avoiding explosive mixtures in hydrogen equipment

Explosive mixtures cannot be tolerated in hydrogen equipment with regard to safety aspects. Such mixtures are easily ignited by e.g. the friction heat generated in activating a valve or by the friction generated by rust particles dragged through. Even the heating of the gas caused by a pressure surge during rapid inflow of hydrogen into a equipment component filled with air can induce ignition.

Prior to commissioning, the air has to be removed from the hydrogen equipment, e.g. by evacuation or flushing. The safest method is by flushing with hydrogen, when an oxygen content of below 1 percent by volume is achieved inside the plant.

When decommissioning hydrogen equipment it is necessary to render the equipment free of gas by evacuation or flushing. To achieve this, the hydrogen content must be below 1 percent by volume, before the equipment can be opened.

Please observe in all flushing procedures that flush gas always takes the path of lowest resistance. Therefore, the flush gas flow must be directed such that „dead pockets“ are avoided.

Hydrogen compression with MAXIMATOR booster

MAXIMATOR hydrogen booster design

MAXIMATOR booster are especially modified for the compression of hydrogen in the following areas:

- Material suited for pressurised components
- Sealing geometry
- Flushing Connection
- Air drive section suitable for Atex

These modifications are available for the following high-pressure sections:

- DLE 2
- DLE 5
- DLE 15
- DLE 30
- DLE 75

MAXIMATOR hydrogen boosters are marked with the suffix H2-ExIIC and are generally suited for applications in explosion class IIC.

Materials

Hydrogen places significant demand on material choice. In this area, the phenomenon of hydrogen embrittlement must be especially mentioned.

Hydrogen embrittlement describes the change in the ductility of metals. Atomic hydrogen penetrates the microstructure of metallic material. At voids or grain boundaries, the atomic hydrogen recombines to form molecular hydrogen, thus increasing the pressure inside the structure.

This process causes internal stresses and leads to material embrittlement. Material failure becomes apparent in cracks that spread outside (hydrogen-induced crack formation).

In practical tests, austenitic steel has proven to be especially successful. After high performance tests, the MAXIMATOR hydrogen booster showed no sign of hydrogen embrittlement.

Piston compressors with dynamically loaded seals are not absolutely gas-tight. To increase the performance of the piston seal for hydrogen compression purposes, both sealing geometry and material were adapted to the special requirements.

Flushing Connection

From a technical point of view, the most important part in the compression of hydrogen is to avoid the formation of explosive atmospheres. As gas leakages cannot be ruled out, MAXIMATOR hydrogen boosters have to be flushed with inert gas (preferably nitrogen) prior, during and after use.

An explosive mixture can form inside the compressor chamber, but also in the rear piston chamber due to a little leakage at the high-pressure seals.

To provide safe flushing of these areas, the MAXIMATOR hydrogen boosters are also fitted with an additional flushing connection. In accordance with the boosters operating principle, different flushing processes shall be carried out to ensure safe operation.

If no flushing is carried out, these areas are characterised by zone zero. In this case, MAXIMATOR boosters would belong in category 1 (which requires type approval test). In the current version, the boosters do not meet the requirements of category 1. Therefore, operation without flushing is expressly prohibited.

Flushing plans for MAXIMATOR hydrogen boosters

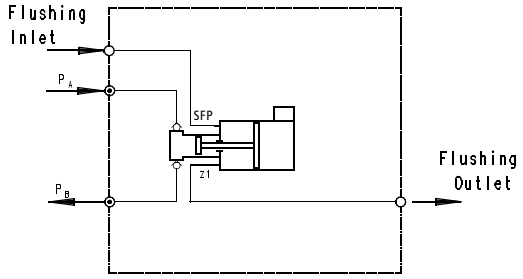
To be able to effectively flush the rear piston chamber of the booster, please observe the following installation scheme when fitting the flushing line.

It is important that there is a continuous flow of flushing gas through the flushing lines during the complete duty cycle. Make sure in particular that flushing lines are not pressurised. Otherwise this might result in damage of the high-pressure section.

Prior and after operation of the booster or equipment, the booster chamber and associated lines shall be flushed with copious amounts of nitrogen (or another inert gas). Through the flushing process it must be ensured that the oxygen content inside the booster or equipment falls below 1 percent by volume.

Flushing plan for single-stage, single-acting booster:

(With SFP flushing connection and Z1 leakage connection on the high-pressure side).

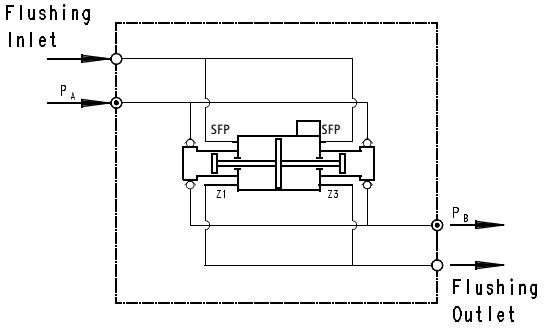


Flushing procedure:

1. Prior to booster start-up, connect the nitrogen supply to the inlet pressure connection (PA) and to the flushing connection (SFP).
2. Switch on the booster for approx. 1 min. (depending on the volume to be flushed).
3. Switch off the booster after completion of the flushing process.
4. Afterwards, the inlet pressure line (PA) can be connected to the hydrogen supply. During hydrogen compression, the flushing connection shall be continuously flushed with nitrogen.
5. After completion of hydrogen compression, the booster chamber shall again be flushed as described under item 2.

Flushing plan for single-stage, double-acting boosters:

(With SFP flushing connection and Z1 and Z3 leakage connection on the high-pressure side)

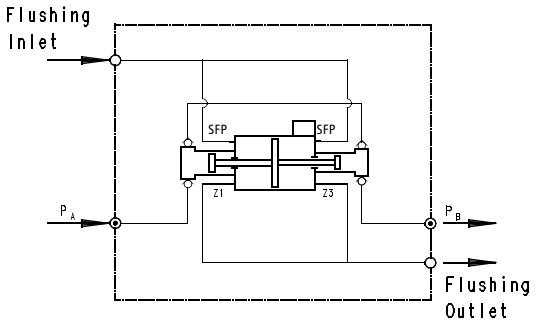


Flushing procedure:

1. Prior to booster start-up, connect the nitrogen supply to the inlet pressure port (PA) and to the flushing connections (SFP).
2. Switch on the booster for approx. 1 min. (depending on the volume to be flushed).
3. Switch off the booster after completion of the flushing process.
4. Afterwards, the inlet pressure line (PA) can be connected to the hydrogen supply. During hydrogen compression, the flushing connection do not neet to be continuously flushed with nitrogen, because in single-stage, double-acting compressors no ambient air is sucked in via the leakage ports.
5. After completion of hydrogen compression, the booster chamber shall again be flushed as described under item 2.

Flushing plan for two-stage booster:

(With SFP flushing connections and Z1 and Z3 leakage connections on the high-pressure side)



Flushing procedure:

1. Prior to booster start-up, connect the nitrogen supply to the inlet-pressure port (PA) and to the flushing connection (SFP).
2. Switch on the booster for approx. 1 min. (depending on the volume to be flushed).
3. Switch off the booster after completion of the flushing process.
4. Afterwards, the inlet pressure line (PA) can be connected to the hydrogen supply. During hydrogen compression, the flushing connection shall be continuously flushed with nitrogen.
5. After completion of hydrogen compression, the booster chamber shall again be flushed as described under item 2.

Volume flow for gas flushing

Depending on the type of booster, different volume flows must be ensured to provide for sufficient flushing performance. The table below shows the minimum required volume flow.

Boosters marked in red only require volume flow during start-up and decommissioning, whereas no volume flow is required during operation.

Apart from flushing gas volume flow, the cross sections of flushing lines are also significant. We recommend not to fall below an inner diameter of 0.157 in (4 mm). If the diameter is smaller, this involves the hazard of gas pressure accumulating inside the flushing line. Under certain circumstances, the high-pressure component of the booster might be damaged. Also make sure the flushing line exit remains unobstructed.

Type	Volume Flow scfm
DLE 2-1	6.71
DLE 5-1	3.17
DLE 15-1	1.41
DLE 30-1	0.71
DLE 75-1	0.35
DLE 2	6.00
DLE 5	3.17
DLE 15	1.06
DLE 30	0.71
DLE 75	0.35
DLE 2-5	3.88
DLE 5-15	2.12
DLE 5-30	2.47
DLE 15-30	0.71
DLE 15-75	1.06
DLE 30-75	0.35
DLE 2-1-2	6.71
DLE 5-1-2	3.17
DLE 15-1-2	1.06
DLE 30-1-2	0.71
DLE 75-1-2	0.35
DLE 2-2	6.00
DLE 5-2	2.83
DLE 15-2	1.06
DLE 30-2	0.71
DLE 75-2	0.35
DLE 2-5-2	3.53
DLE 5-15-2	2.12
DLE 5-30-2	2.47
DLE 15-30-2	0.71
DLE 15-75-2	0.71
DLE 30-75-2	0.35

Temperature

Booster temperature is dependent of the medium temperature, the degree of compression and other operating conditions.

A prerequisite for safe operation is that the booster is correctly connected to earth potential.

For ideal gases, the temperature to be expected can be calculated by the following formula:

$$T_2 = \left(\frac{P_2}{P_1} \right)^{\frac{\chi-1}{\chi}} \cdot T_1$$

with
T_2 = Temperature after compression (in K)
T_1 = Temperature prior to compression (in K)
P_2 = Pressure after compression (in bar)
P_1 = Pressure prior to compression (in bar)
χ = Isentropic exponent
The isentropic exponent for hydrogen is 1.41.

Due to the fact that compression cannot take place without a heat exchange with the environment, the actual temperature will always remain below the calculated temperature. If the temperature of the compressed gas exceeds the maximum admissible temperature, compression has to be performed in several steps, with a cooling phase in between the individual compression steps.

If the temperature of the compressed gas lies below the maximum admissible temperature, you have to ensure that - in dependence with the respective explosion zone - that operating conditions do not change. A slightly less inlet pressure would result in a higher temperature!

High-pressure screw connections and hydrogen

As a rule, high-pressure screw connections (cone and thread) are suitable for hydrogen operation.
The operator of hydrogen equipment with high-pressure screw connections has to be advised that there might be possible leakage from leakage bores in fittings (t-pieces, elbows, crosspieces etc.).

If required, suitable monitoring measures shall ensure that equipment using this type of screw connection is only used when tightness of the connection is assured. The requirements are stipulated by the classification into explosion zones.

MAXIMATOR hydrogen stations

ATEX for housing and electrical cabinets

Suitability of the housing or electrical cabinets for ATEX IIC shall be separately examined for the relevant application.

As a rule, the following criteria should be met:
- Stainless steel
- no potential source of ignition
- Ventilation ports on top and at the bottom

All accessory parts have to be electrically conductive. Varnished surfaces or sight glasses normally do not meet these requirements.

In case this is required, the availability of such components (with the corresponding manufacturer‘s confirmation) must be checked.

Due to the material‘s non-conductive properties, noise insulation of the housing is also inadmissible.

ATEX for power packs

The standard MAXIMATOR power packs are not admissible for ATEX IIC. The reason here is the labelling foil. The foil with a printed flow diagram on instrumentation is approximately 0.039 in (1 mm) thick. However, the ATEX 94/9/EC Directive limits maximum thickness of foil suitable for category IIC to 0.0079 in (0.2 mm).

In case ATEX IIC is required, the stations are also available with plates as an alternative to foil. The frame itself remains unchanged.

Special features in project planning of hydrogen stations

Generally, the compression of hydrogen does not place special demands on safety installations. For example, the installation of additional temperature and pressure monitoring devices is normally not necessary.

In the selection of the various components (regulators, valves, filters etc.) special emphasis must be placed on their suitability for hydrogen.

In general it must be ensured that only such components are used, which do not have a potential source of ignition. The material also has to be resistant against hydrogen embrittlement. Therefore, medium-carrying lines should be of stainless steel grade 1.4404, 1.4571 or similar.

Hose lines are unsuitable for hydrogen stations according to ATEX IIC because of their lack of conductivity.

B Connection drawing

C Installation plan

D Cross-sectional drawings and bills of materials

E Safety data sheet for lubricating grease

MATERIAL SAFETY DATA SHEET

Print date: 14-Dec-2010 *Revision Number: 2* *Revision date: 14-Dec-2010*

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product Name: ISOFLEX TOPAS NB 52
Article Code: 004131
Synonyms: No information available
Chemical characterisation: Not applicable..

Supplier:
Klüber Lubrication North America L.P.
32 Industrial Drive
Londonderry, NH 03053
(603) 647-4104
Fax (603) 647-4106

Emergency telephone number CHEMTREC: 1-800-424-9300 International: (703) 527-3887

2. COMPOSITION/INFORMATION ON INGREDIENTS

Components	CAS-No	ACGIH (TWA mg/m³):	OSHA (TWA mg/m³):
Synthetic hydrocarbon oil		None	None
Barium complex soap		None	None

3. HAZARDS IDENTIFICATION

Properties affecting health: Harmful if swallowed

Principle routes of exposure: Skin.

Skin contact: Substance may cause slight skin irritation.

Eye contact: Contact with eyes may cause irritation.

Inhalation: Vapors and/or aerosols which may be formed at elevated temperatures may be irritating to eyes and respiratory tract.

Ingestion: Harmful if swallowed. Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhoea

4. FIRST AID MEASURES

General advice: If symptoms persist, call a physician.

Skin contact: Rinse with plenty of water. If skin irritation persists, call a physician.

Inhalation: Move to fresh air in case of accidental inhalation of fumes from overheating or combustion. If symptoms persist, call a physician.

Eye contact: Flush eye with water for 15 minutes. If symptoms persist, call a physician.

Ingestion: Do not induce vomiting. Consult a physician.

Notes to physician: Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media:
Carbon dioxide (CO2), Dry chemical, Dry sand, Water spray mist or foam

Extinguishing media which must not be used for safety reasons:
Do not use a solid water stream as it may scatter and spread fire.

Special protective equipment for firefighters:
In the event of fire and/or explosion do not breathe fumes. In the event of fire, wear self-contained breathing apparatus. Standard procedure for chemical fires.

Specific hazards: Burning produces irritant fumes In the event of fire and/or explosion do not breathe fumes

Unusual hazards: No hazards resulting from the material as supplied

Specific methods: Water mist may be used to cool closed containers. Standard procedure for chemical fires.

Flash point: Not applicable.

Autoignition temperature: Not determined..

Flammability Limits in Air:

Lower No information available

Upper No information available

6. ACCIDENTAL RELEASE MEASURES

Personal precautions: Contaminated surfaces will be extremely slippery. Avoid contact with skin, eyes and clothing. Wear personal protective equipment.

Environmental precautions: Prevent further leakage or spillage if safe to do so. Do not allow material to contaminate ground water system. Prevent product from entering drains.

Methods for cleaning up: Scrape-up. Pick up and transfer to properly labelled containers. Clean contaminated surface thoroughly.

7. HANDLING AND STORAGE

Handling

Technical measures/precautions: No special technical protective measures required.

Safe handling advice: Spilling onto the container`s outside will make container slippery. Avoid contact with skin, eyes and clothing. Handle in accordance with good industrial hygiene and safety practice.

Storage

Technical measures/storage conditions: Keep containers tightly closed in a dry, cool and well-ventilated place. Keep away from open flames, hot surfaces and sources of ignition. Keep in properly labelled containers. Keep out of reach of children.

Incompatible products: Oxidising and spontaneously flammable products.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering measures to reduce exposure:
Ensure adequate ventilation, especially in confined areas..

Personal Protective Equipment

Respiratory protection:	No personal respiratory protective equipment normally required.
Hand protection:	Preventive skin protection
Skin and body protection:	Usual safety precautions while handling the product will provide adequate protection against this potential effect..
Eye protection:	Avoid contact with eyes..
Hygiene measures:	Avoid contact with skin, eyes and clothing.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Grease	**Appearance:**	Paste
Color:	Beige	**Odor:**	Not significant
Specific gravity:	~ 0.96	**Boiling point/range**	No information available
Evaporation rate:	Not determined	**Vapor density:**	Not determined
Vapor pressure:	Not determined	**Solubility:**	Insoluble.

10. STABILITY AND REACTIVITY

Stability:	No hazards to be especially mentioned
Polymerization:	Hazardous polymerisation does not occur.
Hazardous decomposition products:	None under normal use
Materials to avoid:	Strong oxidising agents.
Conditions to avoid:	Heat, flames and sparks..

11. TOXICOLOGICAL INFORMATION

Acute toxicity: No data available

12. ECOLOGICAL INFORMATION

Mobility: No information available.

Bioaccumulative potential: No information available.

Ecotoxicity effects: No data available.

Aquatic toxicity: No information available

13. DISPOSAL CONSIDERATIONS

Waste from residues / unused products: In accordance with local and national regulations.

Contaminated packaging: Empty containers should be taken for local recycling, recovery or waste disposal

14. TRANSPORT INFORMATION

DOT

Proper shipping name: Not regulated by DOT

TDG (Canada)

14. TRANSPORT INFORMATION

IMO / IMDG

ICAO

IATA

15. REGULATORY INFORMATION

TSCA

TSCA: Listed in TSCA

U.S. Regulations:

Barium complex soap
SARA 313 Threshold: Barium compound (25 - 35%)

Sara (311, 312) hazard class:

Canada
WHMIS hazard class:
Non-controlled

16. OTHER INFORMATION

NFPA	**Health:**	1	**Flammability:**	1	**Instability:**	0	
HMIS	**Health:**	1	**Flammability:**	1	**Physical Hazard:**		0

Reason for revision: Not applicable
Prepared by: Health & Safety

The information and recommendations contained herein are based upon tests believed to be reliable. However, Klüber does not guarantee their accuracy or completeness NOR SHALL ANY OF THIS INFORMATION CONSTITUTE A WARRANTY, WHETHER EXPRESSED OR IMPLIED, AS TO THE SAFETY OF THE GOODS, THE MERCHANTABILITY OF THE GOODS, OR THE FITNESS OF THE GOODS FOR A PARTICULAR PURPOSE. Adjustment to conform to actual conditions of usage maybe required. Klüber assumes no responsibility for results obtained or for incidental or consequential damages, including lost profits arising from the use of these data. No warranty against infringement of any patent, copyright or trademark is made or implied.