SF_6 / CF_4 mixing and maintenance unit
Operating Manual (original version)

Type-no.: Z863R01 | Comm-no.: 30000400 |
Year of construction: 2014

DILO. Sustainably tight.

Made in Germany

Table of contents

Please read this operating instruction before putting the device into operation. Thus operating faults can be avoided. In case of nonobservance of the operating instruction the manufacturer cannot assume any liability or warranty.

General safety notes

Obligation to exercise due care

The device has been designed and constructed bearing in mind the standards to be observed as well as additional technical specifications.
Safe use of the machine can only be achieved if all the necessary measures are followed.

The operator has to ensure that

- the device is only used for the purposes for which it is intended (see chapter 2 product description).
- the device is only operated in accordance with the instructions and in good condition and that the safety devices are regularly checked.
- maintenance and repair personnel are issued with all the required safety and protective clothing, which shall always be used.
- complete and legible operating manuals are available on site.
- only qualified personnel operates or repairs the device.
- this personnel is regularly instructed in safety procedures and environmental protection and that this personnel is fully aware of the complete operating manuals and particularly in the safety notes.
- the safety and warning notes mounted on the device are legible and not removed.
- all obligatory registrations and tests prescribed by law are carried out on the devices in accordance with the local regulations (e. g. pressure vessel tests, test for electrical safety etc.)
- the safety data sheet on SF_6 (can be obtained from the SF_6 supplier) is available for the operating personnel. The instructions mentioned in the data sheet and safety precautions must be known and observed by the operating personnel.

General safety notes

Specific safety notes and standard symbols

In the following operating manual specific safety warnings are given in order to draw your attention to residual risks which cannot be avoided during the operation of the device.

These residual risks contain dangers for

- Persons
- Product and machine
- The environment

The symbols used in the operating manual should draw your attention specially to the safety notes:

Danger

This symbol refers to risks for persons (danger to life, danger of injury)

Warning

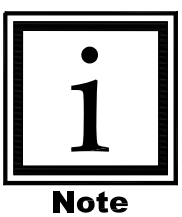
This symbol refers to risks for machines, material and the environment.

This symbol refers to electric shock

The most important aim of the safety notes is to prevent personal injuries.

- If the warning sign „**Danger“,** appears, danger from machines, materials and the environment are not excluded.
- If the warning sign **„Warning“**, appears, there is no danger for persons.

The corresponding symbol which is used cannot replace the text of the safety note.
Therefore the complete text must always be read.

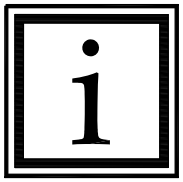


Note

This symbol is not for safety notes, but for information to understand the device better.

General safety notes

Basic safety measures during normal operation



Note

The equipment may only be operated throughout the EU by trained and qualified persons who have been certified in accordance with EC 305/2008 regulations. Transition period until 30th June 2009.

Only trained and authorized persons who are fully aware of the operating manuals should operate the device and should do so in accordance with the operating manuals.
Before switching on the device ensure that

- only authorized persons are present at the device
- nobody can be hurt by the operation of the device

Whenever the device is started check for visible damage beforehand and ensure that it is operated in the correct conditions. Eliminate any damage immediately or inform your supervisor.

Prior to each start check and make sure that the safety features are properly set.

Warning

For concentrations of SF_6 decomposition products of > 100 ppm_v we recommend using a pre-filter unit to protect the device.
In case of contamination, rinse the device (for at least 10 minutes) with pure SF_6-gas, e. g. by circulation.

Danger

All gas compartments and vessels connected to the device via gas connecting coupling and connecting hose must be equipped with their own safety equipment against overpressure and vacuum.
The safety equipment integrated in the device only serves for the self-protection of the device without consideration of the load-bearing capacity of the gas compartment connected. In case of non-observance there is the danger of implosion or explosion of the gas compartment if the device is not operated correctly.

General safety notes

Installation of the device

- Position the device on level surface and hard subgrade only. The locking device of the wheels is **not appropriate** to put the device on hilly ground.
- Only operate the device in sufficiently large and ventilated compartments (room volume > 100 m³) so that the admissible SF_6 concentration in ambient air is not exceeded in case of leakages incurring suddenly.
- For operation in smaller compartments SF_6 warning devices must be available as well as the possibility to leave the compartment quickly.
- In case the device is burning the pressure vessel must be cooled down to prevent an inadmissible high increase in pressure.

Personal protective equipment for operating personnel

- Safety gloves which allow the operation of the electrical operating elements.
- Ear protection is recommended for all devices with a sound power level of > 80 dB(A). As from 85 dB(A) the use of ear protection is compulsory.
- Safety shoes
- Wearing safety goggles is necessary in case hoses and tubes which are under pressure are opened (e. g. cylinder threads on SF_6-gas bottles), as gas or fluid jet could escape.

Basic safety measures during maintenance

- Follow inspection and maintenance periods described in the operating manuals.
- Follow maintenance and repair instructions for individual components in these operating manuals.
- Prior to carrying out maintenance and repair works turn off the main switch for the power supply and secure it with a padlock. The key for this lock must be in the hands of the person who carries out the repair works.
- If there is no main switch unplug the power supply cable at the plant and secure against it being plugged back in.
- When exchanging heavy machine parts only use suitable lifting devices in good working condition. Heavy components are to be secured against falling down by proper facilities.
- Prior to carrying out maintenance or repair works ensure that parts which may need to be handled have cooled down to room temperature.
- Dispose of grease, coolant or cleaning material in accordance with environmental regulations.
- If a device has been contaminated with SF_6 decomposition products additional safety measures are to be taken. Furthermore protective clothing and a dust mask depending on the degree of contamination is required.
- The working protection set is available under the order number: 3-442-R001.

General safety notes

Work on electrical equipment

Only properly trained electricians should carry out repair works on the device electrical equipment.

Regularly check the electrical equipment.

Re-tighten loose connections.

Replace damaged lines/cables immediately.

Always keep the control cabinet closed. Only authorized persons with key/tools should work on the device.

Never clean control cabinets and other electrical equipment housings using a water hose.

Work on SF_6-gas filled equipment

Only specially trained personnel should carry out maintenance and repair works on pressure gas filled equipment.
Prior to maintenance and repair works depressurize the pressure gas filled equipment of the device. Replace hose lines for preventive purposes even if no damage is visible. (Follow recommendations of manufacturer).
After having carried out maintenance and repair works and prior to putting back into service

- check that loosened screw connections are properly seated.
- ensure that the tank caps, sieves or filters that have been removed have been re-installed.

After having carried out the maintenance and repair works and before operation ensure that

- all materials, tools and other equipment which were necessary for the maintenance or repair works have been removed from the working area of the device.
- liquids that may have come out have been removed (wiped away)
- all safety devices for the unit are properly set and in working order.

General safety notes

Observe environmental standards
Whenever working on and with the device please observe legal requirements for waste handling and disposal.
Particularly during installation, repair and maintenance works substances that cause water pollution such as:

- lubricating greases and oil
- hydraulic oils
- cooling agents
- cleansing liquors containing solvent

must not contaminate the soil or flow into drains.
These substances should be stored in suitable vessels, and removed and disposed of according to local regulations.

Danger

The equipment contains the greenhouse gas SF6 as stipulated in the Kyoto Protocol, with a global warming potential (GWP) of 22200. SF6 needs to be recovered and must not be released into the atmosphere.
When using and handling SF6 please observe IEC 62271-4 (High-voltage switchgear and controlgear – Part 4: Handling procedures for sulphur hexafluoride (SF_6) and its mixtures).

Product description

Product description

Correct use

This service cart is designed for the recovery and putting into storage of SF_6-gas from gas compartments. Gas compartments can also be flooded with air, evacuated and filled with SF_6-gas.
During each recovery and filling operation the SF_6-gas passes through filters, which dry and purify the gas.
Do not use the cart to exhaust or compress liquids or other gases.

Danger

Use of the SF_6-gas service cart for any other purpose may not be safe.

The manufacturer will not accept any liability in case of injury and damage caused by use of the cart for applications for which it was not intended.

We recommend that all persons who are involved in the operation and repair of DILO devices are properly and specially trained.

Construction and operation of the service cart

The service cart consists of the following components:

Sheet metal frame	evaporator (only for liquid storage)
Compressor	storage tank or storage bottles (option)
Vacuum compressor or suction pump	particle filter / dry filter
Vacuum pump	electric control

Sheet metal frame:

The frame is of sheet metal construction.
It is designed with provisions for fork lift loading and unloading. The standard version is equipped with fixing- and steerable rollers with brakes.
The wheels on versions with a storage tank or SF_6-bottle storage are bolted to the frame. This type of wheel is not provided on road trailer versions.

Product description

Compressor:
The compressor is a dry running type and operates entirely without oil. It is available for different delivery rates and different final pressures (see technical data).
The compressor housing is absolutely gastight, but the maintenance of the compressor can be carried out easily. The working overpressure is controlled by a pressure reducer and a contact gauge. The operating temperature of the motor winding and the cylinder heads are controlled by a thermistor.

(Technical data and description see chapter 11 of the operating manuals for the compressor).

Suction pump: (if included)
The suction pump allows the recovery of gas down to < pa 1 mbar (absolute). The suction pump is a dry-running type, which operates entirely without oil. It is protected from inadmissible operating conditions by a pressure switch, pressure sensor, solenoid valves and regulating valve. The suction pump only switches on automatically at pressures of about p_e = 0.1 bar.
The pressure on the output side of the suction pump is controlled by a pressure sensor. The regulating valve on the suction side prevents a too high output pressure by throttling on the input side.
The output pressure is regulated to about pa 1000- 1050 mbar by the regulating valve on the output of the suction pump so that the compressor cannot generate any depression on the suction pump and cause ambient air to be sucked in.


Warning

Do not connect any gas compartment with overpressure to the suction side while the suction pump is running as the suction pump can be damaged by overpressure.

(Technical data and description see chapter 11 of the operating manuals for the suction pump).

Vacuum compressor: (if included)
The vacuum compressor allows the recovery of gas down to < pa 50 mbar.
The vacuum compressor is a dry-running type and is protected from inadmissible operating conditions by manostat, solenoid valve and return valves.
The vacuum compressor switches on automatically during the gas recovery process.

(Technical data and description see chapter 11 of the operating manuals for the vacuum compressor).

Product description

Vacuum pump:
The vacuum pump allows the evacuation of air from gas compartments.
To avoid any damage to the vacuum pump it must be protected from overpressure. The solenoid valve upstream from the vacuum pump only opens if there is no overpressure on the suction side. Reduce the SF_6-overpressure with the compressor and vacuum compressor or suction pump as described under the operating description “Gas recovery”.
Release air or nitrogen via the venting ball valve.
The vacuum pump only exhausts into the atmosphere.

(Technical data and description see chapter 11 of the operating manuals for vacuum pump).

Evaporator: (only for devices with liquid storage)
The evaporator consists of a special steel housing with electric heating coils inside. It serves to ensure vaporisation of liquid SF_6.
The temperature is regulated via a control unit.

Storage tank:
The SF_6-gas is stored in gaseous form or at higher pressure in liquid form. We distinguish between storage in a pressure tank in gaseous form up to 25 bar and in liquid form up to 50 bar. (Attention! Do not use these pressure tanks for transport of SF_6-gas).
Check the pressure rating of the tank to confirm gaseous or liquid storage. If gas is stored in transport bottles (in liquid form), please ensure the maximum fill weight stamped on the bottle is not exceeded.
Only use bottles registered for SF_6-gas.


Warning

For transport of tanks with weight indication the weight must be taken off the load cell prior to weighing it.
Pressure vessels must not be worked on mechanically, welded or heated. The type plate must not be removed or made illegible.

Pressure vessels (e. g. SF_6-tank, dry filter 64bar) should be approved by the local technical control organisation.

The pressure vessels are produced and approved in accordance with the corresponding regulations. (e.g. 97/23 EC).
The operator is responsible for approval and repeating checks.

Particle filter/ Dry filter:
The SF_6-gas is purified and dried with the particle filter and dry filter installed in the system. During each gas handling process the SF_6-gas passes through these filters.
(see chapter 9 dry filter or particle filter)

Product description

Functional description of the unit:

Electric control:

Power is supplied through the plug mounted on the control cabinet.
The correct phase sequence is checked by a device monitoring the direction of rotation.
The direction of rotation can be modified by means of the integrated reversing switch.
All components are protected by motor protection circuit breakers.
The control circuits are powered at 24V DC.
All other electrical components (e. g. temperature regulation) are supplied at 230V AC.
Both voltages (230 V AC and 24V DC) are generated from the connected supply voltage with a transformer or a power supply unit.

All important process parameters are displayed on the operating panel.
The device is operated via the operating panel, the knob switch and the start / stop key.
Furthermore, the operating times of the components are indicated on the operating panel. The weight of the storage tanks (if included) and the weight of the integrated bottle scales are also displayed on the operating panel.

General information:

All operating elements and control monitoring systems are well arranged on the front panel.
All connecting lines are produced according to the well-proved DILO metal-to-metal sealing principle and are absolutely tight.

Product description

Function selection:

The desired functions are to be selected by means of the knob switch.
The following functions are available:

1: Evacuation of air
2: Recovery of SF_6
3: Filling of SF_6
4: Purge compressor
5: Pressure reduction
6: Recovery of filter
7: Evacuation of filter
8: Pressure test of compressor
9: Manual operation

The selected function is displayed on the operating panel in the upper line.

Double key "1"/ "0":

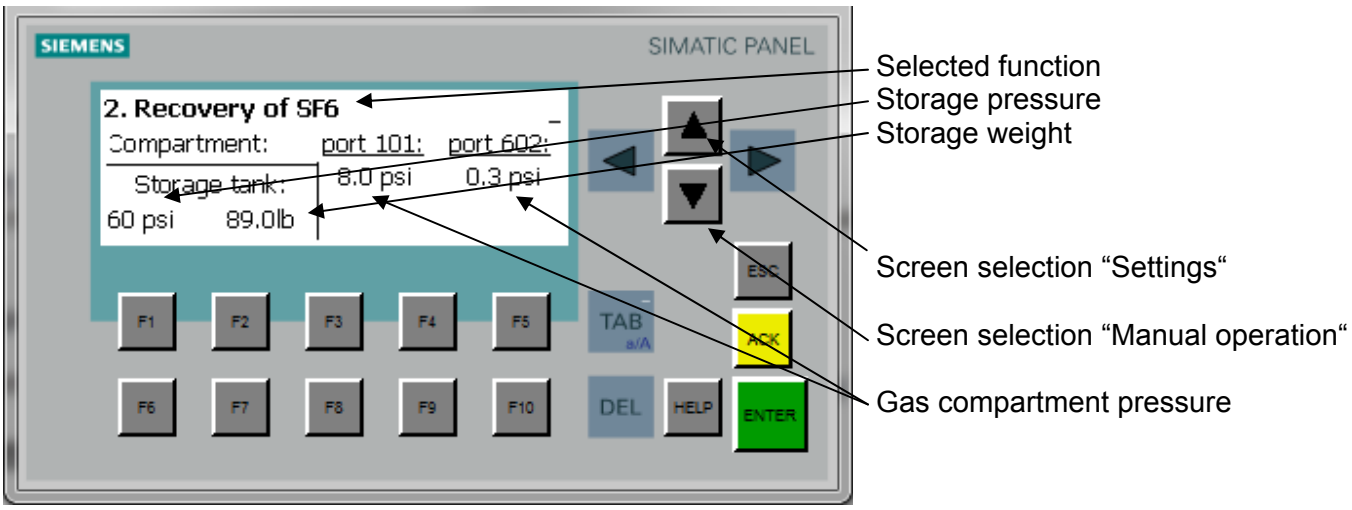
This double key serves for starting and stopping the functions.

0: This key has a double function.
When pressing this key the active function is completed. It is also used to confirm the indicated malfunction message.

1: If there is no malfunction message the function selected by the knob switch can be started.

There is a control lamp between both buttons of the double key which lights up if a function is running.

Operating panel (basic configuration):



Product description

Input of values and activation of screen selection

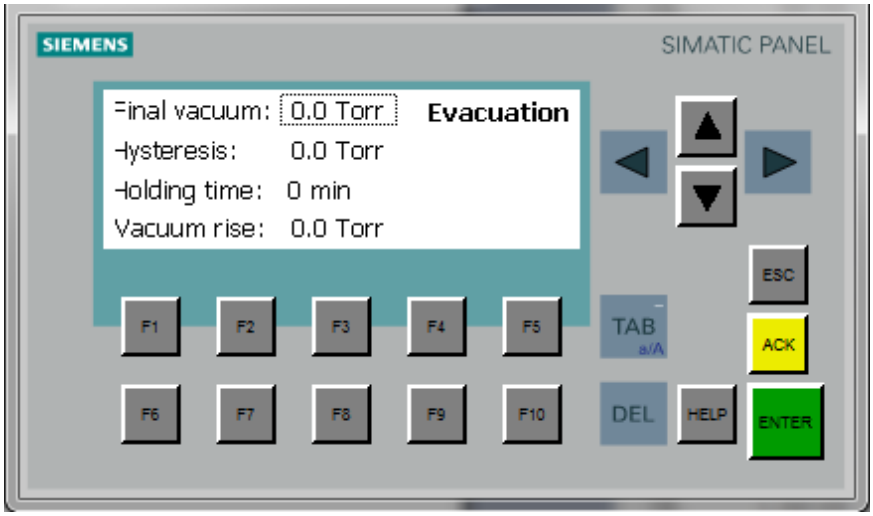
Symbols and digits are input by means of the “F1 – F10” function keys on the operating panel.
Proceed as follows:

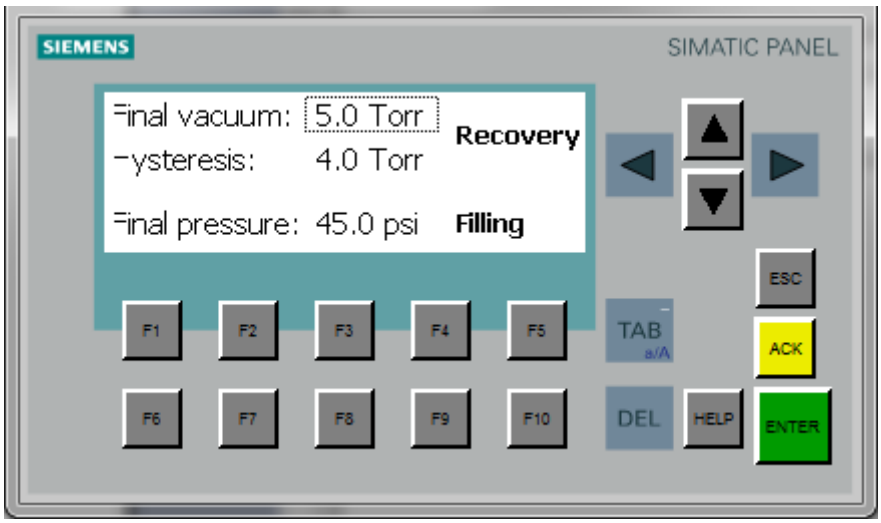
1. Select the desired parameter by means of the arrow keys.
2. For modification of the parameter press the <ENTER>- key.
3. Press the corresponding “F1 - F10” key until the desired digit is displayed on the screen.
   The desired digit is accepted after one second or immediately after having pressed another key.
4. For navigation between the digits use the arrow keys.
5. Confirm the input by pressing the <ENTER> key.

Product description

Settings:

When pressing the “Settings“ screen selection key the settings screen can be paged through and modifications can be carried out.

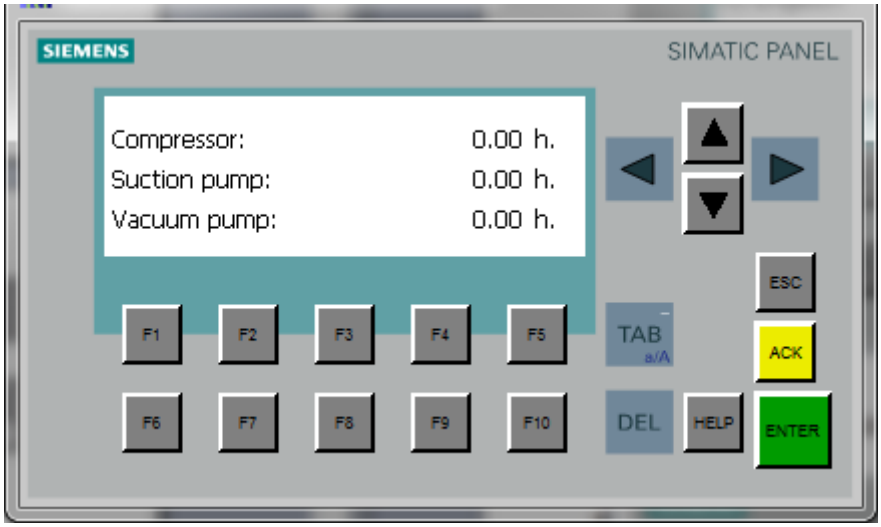




Note for hysteresis: Input of final vacuum: e. g. 5 Torr
Input of hysteresis: e. g. 4 Torr

The suction pump starts the recovery process after having reached the final vacuum of 1 Torr (difference final vacuum to hysteresis). Finally a vacuum test is carried out. If the pressure does not exceed the final vacuum the function is completed automatically.
Note: the entered final vacuum must be higher than the hysteresis entered!

Product description



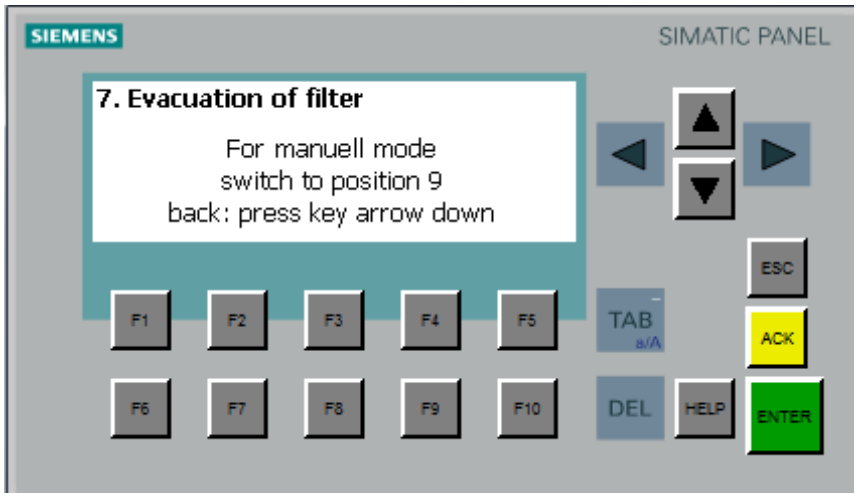
The running times of the components are displayed here.

Product description

Manual operation

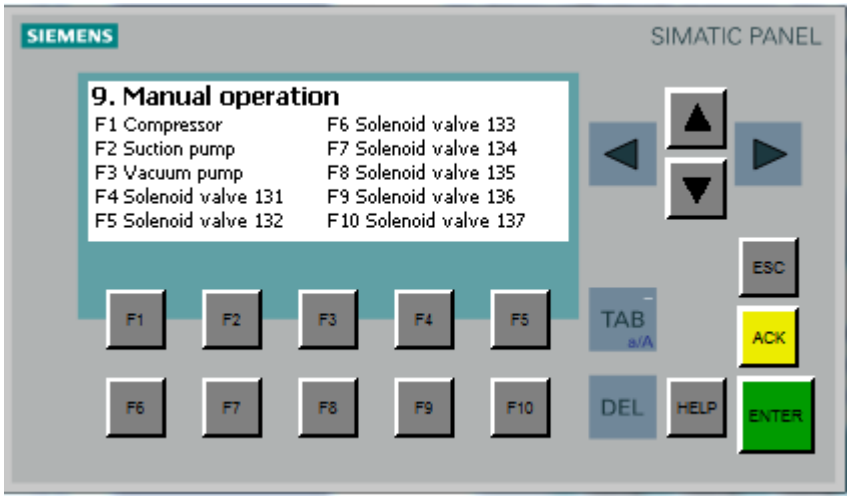
In manual operation the components and the valve can be switched separately.
In order to reach the manual operation the basic configuration must be set on the operating panel.
Press the “down arrow” key and turn the knob switch to the position 9.

In case the knob switch is not in position 9 the following page appears:



This page can be left by pressing the “down arrow” key or turn the knob switch to the position 9.

If the manual operation is selected correctly the following page appears:



Now the components indicated on the operating panel can be switched on and off or the valves can be opened and closed by means of the corresponding function key.
In order to complete the manual operation press the “down arrow“ key and select another function with the knob switch.

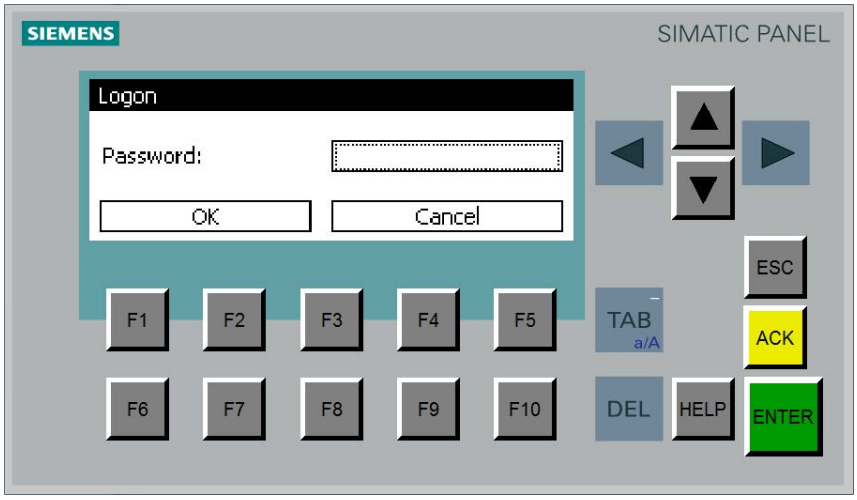
Product description

Modification of the running times of the components:

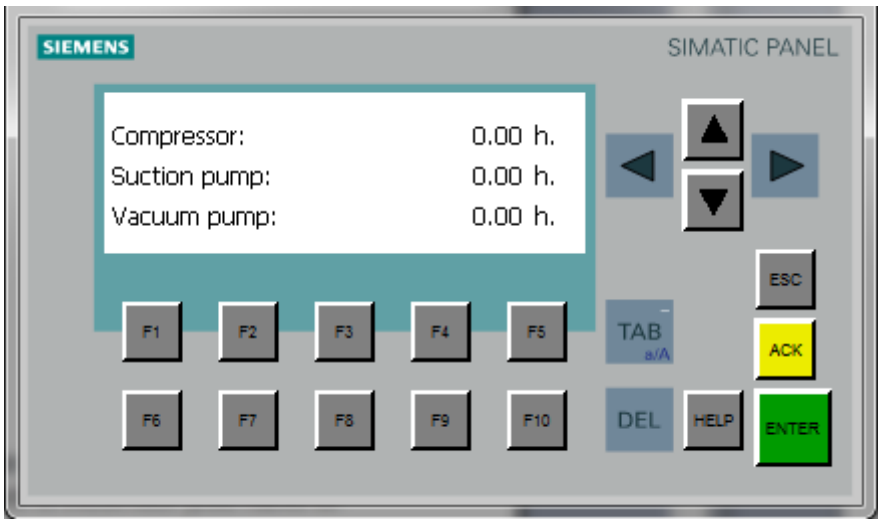
Danger

This section is only accessible for authorized operators as the switching off parameters of the scales can be set here.

The running times of the components can only be modified by the supervisor.
For modification press the <F10> key on the basic configuration.
Then enter the password.

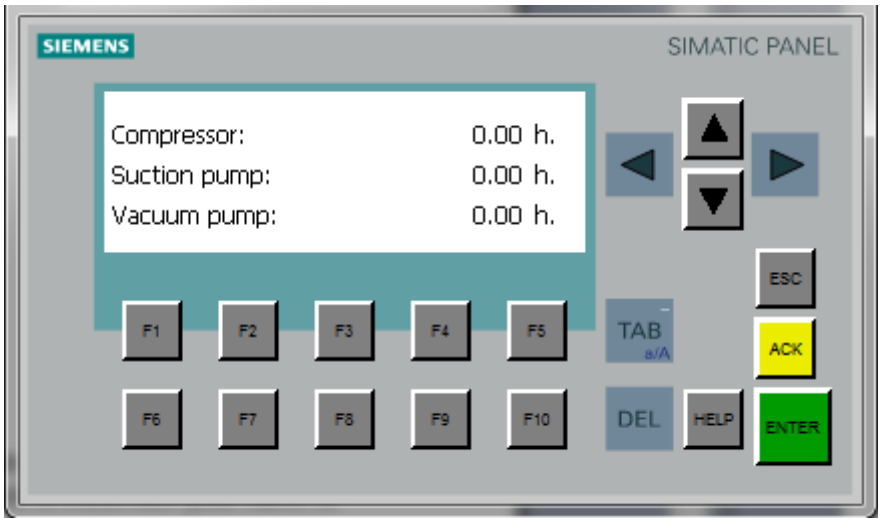


After entering the correct password press the <F910> key once again and the page for setting the running times of the components appears. If the password is incorrect you have to enter the password again.



Product description

The running times of the components can be modified here.
Press the “up arrow” key to leave this page and to reach the storage weight page.



Return to the basic configuration by pressing the “up arrow” key.

Dimension sheet / Technical data

Z863R01

Illustration: without storage rack

Dimensions	Length	Width	Height	Net weight
without storage rack	2300 mm	1200 mm	1000 mm	780 kg

Compressor:	**Theoretical delivery rate:**	**Final pressure max. p_e**	**Differential pressure max.**
	5.7 m³/h	50 bar	49 bar
Suction pump:	**Theoretical delivery rate:**	**Final vacuum:**	
	15 m³/h	< 1 mbar	
Vacuum pump:	**Theoretical nominal suction capacity:**	**Final vacuum:**	
Standard	40 m³/h	< 1 mbar	

Sound level: < 85 dB(A)
Paint: orange RAL 2004
Operating voltage: see type plate
Admissible ambient temperature: 0 to 45°C (Busch vacuum pump)

Electrical connection:

Operating voltage:	208-240V, 50/60 Hz	380-500V, 50/60 Hz
Fuse protection:	32 -50 A time delay	25-32 A time delay
Conductor diameter:	≥ 10 mm² (AWG 7)	≥ 6 mm² (AWG 9)
Power plug:	63 A	32 A

Transport and installation

Transport:

To avoid damage to devices and life threatening injuries during transport:

Danger

- Lifting slings must correspond to local health and safety regulations.
- Slings should be chosen in accordance with the weight of the device. (for weight see dimension sheet).
- Version with lifting eyes:
  Check that fork lift truck forks are long enough.
- If the device is equipped with lifting eyes then a crane can be used. Ensure that slings are of the correct length and chains do not cause damage to the device.
- Do not stand underneath the load.
- Only qualified and authorized persons should carry out transport operations.
- Service carts with chassis may only be moved on even and solid ground. The chassis is designed for a maximum speed of 6km/h.

Notes for transport of DILO devices with hydraulic weighing device
(not applicable for electronic weighing device)

Warning

The weight must be taken off the load cell prior to transport of the device.
(Danger of vibration/shock for the measuring system)
(see chapter 9 weighing device)

Transport regulations for DILO service carts

ADR regulations:

SF_6 (Sulphur hexafluoride) filled service carts are exempt from the ADR transport regulations if the pressure of the gas in the vessel or tank is not exceeding 200 kPa (2 bar) at a temperature of 20°C and the gas is neither liquid nor refrigerated liquefied gas.
This includes each kind of vessel or tank as well as machinery parts (see ADR 1.1.3.2 c exemptions with regard to the transport of gases).

Otherwise please observe your country-specific transport regulations or guidelines.

Transport and installation

Installation:


Warning

Only operate the device indoors or in dry places outdoors.
Operation in humid places may cause corrosion of couplings and valves.
For outdoor operation we recommend using a tarpaulin cover for protection.
When using the device the tarpaulin must partially be raised to allow ventilation for cooling.
The ambient temperature during operation of the device should be in the range of +10°C to +40 °C.
In case of temperatures from - 10 to + 10 °C the vacuum pump oil may need to be changed.
(see operating manuals for vacuum pump)

Electrical connection:


Danger

Only trained and authorized personnel should connect the device!
A three phase neutral and ground power supply must be used!
Power supply must be protected via a residual current device (RCD) with a max. operating current of 30mA.
For operating voltage, fuse protection and recommended connecting cable:
see chapter 2, technical data

Electrical connection:
Connect the cable to the plug supplied.
Note: Cable must be disconnected from the power socket.
Connect the 3 phases to terminals L1, L2, L3, the neutral to terminal N and the ground to the terminal marked with the symbol. ⏚
However for the operation of the service cart no neutral is necessary.
Power is supplied through the plug mounted on the control cabinet. Electrical accessories (e. g. remote control, bottle balance with switch contact) must also be connected to the service cart.

Checking for the correct power supply:
Plug in the device.
Turn on the main- or reversing switch (if available).
The phase sequence relay installed in the device checks the connected mains supply for phase failure and the direction of rotation (for devices dependant on direction of rotation).
The “Power, correct direction of rotation“ lamp lights up if the power connection is correct.
The “Incorrect direction of rotation” lamp lights up if the power connection or direction of rotation is incorrect. Operation is blocked.
Check the power connection or exchange the phase connections of the incoming power supply or reverse the reversing switch (if available).
Attention: Disconnect the power plug beforehand!

Setting into operation

Prior to setting the device into operation check the following:

1. Electrical supply
   Check that all necessary connections have been made correctly.

2. Oil level of the vacuum pump (if available)
   (see vacuum pump operating instructions)

3. Put the weighing device (if available) to the working position

After the initial start and prior to operation check that all safety equipment is operating correctly!

Filling of the buffer tank with mixing gas

Preparation of the buffer tank with the desired gas mixture.

During the initial setting into operation and while changing the mixing ratio, the intermediate tank should be prepared with the correct mixing ratio. If not, there might occur any faults especially when mixing small gas quantities.

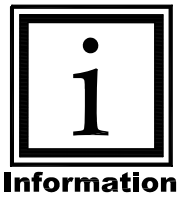
For this purpose see chapter “Premixing of buffer tank“.

Setting into operation

Filling for transport

All devices are filled with gas to a slight overpressure (≈ pe 0.2 bar) in our works. Labels giving the correct details for transport are provided.

Red label for devices filled with N_2 for transport



Green label for devices filled with SF_6 for transport

After setting the device into operation remove the label for transport filling.

Accessories, which are filled with SF_6-gas (e. g. pre-filter units) are provided with a green "SF_6-filled for transport" label.

Accessories, which are filled with N_2-gas (vacuum pump units) are provided with a red "N_2-filled for transport" label.

Accessories which are filled with air (e. g. hoses) are not provided with a label.

Devices or accessories, which are filled with SF_6-gas, can be put into operation without carrying out any additional preparatory operations.

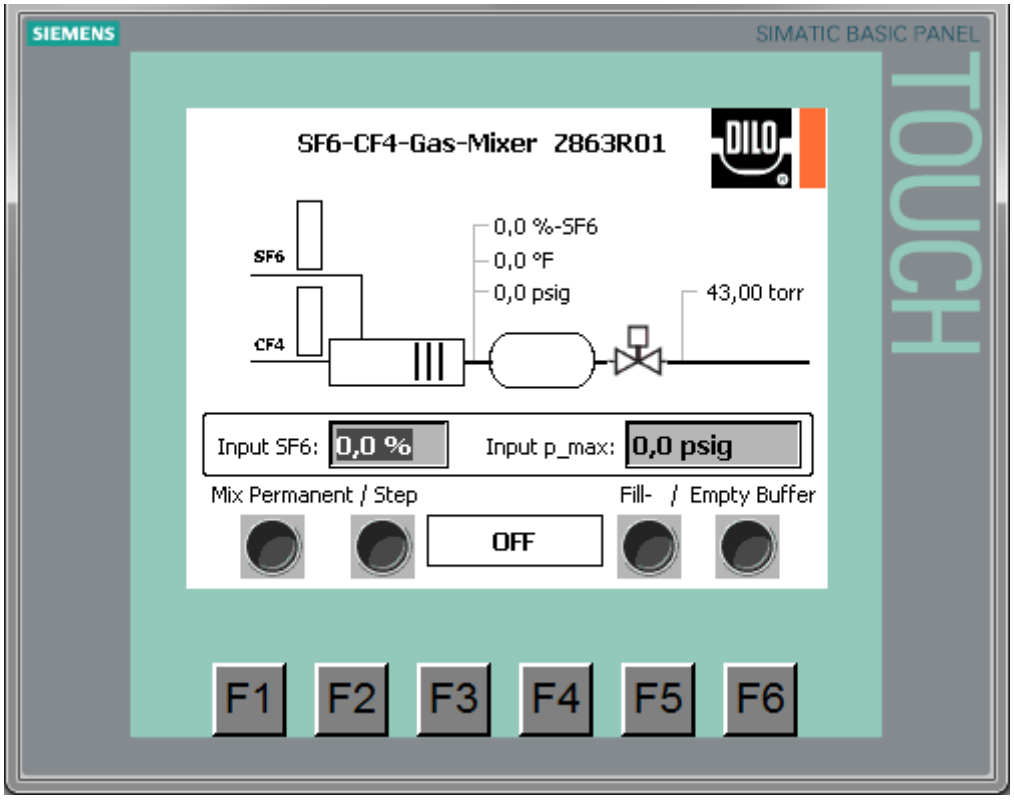
Devices or accessories, which are filled with N_2-gas or air, must be evacuated before use with SF_6-gas otherwise the SF_6-gas will be contaminated.

For pressure tanks, which are installed by the customer observe the following:
As the connecting hose is filled with air it must be evacuated after the installation, otherwise the SF_6-gas could be contaminated.

Functional description

Starting the SF_6 / CF_4 mixing unit

If the device is started the operating menu appears.



On the graphic illustration there is a bar graph for opening the control valves for SF_6 and CF_4 on the left side.
The mixing cell and the mixing tank with their SF_6-percentage, pressure and temperature indications are illustrated in the middle of the screen. Downstream from the valve pos. 607 there is a vacuum indication for the mixing tank. When starting the mixing process a small animation is generated on the screen. The pressure indications are in **effective pressure**.

The desired SF_6-percentage “Input SF_6-%“, as well as the max. filling pressure on the storage tank side “Input p_max.“ are entered into the framed part of the illustration. This is done by touching the input field and the dialog box opens for the input of numbers. After completion of the input confirm with “Return” and the input field is closed again.
The input range for the SF_6-percentage is from 10– 80 vol. percent. The max.filling pressure is 580 psig.

In the lower field there are 4 switches for the main functions of the device:

“Mix Permanent“	permanent mixing is carried out. This is only applicable for large gas quantities (as from 5 norm m³).
“Mix Step“	mixing step-by-step for small gas quantities is carried out.
“Fill Buffer“	for pre- filling the buffer with the required gas mixture
“Empty Buffer“	empties the buffer tank by means of the compressor to the outlet

The switches are started or stopped by pressing. In the middle there is a status indication which can output different conditions e. g. Breakdown, Run, Off, End or Lack of gas.

In case of errors an additional error window with a plaintext message appears.
(e. g. overpressure compressor)

Functional description

Preparatory steps

Prior to using the device the SF_6 and CF_4 supply is to be connected.
The SF_6 should be taken from a tank in liquid form, if possible. The tank (e. g. large capacity tanks) can be put into the correct position by turning. The SF_6 is converted to the gaseous phase with the installed evaporator. The tank is connected to the coupling pos. 734 with the connecting hose.

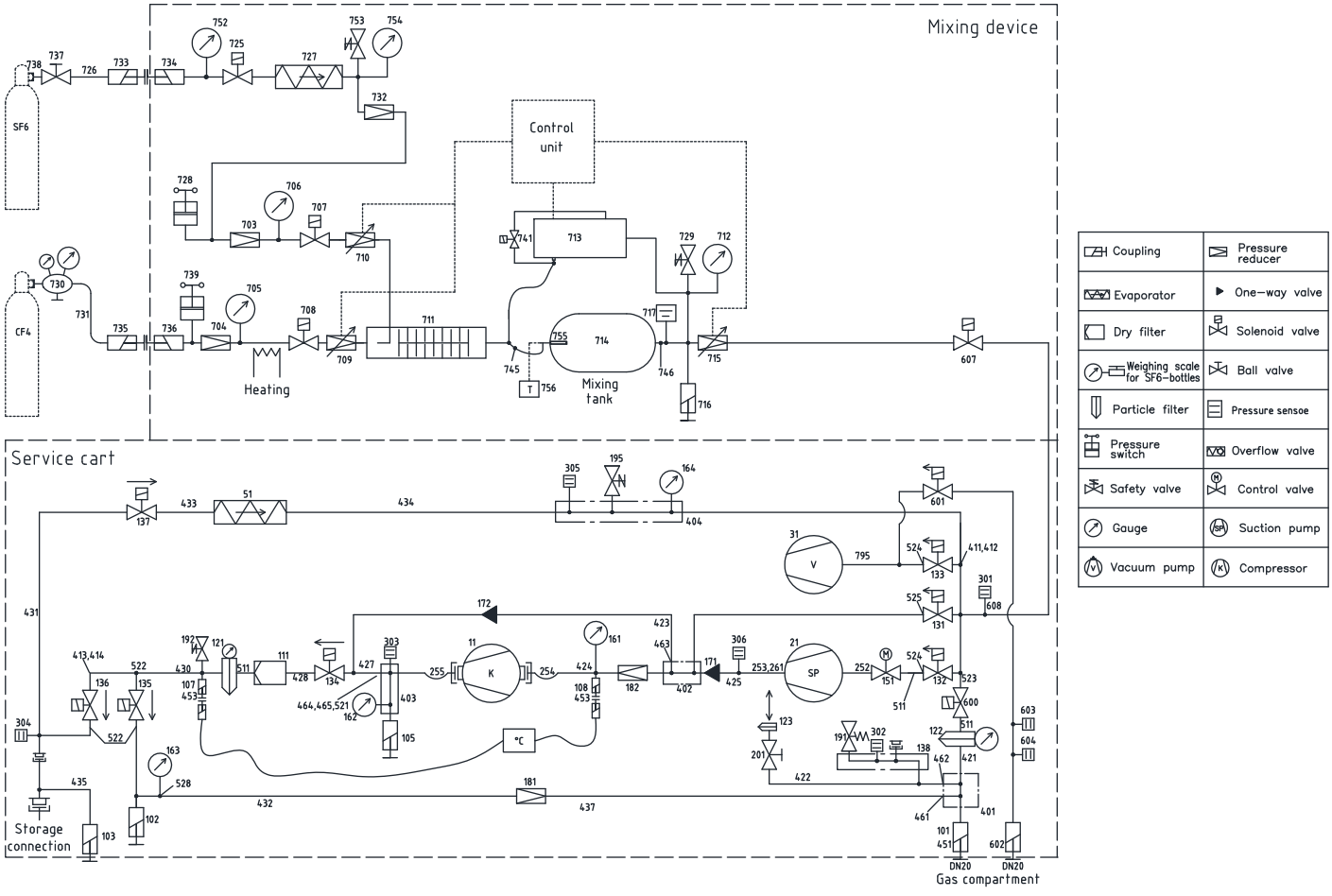
Warning

The connecting hoses must be evacuated or filled with gas!

The CF_4 is taken from a gas cylinder in gaseous form.
The bottle pressure reducer should be set to 8– 10 bar (116- 145 psig) so that a sufficient high primary pressure is available for mixture. The connecting hose is connected to the coupling pos. 736.

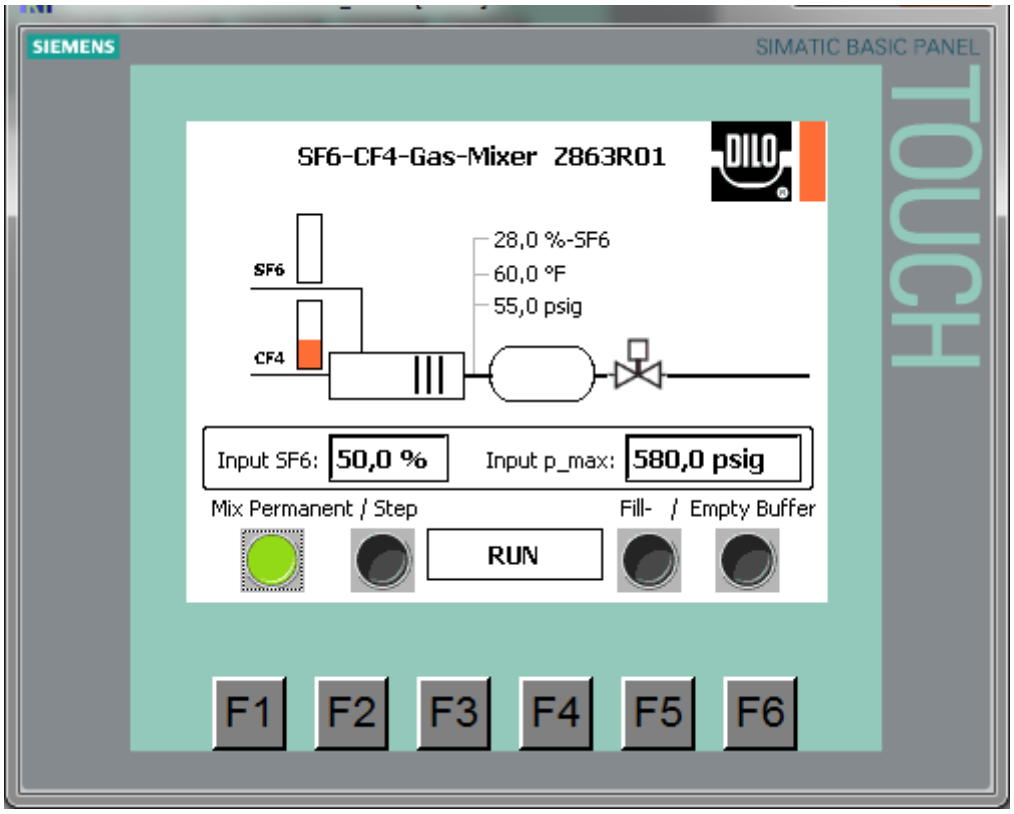
For both gases a pressure switch (adjusting pressure about 4 bar/ 58 psig) is provided. If the primary pressure of a gas is too low the mixing process is to be interrupted. But this should be avoided as divergences in the mixing ratio may occur.

A tank for the final mixture is connected to the outlet coupling (pos. 103). The max. filling pressure is 40 bar (580 psig).



Functional description

Mixing of SF_6 and CF_4



After having carried out the preparatory steps the mixing process can be started.

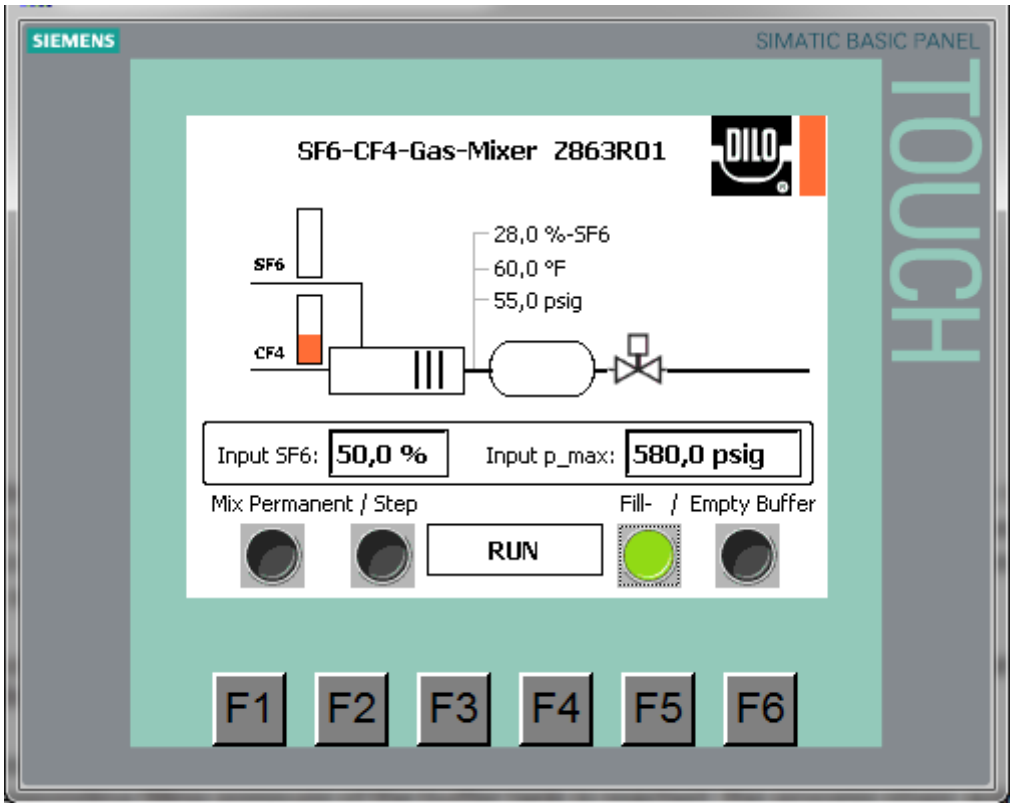
This process is only provided for mixing of larger gas quantities (> 5000 l norm volume). The flow of SF_6 and CF_4 is controlled so that the correct mixing ratio is generated. The mixture is monitored permanently by the integrated SF_6-monitoring system. When starting the process a certain time is needed until the correct mixing ratio is generated. Thus the measured values are integrated and corrected until the value has stabilized.

Procedure:

- Setting of the desired mixing ratio on the operating panel
- Attention: in case the mixing ratio should be modified the tank is to be emptied (see function “Filling of the buffer tank“) and refilled with the correct mixing ratio with the “Filling of buffer tank“ function.
- Setting of the filling pressure on the operating panel
- Start of the mixing function (**Mix Permanent**)
- If the set filling pressure is reached the function stops automatically.

Functional description

Filling the buffer tank



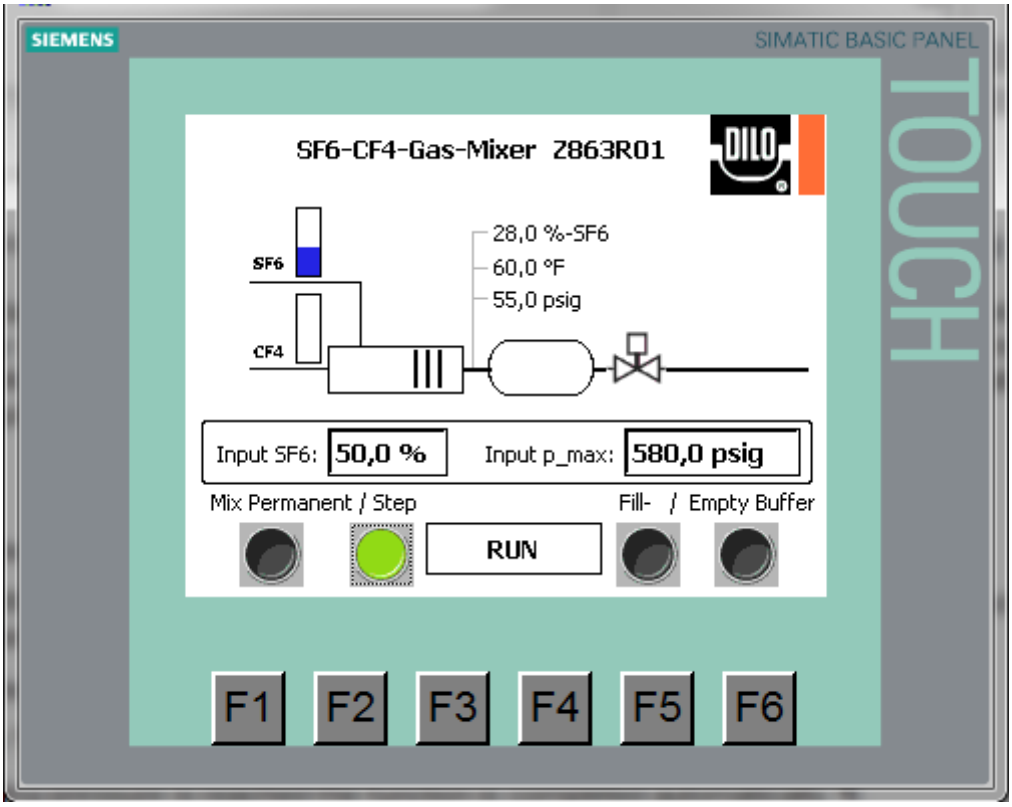
When setting the device into operation or after modification of the percentage for the mixture the buffer tank must be filled again with the actual mixing ratio so that no error mixtures are generated. The buffer tank is recovered with the “Emptying of the buffer tank“ function and the gas is delivered into an external tank up to a residual pressure of 1 mbar.

For this purpose the described preparatory steps must be followed. It is not necessary to connect any tank for filling.

The process is started by pressing the “**Fill Buffer**“
If the corresponding filling pressure of the buffer tank is reached, the process stops automatically.

Functional description

Mixing of small quantities



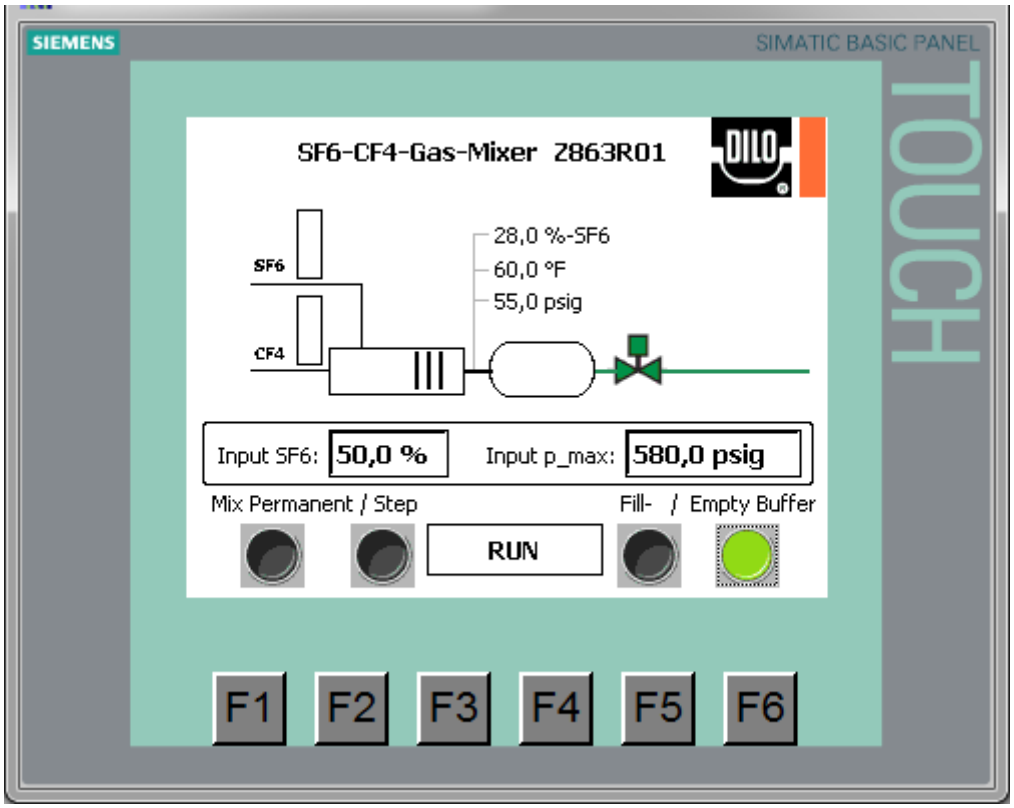
This process is provided for mixing of quantities which cannot be mixed with the mixing process described.
For this the buffer tank is first filled with SF_6 and then with CF_4, the final mixture is then delivered into the connected tank by means of the compressor. This process is continued as long as there is the set pressure in the tank. Due to the step-by-step procedure the mixing performance is considerably lower than during the regulated mixing process.

Procedure:

- Setting of the required mixing ratio on the operating panel.
- Attention: When modifying the mixing ratio, the tank must be empty (see “Fill buffer” function) and refill it by using the “Fill buffer tank” function with the correct mixing ratio.
- Setting of the filling pressure on the operating panel.
- Starting the “Mixing“ function (**Mix Step**).
- If the set filling pressure is reached the function is completed automatically.

Functional description

Emptying of the buffer tank



The buffer tank is emptied into a tank connected to the storage coupling.

Procedure:

Connect an appropriate tank to the ‘storage connection” or coupling pos. 103

- Start the “**Empty Buffer**“ function on the operating panel.
- If the set recovery vacuum is reached the function is completed automatically.

Functional description

Recovery of decomposed or undefined SF_6

Warning

For the recovery of decomposed or humid SF_6 gas we recommend connecting a B007R11 prefilter unit upstream from the service cart.

For the recovery of oil-contaminated SF_6 gas we recommend connecting a B071R11 oil separating filter unit upstream from the service cart.

For the recovery of undefined SF_6 gas we recommend connecting a B007R11 prefilter unit upstream from the service cart.

For the recovery of decomposed and oil-contaminated SF_6 gas we recommend connecting a B071R11 oil separating filter unit and finally a B007R11 prefilter unit upstream from the service cart.

Note

After the recovery of contaminated or humid SF_6 gas, the SF_6 in the device is to be dried in circulation or purified for a short time.

In the service cart the “Rinsing compressor“ special function is provided. This function can be carried out automatically via the special functions key (see chapter 6).

Functional description

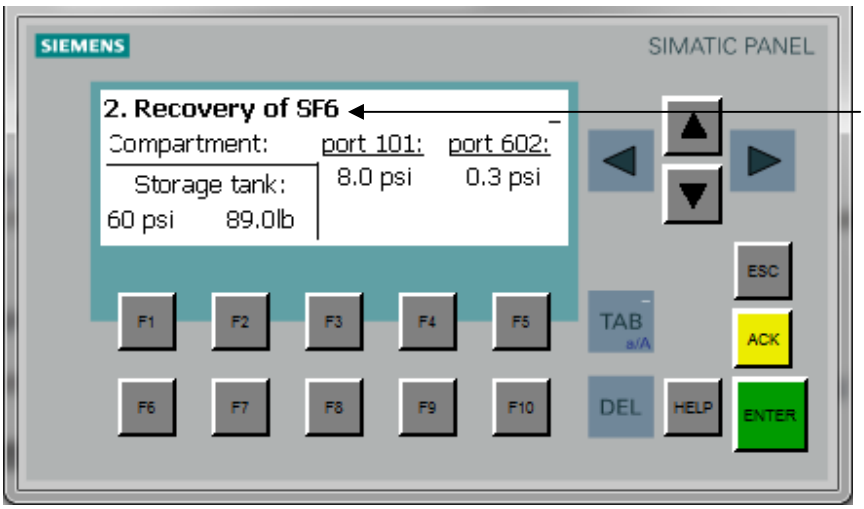
Starting the service cart

Automatic functions:

The following automatic functions can be carried out:

1. Evacuation of air
2. Recovery of SF_6
3. Filling of SF_6

Each function has to be preselected by means of the knob switch on the device.
The preselected function is displayed in the first line on the operating panel.



Preselected function

Then the preselected function can be started by pressing the green “I" key.
The activated function can be stopped by the red "0" key.

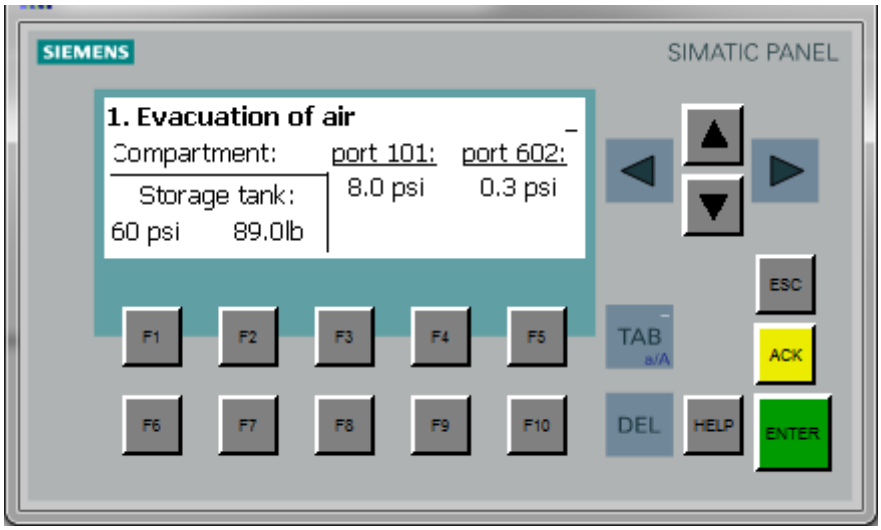
During the “Filling of SF6" function the compressor switches on automatically if there is a certain pressure difference between storage pressure and gas compartment pressure.

The automatic functions stop as soon as the knob switch is turned to another position.

Functional description

Evacuation of air from the gas compartment

Evacuation at port 101:



To avoid mixing of ambient air with SF_6 gas the gas compartment must be evacuated beforehand.

1. Connect the gas compartment to pos. 101.

If there is gas overpressure (pressure indication on the operating panel) the gas must be recovered beforehand (see "Removal and storage of SF_6")

2. Open the filling pressure reducer pos. 181 (max. filling pressure).
3. Select the "Evacuation of air" function by means of the knob switch.
4. Start the evacuation function by pressing the green "I" key. If there is a too high pressure on the valve upstream from the vacuum pump the solenoid valve does not open. An error message is indicated on the operating panel. Reduce the overpressure as described in the "Removal and storage of SF_6-gas" chapter.
5. After having reached the set final vacuum the function stops automatically and the 'vacuum test' message appears.
6. In case the vacuum (during the holding time) is lower than the input value, the "function completed" message appears.
   If the vacuum (during the holding time) exceeds the input value the "vacuum rise" message appears.
7. Press the red "0" key and the "function completed" respectively the "vacuum rise" message disappears.

Functional description

Evacuation at port 602:

It is possible to evacuate air at port 602 in parallel to all other functions. The function is started independent of the selector switch position (0 – 9).

To avoid mixing of ambient air with SF_6 gas the gas compartment must be evacuated beforehand.

1. Connect the gas compartment to pos. 602.

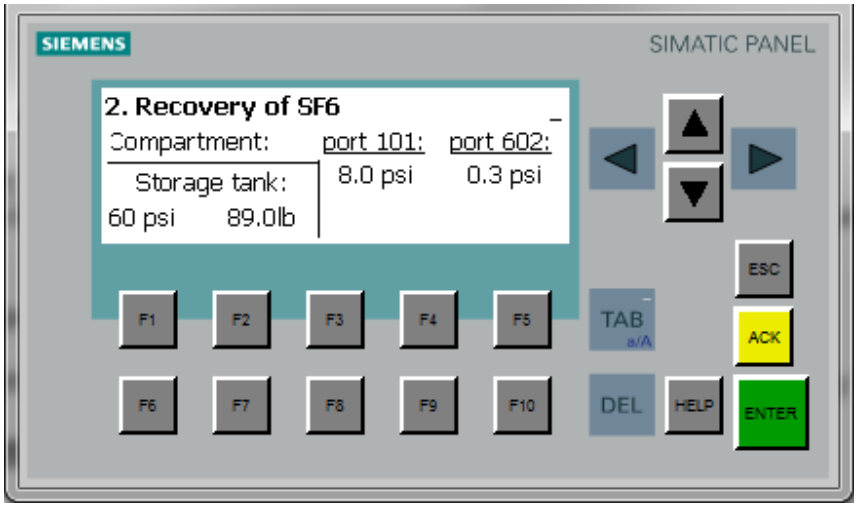
If there is gas overpressure (pressure indication on the operating panel) the gas must be recovered beforehand (see “Removal and storage of SF_6“)

2. Start the evacuation function by pressing the green “I“ key. If there is a too high pressure on the valve upstream from the vacuum pump the solenoid valve does not open and the vacuum pump does not start. Reduce the overpressure.
3. After having reached the set final vacuum the function stops automatically and the ‘vacuum test’ message appears.
4. In case the vacuum (during the holding time) is lower than the input value, the “function completed“ message appears.
   If the vacuum (during the holding time) exceeds the input value the “vacuum rise” message appears.
5. Press the red “0“ key and the “function completed“ respectively the “vacuum rise” message disappears.

Functional description

Removal and storage of SF_6

If a gas compartment is to be opened or the gas is to be exchanged the SF_6 gas can be recovered with the “Gas recovery“ function and stored in a storage tank.



1. Connect the gas compartment (coupling pos. 101) and the storage tank (coupling pos. 103), if necessary. Open the valves to the gas compartment (if available). Open the ball valve on the storage tank.

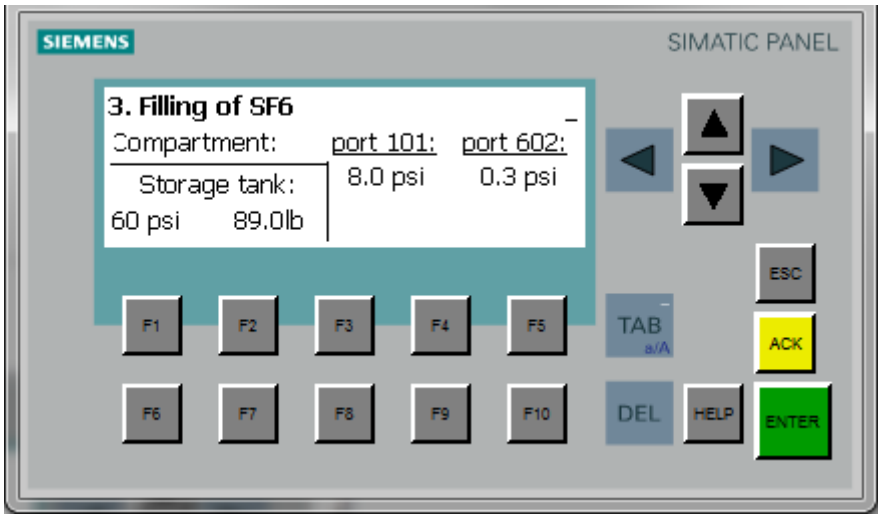
Warning

<u>Attention:</u> Do not connect the gas compartment while the suction pump is running as the suction pump can be damaged.

2. Select the “2. Recovery of SF6” function by means of the knob switch.
3. Start the recovery function by pressing the green “I“ key.
4. After having reached the set final vacuum the function stops automatically and the ‘function completed’ message appears.
5. Press the red “0“ key and the “function completed“ message disappears.

Functional description

Filling the gas compartment with gas



1. In case a storage tank is not integrated in the service cart connect a SF_6 cylinder or external storage tank to pos. 103 and open the ball valve to the storage tank. Connect the gas compartment.

The connecting hoses must be evacuated or filled with gas.

2. Open the pressure reducer by turning clockwise (maximum pressure).
3. Select the “Filling of SF_6” function by means of the knob switch.
4. Start the filling function by pressing the green “I“ key. The evaporator and the solenoid valves are activated. The solenoid valve upstream from the evaporator only opens if the evaporator has reached its operating temperature.
5. When reaching a certain pressure difference the compressor switches on automatically.
6. After having reached the set final pressure the function stops automatically and the ‘function completed’ message appears.
7. Press the red “0“ key, the “function completed“ message disappears.

Functional description

Flooding the gas compartment with ambient air

In case it is necessary to open the gas compartment for maintenance works it is under vacuum after the recovery of SF_6 gas.

The gas from the connecting hoses and the piping should be recovered beforehand.

1. Connect the gas compartment to pos. 101.
2. Open the venting ball valve (pos. 201) and wait for pressure compensation.
3. After having reached pressure compensation it is absolutely necessary to close the venting ball valve (pos. 201) to avoid gas from flowing into the atmosphere later on during gas handling.

After flooding uncouple the connecting hose from the gas compartment and evacuate to < 1 mbar. (see “Evacuation of the gas compartment“).
This is to avoid mixing ambient air from the connecting hose with gas later on during gas handling.

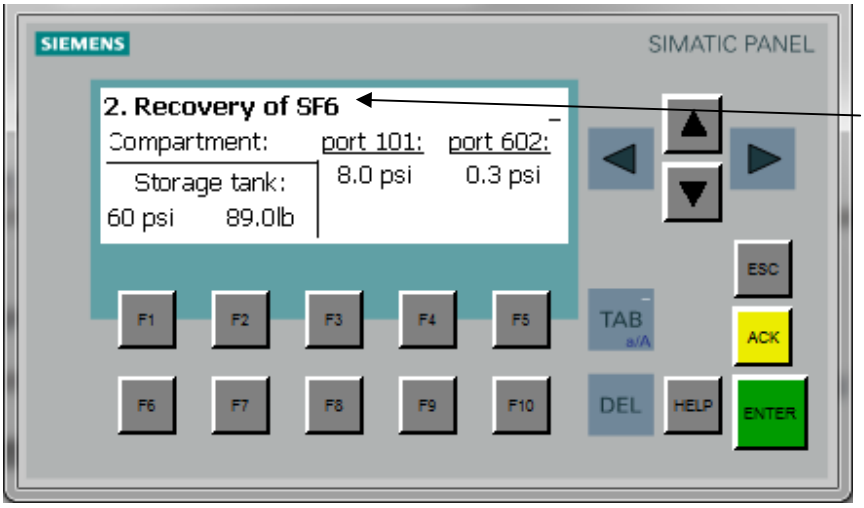
Special functions for maintenance

Special functions:

The following special functions can be carried out:

4. Purge compressor
5. Empty device (Pressure reduction)
6. Recovery of filter
7. Evacuation of filter
8. Pressure test compressor
9. Manual operation
10. Evacuation of air from the service cart
11. Filling of external cylinders from the internal storage tank

Each function has to be preselected by means of the knob switch on the device.
The preselected function is displayed in the first line on the operating panel.



Then the preselected function can be started by pressing the green “I" key on the double key.
The activated function can be stopped by the red "0" key on the double key.

The special functions stop as soon as the knob switch is turned to another position.

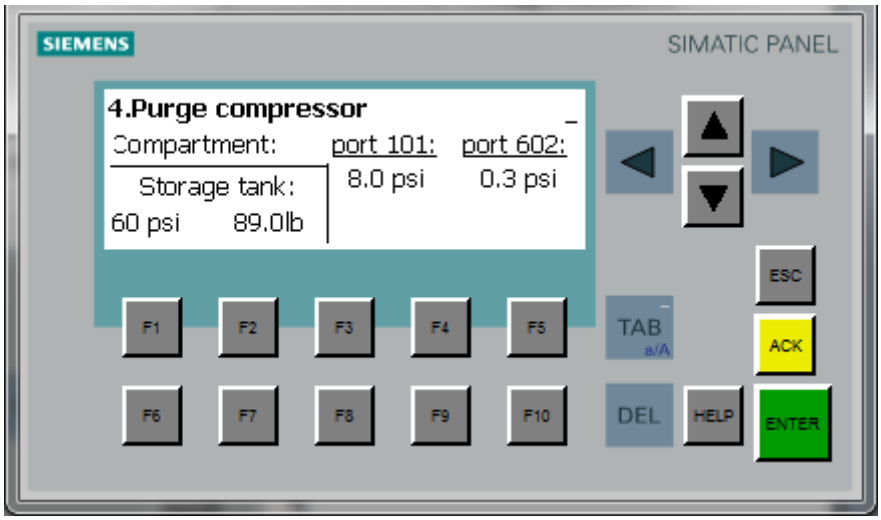
Special functions for maintenance

4. Purge compressor

Prior to shut down the service cart or after recovery of humid gas the SF_6 gas remaining in the service cart should be dried to avoid corrosion inside the device. The SF_6 gas in the internal storage vessel is not purified.

Note

Attention: **There is no gas and air separation**.
It is possible to filter humidity and particles out of the SF_6 gas.



1. Do not connect any gas compartment and storage tank to the coupling pos. 101 and 103.
2. Select the “4. Purge compressor” function by means of the knob switch.
3. Start the function by pressing the green “I” key.
4. The filling pressure reducer pos. 181 can be opened (max. filling pressure).
5. After about 6 minutes set the pressure on the gas compartment side to < 0 psig. by means of the filling pressure reducer pos. 181. Then the gas flows through the suction pump.

   The function runs for max. 10 minutes and stops automatically. But the function can also be stopped by pressing the red “0” key.

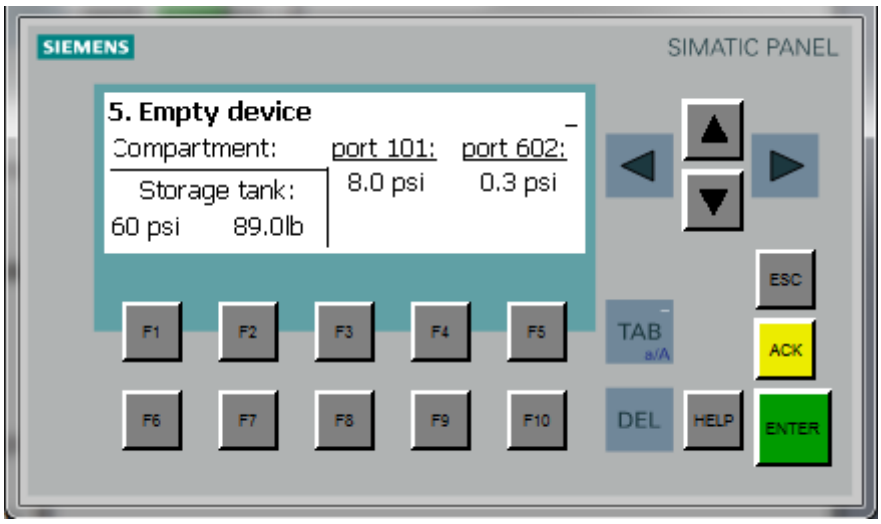
Special functions for maintenance

5. Empty device (Pressure reduction)

For transportation of the service cart on roads the pressure in the device must be reduced to a pressure lower than 2 bar (overpressure).

Note

Store the gas from the service cart in an empty cylinder.



1. Select the “5. Empty device” function by means of the knob switch.

Warning

The connecting hoses must be evacuated or filled with gas.

2. Connect the SF_6 gas cylinder to the coupling pos. 105 and open the cylinder valve and the filling pressure reducer pos. 181.
3. Start the function by pressing the green “I” key.
4. The cylinder pressure can be read on the gauge pos. 162 (at coupling pos. 105). If the pressure in the cylinder increases to > 20 bar exchange the cylinder.
5. Stop the function when a pressure of < -7 psig has been reached.
6. Close the cylinder valve.
7. Establish pressure compensation in the device (in manual operation see chapter 2) open all solenoid valves except pos. 133 and 132).
8. Check the pressure (all gauges and pressure indications should display a value of < 29 psig).
9 Close the ball valve on the SF_6 cylinder and uncouple the storage connecting hose.

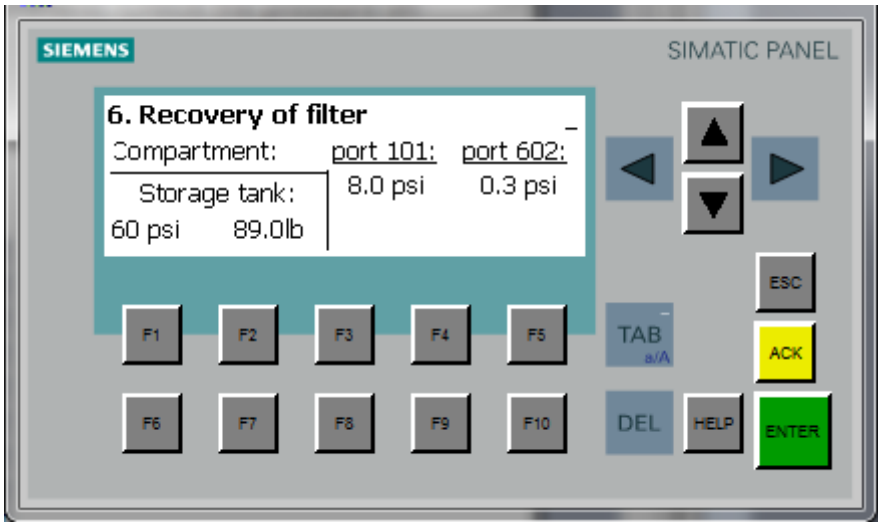
Special functions for maintenance

6. Recovery of filter

To open the filters for filter revision the filters must be depressurized beforehand. Check the pressure on the gauge pos. 121 (observe the gauge on the filter).

Danger

Attention: Danger to life! Do not open the filters under pressure!



Attention: **Do not connect any storage cylinder or storage vessel to pos. 103. The ball valve on the integrated pressure vessel must be closed. The bottle valves on the integrated cylinders must be closed as well.**

1. Select the “6: Recovery of filter” function by means of the knob switch.
2. Connect an SF_6 gas cylinder to the coupling pos. 105 and open the cylinder valve and the filling pressure reducer (pos. 181).
3. Start the function by pressing the green “I” key.
4. The cylinder pressure can be read on the gauge pos. 162 (at coupling pos. 105).
5. If the filter is recovered to the desired filling pressure (< 0.75 Torr) stop the function with the red “0” key.
6. Check the pressure. The gauge on the filters has to indicate “0”.
7. Close the cylinder valve and uncouple the SF_6 cylinder.

Prior to opening the filter it must be flooded with ambient air.

1. Open the valve pos. 135 in manual operation (see chapter 2)
2. Open the filling pressure reducer pos. 181.
3. Open the venting ball valve pos. 201 and wait for pressure compensation.
4. Close the venting ball valve.
5. Close the solenoid valve pos. 135.

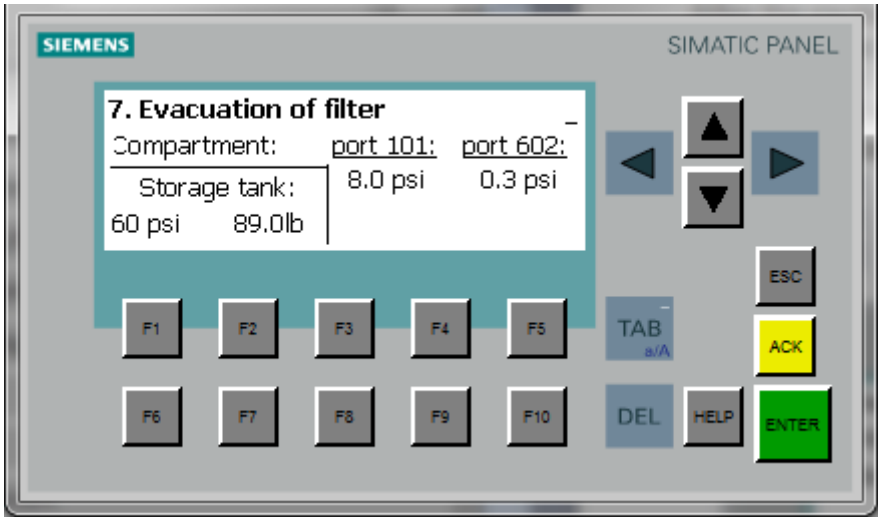
Special functions for maintenance

7. Evacuation of filter

After the exchange of the filters the air must be evacuated from the filters.
Otherwise the SF_6-gas is mixed with ambient air.

Only carry out this function if there is air in the filters.
Otherwise the gas is released into the atmosphere.

Warning

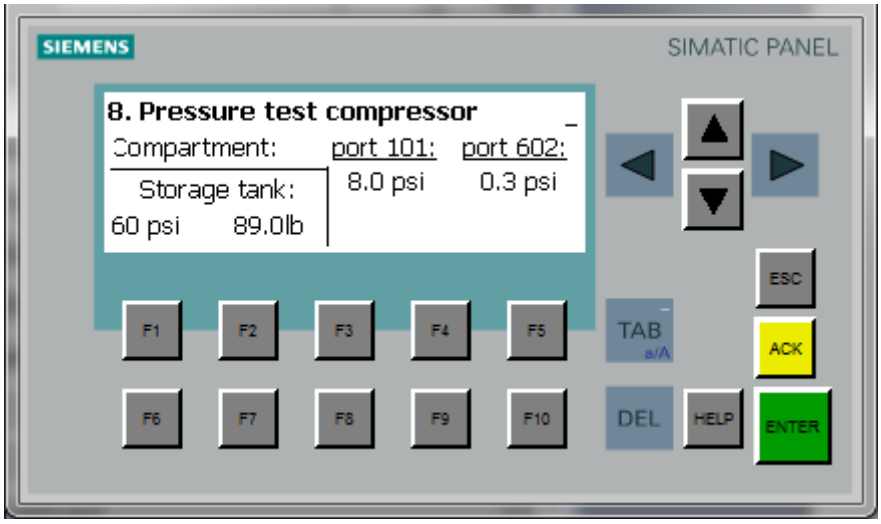


1. Select the “7: Evacuation of filter “ function by means of the knob switch.
2. Open the filling pressure reducer pos. 181.
3. Start the function by pressing the green “I” key.
4. If the filter is evacuated to the desired final vacuum (< 0.75 Torr) stop the function with the red “0” key.

Special functions for maintenance

8. Pressure test compressor

To check the compressor for correct function a pressure test has to be carried out.



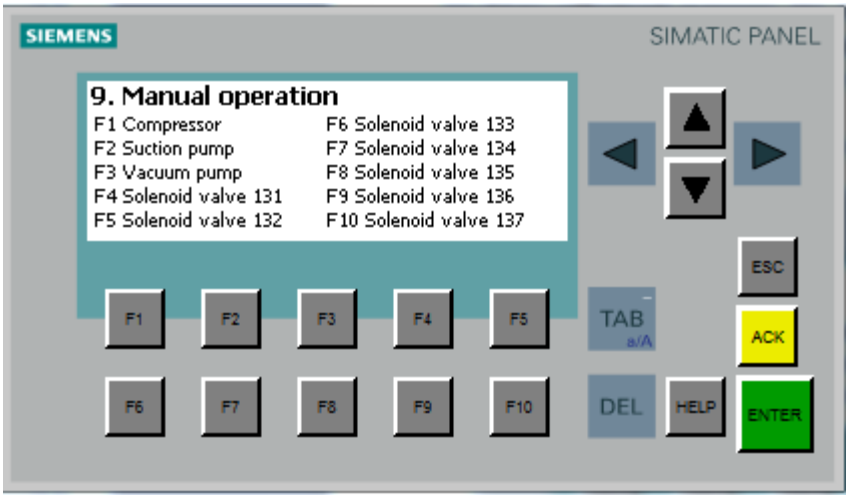
1. Select the “8. Pressure test compressor” function by means of the knob switch.
2. Connect the SF_6 gas cylinder to the coupling pos. 103 or open the ball valve (if available) to the pressure tank.
3. Start the function by pressing the green “I“ key.
4. Set the filling pressure reducer to p= 0 psig input pressure. The pressure can be read on the gas compartment pressure indication on the operating panel.
5. Observe the increase in pressure on the gauge pos. 162.
6. The function stops when reaching the final pressure. (Pressure value about p 696 psig).
7. After the test reduce the pressure by opening the solenoid valve pos. 134. This is carried out in manual operation.
8. If the indicated final pressure is not reached during the functional test the valve seats and piston rings must be checked (see operating instructions of the compressor).

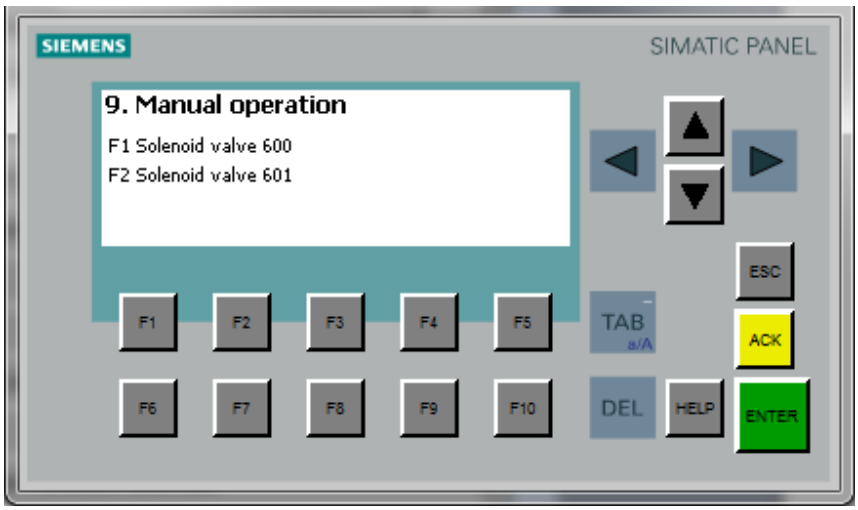
Special functions for maintenance

9. Manual operation:

Note

During the manual operation the **operator** is responsible for the correct gas handling.





Individual valves and components can be actuated in manual operation.

The device is equipped with four solenoid valves which are to be opened under certain conditions only (pos. 133, 132, 137, 601).
The solenoid pos. 133, 132 and pos. 601 cannot be opened under overpressure.
The solenoid valve pos. 137 only opens if the evaporator has reached its operating temperature.
These solenoid valves can only be preselected and open as soon as the corresponding conditions are fulfilled.
In case the solenoid valve pos. 137 is preselected or opened the evaporator is activated as well.

For detailed information on the manual operation please see chapter 2.

Special functions for maintenance

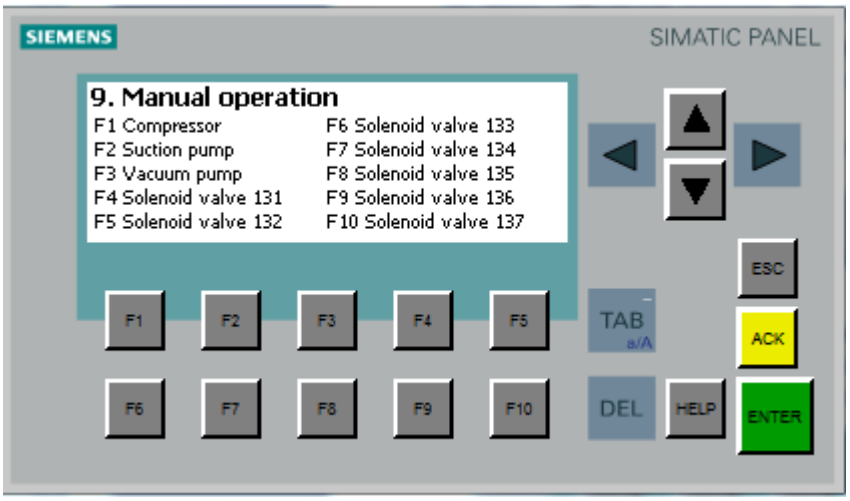
10. Evacuation of air from the service cart

The “Evacuation of service cart“ function is only to be carried out if there is air in the device (e. g. after maintenance works). The function can only be started if there is atmospheric pressure in the service cart. Check the pressure on the pressure indications.

Warning

Only carry out this function if there is air in the service cart.
Otherwise the SF_6-gas is released into the atmosphere.

The function has to be started via the manual operation.

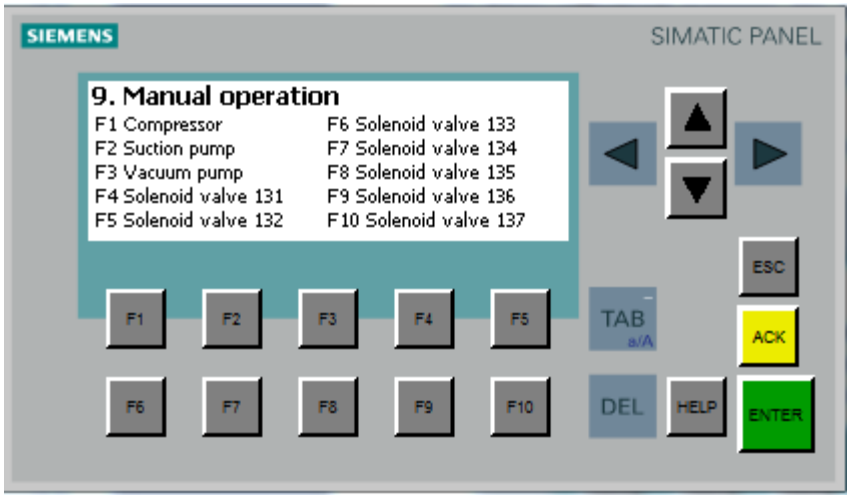


1. Open all solenoid valves.
2. Start the vacuum pump by means of the <F3> key.
3. If the device is evacuated to the required final vacuum (< 1mbar) stop the function with the red “0“ key.

Special functions for maintenance

11. Filling of external cylinders from the internal storage tank

The function is to be started manually.



1. Connect the SF_6 gas cylinder to the coupling pos. 105. The coupling is on the left side of the service cart. Open the cylinder valve on the SF_6 gas cylinder. Open the ball valve on the storage tank.

The connecting hoses must be evacuated or filled with SF_6-gas.

2. Start the compressor with the <F1> key.
3. Preselect the solenoid valve pos. 137 with the <F8> key. This solenoid valve only opens if the evaporator has reached its operating temperature.
4. The cylinder pressure can be read on the gauge pos. 162 (at coupling pos. 105).

Observe the filling weight of the storage tank (1kg/l)!

5. After having reached the desired filling weight in the SF_6 cylinders switch off the solenoid valve pos. 137 and the compressor by means of the corresponding keys on the operating panel.
6. Close the cylinder valve on the SF_6 gas cylinder. Establish pressure compensation in the device and disconnect the gas cylinder.

Fault correction

In case of malfunction or if the device cannot be started only authorized and qualified personnel should carry out maintenance and repair works.

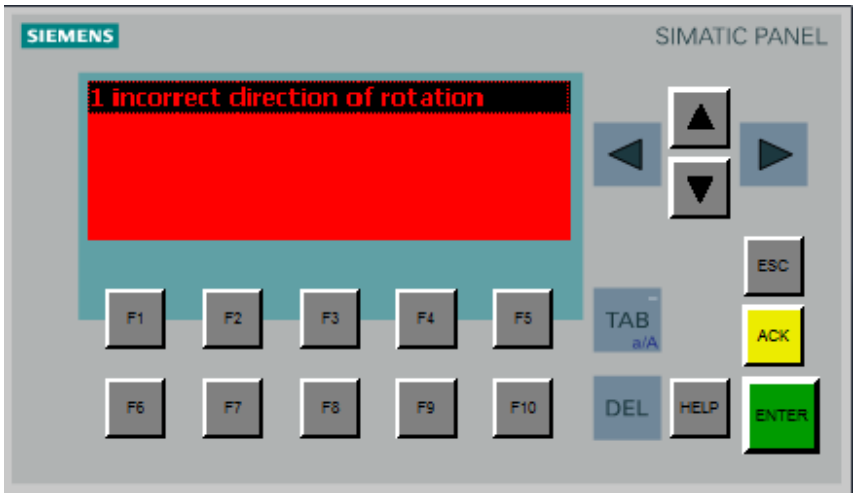
Inform your supervisor. Only trained and authorized personnel should eliminate malfunctions on electrical equipment (see chapter 1).

To avoid danger to life by electrical shock:

Danger

- **Only properly trained electricians should carry out maintenance and repair works on electrical equipment.**
- **The operator should only eliminate faults, which result from operating or maintenance errors.**

Malfunction indications and warning messages are displayed on the operating panel. The background colour of the display changes into red.



The following error messages are indicated on the operating panel:

- incorrect direction of rotation
- suction pump pressure to high
- vacuum pump pressure too high
- compressor pressure too high
- motor protection circuit breaker / Thermistor switched off
- sensor pos.301 interrupted
- sensor pos.302 interrupted
- sensor pos.304 interrupted
- sensor pos.305 interrupted
- sensor pos.306 interrupted
- sensor pos.603 interrupted
- sensor pos.604 interrupted
- bottle sensor interrupted
- lack of gas

After elimination of the cause of breakdown the “Overpressure vacuum pump“ and the “Gas lack“ error message must be reset by means of the red “0” key of the double key.

Fault correction

List of failure on the operating panel:

Error message	Possible cause of error	Correction
Incorrect direction of rotation	Phase failure, incorrect direction of rotation Defective phase sequence relay	Check the power supply. Change the position of the reversing switch Exchange the phase sequence relay
Vacuum compressor pressure too high	Pressure upstream or downstream from the vacuum pump too high	Reduce pressure as described under item “Recovery of SF_6 –gas“
Vacuum pump pressure too high	Pressure upstream from the vacuum pump too high	Reduce pressure as described under item “Recovery of SF_6 –gas“
Compressor pressure too high	Ball valve (valve) on the storage tank is closed Ball valve pos. 202 is closed Solenoid valves downstream from the compressor do not open	Check the ball valve (valve) on the storage tank Check the solenoid valves
Motor protection circuit breaker / Thermistor switched off	Overcurrent of a component Due to excess temperature the thermistor has switched off (red LED in the Thermistor lights up)	Check the motor protection circuit breaker Check the temperature of the compressor and let the compressor cool down if necessary. Check the Thermistor.
Sensor pos.301 interrupted	Defective pressure sensor pos.301 Cable is not connected.	Check the pressure sensor pos. 301 Check the sensor connection.
Sensor pos.302 interrupted	Defective pressure sensor pos.302 Cable is not connected	Check the pressure sensor pos. 302 Check the sensor connection.
Sensor pos.304 interrupted	Defective pressure sensor pos.304 Cable is not connected.	Check the pressure sensor pos. 304 Check the sensor connection.
Sensor pos.305 interrupted	Defective pressure sensor pos.305 Cable is not connected.	Check the pressure sensor pos. 305 Check the sensor connection.
Sensor pos.306 interrupted	Defective pressure sensor pos.306 Cable is not connected.	Check the pressure sensor pos. 306 Check the sensor connection.
Sensor pos.603 interrupted	Defective pressure sensor pos.603 Cable is not connected.	Check the pressure sensor pos. 603 Check the sensor connection.
Sensor pos.604 interrupted	Defective pressure sensor pos.604 Cable is not connected.	Check the pressure sensor pos. 604 Check the sensor connection.
Bottle sensor interrupted	Defective DMS measuring transducer.	Exchange the DMS measuring transducer.
Lack of gas	Storage tank is empty Storage pressure < 2bar Ball valve on the storage tank is closed	Check the pressure in the storage tank (fill the storage tank) Check the position of the ball valve

Fault correction

List for other breakdowns:

Error message	Possible cause of error	Correction
The compressor does not reach any high output pressure	The incorrect solenoid valves are opened. Defective piston rings and valve seats	Check the position of the solenoid valves. Check the compressor according to the operating instruction “Pressure test”
The indicated final vacuum of 0.75 Torr is not reached during the recovery process	The solenoid valves on the suction side are closed. The suction pump does not switch on. Leak on the recovery line. Defective suction pump. Defective regulating valves.	Check the position of the solenoid valves. Check the corresponding pressure switches. Check the recovery line. Check the pump (sounds, temperature and current consumption) Check the movement of the regulating valve
The vacuum pump does not reach the final vacuum	Solenoid valve upstream from the vacuum pump is closed Not enough oil Incorrect oil Humidity in the oil (white colour of the oil) Defective vacuum controller or sensor	Check the position of the solenoid valves. Refill oil Exchange oil and filter Exchange oil and filter Exchange vacuum controller or sensor

“1999" indication on the temperature regulating device	Interruption or short-circuit in the temperature sensor or in the connecting cable	Check the resistance of the connected PT-100-sensor (~ 100Ω at 20°C)
The evaporator does not heat	Due to excess temperature the safety temperature limiter has switched off	Press in the blue button of the safety temperature limiter (see label in the terminal box of the evaporator) Check the temperature control of the evaporator.

Maintenance and functional test

Maintenance

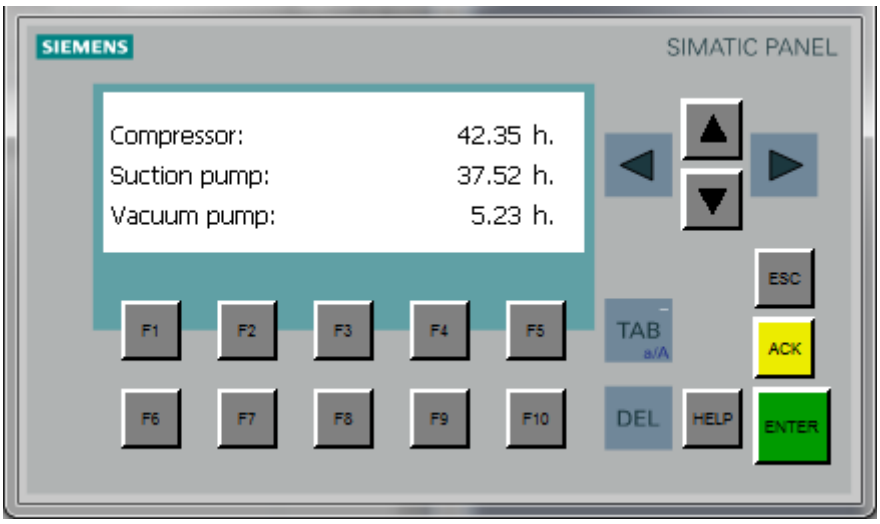
Only authorized personnel should carry out purification, lubrification and maintenance works in accordance with maintenance instructions and regulations for the prevention of accidents.
In case of non compliance this could result in injury or death and also considerable damage to the equipment.

Carry out maintenance works only if the device is switched off.

Danger

- Touch hot components (e. g. evaporator, pump parts) only after they have cooled down!
- Ensure that used oils and filter materials are disposed of in accordance with local environment regulations.
- When working with harmful materials (e. g. filter cartridge) the working protection set should be used (DILO-working protection set 3-442-R...)
- Exchange filters which contain or are saturated with decomposition products.

The operating hours of the individual components can be displayed on the operating panel (see chapter 2)



When reaching a maintenance interval the maintenance is to be carried out in accordance with the maintenance schedule.

Maintenance and functional test

General operating instructions for hoses

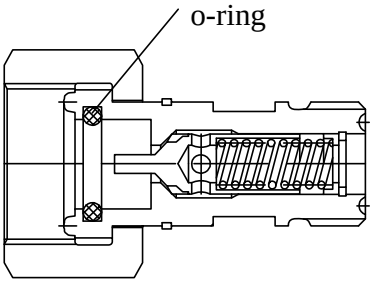
1. Period of use for rubber hoses: 6 years (see DIN 20066)
   The hoses used at service carts should be checked for tightness once a year. For this purpose the following two tests should be carried out:

a) Pressure test
   Connect the hose so that there is a pressure indication on the gauge. The hose must be pressurized. Look at the gauge, no pressure drop should occur.

b) Vacuum test
   Connect the hose to the vacuum pump. Interconnect suitable vacuum gauge. Produce vacuum. After having switched off the vacuum pump, the vacuum indication should remain unchanged at constant room temperature.

2. The DILO-coupling tongue parts DN8 and DN20 are equipped with an O-ring which is to provide an external seal during the coupling process. As the O-ring is used for each coupling process and because of abrasion, it should be replaced from time to time.

3.



O-ring for coupling tongue part DN8:
order no.: 05-0057-R024
dimension: ID 13.95 x W 2.62 EPDM

O-ring for coupling tongue part DN20:
order no.: 05-0057-R010
dimension: ID 20.29 x W 2.62 EPDM

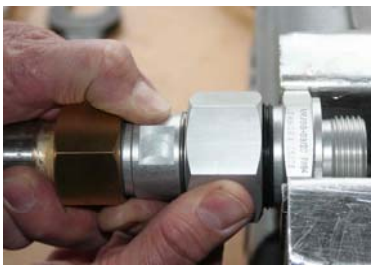
O-ring for coupling tongue part DN40:
order no.: 05-0057-R141
dimension: ID 44.12 x W 2.62 EPDM

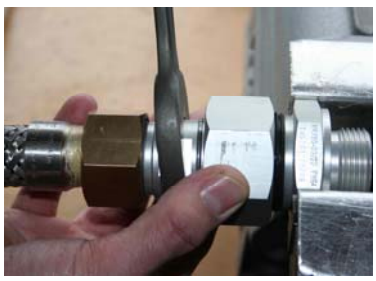
4. In order to protect the connecting hose and the piping system from contamination by decomposition products, we recommend using a **pre-filter unit.**

Attention:

When coupling it is absolutely necessary to use counteracting force on the coupling tongue part to avoid “turning“ of the coupling body.

This can be done by hand or by using a wrench. Please see pictures.





Maintenance and functional test

Preventive maintenance

Component	Maintenance interval operating hours	Object	Maintenance work
Compressor	every 500 hours or every year	piston and guide rings valve seats	carry out pressure test
	every 1500 hours	piston and guide rings valve seats	check, measure, exchange if necessary
	every 2500 hours	crank gear non return valve	exchange check and exchange if necessary
Suction pump	every week	noises, heating	check
	every 8000 hours	Tip Seals	exchange
Vacuum pump	daily or prior to each operation	oil level	check
	every 500 hours or every year	oil, oil filter exhaust filter	exchange functional test
Dry filter	after filtering of contaminated gas, after saturation of the filter (measurement downstream from the filter)	filter cartridge or filter content	exchange
Particle filter	check during each exchange of the dry filter	filter cartridge	exchange if necessary

Maintenance and functional test

Functional test of the service cart

We recommend checking the service cart functions and for faults once a year or not later than the maintenance interval indicated.

Compressor:

The compressor can be tested for its functional capability with the “Pressure test compressor“ special function (see chapter 6)

Suction pump: Verification of the function and the final vacuum

Do not connect any gas compartment.

Start the “Recovery of SF_6“ main function.

The pressure on the suction pump is controlled by two pressure switches.

If the suction pressure is less than pe 0.1 bar the suction pump starts running and the solenoid valve upstream from the suction pump opens. When exceeding one of these switching points the suction pump switches off and the solenoid valves close.

The compressor is still running.

The lower the output pressure the more the regulating valve opens.

Check the final vacuum on the pressure indication of the gas compartment and stop the gas recovery.
If the indicated final vacuum (< pa 1 mbar) is not reached also follow the instructions in chapter 8 “Fault correction”.

Vacuum pump:

Uncouple the connecting hose from the service cart.
Start the “Evacuation“ main function.
Open the filling pressure reducer pos. 181 (set the max. filling pressure).

The vacuum pump and the vacuum controller must have reached their operating temperatures (operating time about 15 minutes).

If the vacuum is less than 1 mbar stop the function.
(operating time about 15 min.)

Observe the vacuum on the vacuum controller. After 15 minutes the increase of pressure with the vacuum pump being stopped should be less than 5 mbar.

Evaporator:

To allow the temperature probe in the evaporator to react quickly on the temperature changes there should be SF_6-gas overpressure in the evaporator and no vacuum.

Preselect the “Filling“ function.

Start the automatic “Filling“ function.

The evaporator heating is controlled by a temperature regulating device.

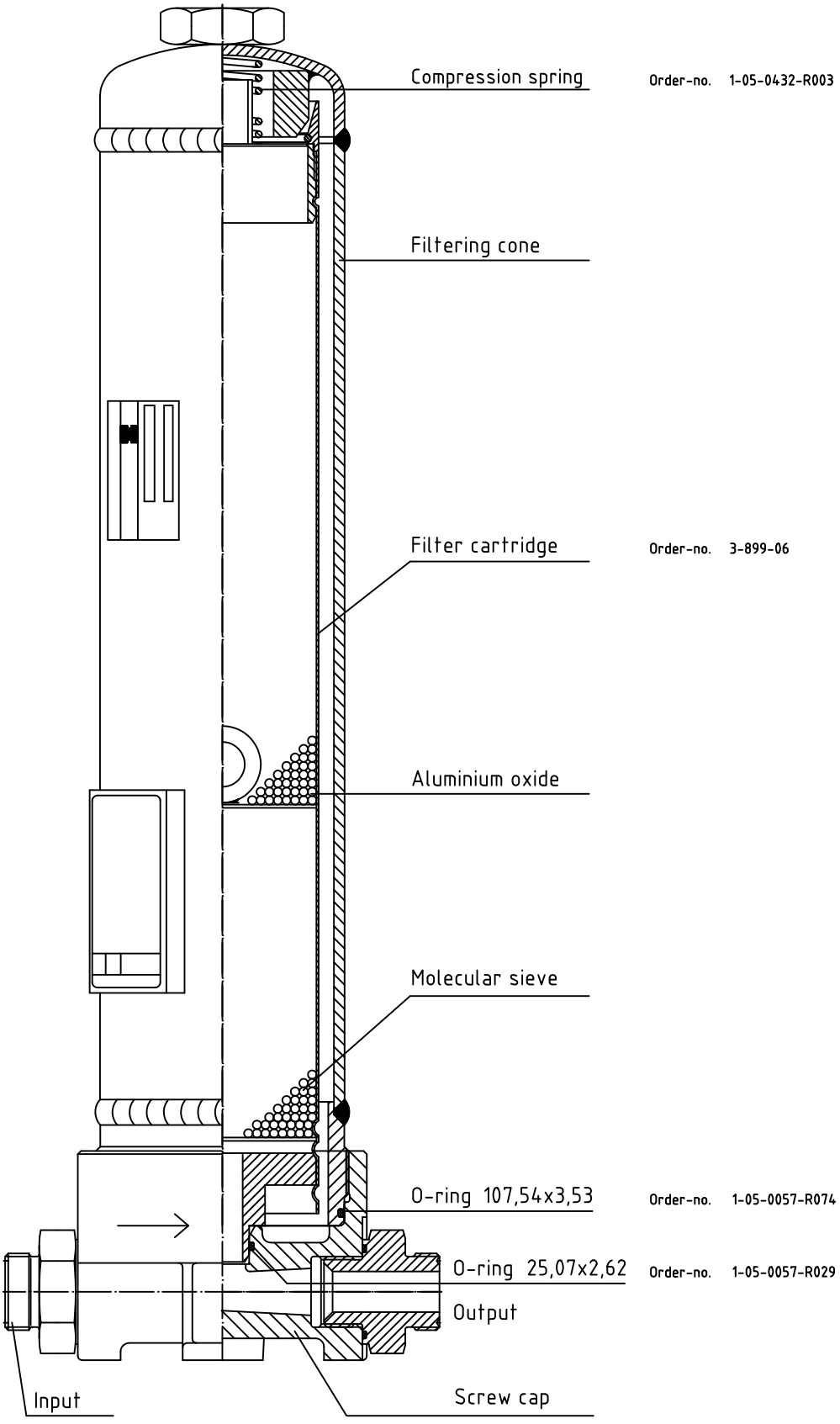
The solenoid valve on the input of the evaporator, which releases the gas flow, is also controlled via the temperature regulating device (The solenoid valve opens as soon as the evaporator has reached its adjusted temperature).

Maintenance and functional test

Spare parts list:

Piece	Designation	Article-no.
	TM 5,0 B compressor	
1	see operating instructions of the TM 5,0 B compressor	6-1010-R011
	vacuum pump (standard version) **3-690-R007** (40m³/h, < 1mbar)	
1	Spare filter kit	6-1047-R011
2	1 litre vacuum pump oil VM 100 (ISO VG100)	3-690-R201
1	gasket kit	6-1047-R024
	vacuum pump 3-690-R008 / R009 vacuum pump (63 / 100m³/h, < 1mbar) **6-057VP-R001 / 6-057VP-R002**	
1	Spare filter kit	6-1047-R012
2	1 litre vacuum pump oil VM 100 (ISO VG100)	3-690-R201
1	gasket kit	6-1047-R025
	vacuum pump 3-745-R004 (40m³/h, < 2x10⁻³mbar) **6-057VP-R004**	
1	maintenance kit	6-1049-R032
1	exhaust filter	6-1049-R011
3	1 litre (LVO100) vacuum pump oil	3-745-R201
1	gasket kit	6-1049-R002
	3-899-R002 dry filter	
1	spare filter cartridge for dry filter	3-899-06
	Partikelfilter 3-377-R001/R020 particle filter	
2	spare filter cartridge for particle filter DN20	3-377-08
	L057	
1	Spare parts kit for general parts	6-1048-R019

Dry filter revision | 3-899-R…



Use of the filter

The dry filter is provided for treating sulphur hexafluoride (SF_6). The use for other purposes should be agreed with the manufacturer.

max. operating pressure	see type plate
max. operating temperature	see type plate

The dry filter is a pressure vessel and is subject to the Pressure Vessels Directive CE 97/23.
It is classified in the category II in accordance with the Directive (if it is used for the purposes for which it is intended). Prior to setting the filter into operation it should be equipped with the required safety equipment such as gauge and safety valve or connected to non-blockable tube lines. These parts are not included in the scope of supply.
Prior to setting the filter into operation it must be approved in accordance with the legal regulations which are in effect. The operator is responsible for carrying out regular checks according to local laws and regulations which are in effect. Only use the filter under the indicated pressure and temperature limiting values. These values must not exceed or be lower than the limiting values.

Installation instructions

The flow direction of the filter should be observed.

The filter can be installed in a vertical or horizontal position.

The filter is to be installed and fixed so that it will not be damaged by vibrations. Furthermore, there should not be any tensile force on the filter housing and the tube lines.

The filter housing must not be exposed to fluids or very humid and corrosive medium. If so, exchange the desiccative immediately and check the housing parts for corrosion and replace them if necessary. Carefully remove the penetrated humidity from the housing parts. If decomposed SF_6 is in the filter it could be warmed by physical and chemical reactions. In this case the flow should be blocked or reduced so that the temperture of the filter housing does not exceed the admissible operating temperature.

The housing parts which are under pressure must not be worked on mechanically and welded.
The type plate should not be modified, made illegilbe or removed.

Dry filter revision | 3-899-R…

1. Description

The dry filter serves for adsorbing moisture and decomposition products out of SF_6-gas.
An exchangeable filter cartridge is installed in the dry filter.
The filter cartridge consists of a tube filled with approx. 2.3 kg (5 lbs) desiccative. At the input side there is the aluminium oxide, at the output side the molecular sieve.

1.7 kg (3.8 lbs) aluminium oxide Al_2O_3 pore size 20-50 Angström, granular size 2 - 5 mm
0.6 kg (1.3 lbs) molecular sieve pore size 4 Angström, granular size 4 mm (0.08 to 0.2 in)

This filter mixture proved to be the best for the adsorption of moisture and decomposition products.

With the filter cartridge a dew point temperature of below -50 °C (-58 °F) can be obtained within one drying process.

The throughput is one of the decisive factors for the optimum drying effect.
As the filtering is based on the adsorption the adsorbability for humidity and decomposition products depends on the concentration of these substances on the input, on the contact time with the filter as well as on the degree of saturation of the filter.

The throughput of a filter unit is raised by using several filter units in parallel, however not in series because the filter material needs a minimum contact time with the gas, in order to enable an adsorption.

The desiccative can absorb approx. 120 g (4.2 ounzes) water without the residual moisture of the gas behind the filter exceeding 10 ppm_m (= -44 °C dew point temperature at p_a = 1 bar).
(= -77.2 °F dew point temperature at atmosphere)

SF_6 gas molecules can decompose to fluoride and sulphur-fluoride compounds because of discharges or high temperatures. Normally these substances recombine to SF_6 again. However, if water and other substances exist at the same time the recombination is not complete and gaseous residues, the decomposition products, are left behind. If metals exist also metallic fluorides can arise in form of dust.
The following gaseous decomposition products appear most frequently beside others in used SF_6-gas:

HF	hydrogen fluoride
SO_2	sulphur dioxide
SOF_2	thionyl fluoride
SO_2F_2	sulfuryl fluoride
SF_4	sulfur tetrafluoride

With the dry filter 3-899 these gaseous decomposition products can be adsorbed.

The solid particles that can be found in the decomposed SF_6 like tungsten trioxide (WO_3), cupric fluoride (CuF_2) and others are effectively retained in particle filters 3-377-R001 that are placed behind.

The absorbing capacity of the filter cartridge for decomposition products is different and depends on the substance. For sulphur dioxide (SO_2) and thionyl fluoride (SOF_2) it is about 15-20 % by weight, that means 90-120 g (2.6 - 3.9 ounces) for each filter cartridge.

Note:

The absorption of humidity and decomposition products generates an exothermic reaction in the filter. Therefore a dry filter can become hot if these substances are fed in high concentrations.

2. Revision intervals

There is no formula to determine the revision intervals generally as it depends on the substances the filter is fed with. Therefore it is important to control the efficiency of the dry filter from time to time using a moisture measuring device and a decomposition products measuring device.

a) If it is known that the dry filter had been admitted with decomposed SF_6 the filter cartridge must be exchanged in any case.

b) Example: When drying SF_6 a dew point temperature of less than -50 °C (-58 °F) is obtained with a practically new filter cartridge.
A dew point temperature of -20 °C (-4 °F) is measured for SF_6-gas, filled into a storage tank. Now the question is: How much SF_6 can be dried to a dew point temperature of less than -50 °C (-58 °F) with one filter cartridge?

A dew point temperature of -20 °C (-4 °F at atmosphere) at 1 bar is 1000 ppm_V and thus $\frac{1000}{8,1} = 123,5$ ppm_m. Thus the moisture content of the gas is 123.5 mg/kg. With one filter cartridge can therefore be dried a gas quantity of $\frac{120g}{0,1235\frac{g}{kg}} = 971$ kg (2140 lbs) .

c) If the filter had been charged with decomposed SF_6 as a consequence of max. 1.700 kJ arc energy (= arc current x arc voltage x duration of the arc) the filter cartridge must be exchanged. Investigations showed that SOF_2 is the most abundant decomposition product as a consequence of electric arcs and spark discharge. Other decomposition products appear in considerably lower concentrations. The production rate of SOF_2 directly depends on the arc energy that affects the SF_6. If SF_6 that was exposed to such an arc energy had been led over a dry filter the filter cartridge has to be exchanged.

d) If a moisture of more than -50°C (-58 °F) dew point temperature is detected at a throughput of not more than 1 kg/min (2.205 lbs/min) the filter cartridge must be exchanged as the dry filter will soon be exhausted if only a small quantity of moisture is additionally absorbed.

The proof that decomposition products are retained in the filter cartridge can be furnished by a comparison measurement between the input and the output side with a decomposition products measuring device. If it is already known that the SF_6 the filter is fed with contains decomposition products a measurement at the output of the filter is sufficient in order to detect the retaining.

If decomposition products (more than some ppm_V) are detected at the output the filter cartridge must immediately be exchanged as the filter will soon be exhausted in case of further absorption of decomposition products.

Note:

We recommend not to effect a regeneration of aluminium oxide or molecular sieve by heating up or vacuum drying as vapours that are injurious to health and ecologically harmful can be set free. Furthermore this method is very cost-intensive and there is no proportion to the use of new material.

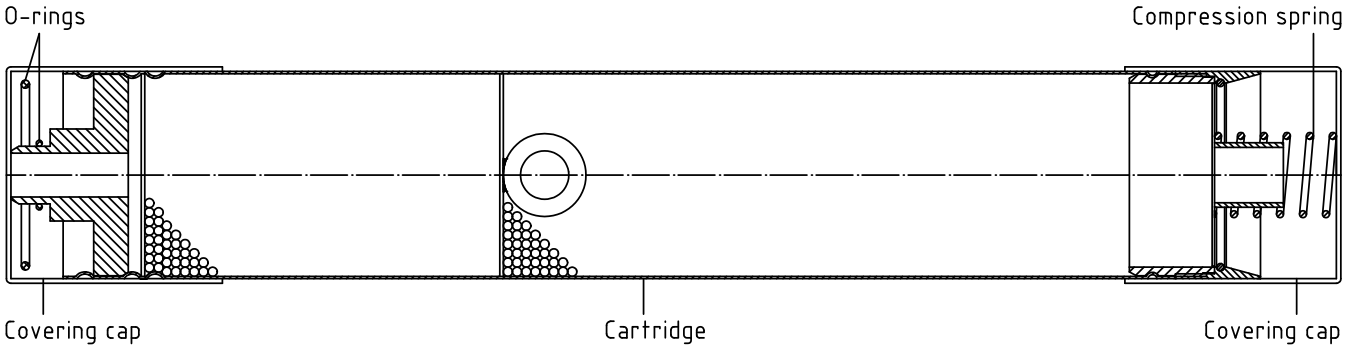
3. State at delivery, control, storage:

The filter cartridge is delivered airtight sealed.

Before using the filter cartridge check if the covering caps are still tight and not damaged. Only use filter cartridges which are delivered in perfect packing.

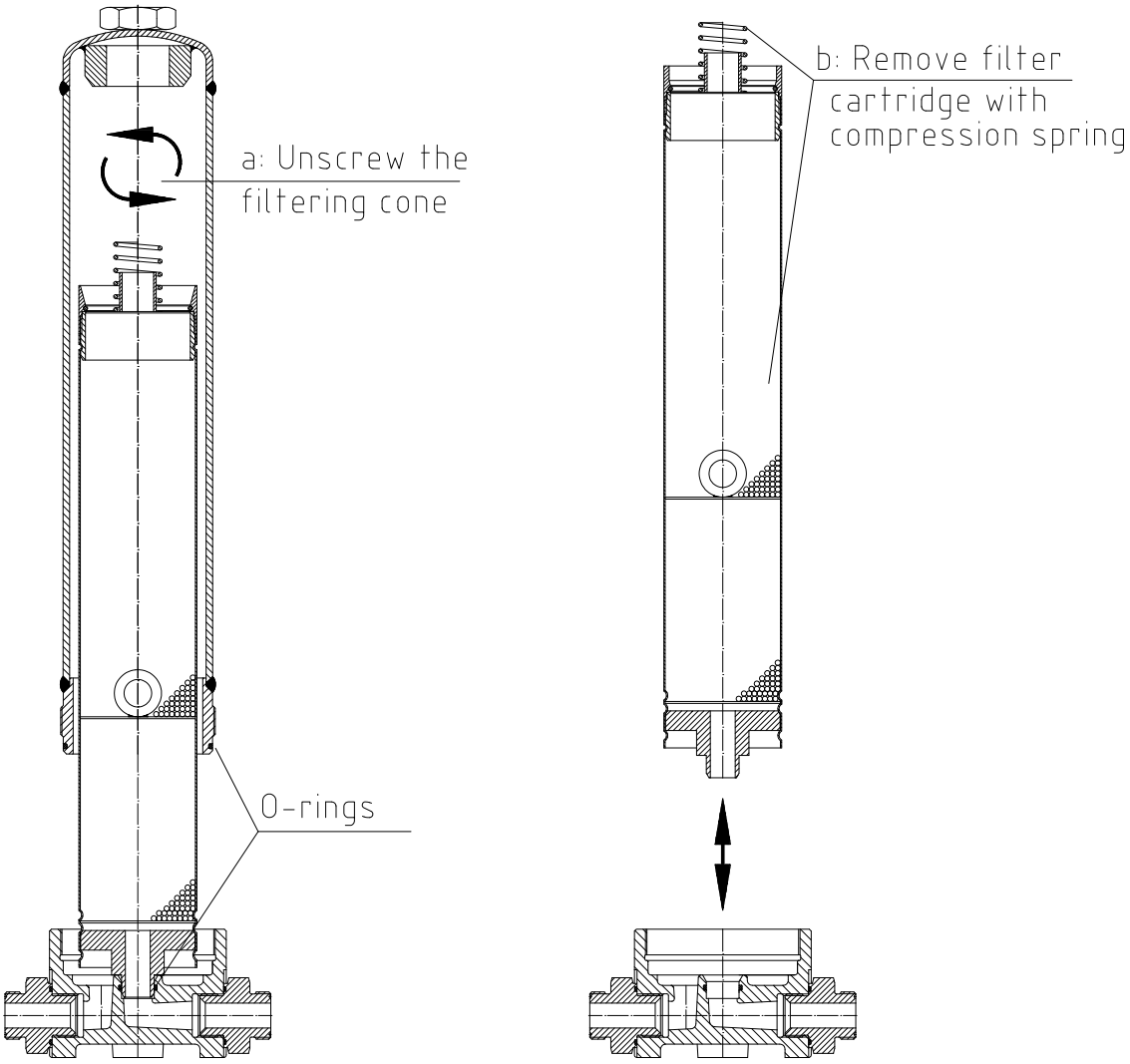
Store the filter cartridges in dry rooms. Remove packing and sealing caps only short time before the installation.

Scope of supply of the filter cartridge



4. Exchange of the filter cartridge

Attention: Depressurize the dry filter before dismounting the filter cartridge.
Pay attention to the protective regulations concerning the handling of SF_6 gas [1].



c: Remove the sealing caps of the new filter cartridge.

d: Exchange both O-rings. Slightly grease threads and O-rings with a suitable sliding means (e.g. silicone grease).

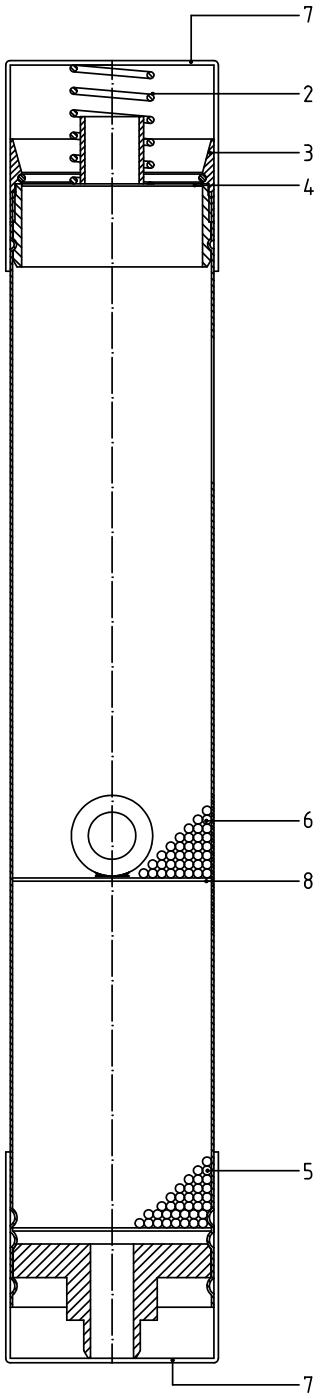
e: Put the filter cartridge with compression spring in the screw cap as illustrated.

f: Screw in the filtering cone until the stop.

Attention: The dry filter must be evacuated before putting it into operation.

5. Exchange of the desiccative of the filter cartridge

Attention: When exchanging the used desiccative avoid any contact.
Do not blow up dust. Work in a well ventilated room or outdoors. Before opening the filter cartridge corresponding protective measures have to be taken, see our working protection set 3-442.



Please observe:

- The DILO-refilling device 3-834-R002 should be used for the exchange of the used desiccative (to be ordered separately).
- Remove the sealing caps (pos. 7).
- Remove the spring (pos. 2).
- Unscrew the threaded ring (pos. 3) by using a strap wrench 1-05-1196-R001 (to be ordered separately)
- Remove the perforated plate (pos. 4).
- Fill the desiccative into a plastic packing and seal it tightly. Observe that for this the perforated plate (pos. 8) is removed and will be kept until refilling.
- Clean the interior space of the filter cartridge with a fibreless piece of cloth.
- Fill with new desiccative in a dry room. Dust abrasion and absorption of moisture by ambient air are avoided if one lets flow N_2 with slight overpressure (max. pe 0.5 bar) from the bottom through the filter cartridge that is put upright during the filling process.
- Filling process:
  Fill 1/3 of the cartridge with molecular sieve (pos. 5). Compress the desiccative by slightly knocking (rubber mallet) until it does no longer sink.
  Then insert the perforated plate (pos. 8).
  Fill in aluminium oxide (pos. 6) until the top edge of the cartridge, compress and refill until it does no longer sink.
  (Desiccative - packed in tins - can be ordered under the following order-no.: 3-899-07.)
- Clean the thread (lubricate with the "Molykote" spray D-321R)
- Put on the perforated plate (pos. 4) and screw on the threaded ring (pos. 3).
- Insert the spring (pos. 2).
- If the installation into the dry filter is carried out later the sealing caps (pos. 7) must be plugged on to avoid that ambient moisture is absorbed.

6. Disposal of filter cartridge and desiccative

Attention: If the used filter cartridge is left until disposal both sealing caps must be plugged on so that decomposition products cannot desorb because of absorption of air moisture in the course of time.

The material is waste that must be controlled and for further disposal it has to be treated according to the regulations for the control of waste and recycling valid in your country.

Furthermore it is possible to neutralize the desiccative and to dispose it afterwards, for this see our working protection set 3-442.

7. Bibliography:

[1] SF_6-Anlagen, BGI 753
Berufsgenossenschaft der Feinmechanik und Elektrotechnik,
Gustav-Heinemann-Ufer 130, Köln

Conversion for SF_6 gas

8.1 ppm_V = 1 ppm_m

1 ppm_m = 1 mg/kg

1 Angström = 10^{-10}m

Particle filter revision | 3-377

1. Filter cartridge

The particle filter is intended for filtering solid particles and solid decomposition products out of SF_6 gas. Gaseous decomposition products can be adsorbed by a dry filter 3-376.

The filter cartridge is folded to a cylinder with star-shape section.

The result of this arrangement of the surface is a large filtration surface (0.12 m^2 / 1.3 sq. f.), that makes possible a long service life.

A retention rate of 100% is obtained from a particle size of ≥ 1.0 µm

2. Revision intervals

The exchange of the filter cartridge in the particle filter should be carried out together with the exchange of the cartridge of the dry filter or when performing a revision of the compressor.

3. Exchange of the filter cartridge and disposal

Attention: Depressurize the particle filter before dismantling the filter cartridge.
Pay attention to the protective rules concerning the handling of SF_6 gas [1].

- Unscrew the filtering cone
- Remove the filter cartridge
- Clean the interior space of the filter cone with a fibreless piece of cloth
- S l i g h t l y grease the o-ring in the new filter cartridge and the o-ring in the filter cone as well as the thread with a suitable sliding means
- Push the new filter cartridge on the guide pipe in the screw cap (do not forget the compressing spring!)
- Screw in the filter cone until the stop

Attention: The particle filter must be evacuated before putting it into operation.

Attention: If the filter cartridge is left until disposal it has to be put into a plastic packing and sealed tightly. Thus the decomposition products are no longer set free.

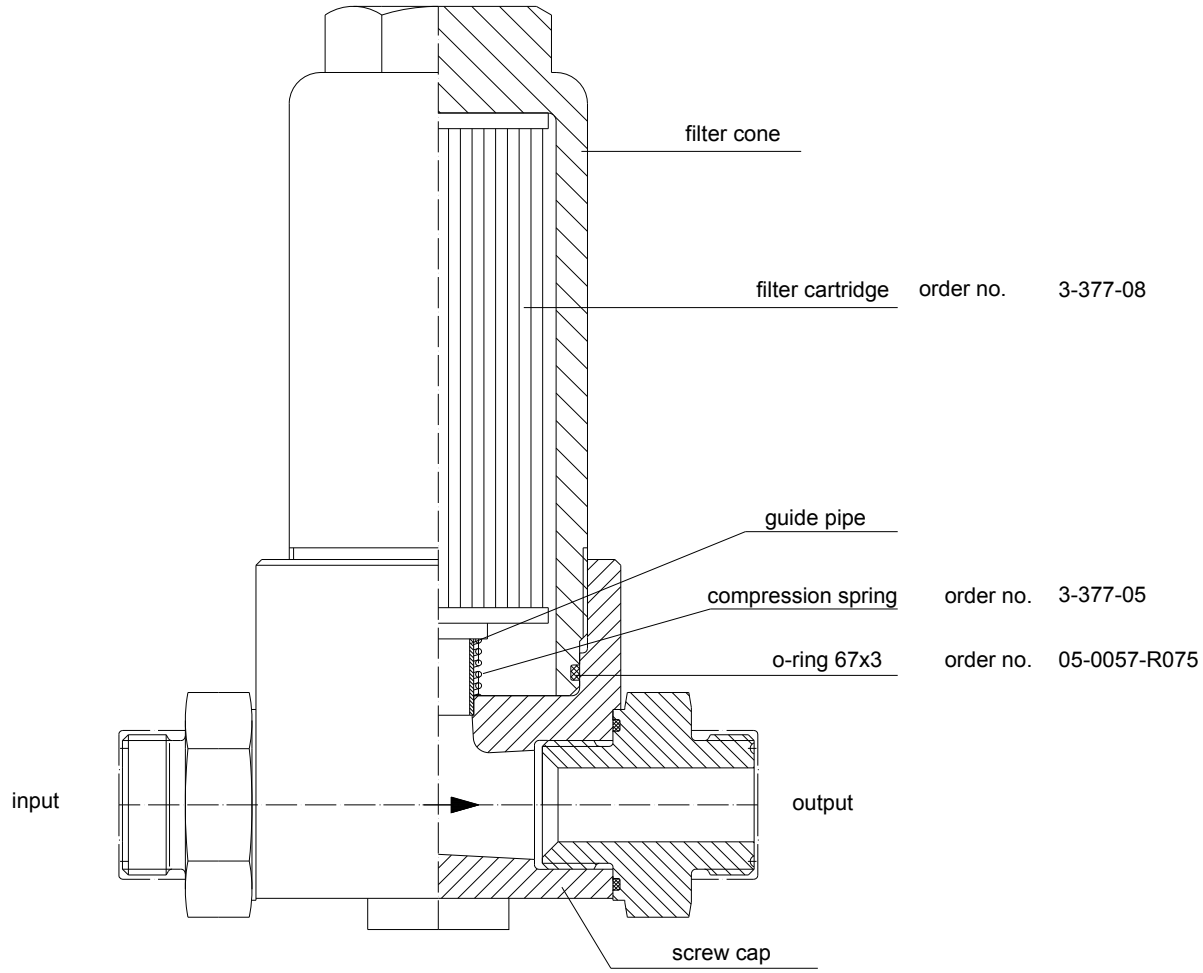
The material is waste that must be controlled and for further disposal it has to be treated according to the regulations for the control of waste and recycling valid in your country.

Furthermore it is possible to neutralize the filter cartridge and to dispose it afterwards, for this see our working protection set 3-442.

Note:

Normally polluted or unused filter cartridges that are not charged with decomposition products are unrisky and can be disposed as usual rubbish.

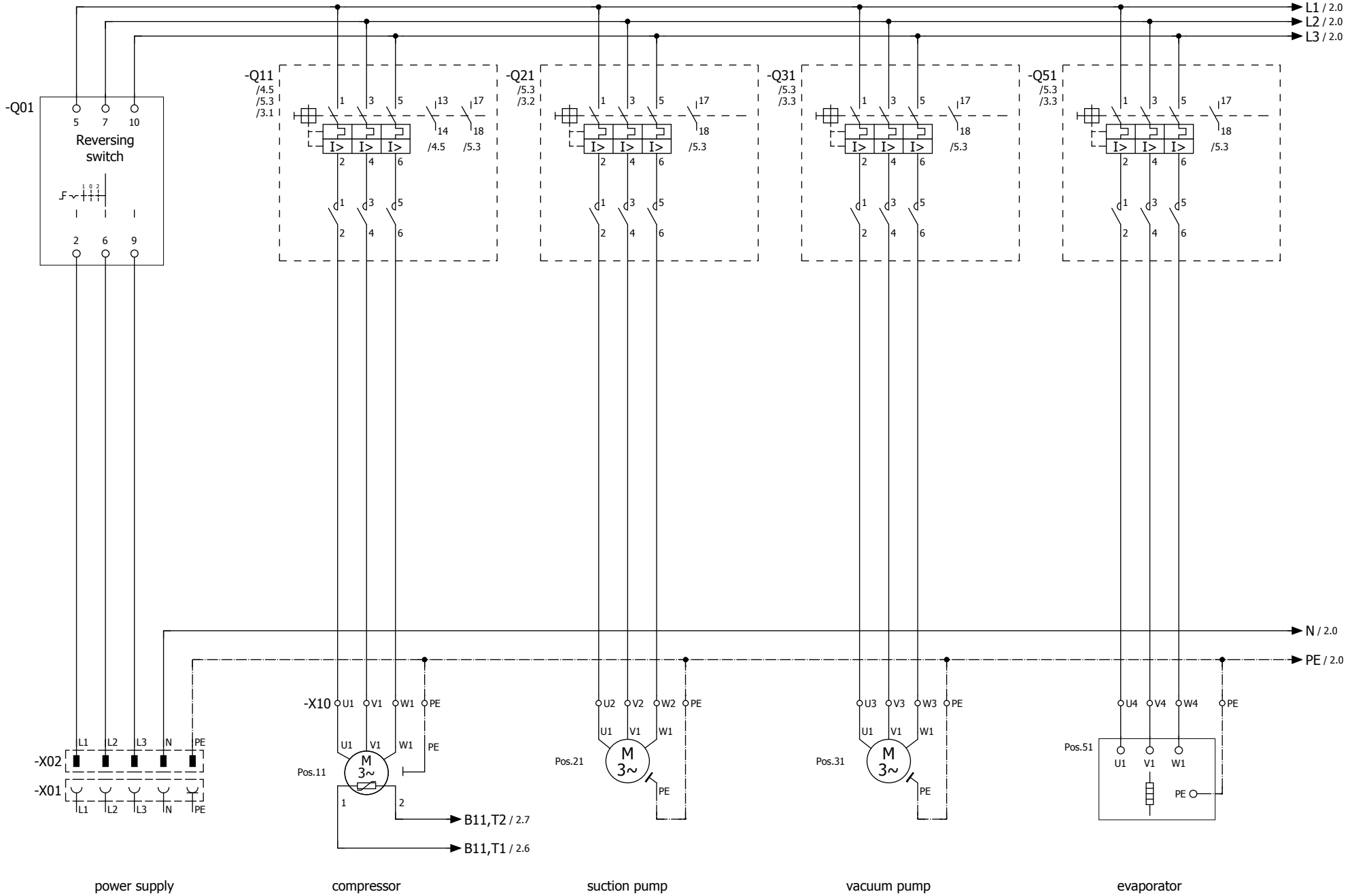
4. Particle filter



5. Bibliography

[1] SF_6-Anlagen, BGI 753
Berufsgenossenschaft der Feinmechanik und Elektrotechnik,
Gustav-Heinemann-Ufer 130, Köln

Abt.	Nr.	Anz.
TB	1	1
AV	2	
Betr	3	
Betr	4	
Betr	5	
Betr	6	
Betr	7	
AB	8	1
VM	9	
MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
dxf	16	
KE	17	
GF	18	
MT	19	
DX	20	



Modification	Date	Name

	Date	Name
gez	28.07.2014	deilt
gepr./frei		

power supply
main circuit diagram

service cart

DILO **Z863R01-01S**
D-87727 Babenhausen

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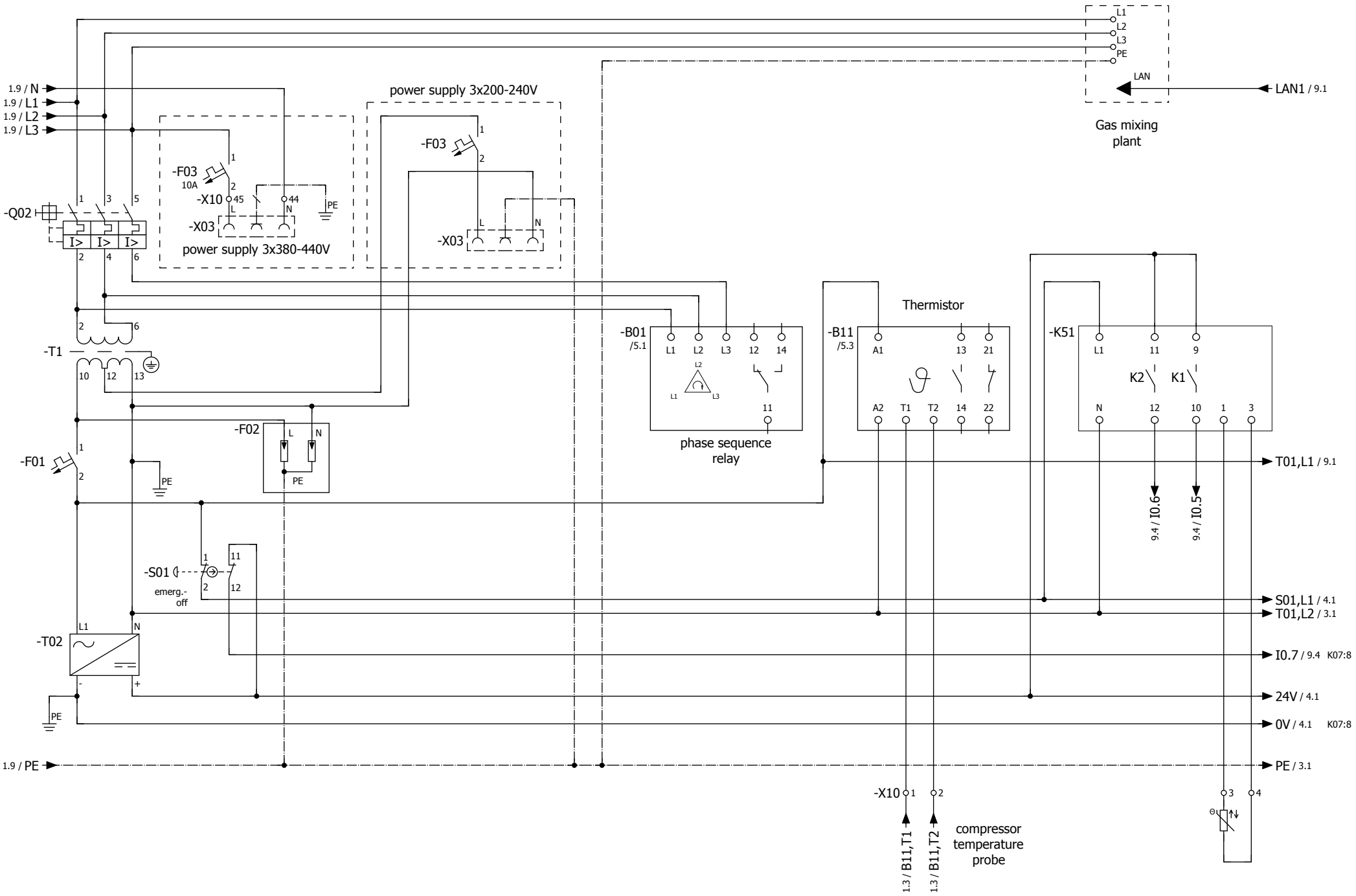
Page 1 / 9



Abt.	Nr.	Anz.
TB	1	1
AV	2	
Betr	3	
Betr	4	
Betr	5	
Betr	6	
Betr	7	
AB	8	1
VM	9	
MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
dxf	16	
KE	17	
GF	18	
MT	19	
DX	20	

Modification	Date	Name
04 Umstellung Wägetechnik	26.03.14	mo
03 Umstellung Steckdose 380V - 440V	18.02.14	mo

	Date	Name
gez	28.07.2014	deilt
gepr./frei		

control circuit diagram

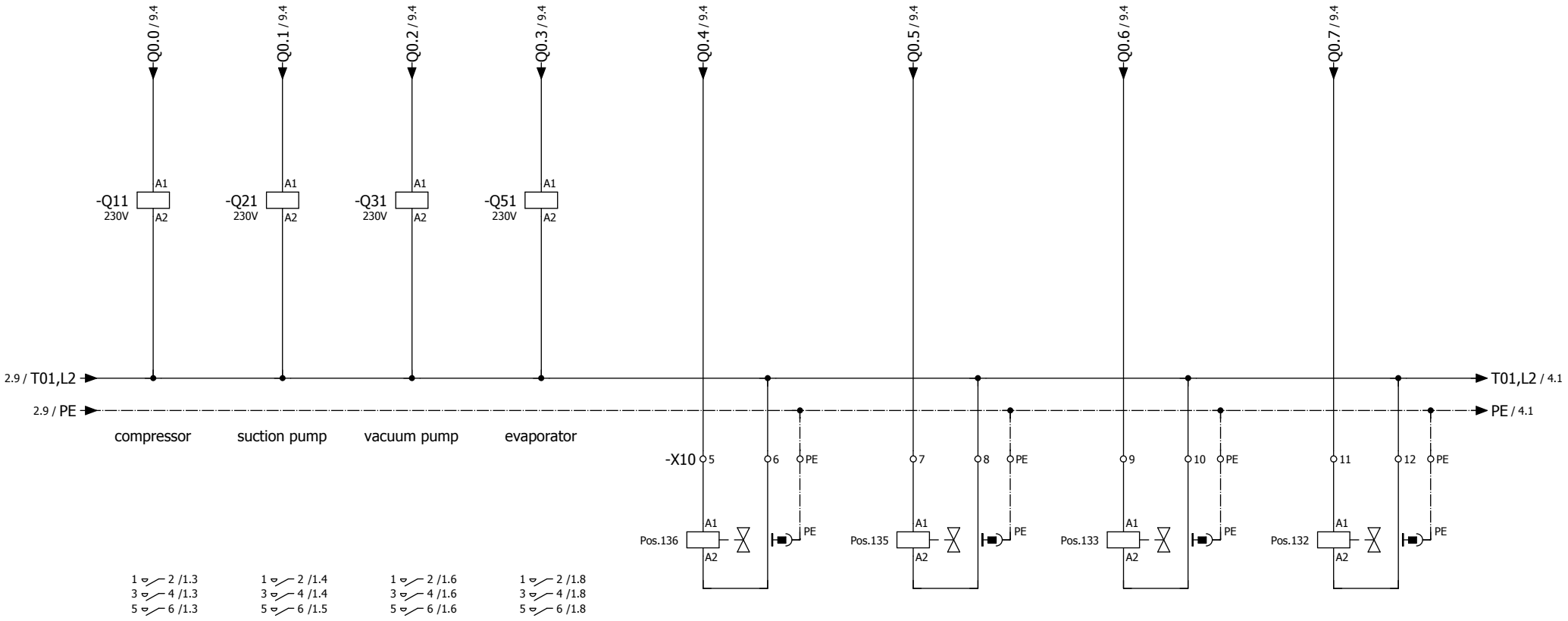
service cart

DILO **Z863R01-01S**

D-87727 Babenhausen

= Anlage
+ Ort
Page 2 / 9

Abt.	Nr.	Anz.
TB	1	1
AV	2	
Betr	3	
Betr	4	
Betr	5	
Betr	6	
Betr	7	
AB	8	1
VM	9	
MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
dxf	16	
KE	17	
GF	18	
MT	19	
DX	20	



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4

Modification	Date	Name

	Date	Name
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control circuit diagram

service cart

Z863R01-01S

D-87727 Babenhausen

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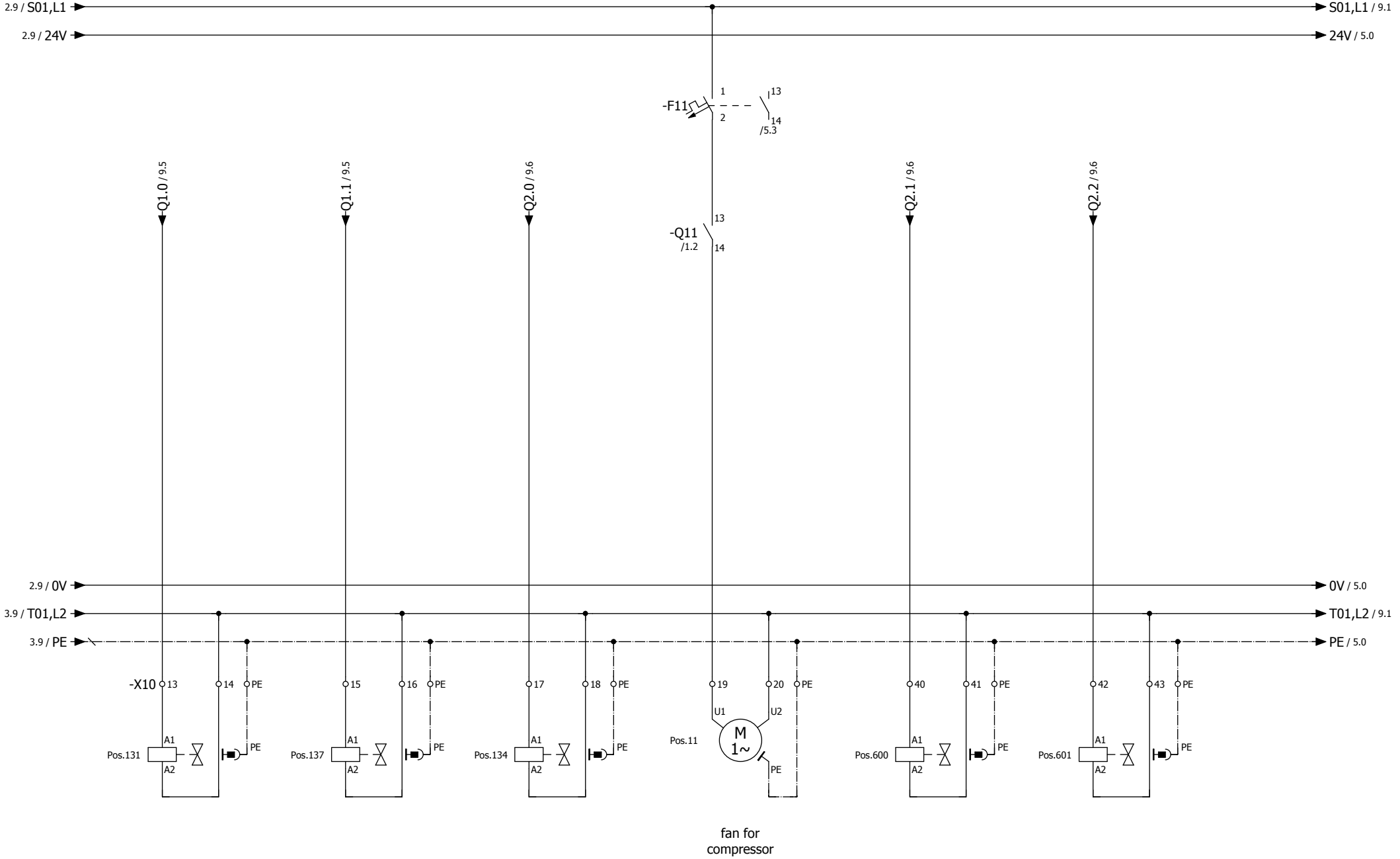

fan for
compressor

Abt.	Nr.	Anz.
TB	1	1
AV	2	
Betr	3	
Betr	4	
Betr	5	
Betr	6	
Betr	7	
AB	8	1
VM	9	
MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
dxf	16	
KE	17	
GF	18	
MT	19	
DX	20	

Modification	Date	Name

	Date	Name
gez	28.07.2014	deilt
gepr./frei		

control circuit diagram

service cart

DILO **Z863R01-01S**
D-87727 Babenhausen

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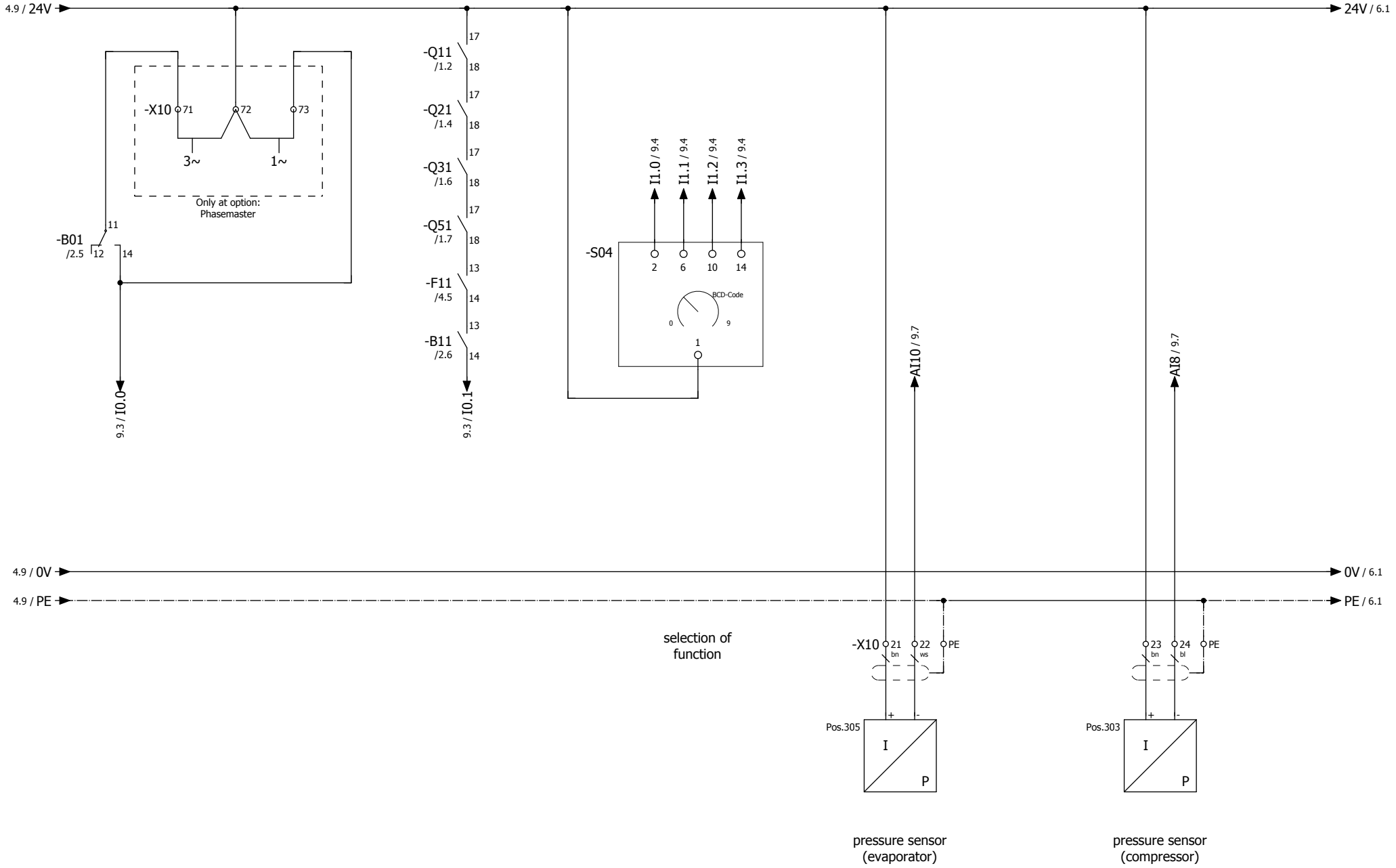
Page 4 / 9



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MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
dxf	16	
KE	17	
GF	18	
MT	19	
DX	20	

4

6

Modification	Date	Name

	Date	Name
gez	28.07.2014	deilt
gepr./frei		

control circuit diagram

service cart

Z863R01-01S

D-87727 Babenhausen

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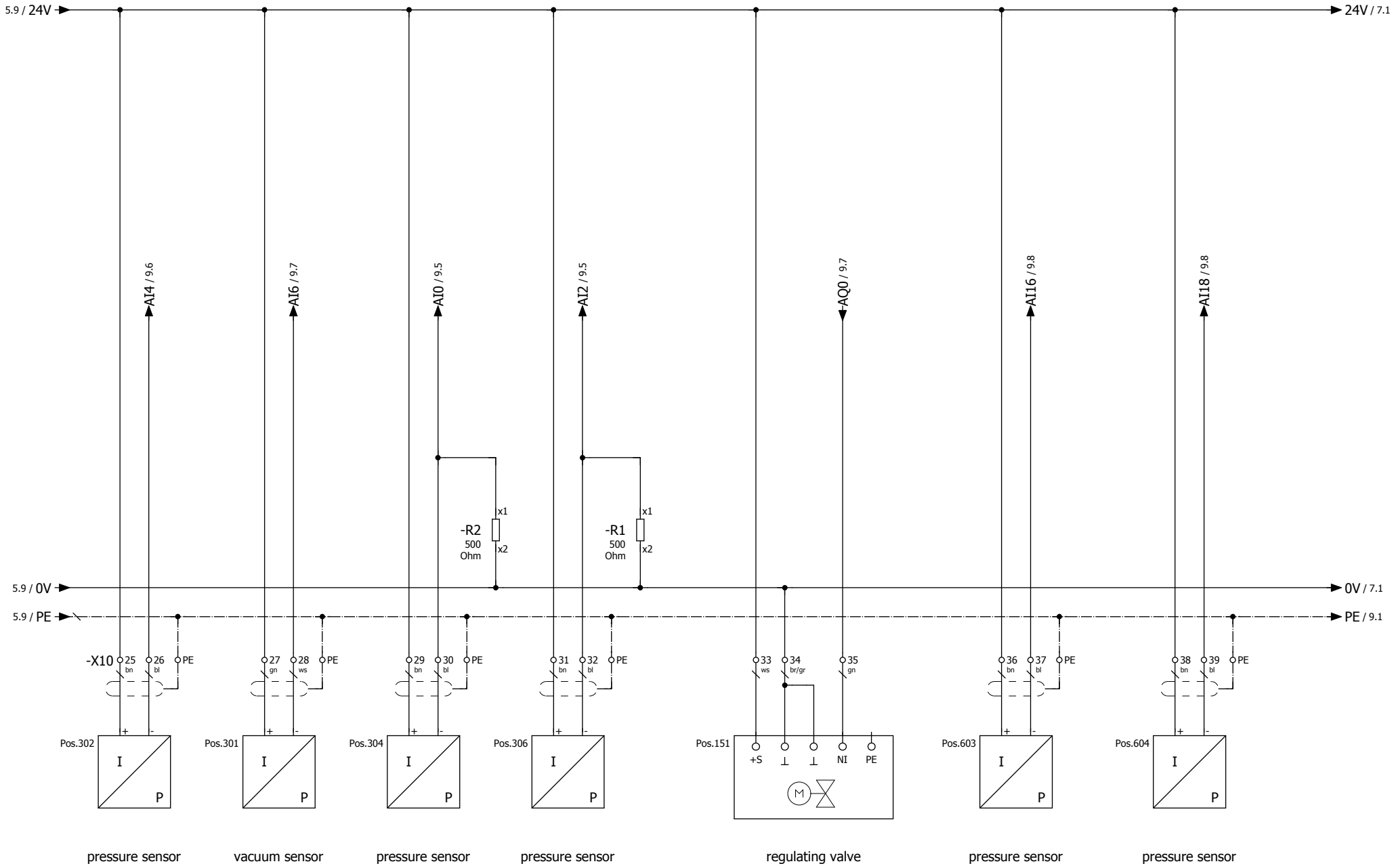

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MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
dxf	16	
KE	17	
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MT	19	
DX	20	

5

7

04 Umstellung Wägetechnik	26.03.14	mo
Modification	Date	Name

	Date	Name
gez	28.07.2014	deilt
gepr./frei		

control circuit diagram

service cart

Z863R01-01S

D-87727 Babenhausen

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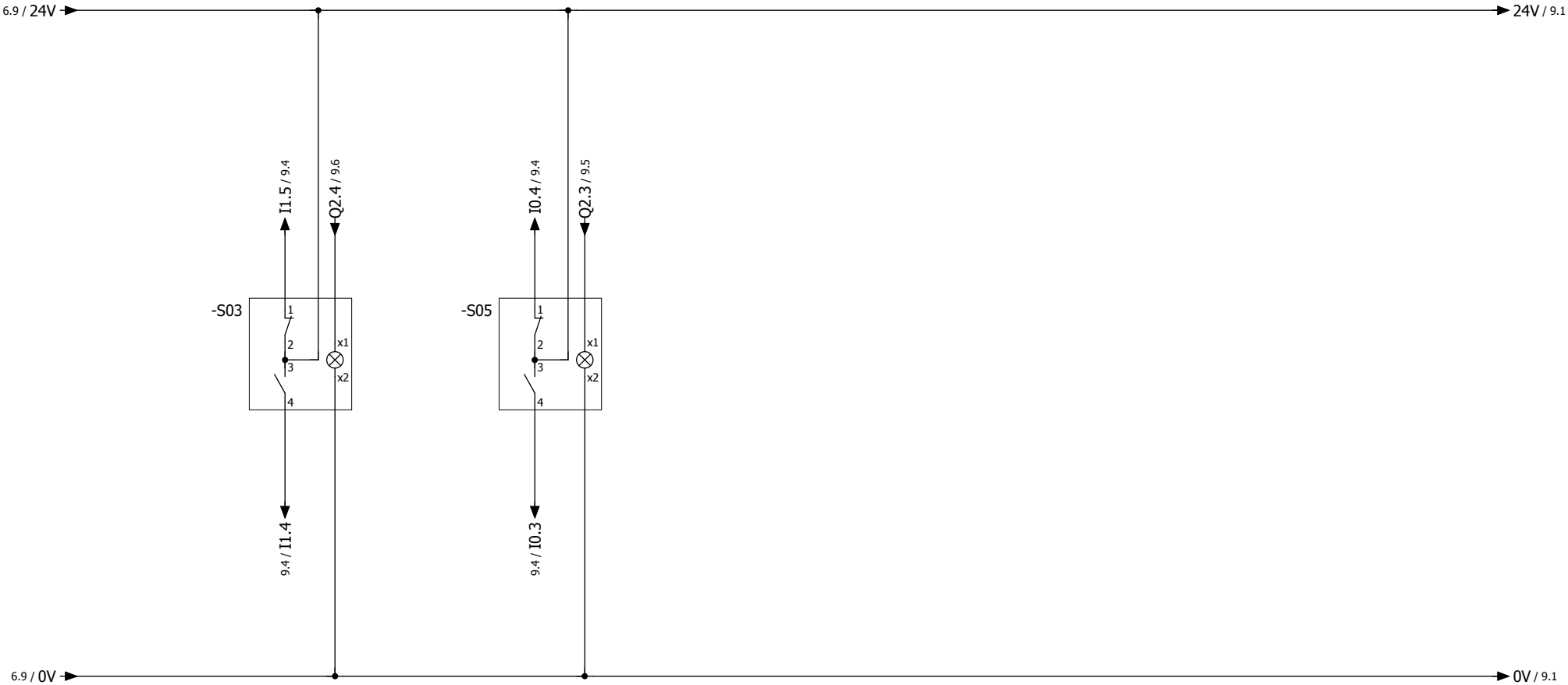
Page 6 / 9



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dxf	16	
KE	17	
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MT	19	
DX	20	

6

8

Modification	Date	Name

	Date	Name
gez	28.07.2014	deilt
gepr./frei		

control circuit diagram

service cart

DILO **Z863R01-01S**

D-87727 Babenhausen

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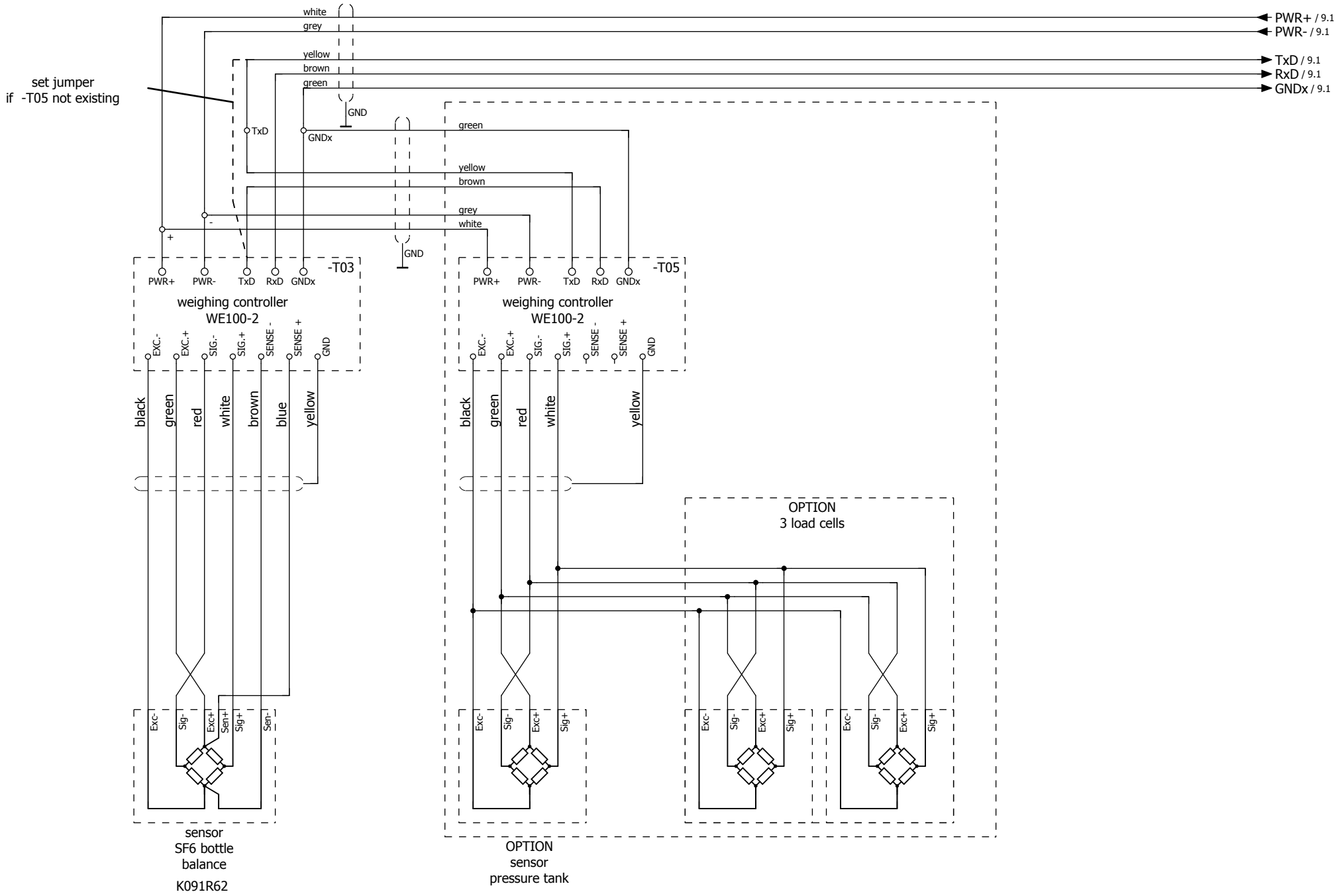
Page 7 / 9



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MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
dxf	16	
KE	17	
GF	18	
MT	19	
DX	20	

7

9

Modification	Date	Name

	Date	Name
gez	28.07.2014	deilt
gepr./frei		

control circuit diagram

service cart

DILO **Z863R01-01S**

D-87727 Babenhausen

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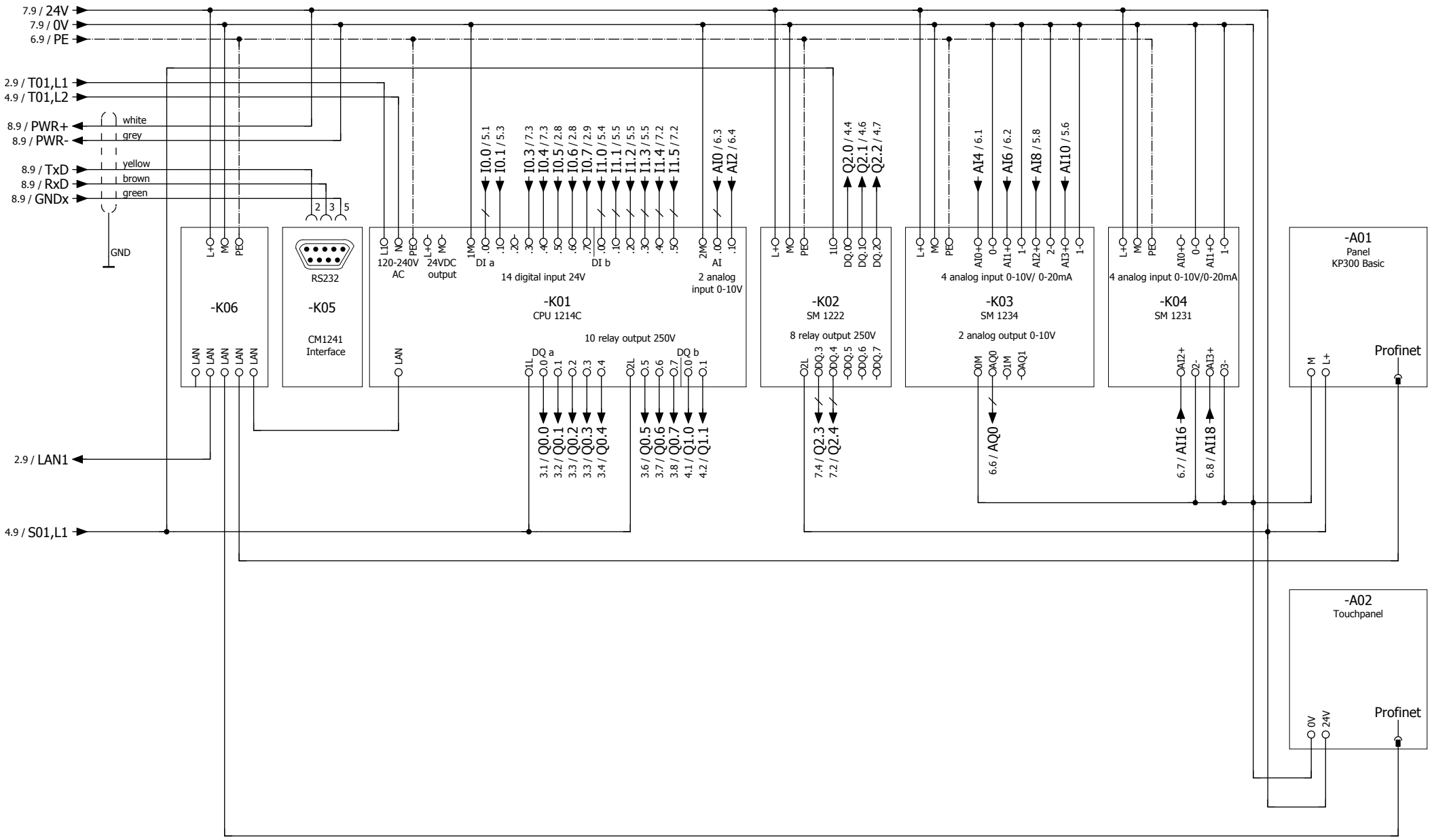
Page 8 / 9



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Betr	6	
Betr	7	
AB	8	1
VM	9	
MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
dxf	16	
KE	17	
GF	18	
MT	19	
DX	20	

8

04 Umstellung Wägetechik	26.03.14	mo
Modification	Date	Name

	Date	Name
gez	28.07.2014	deilt
gepr./frei		

PLC and panel

service cart

DILO **Z863R01-01S**
D-87727 Babenhausen

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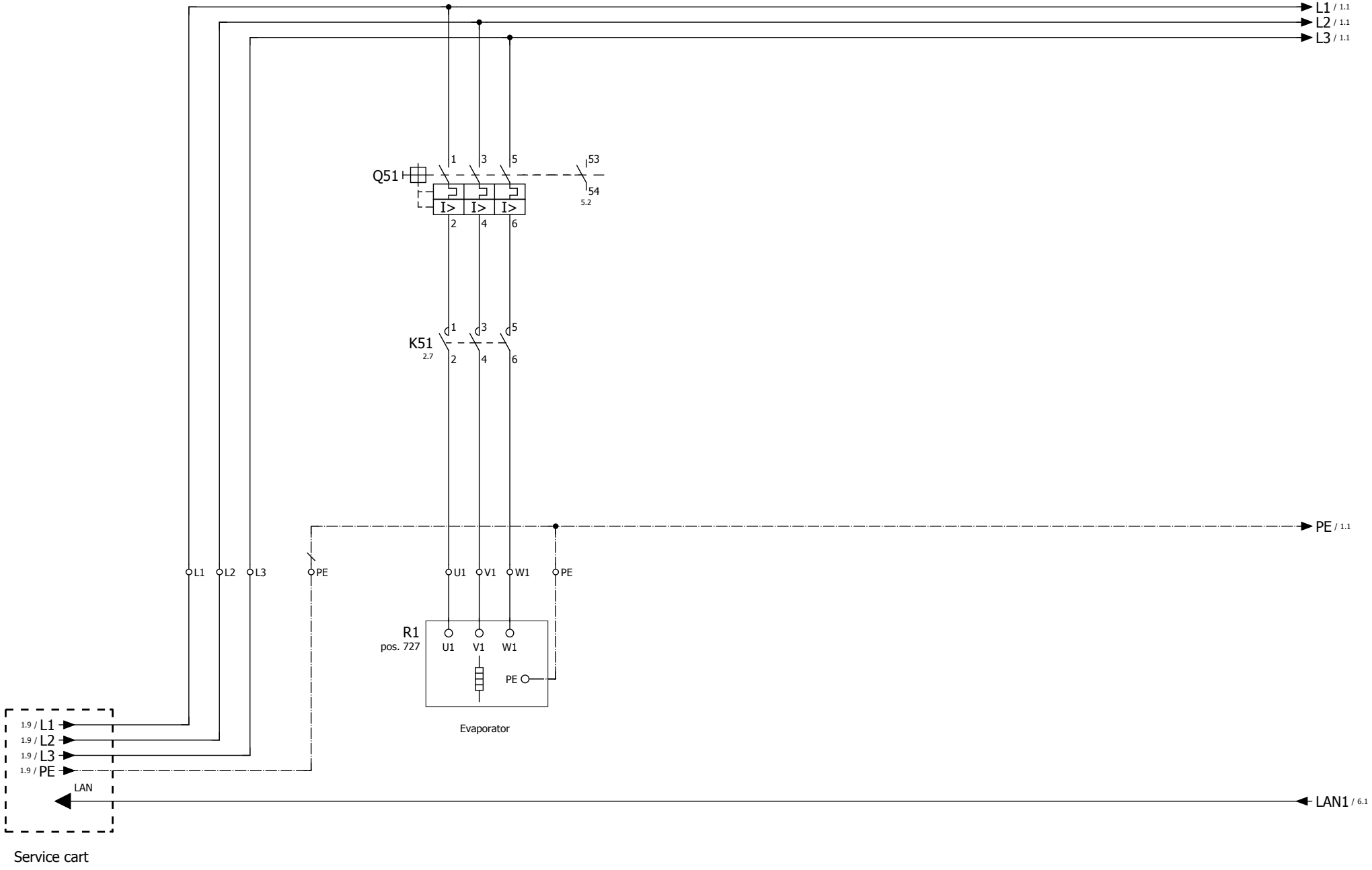
Page 9 / 9



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Betr	6	
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MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
	16	
KE	17	
	18	
MT	19	
	20	

2

		Datum	Name		
	gez.	14.10.2014		Main circuit diagram	SF6/CF4-gas mixing plant
	gepr.				
Mitteil-Nr., Änderung, Tag/Name	Ers. f.				

Z863R01-02S Bl. 1/ 6

DILO D-87727 Babenhausen

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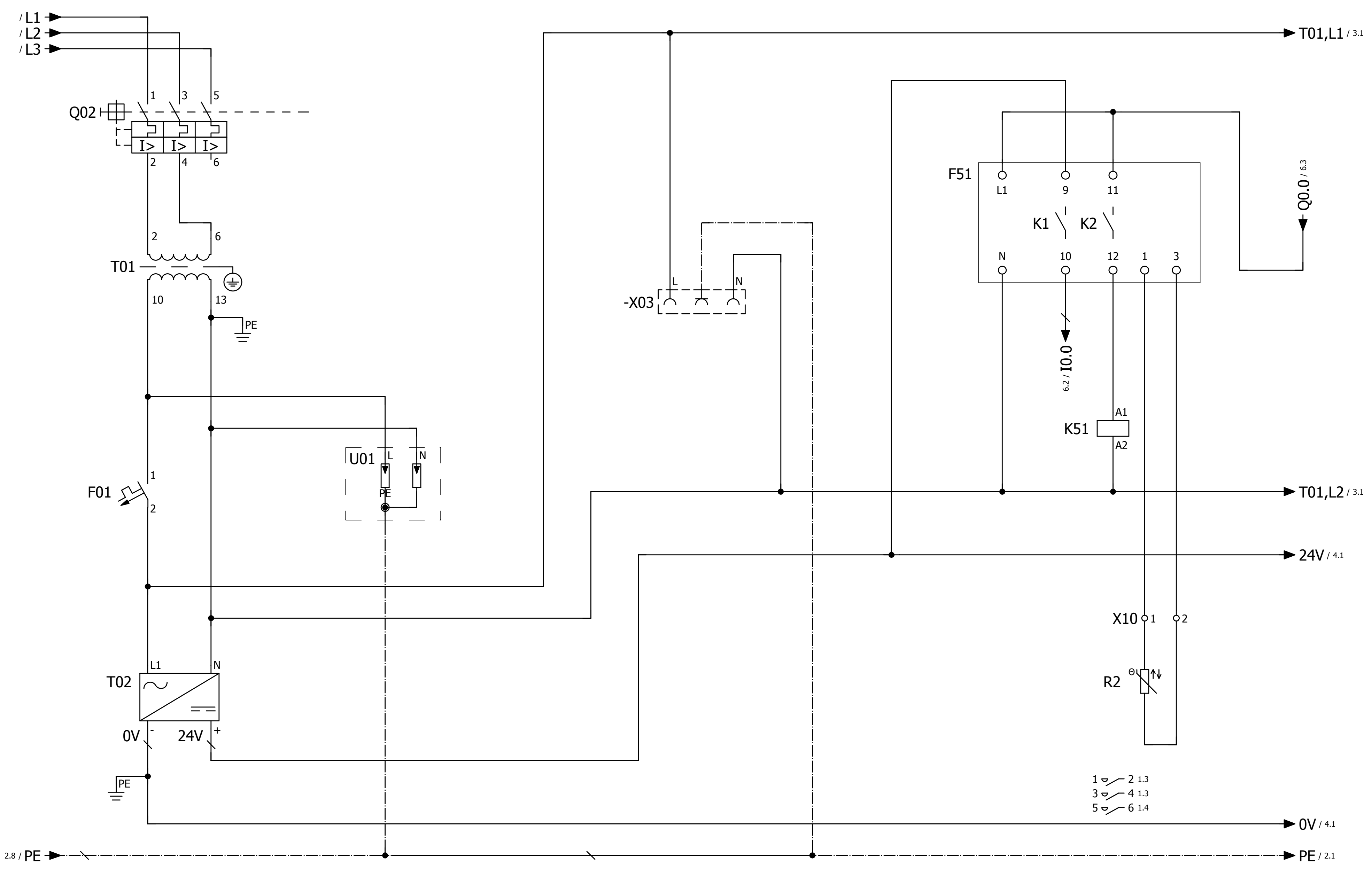

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Betr	3	
Betr	4	
Betr	5	
Betr	6	
Betr	7	
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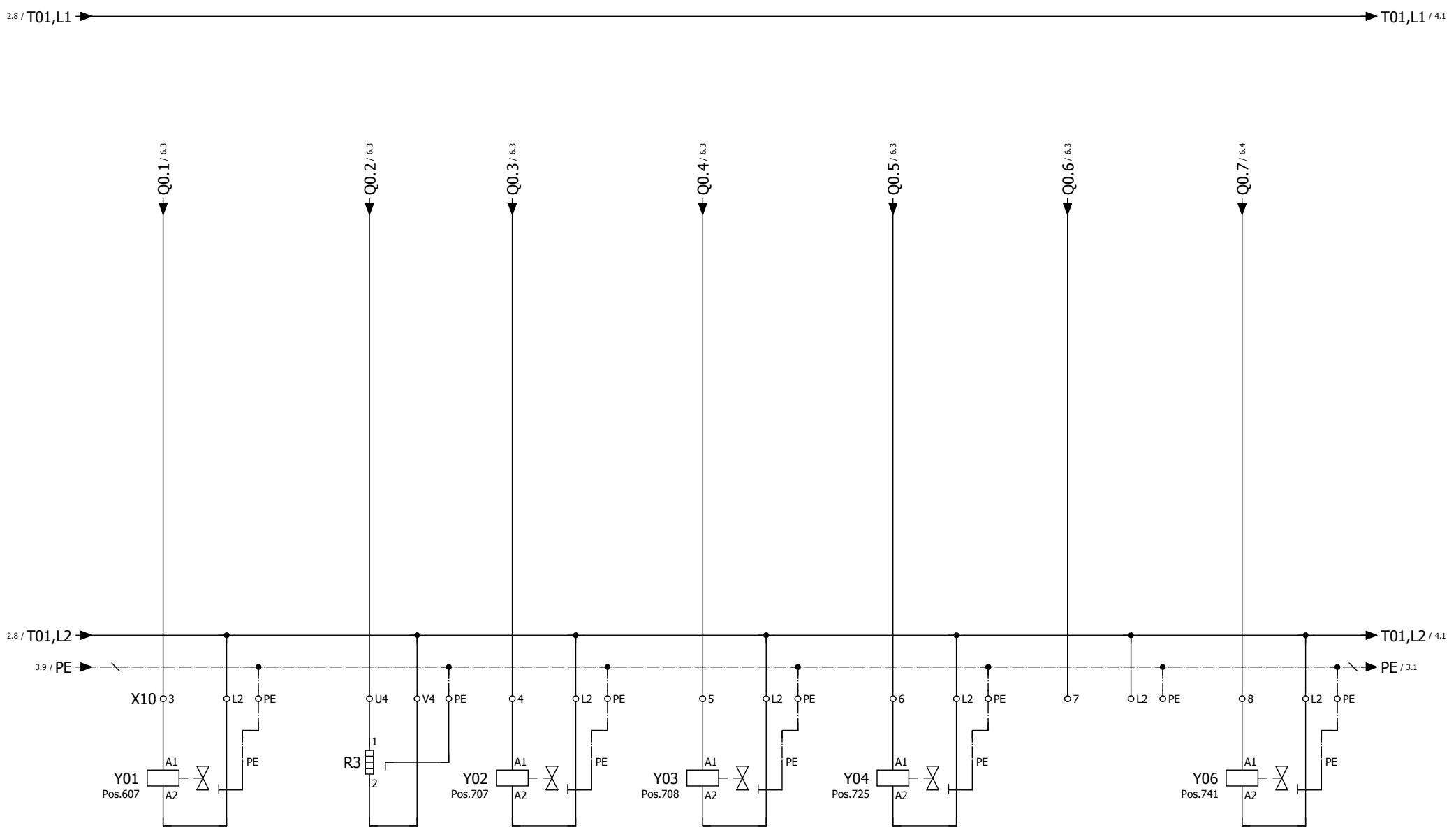
MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
	16	
KE	17	
	18	
MT	19	
	20	

1 3

	Datum	Name				
gez.	14.10.2014		Main circuit diagram	SF6/CF4-gas mixing plant	Z863R01-02S	Bl. 2/ 6
gepr.					D-87727 Babenhausen	
Ers. f.						

Mitteil-Nr., Änderung, Tag/Name



Abt.	Nr.	Anz.
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Betr	3	
Betr	4	
Betr	5	
Betr	6	
Betr	7	
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VM	9	
MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
	16	
KE	17	
	18	
MT	19	
	20	

2

4

	Datum	Name		
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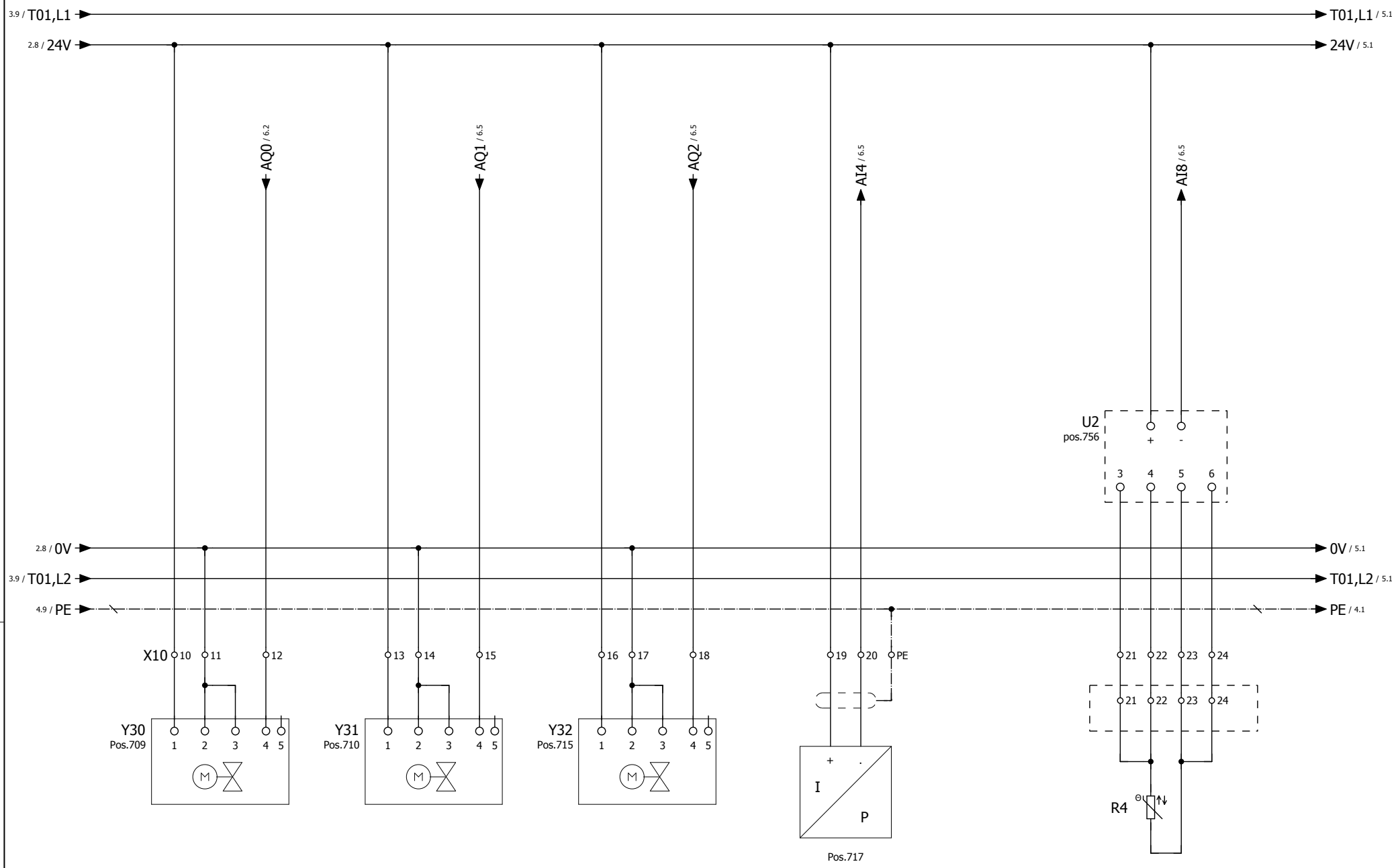
gepr.				
Mitteil-Nr., Änderung, Tag/Name	Ers. f.			

Z863R01-02S Bl. 3/ 6

D-87727 Babenhausen



Abt.	Nr.	Anz.
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Betr	3	
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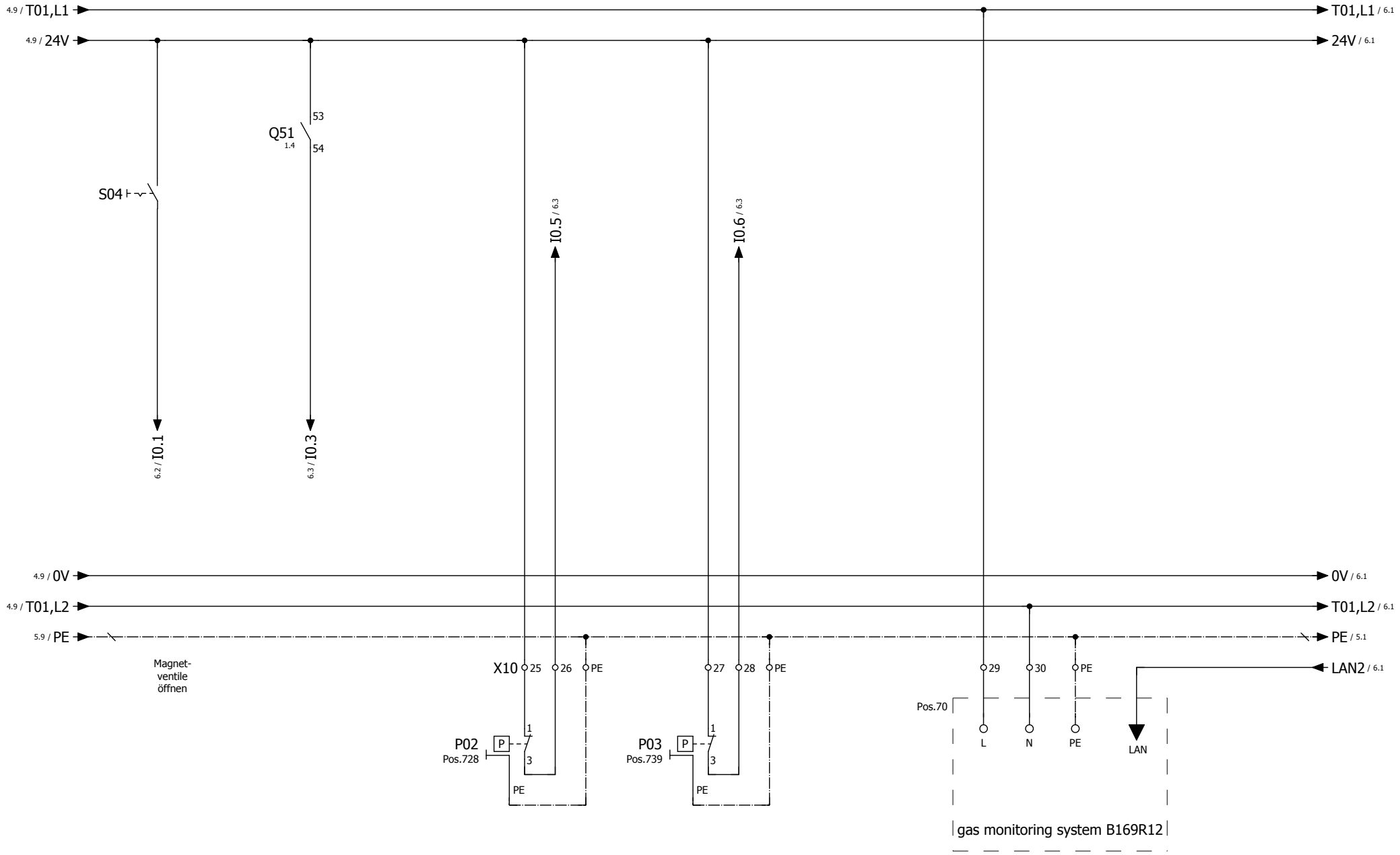
VK	13	
EK	14	
EL	15	2
	16	
KE	17	
	18	
MT	19	
	20	

	3			5
		Datum	Name	Main circuit diagram
	gez.	14.10.2014		
	gepr.			
Mitteil-Nr., Änderung, Tag/Name	Ers. f.			

SF6/CF4-gas mixing plant

Z863R01-02S Bl. 4/ 6

D-87727 Babenhausen



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Betr	7	
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MG	10	
GL	11	
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EK	14	
EL	15	2
	16	
KE	17	
	18	
MT	19	
	20	

4

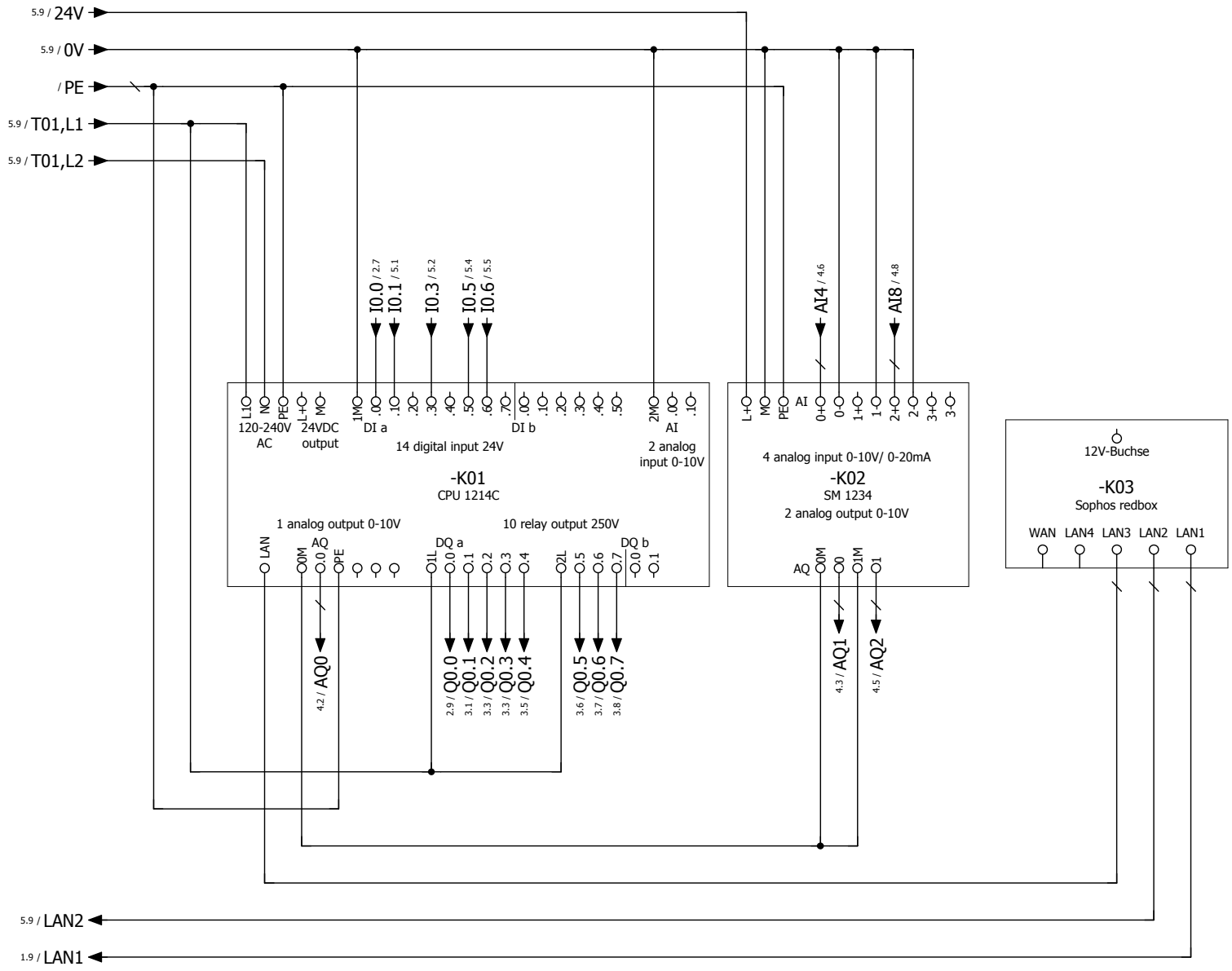
6

	Datum	Name	
gez.	14.10.2014		Main circuit diagram
gepr.			
Mitteil-Nr., Änderung, Tag/Name	Ers. f.		

SF6/CF4-gas mixing plant

Z863R01-02S Bl. 5/ 6

D-87727 Babenhausen



Abt.	Nr.	Anz.
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Betr	3	
Betr	4	
Betr	5	
Betr	6	
Betr	7	
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MG	10	
GL	11	
TL	12	
VK	13	
EK	14	
EL	15	2
	16	
KE	17	
	18	
MT	19	
	20	

	5				
		Datum	Name	Main circuit diagram	SF6/CF4-gas mixing plant
	gez.	14.10.2014			
	gepr.				
Mitteil-Nr., Änderung, Tag/Name	Ers. f.				

Z863R01-02S Bl. 6/ 6

D-87727 Babenhausen

Parts list for circuit diagram

Gas handling unit

Pos.	Designation	Article no.	Piece
A01	3.6" Display	05-1657-R100	1
A02	5.7" colour Touch panel	05-1657-R103	1
B01	Phase sequence relay	05-1456-R001	1
B11	Thermistor control device 230V	05-0228-R006	1
F01	1 pole cut-out B6	05-0725-R003	1
F02	Discharger 230V	05-1509-R001	1
F03	1 pole cut-out Power supply 3x208-240V: B6A	 05-0725-R003	 1
F11	1 pole Z1 cut-out	05-0725-R052	1
K01	SPS S7-1214C 14DE,10RA,2AE	05-1657-R003	1
K02	Extension module 8RA	05-1657-R021	1
K03	Extension module 4AE	05-1657-R031	1
K04	Extension module 4AE	05-1657-R031	1
K05	Communication module CM241	05-1657-R041	1
K06	Ethernet- switch	05-1587-R002	1
K51	Microprocessor controller	05-0701-R003	1
Q01	Reversing switch	05-0727-R007	1
Q02	Motor protection circuit breaker PKZM0-2,5	05-0891-R007	1
Q11	Motor starter basic device Motor starter control device Motor starter auxiliary switch	05-1592-R002 05-1592-R016 05-1592-R021	1 1 1
Q21	Motor starter basic device Motor starter device Motor starter auxiliary switch	05-1592-R001 05-1592-R014 05-1592-R021	1 1 1
Q31	Motor starter basic device Motor starter control device Motor starter auxiliary switch	05-1592-R001 05-1592-R014 05-1592-R021	1 1 1
Q51	Motor starter basic device 12A Motor starter control device Motor starter auxiliary switch	05-1592-R001 05-1592-R016 05-1592-R021	1 1
S01	Emergency Off key 1Ö Contact element 1Ö	K101R31 05-0736-R102	1 1
S02	BCD switch, T0-4-15602/E	05-0728-R005	1
S03, S05	Double key 24V 1S 1Ö	K101R01	2
S04	1 pole snap action switch	05-0467-R001	
T01	Universal transformer, WA-U 630	05-0747-R020	1
T02	Power supply unit 24VDC/0,6A	05-1461-R101	1
T05	Operator display WE100-2	05-1820-R002	1
X01	Coupling	05-0751-R009	1
X02	Power plug	05-0752-R009	1
X03	Built-in socket; 1461-050	05-0753-R004	1

Parts list for circuit diagram

Performance data:

❑ **6-057SP-R001**	Range of operating voltage:	208-240V	60 Hz
	Control voltage	230V	
	Compressor: TM 5.0B	5.00 kW	19.5 A
	Suction pump: 15m^3/h	0.45 kW	4.25 A
	Vacuum pump: 40m^3/h	1.7 kW	6.6 A
	Evaporator: K032R01	4.80 kW	12.5 A
	Control:	0.50 kW	2.55 A

Parts list for circuit diagram

Gas mixing device SF_6 / CF_4

Pos.	Designation	Order-no.	Piece
F01	Cut-out	05-0725-R003	1
F51	Microprocessor controller	05-0701-R003	1
K01	SPS S7-1214C	05-1657-R003	1
	Onboard module	05-1657-R012	1
K02	Extension module	05-1657-R033	1
K03	Router	05-1829-R001	1
K51	Motor contactor	05-0722-R002	1
Q51	Motor protection circuit breaker	05-0891-R011	1
Q02	Motor protection circuit breaker	05-0891-R006	1
Q51	Motor protection circuit breaker	05-0891-R011	1
	Auxiliary switch	05-0723-R004	1
R3	Heating band	05-1091-R001	5 m
	Connecting kit	05-1091-R002	1
S04	Flip switch 1 pole	05-0467-R001	1
T01	Universal transformer	05-0747-R008	1
T02	Power unit	05-1461-R103	1
U01	Discharger 230V	05-1509-R001	1
X03	Socket	05-0753-R014	1

	Range of operating voltage:	208-240V	60 Hz
	Control voltage:	230V	
	Evaporator:	4.80 kW	12.5 A
	Control:	0.70 kW	0.8 A

Spare parts list

Gas handling unit

Pos.	Designation	Article-no.	Piece
11	Compressor (50Hz)	4-200-00	1
21	15 m³/h suction pump	B105R51	1
31	40 m^3/h vacuum pump (nominal suction capacity, final vacuum < 1 mbar)	3-690-R007	1
	Wire-braided hose	SM0120L00750	1
51	Evaporator	K032R01	1
101	Coupling groove part DN20	VK/A-02/20 P	1
102	Coupling groove part DN20	VK/A-02/20 P	1
103	Coupling groove part DN20	VK/A-02/20 P	1
105	Flange coupling DN20	VK/FL-01/20 T	1
107	Coupling groove part DN8	VK/A-02/8 P	1
108	Coupling groove part DN8	VK/A-02/8 P	1
111	Dry filter	3-899-R002	1
121	Particle filter DN20	3-377-R020	1
122	Particle filter DN40	K072R21	1
123	Filter with connection	3-337-R002	1
131	Solenoid valve DN20	05-1718-R160	1
132	Solenoid valve DN20	05-1718-R201	1
133	Solenoid valve DN20	05-1718-R201	1
134	Solenoid valve	K132R11	1
135	Solenoid valve DN10	05-1718-R102	1
136	Solenoid valve DN10	05-1718-R102	1
137	Solenoid valve	K132R11	1
138	Block	3-1011-01 T	1
151	Control valve DN20	K066R05	1
152	Control valve	K066R05	1
161	Gauge	05-1643-R001	1
162	Gauge	05-0486-R031	1
163	Gauge	05-1239-R002	1
164	Gauge	05-0486-R031	1
171	Conical non return valve DN20	VR/A-03/20 P	1
172	Conical non return valve DN20	VR/A-02/20 P	1
181	Pressure reducer	3-300-R003	1
182	Pressure reducer	3-301-R002	1
191	Safety valve	05-0110-R100	1

Spare parts list

Pos.	Designation	Article-no.	Piece
192	Safety valve	05-1200-R052	1
195	Safety valve	05-0110-R400	1
201	Ball valve with hand wheel	3-365-R008 P	1
252	Wire-braided hose	SM0320L00600	1
253	Wire-braided hose	SM038L00600	1
254	Wire-braided hose	SM018L01300	1
255	Wire-braided hose	SM018L00900	1
271	Storage connecting hose	6-1037-R050	1
301	Pressure transformer	05-1601-R001	1
302	Pressure transformer	05-1563-R022	1
303	Pressure transformer	05-1563-R020	1
304	Pressure transformer	05-1563-R020	1
305	Pressure transformer	05-1563-R020	1
306	Pressure transformer	05-1563-R021	1
401	Manifold block	3-1011-R004	1
402	Manifold block	3-1011-R008	1
403	Manifold block	3-1011-02 T	1
404	Manifold block	3-1011-05 T	1
411	End cover	05-1718-R203	1
412	Connecting piece on the right side	05-1718-R210	1
413	End cover on the left side	05-1718-R103	1
414	Connecting piece on the right side	05-1718-R109	1
421	Line	L057R01P41	1
422	Line	L057R01P37	1
423	Line	L057R01P30	1
424	Line	L057R01P21	1
425	Line	L057R01P31	1
426	Angle piece	K018R47	1
427	Tee piece	K020R77	1
428	Line	L057R01P33	1
430	Line	L057R01P40	1
431	Line	L057R01P34	1
432	Line	L057R01P36	1
433	Line	L057R01P38	1
434	Line	L057R01P39	1
435	Line	L057R01P35	1

Spare parts list

Pos.	Designation	Article-no.	Piece
436	Line	L057R01P42	1
437	Line	L057R01P44	1
451	Covering cap	VK/KN-04/20 T	4
452	Covering cap	VK/KN-04/8 T	2
461	Screw-in stub	ML1-AD15-14 P	1
462	Screw-in stub	ML1-AD10-14 P	1
463	Screw-in stub	ML1-AD10-14 P	1
464	Screw-in stub	ML1-AD22-14 P	1
465	Transition piece	3-240-R001 P	1
511	Intermediate piece	3-311-R001 P	3
521	Screw-in stub	3-845-R003	2
522	Screw-in stub	ML1-AD10-14 P	4
523	Screw-in stub	ML1-AD22-14 P	1
524	Transition piece	SK-422 P	1
525	Screw-in stub	3-845-R002	1
528	Groove part for pressure reducer connection	3-288 P	1
600	Solenoid valve	K132R13	1
601	Solenoid valve	K132R13	1
602	Coupling groove part DN20	VK/A-02/20 P	1
603	Pressure transformer	05-1601-R001	1
604	Pressure transformer	05-1563-R021	1
607	Solenoid valve	K132R13	1
608	Overpressure protection	05-01184-R001	1

Spare parts list

Gas mixing device SF_6 / CF_4

Pos.	Designation	Order-no.	Piece
703	Pressure reducer	3-302-R002	1
704	Pressure reducer	3-302-R002	1
705	Gauge	05-0486-R012	1
706	Gauge	05-0486-R012	1
707	Solenoid valve	K132R13	1
708	Solenoid valve	K132R13	1
709	Control valve	K066R05	1
710	Control valve	K066R05	1
711	Mixing cell	K071R01	1
712	Gauge NG63	05-0486-R012	1
713	Gas monitoring system	B169R12	1
714	Pressure tank	3-941-R001	1
715	Control valve	K066R05	1
716	Coupling tongue part	VK/A-02/20 P	1
717	Pressure transformer	05-1563-R022	1
725	Solenoid valve	K132R13	1
726	Rubber hose	GS0108L05000	1
727	Evaporator	K032R01	1
728	Pressure switch adjusted pressure: pe 4 bar	K016R03	1
729	Safety valve	05-1028-R098	1
730	Pressure reducer for CF_4	3-782-R001	1
731	Rubber hose	GS0108L05000	1
732	Pressure reducer	3-300-R003	1
733	Coupling tongue part	VK/F-02/20 P	1
734	Coupling tongue part	VK/A-02/20 P	1
735	Coupling tongue part	VK/F-02/20 P	1
736	Coupling tongue part	VK/A-02/20 P	1
737	Ball valve	3-365-R008 P	1
739	SF_6 bottle connection	3-316-R001 P	1
739	Pressure switch adjusted pressure: pe 4 bar	K016R03	1
741	Solenoid valve	05-1061-R021	1
745	Rubber hose	GS0320L01000	1
746	Rubber hose	GS0320L01000	1
752	Gauge	05-1239-R002	1
753	Safety valve	3-298-R050	1
754	Gauge	05-0486-R001	1
755	Temperature sensor	05-0679-R011	1
756	Temperature transformer	05-0679-R021	1

Dry-running compressor | TM 5.0 B

Operating Manual (original version)

Year of construction: 2014

DILO. Sustainably tight.

Made in Germany

Please read this operating manual before putting the device into operation. Thus operating faults can be avoided. In case of nonobservance of the operating manual the manufacturer cannot assume any liability or warranty.

Dry-running compressor | TM 5.0 B

Product description

Correct use

The compressor is designed for the recovery and compression of SF_6-gas and SF_6-gas mixtures.
Do not use the device to exhaust or compress liquids or other gases.

Danger

Use of the compressor for any other purpose may not be safe.

The manufacturer will not accept any liability in case of injury or damage caused by use of the compressor for applications for which it was not intended.

The TM5.0B compressor is a dry-running two-stage, low maintenance piston compressor and works entirely without oil.
The compressor housing is enclosed and thus absolutely gastight.
The position of the 2 cylinders guarantees a smooth running even at high back pressure.
The gas is stored in gaseous or liquid form depending on the pressure.
For cooling the compressor and the compressed SF_6-gas with ambient air a ventilator and an intermediate cooler and after cooler are integrated.

The operating overpressure is to be limited to max. pe 4 bar on the suction side by a pressure reducer. Furthermore, the output pressure has to be monitored by a contact gauge (or pressure switch) which turns off the compressor in case the max. admissible operating pressure (pe 50 bar) is exceeded.
The compressor is protected against overcurrent by a motor protection circuit breaker.
Lead probes are installed in the motor winding and in each cylinder cap.
When exceeding the admissible temperature the compressor is switched off by the thermistor.

In case the compressor is integrated in a device or system which is - in accordance with the legal regulations - liable to registration in the country of operation, the operator is responsible for commissioning and further tests.

It is not allowed to expose the compressor to humid or corrosive substances permanently.
However in case the compressor has been charged with moisture for a short time it must be rinsed with pure and dry gas for min. 30 minutes.
For this purpose nitrogen can also be used if the rinsing gas is released into the atmosphere.
Finally evacuate the compressor.
Furthermore the compressor must not be operated with substances containing oil and oil mist as this would damage the piston and guide rings.

Do not switch on the compressor if the input or output pressure or pressure in the housing is < 100 mbar (absolute pressure). After evacuation flood the compressor with SF_6 before it is put into operation. Otherwise this could result in flashovers or leakage current on the grommet.

Dry-running compressor | TM 5.0 B

Dimension sheet

Length mm	Width mm	Height mm	Weight
780	505	430	132 kg

Dry-running compressor | TM 5.0 B

Technical data

Dry running compressor:

Number of cylinders	1. stage	1	
	2. stage	1	
Theoretical delivery rate (at nominal speed)	5.7 m³/h (50 Hz)		6.8 m³/h (60 Hz)
Direction of rotation	right or left		
Sound level	70 dB(A)		
Protection system	IP44		

Built-in motor: (standard version)

Frequency	50 / 60 Hz
Nominal speed	1460 / 1750 min^{-1}
Three phase short-circuit motor, 4 poles	5.0 kW
Operating voltage	* 380-460 V (Y) / 208-240 V (Δ)
Nominal current	* 9.9-14 / 17.3-21 A
Insulation class (VDE 0530)	F

For special voltage the data of the type plate marked with * are valid.

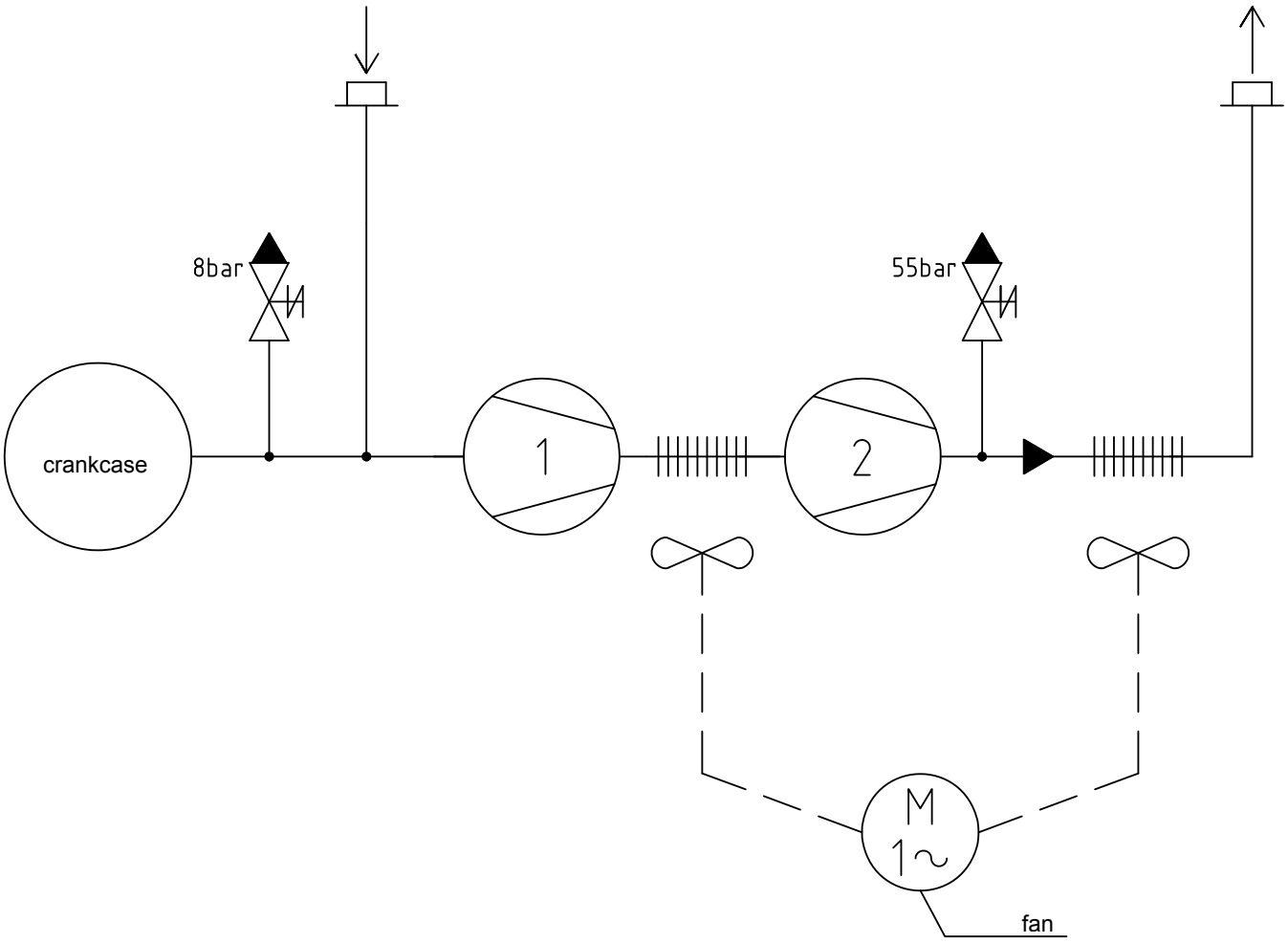
Fan motor:

Frequency	50 / 60 Hz
Single phase motor 2 poles	115 / 150 W
Operating voltage	230 V
Nominal current	0.51 / 0.66 A

Admissible limiting values at continuous operation with SF_6-gas (pressure indication in p_e)

Suction pressure	-0.5 to 4 bar
Max. back pressure	50 bar
Admissible ambient temperature	-10 °C to +45 °C

Functional diagram



safety valve	non return valve	cooler	compression stage

General safety notes

- The compressor has been designed and constructed bearing in mind the standards to be observed as well as additional technical specifications. Safe use of the machine can only be achieved if all necessary measures are taken.
- The operator has to ensure that
  - the device is only used for the purposes for which it is intended (see product description).
  - the device is only operated in accordance with the instructions and in good condition and that the safety devices are regularly checked.
  - maintenance and repair personnel are issued with all the required safety and protective clothing, which shall always be used.
  - complete and legible operating manuals are available on site.
  - only qualified personnel operates or repairs the device.
  - this personnel is regularly instructed in safety procedures and environmental protection and that this personnel is fully aware of the complete operating manuals and particularly in the safety notes.
  - the safety and warning notes mounted on the device are legible and not removed.
  - all obligatory registrations and tests prescribed by law are carried out on the devices in accordance with the local regulations (e. g. pressure vessel tests, test for electrical safety etc.)
  - the safety data sheet on SF_6 (can be obtained from the SF_6 supplier) is available for the operating personnel. The instructions mentioned in the data sheet and safety precautions must be known and observed by the operating personnel.

Specific safety notes and standard symbols

The symbols used in the operating manuals should draw your attention specially to the safety notes

Danger

This symbol refers to risks for persons (danger to life, danger of injury)

Warning

This symbol refers to risks for machines, material and the environment.

The most important aim of the safety notes is to prevent personal injuries.

- If the warning sign "Danger" appears, danger from machines, materials and the environment are not excluded.
- If the warning sign "Warning" appears, there is no danger for persons.

The corresponding symbol which is used cannot replace the text of the safety note.
Therefore, the complete text must always be read!

Basic safety measures during normal operation

Only trained and authorized persons who are fully aware of the operating manuals should operate the device in accordance with the operating manuals.

Before switching on the device ensure that

- only authorized persons are present at the device
- nobody can be hurt by the operation of the device

Whenever the compressor is started check for visible damage beforehand and ensure that it is operated in the correct conditions! Eliminate any damage immediately!

Basic safety measures during maintenance

Follow inspection and maintenance periods described in the operating manuals!

Follow maintenance and repair instruction for individual components in these operating manuals!

Prior to carrying out maintenance and repair works turn off the main switch for the power supply and secure it with a padlock. The key for this lock must be in the hands of the person who carries out the repair works.
If there is no main switch unplug the power supply cable at the plant and secure it against being plugged in again.

When exchanging heavy machine parts only use suitable lifting devices in good working condition.

Prior to carrying out maintenance or repair works ensure that parts which may need to be touched have cooled down to room temperature!

Dispose of grease, auxiliary or cleaning material in accordance with environmental regulations!

Work on electrical equipment

- Only properly trained electricians should carry out repair works on the electrical equipment of the compressor.
  Regularly check the electrical equipment!
- Re-tighten loose connections!
- Replace damaged lines/cables immediately!

Works on equipment under overpressure

- Only specially trained personnel should carry out maintenance and repair works on equipment which is under overpressure.
- Prior to maintenance and repair works depressurize the compressor equipment which is under overpressure.
- After having carried out maintenance or repair works and prior to putting the equipment back into service:
  - check whether loosened screw connections are properly sealed
  - ensure that the tank caps and components that have been removed have been re-installed!
- After having carried out the maintenance or repair works and before operation ensure that
  - all materials, tools and other equipment which were necessary for the maintenance or repair works have been removed from the working area of the compressor,
  - all safety devices for the unit are properly set and in working order.

Observe environmental standards

- Whenever working on and with the compressor please observe legal requirements for waste handling and disposal.
- Particularly during installation, repair and maintenance works substances that cause water pollution such as
  - lubricating grease
  - auxiliary material
  - cleansing liquors containing solvent

must not contaminate the soil or flow into drains!
These substances should be stored and transported in suitable vessels and removed and disposed of according to local regulations!

Transport


Danger

To avoid damage to devices and life threatening injuries during transport:

- lifting slings must correspond to local health and safety regulations!
- slings should be chosen in accordance with the weight of the device. (Weight see dimension sheet)
- Only qualified and authorized persons should carry out transport operations.

Installation


Warning

The compressor is to be mounted on a frame correspondingly prepared.
Level up unevenness on the frame by distance disks.
The screws or nuts must be fastened.

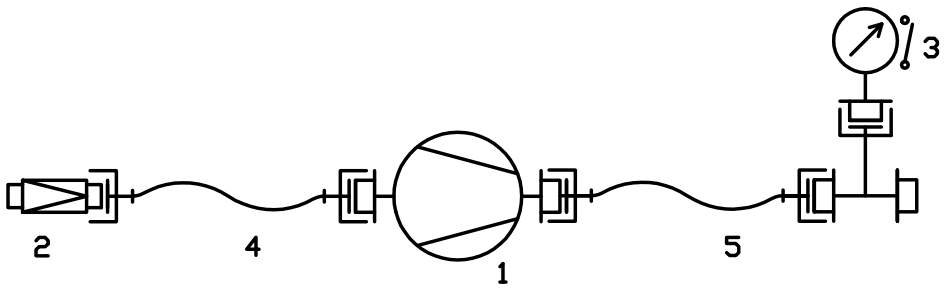
Connections

Suction and back pressure side consist of a DILO union ML1-AD10-3 P.
The suction pressure must not exceed the indicated suction pressure range.
Therefore the suction pressure is to be reduced to its max. value by a pressure reducer before compressing.

Furthermore a pressure-controlled switching contact (e. g. contact gauge or manostat) should be installed on the back pressure side which turns off the compressor if the back pressure is too high.

Connecting proposal:

1 = Dry running compressor
2 = Pressure reducer
3 = Contact gauge
4 = Hose
5 = Hose



Setting into operation

Prior to setting the compressor into operation check the following:
1. Electrical connection
2. SF_6-gas connection

After the initial start and prior to operation check that all safety equipment is operating correctly.

Electrical connection

Voltage indications on the compressor must be suitable for the existing electric network.

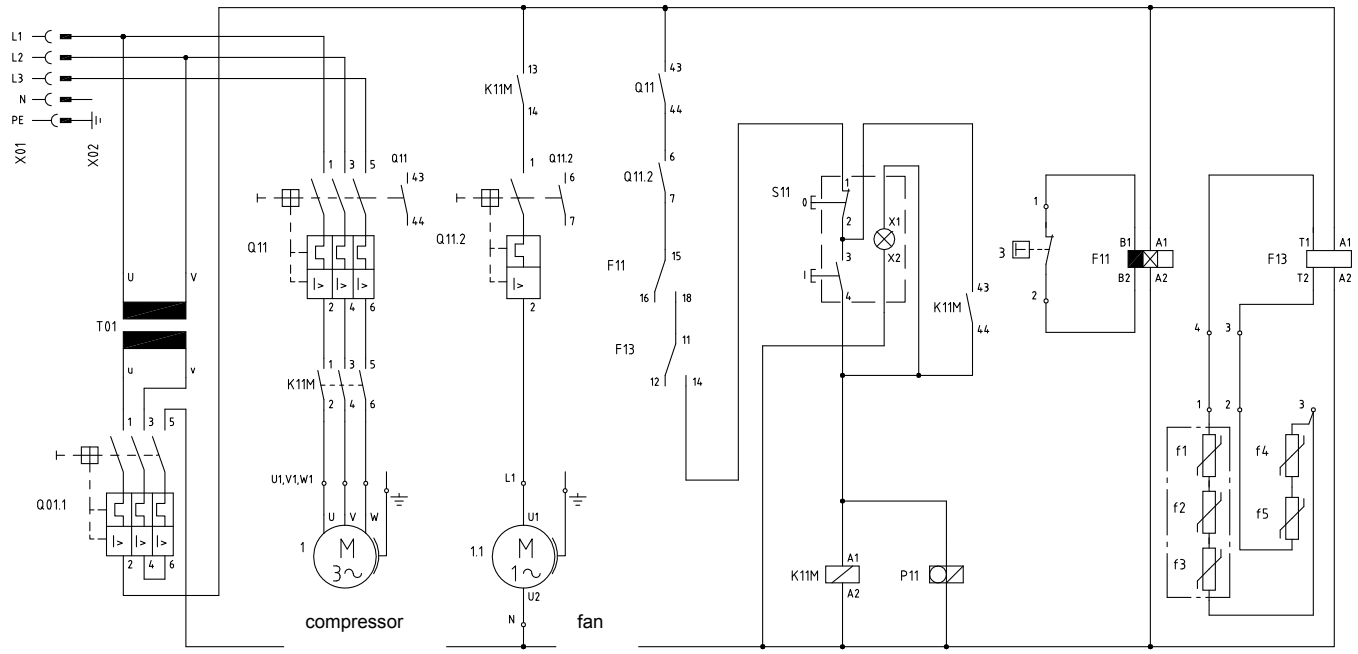
For connecting the compressor remove the cover plate from the upper connecting case.
The following terminals for the electrical connection are provided in the connecting case:

Terminal U1, V1, W1, PE: connection of power supply for the compressor motor
Terminal 1, 2: connection of the lead probes
Terminal L1,N, PE: connection of the power supply for the fan
When connecting the power supply for the compressor motor observe the note in the connecting case for Y- and Δ-connection.

Lead probes are installed (f1 to f5) in the motor winding and in each cylinder cap.
Connect the lead probes to terminal T1 and T2 of the thermistor machinery protection (F13).
The electrical connection of the compressor motor contactor (K11M) must be done via the switching contact of the thermistor.
Thus a thermal protection of the compressor is achieved.

Dry-running compressor | TM 5.0 B

Circuit diagram (wiring example):



f1-f3	Lead probe (in the motor winding of the compressor)
f4/f5	Lead probe (in the cylinder caps of the compressor)
F11	Protective contact relay
F13	Thermistor-machinery protection
K11M	Motor contactor
P11	Working hours counters
Q01.1/Q11/Q11.2	Motor protective circuit breaker
S11	On/Off button with indicator light
T01	Transformer
X01	Coupling
X02	Power plug
3	Contact gauge (the contact gauge must be connected to the output side of the compressor)

SF_6-gas connection

Check that connecting hoses are connected and tightened.
Check whether the suction pressure is limited to its max. value by a pressure reducer.

Verification of the safety equipment

Danger

Check whether the red pointer of the contact gauge (or pressure switch) that controls the output pressure of the compressor which is adjusted not higher
than the max. admissible pressure of the compressor (pe 50 bar)!

Elimination of malfunctions

In case of malfunction the operator has to inform his supervisor. The operator should not eliminate any damage on electrical equipment.

To avoid danger to life by electric shock:

Danger

- Only properly trained electricians should carry out maintenance and repair works on electrical equipment.
- The operator should only eliminate faults, which result from operating or maintenance errors.

Fault correction

The compressor is automatically switched off as soon as the lead probes (f1 – f3) in the motor winding or the cylinder caps (f4- f5) become too hot.

As soon as this breakdown occurs the compressor is switched off by the control provided that the compressor has been connected in accordance with the circuit diagram.
After cooling down the lead probes the compressor is to be restarted with the (S11) button.

In case the motor protection circuit breaker (Q11.2) switches off due the defective fan the contactor (K11M) is turned off as well.

Maintenance:
All bearings are closed and provided with permanent lubrication.
The sliding surfaces of the cylinders are dry-running.
Do not lubricate the compressor with oil or grease.
Only the O-rings are slightly greased with a special grease before installation.

Maintenance interval Operating hours	Object	Work
Weekly	Noises	Check
Every 500 hours or year	Piston and guide rings Valve seats	Carry out pressure test with SF_6 (see page 16)
after 1500 h, 4000 h, 6500 h, 9000 h, ……..	Piston and guide rings Valve seats	Check, measure, exchange if necessary (see page 16 to 18) (1 piece spare part kit - piston ring with O-ring kit, article no.: 6-1010-R013) Check, exchange if necessary (see page 16 to 18) (1 piece spare part kit – valve seats with O-ring kit, article no.: 6-1010-R004)
every 2500 h	Crank gear Non return valve	Exchange (1 piece replacement crankcase mounted completely, article no.: 4-291-61) Check, exchange, if necessary (1 piece non return valve, article no.: VR/A-02/8 P)

Information

The specified maintenance intervals only apply for compressed SF_6 gas corresponding to the quality stipulated in the IEC 60480 regulations. These maintenance intervals are considerably shortened if the gas contains increased humidity values and / or decomposition products.In this case the compressor must be rinsed after each operation (also see the “Correct use” chapter).
Wearing parts are excluded from warranty!

Examination in disassembled condition:

	Radial minimum thickness	Dimension of new ring
Piston ring, Ø 54 mm (Article no.: 05-1054-R012)	**3.0 mm**	4.0 mm
Guide ring, Ø 54 mm (Article no.: 05-1054-R013)	**3.1 mm**	3.5 mm
High pressure piston ring, Ø 23 mm (Article no.: 05-1054-R015)	**4.0 mm**	5.0 mm

Functional test (pressure test with SF_6)

Connect the gauge, then the check valve (ball valve or solenoid valve) to the compressor output (in case they are not already present downstream from the compressor in the service cart. If the compressor is installed in the service cart the exact procedure is described in the operating manuals, chapter 9 “Maintenance and functional test of the compressor).

Close the check valve and start the compressor (suction pressure should be about p_e 0 bar) After a certain time a pressure of **p_e 48 bar** should be obtained. **Turn off the compressor!**
If the compressor is turned off too late the compressed SF_6 is released in the atmosphere via the safety valve p_e 55 bar (upstream from the compressor output).

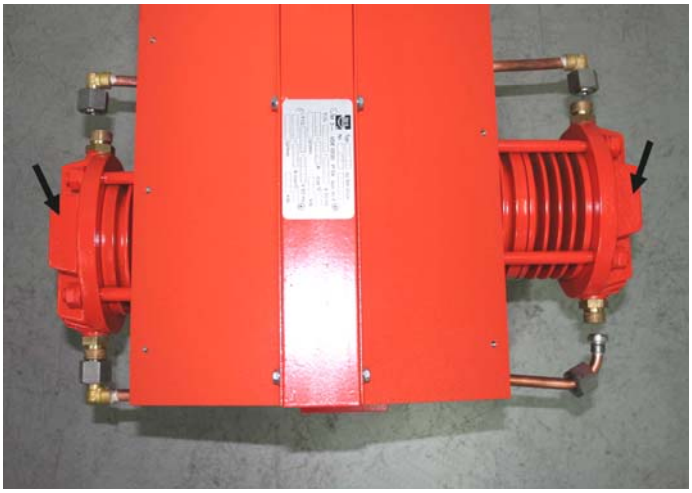
In case a pressure of p_e 48 bar is not reached exchange the valve seats. After the exchange repeat the pressure test.
If the pressure is still not reached the piston and guide rings are to be exchanged.

Verification and disassembly of the piston and guide rings and valve seats

Danger

Attention: Only carry out if the plant is depressurized and disconnected from the power supply!

- Disassemble the front cover (2 pieces).
- Disassemble all tubings on the cylinder caps. Then dismount all cylinder caps.



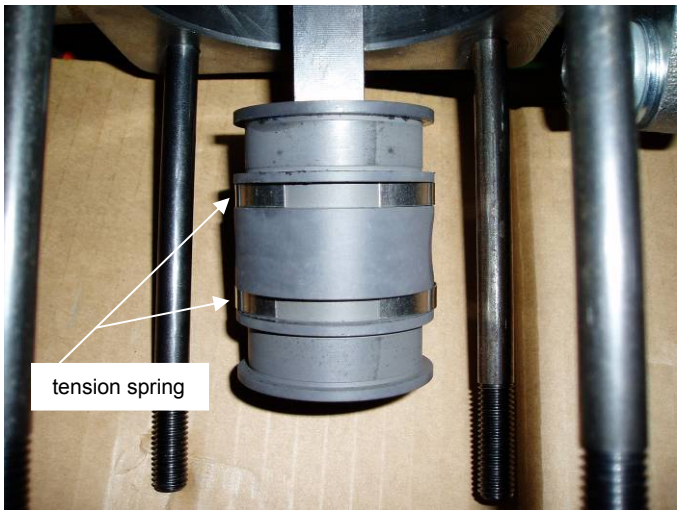
- Remove the valve seats.
- To measure out the piston and guide rings disassemble the cylinders.

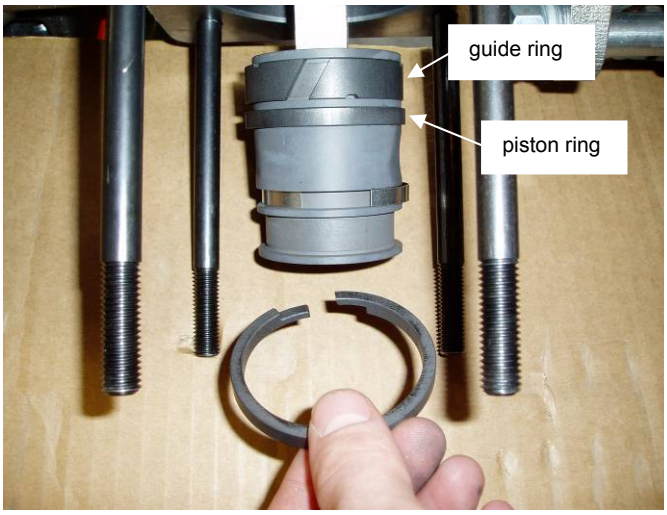
- Exchange the worn-out piston and guide rings (radial minimum thickness page 15).

If contamination is found in the compressor while exchanging the piston and guide rings and valve seats the compressor has to be disassembled and cleaned.

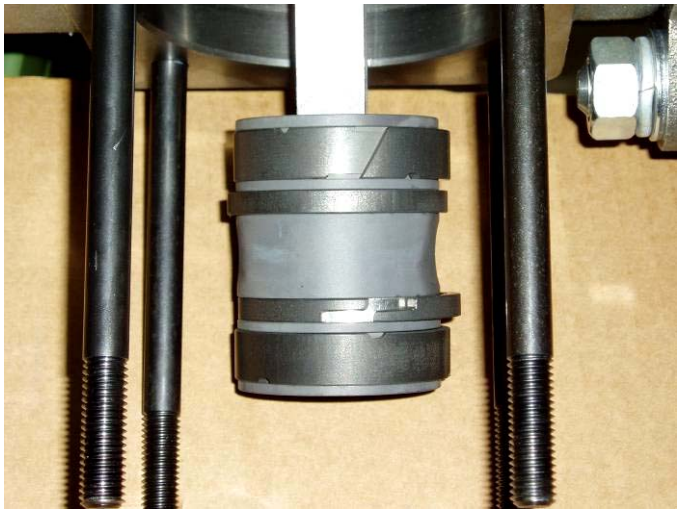
Assembly of piston and guide rings and valve seats

- Prior to assembly, clean all O-rings and piston ring grooves.
- Exchange all O-rings and slightly grease them with silicone grease.
- Mount two tension springs per piston.
- Bend the guide and piston rings as little as possible and slide on to the piston. Mount the piston ring at about 180 degrees with respect to the tension spring (that means in case the open end of the tension spring is at the top the open end of the piston ring must be at the bottom)





- Turn the piston and guide ring so that the open ends are 180 degrees out of position to each other (see photo down left).
- Do not grease the slide surface of the pistons neither with oil nor with grease.
- Assemble the cylinder.



- Clean the valve seats or exchange them if necessary and put them on the cylinders.
- Assemble the cylinder caps and hexagonal nuts and evenly thighten crosswise (**35 Nm**).
- Assemble the complete tubing to the cylinder caps.
- Carry out a leak test.
- Assemble the cylinder covers.

Suction pump | DSP 015

Technical data

Nominal suction capacity:	15 m³/h at 50Hz 18 m³/h at 60Hz
Final pressure:	0.01 mbar
Nominal motor rating:	0.45 kW
Nominal motor speed:	1500/min at 50Hz 1800/min at 60Hz
Motor tension:	
3-phase current – voltage range:	190-240/380-415 V ± 10% 50/60 Hz
Alternating current – voltage range:	200-240 V ± 10% at 50/60 Hz 100-115 V ± 10% at 50/60 Hz
Weight:	48 kg

Cooling air direction check:

Put the palm of your hand on the cooling air openings of the cover in order to check if air is put out from the fan.
In case of too low or none cooling air supply, check the electrical connection of the fan motor.
The cooling openings must be released.

Maintenance:

Cleaning of sieve

It is recommended to regularly check devices without particle filter connected in series for contamination. Contaminated sieves could lower the suction capacity. Clean the sieve if necessary.

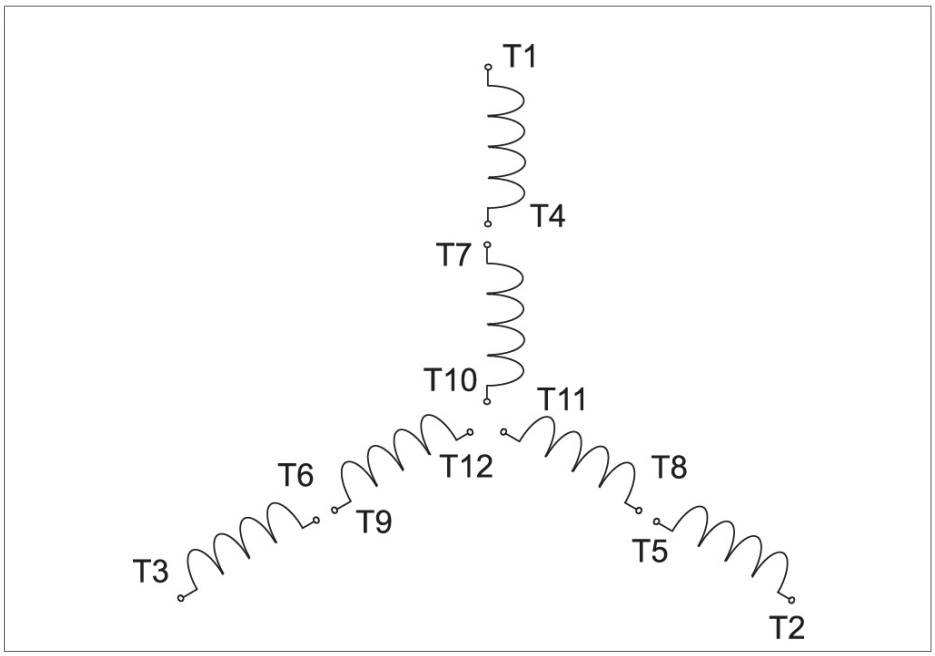
- Unscrew the suction connection and remove the sieve.
- Blow sieve with compressed air and reinstall the sieve with suction connection. Make sure that the suction connection is clean and air tight.

Further maintenance works

We recommend carrying out maintenance works on the pump every 8000 operating hours. For this purpose the pump is to be dismounted from the device. But recover the SF_6-gas from the service cart beforehand. Then dismount the pump.
When ordering the spare part kit for the pump (B105R58) you will receive detailed information on the maintenance works.

Star/ Star-star connection

Motor windings connection



190-220 V 50 Hz star star

link T10-T11-T12: link T4-T5-T6
supply line 1 - T1-T7; lin e 2 - T2-T8; lin e 3 - T3-T9

220-250 V 50 Hz delta

link T4-T7: link T5-T8; link T6-T9
supply line 1 - T1-T12; lin e 2 - T2-T10; lin e 3 - T3-T11

380-415 V 50 Hz star

link T10-T11-T12: link T4-T7; link T5-T8; link T6-T9
supply line 1 - T1; line 2 - T2; line 3 - T3

220-240 V 60 Hz star star

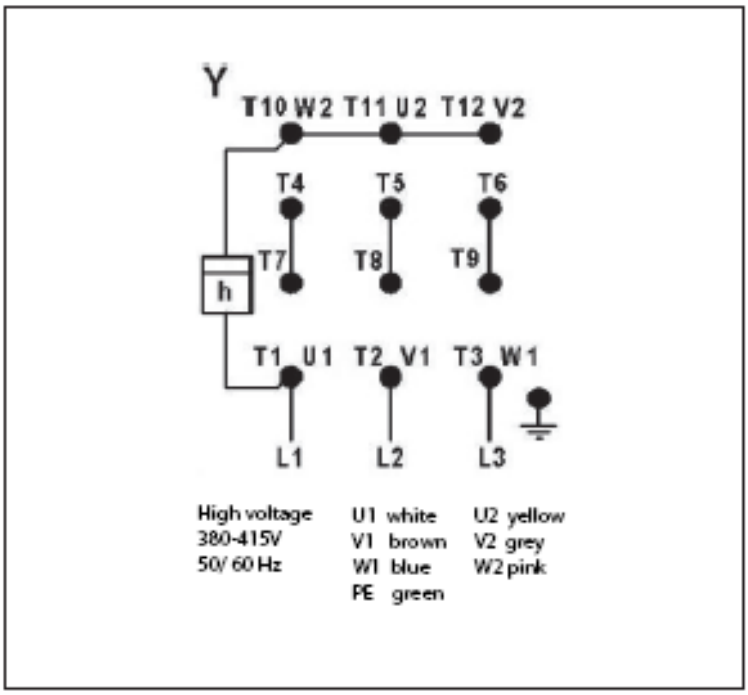
link T10-T11-T12: link T4-T5-T6
supply line 1 - T1-T7; lin e 2 - T2-T8; lin e 3 - T3-T9

440-480 V 60 Hz star

link T10-T11-T12: link T4-T7; link T5-T8; link T6-T9
supply line 1 - T1; line 2 - T2; line 3 - T3

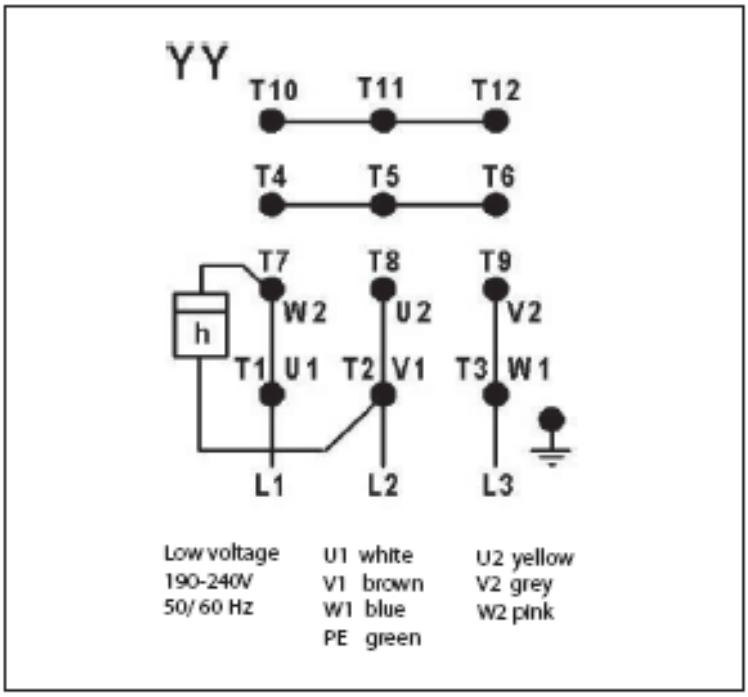
Terminal box connection

Y 380-415 V, 50/ 60 Hz

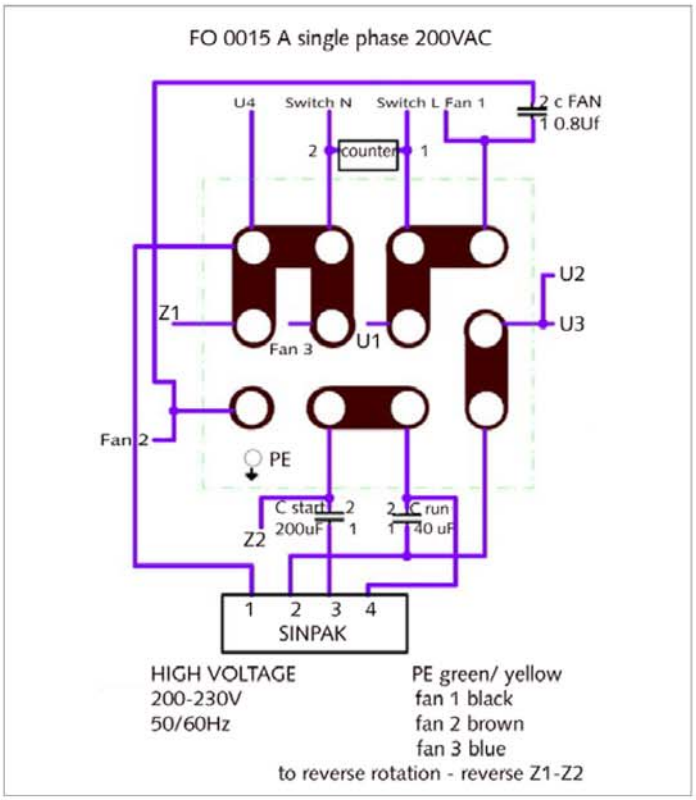


Terminal box connection

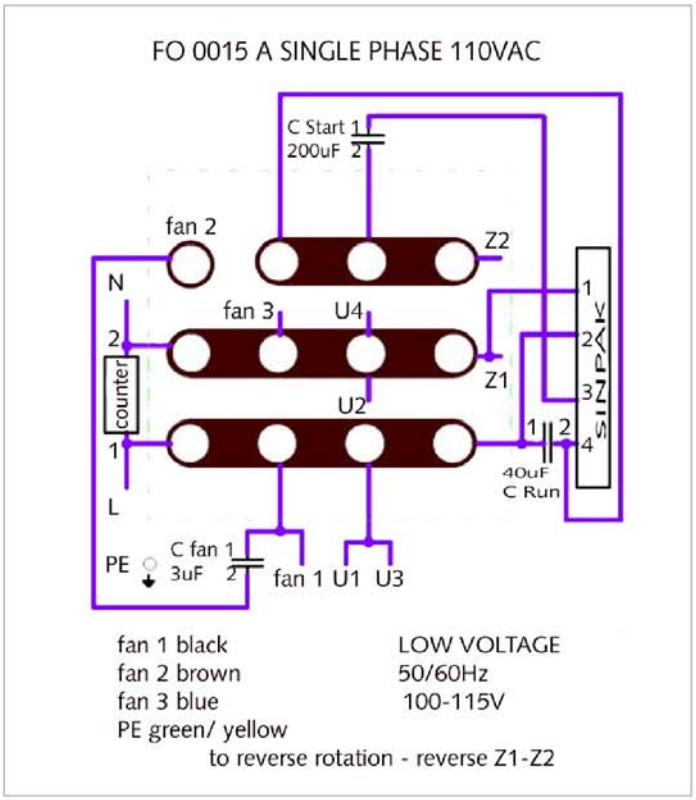
YY 190-240 V, 50/ 60 Hz



Single phase connection (220 - 230 V)



Single phase connection (100 - 115 V)



Installation and Operating Instructions

Vacuum Pumps

R 5 RA 0025 - 0040 F

CE

Busch Produktions GmbH
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79689 Maulburg
Germany

0870139077 / 051214 / Modifications reserved

Table of Contents

Preface

Congratulations on your purchase of the Busch vacuum pump. With watchful observation of the field's requirements, innovation and steady development Busch delivers modern vacuum and pressure solutions worldwide.

These operating instructions contain information for

- product description,
- safety,
- transport,
- storage,
- installation and commissioning,
- maintenance,
- overhaul,
- troubleshooting and
- spare parts

of the vacuum pump.

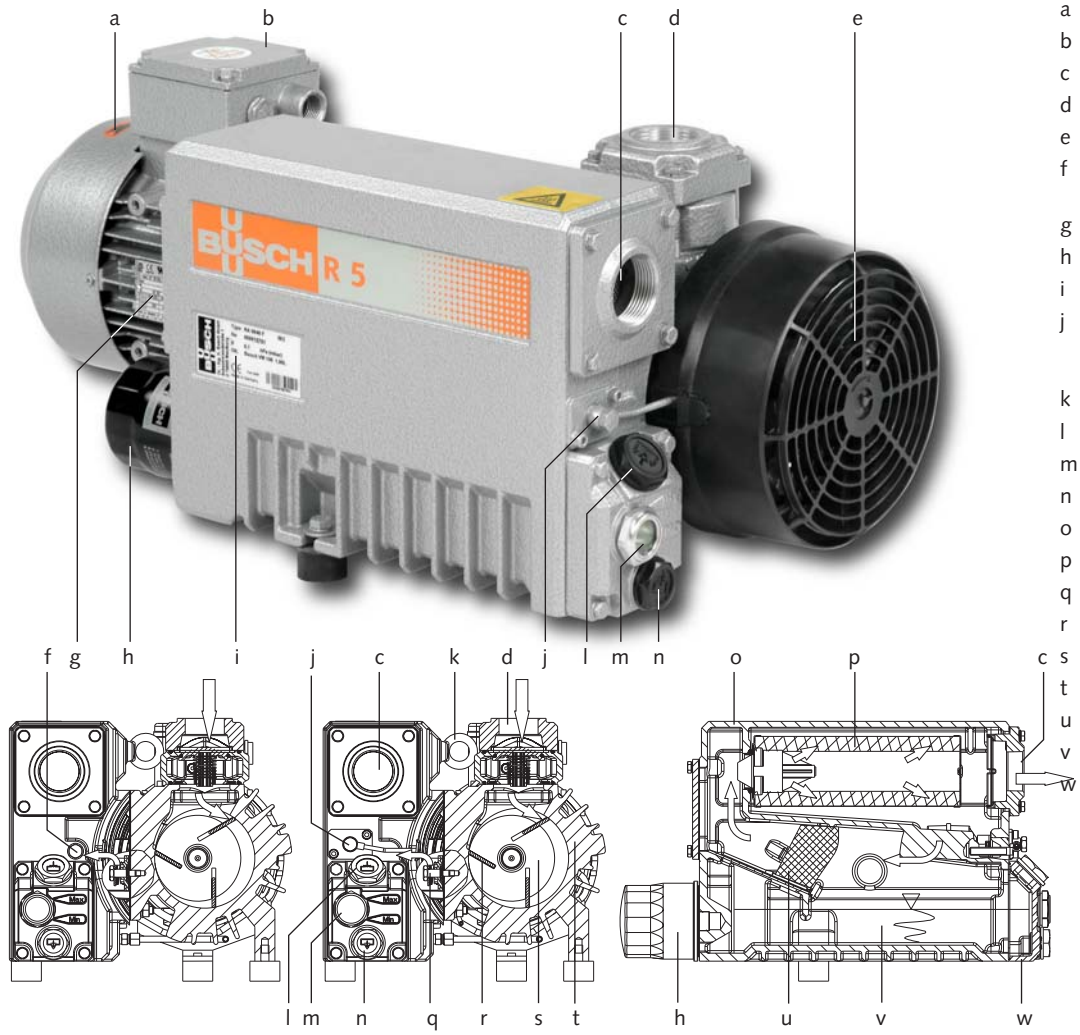
For the purpose of these instructions, "handling" the vacuum pump means the transport, storage, installation, commissioning, influence on operating conditions, maintenance, troubleshooting and overhaul of the vacuum pump.

Prior to handling the vacuum pump these operating instructions shall be read and understood. If anything remains to be clarified please contact your Busch representative!

Keep these operating instructions and, if applicable, other pertinent operating instructions available on site.

Technical Data

Nominal suction capacity (50Hz/60Hz)	m^3/h	RA 0025 F: 25 / 30 RA 0040 F: 40 / 48
Suction capacity at 1 mbar (50Hz/60Hz)	m^3/h	RA 0025 F: 23 / 27 RA 0040 F: 35 / 41
Ultimate pressure	hPa (=mbar) abs.	0.1
Motor nominal rating (50Hz/60Hz)	kW	RA 0025 F: 0.75 / 1.1 RA 0040 F: 1.1 / 1.5
Motor nominal speed (50Hz/60Hz)	min^{-1}	1500 / 1800
Sound pressure level (EN ISO 2151) (50Hz/60Hz)	dB (A)	RA 0025 F: 62 / 64 RA 0040 F: 64 / 67
Water vapour tolerance max.	hPa (=mbar)	40
Water vapour capacity	l/h	RA 0025 F: 0.9 RA 0040 F: 1.1
Operating temperature (50Hz/60Hz)	°C	RA 0025 F: 80 / 85 RA 0040 F: 82 / 90
Ambient temperature range	°C	see "Oil"
Ambient pressure		Atmospheric pressure
Oil quantity	l	1.0
Weight approx. (50Hz/60Hz)	kg	RA 0025 F: 34 RA 0040 F: 38



a Terminal box
b Directional arrow
c Gas discharge
d Suction connection
e Axial flow fan
f Oil return valve (version with oil return valve only)
g Nameplate, drive motor
h Oil filter
i Nameplate, vacuum pump
j Float valve with oil return line (version with float valve and oil return line only)
k Eye bolt
l Oil fill plug
m Oil sight glass
n Oil drain plug
o Oil separator
p Exhaust filter
q Exhaust valve
r Vane
s Rotor
t Cylinder
u Demister
v Oil sump
w Service cover

Product Description

Use

The vacuum pump is intended for

– the suction

of

– air and other dry, non-aggressive, non-toxic and non-explosive gases

Conveying media with a higher density than air leads to an increased thermal and mechanical load on the vacuum pump and is permissible only after prior consultation with Busch.

Permissible temperature range of the inlet gas: see “Oil”, “Ambient temperature range”

In case the vacuum pump is equipped with a gas ballast (optional) water vapour within the gas flow can be tolerated within certain limits (➔ Installation and Commissioning ➘ Operating Notes ➘ Conveying Condensable Vapours). The conveyance of other vapours shall be agreed upon with Busch.

The vacuum pump is intended for the placement in a non-potentially explosive environment.

Version with float valve (j, 200) and oil return line:

The vacuum pump is thermally suitable for continuous operation.

Version with oil return valve (f, 280):

The vacuum pump is thermally suitable for continuous operation (observe the notes with regard to the oil recirculation, ➔ Product Description ➘ Oil Recirculation; ➔ Installation and Commissioning ➘ Operating Notes ➘ Oil Recirculation).

The vacuum pump is ultimate pressure proof.

Principle of Operation

The vacuum pump works on the rotating vane principle.

A circular rotor (s, 14) is positioned centrically on the shaft of the vacuum pump. The shaft of the vacuum pump is driven by the drive motor shaft by means of a flexible coupling (310).

The rotor (s, 14) rotates in an also circular, fixed cylinder (t, 1), the centreline of which is offset from the centreline of the rotor such that the rotor and the inner wall of the cylinder almost touch along a line. Vanes (r, 22), sliding in slots in the rotor, separate the space between the rotor and the cylinder into chambers. At any time gas is sucked in and at almost any time ejected. Therefore the vacuum pump works almost pulsation free.

In order to avoid the suction of solids, the vacuum pump is equipped with a screen (261) in the suction connection.

In order to avoid reverse rotation after switching off, the vacuum pump is equipped with a non-return valve (257).

Note: This valve shall not be used as a non-return valve or shut-off valve to the vacuum system and is no reliable means to prevent suction of oil into the vacuum system while the vacuum pump is shut down.

In case the vacuum pump is equipped with a gas ballast (optional):

Through the gas ballast valve (440) a small amount of ambient air is sucked into the pump chamber and compressed together with the process gas. This counteracts the accumulation of condensates from the process gas inside the vacuum pump (➔ Installation and Commissioning ➘ Operation Notes).

The gas ballast line is equipped with a sinter metal filter.

Gas ballast version with ball valve:

The gas ballast line can be closed partially or completely by means of a ball valve.

In order to improve the operating characteristics the outlet of the pump chamber is equipped with a spring loaded valve (q, 159).

Oil Circulation

The vacuum pump requires oil to seal the gaps, to lubricate the vanes (r, 22) and to carry away compression heat.

The oil reservoir is located on the pressure side of the vacuum pump (i.e. high pressure) at the bottom of the bottom chamber of the oil separator (o, 75).

The feed openings are located on the suction side of the vacuum pump (i.e. low pressure).

Forced by the pressure difference between pressure side and suction side oil is being drawn from the oil separator (o, 75) through the oil supply lines (210) and injected on the suction side.

Together with the sucked gas the injected oil gets conveyed through the vacuum pump and ejected into the oil separator (o, 75) as oil mist. Oil that separates before the exhaust filter (p, 122) accumulates at the bottom of the bottom chamber of the oil separator (o, 75).

Oil that is separated by the exhaust filter (p, 122) accumulates at the bottom of the upper chamber of the oil separator (o, 75).

The flow resistance of the exhaust filters (p, 122) causes the inside of the exhaust filters (which is connected to the bottom chamber of the oil separator) to be on a higher pressure level than the outside of the exhaust filters (i.e. the upper chamber of the oil separator). Because of the higher pressure in the bottom chamber it is not possible to let oil that drips off the exhaust filters simply flow down to the bottom chamber.

Version with float valve and oil return line to the suction connection (j, 200):

Therefore the oil that accumulates in the upper chamber is sucked through the float valve (j, 200) and the oil return line (j, 195) to the suction connection (250).

Version with oil return valve (f, 280):

At continuous operation this would cause the entire supply of oil to accumulate at the bottom of the upper chamber, expel oil droplets through the gas discharge/pressure connection and let the pump run dry. Therefore the vacuum pump must be shut down at the latest after 10 hours of continuous operation, depending on the operating conditions even after a shorter period, for at least approx. 15 minutes (→ Installation and Commissioning ↘ Operating Notes). After turning off the vacuum pump the pressure difference between the inside and the outside of the exhaust filter(s) (p, 122) collapses, hence the two chambers of the oil separator assume an equal pressure level, the oil return valve (f, 280) between the two chambers opens and the accumulated oil in the upper chamber can run down to the bottom chamber.

Cooling

The vacuum pump is cooled by

- radiation of heat from the surface of the vacuum pump incl. oil separator (o, 75)
- the air flow from the fan wheel of the drive motor (400)
- the process gas
- the air flow from the fan wheel (e, 321) on the shaft of the vacuum pump

On/off Switch

The vacuum pump comes without on/off switch. The control of the vacuum pump is to be provided in the course of installation.

Safety

Intended Use

Definition: For the purpose of these instructions, “handling” the vacuum pump means the transport, storage, installation, commissioning, influence on operating conditions, maintenance, troubleshooting and overhaul of the vacuum pump.

The vacuum pump is intended for industrial use. It shall be handled only by qualified personnel.

The allowed media and operational limits (→ Product Description) and the installation prerequisites (→ Installation and Commissioning ↘ Installation Prerequisites) of the vacuum pump shall be observed both by the manufacturer of the machinery into which the vacuum pump is to be incorporated and by the operator.

The maintenance instructions shall be observed.

Prior to handling the vacuum pump these operating instructions shall be read and understood. If anything remains to be clarified please contact your Busch representative!

Safety Notes

The vacuum pump has been designed and manufactured according to the state-of-the-art. Nevertheless, residual risks may remain. These operating instructions inform about potential hazards where appropriate. Safety notes are tagged with one of the keywords DANGER, WARNING and CAUTION as follows:

DANGER

Disregard of this safety note will always lead to accidents with fatal or serious injuries.

WARNING

Disregard of this safety note may lead to accidents with fatal or serious injuries.

CAUTION

Disregard of this safety note may lead to accidents with minor injuries or property damage.

Emission of Oil Mist

CAUTION

The non-OEM spares market offers exhaust filters that are geometrically compatible with Busch-vacuum pumps, but do not feature the high retention capacity of genuine Busch-exhaust filters.

Increased risk of damage to health.

In order to keep the emission on the lowest possible level only genuine Busch-exhaust filters shall be used.

The oil in the process gas is separated to the greatest possible extent, but not perfectly.

CAUTION

The gas conveyed by the vacuum pump contains remainders of oil.

Aspiration of process gas over extended periods can be harmful.

The room into which the process gas is discharged must be sufficiently vented.

Note: The possibly sensible smell is not caused by droplets of oil, though, but either by gaseous process components or by readily volatile and thus gaseous components of the oil (particularly additives).

Noise Emission

For the sound pressure level in free field according to EN ISO 2151 ➔ Technical Data.

Transport

Transport in Packaging

Packed on a pallet the vacuum pump is to be transported with a forklift.

Transport without Packaging

In case the vacuum pump is packed in a cardboard box with inflated cushions:

- ◆ Remove the inflated cushions from the box

In case the vacuum pump is in a cardboard box cushioned with rolled corrugated cardboard:

- ◆ Remove the corrugated cardboard from the box

In case the vacuum pump is laid in foam:

- ◆ Remove the foam

In case the vacuum pump is bolted to a pallet or a base plate:

- ◆ Remove the bolting between the vacuum pump and the pallet/base plate

In case the vacuum pump is fastened to the pallet by means of tightening straps:

- ◆ Remove the tightening straps

CAUTION

Do not walk, stand or work under suspended loads.

Note: The position of the eyebolt (k, 391) fits to the centre of gravity of a vacuum pump incl. drive motor (400). If a vacuum pump without drive motor is to be lifted, attach another belt/rope at a suitable point.

- ● Make sure that the eyebolt (k, 391) is fully screwed in
- ● Attach lifting gear securely to the eyebolt (k, 391) on the oil separator
- ● Attach the lifting gear to a crane hook with safety latch
- ● Lift the vacuum pump with a crane

In case the vacuum pump was bolted to a pallet or a base plate:

- ◆ Remove the stud bolts from the rubber feet

CAUTION

Tilting a vacuum pump that is already filled with oil can cause large quantities of oil to ingress into the cylinder.

Starting the vacuum pump with excessive quantities of oil in the cylinder will immediately break the vanes (r, 22) and ruin the vacuum pump.

Once the vacuum pump is filled with oil it shall not be lifted anymore.

- ● Prior to every transport make sure that the oil is drained

Storage

Short-term Storage

Version with gas ballast device with ball-cock:

- ◆ Make sure that the ball-cock of the gas ballast device (440) is closed

Version with gas ballast device without ball-cock, with sinter metal filter:

- ◆ Close the sinter metal filter of the gas ballast device (440) with adhesive tape

- ● Make sure that the suction connection and the gas discharge are closed (leave the provided plugs in)
- ● Store the vacuum pump

– if possible in original packaging,
– indoors,
– dry,
– dust free and
– vibration free

Conservation

In case of adverse ambient conditions (e.g. aggressive atmosphere, frequent temperature changes) conserve the vacuum pump immediately. In case of favourable ambient conditions conserve the vacuum pump if a storage of more than 3 months is scheduled.

During the test run in the factory the inside of the vacuum pump was completely wetted with oil. Under normal conditions a treatment with conservation oil is therefore not required. In case it is advisable to treat the vacuum pump with conservation oil because of very adverse storage conditions, seek advice from your Busch representative!

Version with gas ballast device with ball-cock:

- ◆ Make sure that the ball-cock of the gas ballast device (440) is closed

Version with gas ballast device without ball-cock, with sinter metal filter:

- ◆ Close the sinter metal filter of the gas ballast device (440) with adhesive tape

- ● Make sure that all ports are firmly closed; seal all ports that are not sealed with PTFE-tape, gaskets or o-rings with adhesive tape

Note: VCI stands for "volatile corrosion inhibitor". VCI-products (film, paper, cardboard, foam) evaporate a substance that condenses in molecular thickness on the packed good and by its electro-chemical properties effectively suppresses corrosion on metallic surfaces. However, VCI-products may attack the surfaces of plastics and elastomers. Seek advice from your local packaging dealer! Busch uses CORTEC VCI 126 R film for the overseas packaging of large equipment.

- ● Wrap the vacuum pump in VCI film
- ● Store the vacuum pump

– if possible in original packing,
– indoors,
– dry,
– dust free and
– vibration free.

For commissioning after conservation:

- ● Make sure that all remains of adhesive tape are removed from the ports
- ● Commission the vacuum pump as described in the chapter ➔ Installation and Commissioning

Installation and Commissioning

Installation Prerequisites

CAUTION

In case of non-compliance with the installation prerequisites, particularly in case of insufficient cooling:

Risk of damage or destruction of the vacuum pump and adjoining plant components!

Risk of injury!

The installation prerequisites must be complied with.

- Make sure that the integration of the vacuum pump is carried out such that the essential safety requirements of the Machine Directive 98/37/EC are complied with (in the responsibility of the designer of the machinery into which the vacuum pump is to be incorporated; note in the → EC-Declaration of Conformity)

Mounting Position and Space

- Make sure that the environment of the vacuum pump is not potentially explosive
- Make sure that the following ambient conditions will be complied with:

– Ambient temperature: see "Oil"
– Ambient pressure: atmospheric

- Make sure that the environmental conditions comply with the protection class of the drive motor (according to the nameplate)
- Make sure that the vacuum pump will be placed or mounted horizontally
- Make sure that in order to warrant a sufficient cooling there will be a clearance of minimum 20 cm between the vacuum pump and nearby walls
- Make sure that no heat sensitive parts (plastics, wood, cardboard, paper, electronics) will touch the surface of the vacuum pump
- Make sure that the installation space or location is vented such that a sufficient cooling of the vacuum pump is warranted

CAUTION

During operation the surface of the vacuum pump may reach temperatures of more than 70 °C.

Risk of burns!

- Make sure that the vacuum pump will not be touched inadvertently during operation, provide a guard if appropriate
- Make sure that the sight glass (m, 83) will remain easily accessible

If the oil change is meant to be performed on location:

- ◆ Make sure that the drain port (n, 95), the oil filter (h, 100) and the filling port (l, 88) will remain easily accessible

- Make sure that enough space will remain for the removal and the reinsertion of the exhaust filter (p, 122)

Suction Connection

CAUTION

Intruding foreign objects or liquids can destroy the vacuum pump.

In case the inlet gas can contain dust or other foreign solid particles:

- ◆ Make sure that a suitable filter (5 micron or less) is installed upstream the vacuum pump

- Make sure that the suction line fits to the suction connection (d, 260) of the vacuum pump
- Make sure that the gas will be sucked through a vacuum-tight flexible hose or a pipe

In case of using a pipe:

- ◆ Make sure that the pipe will cause no stress on the vacuum pump's connection, if necessary use bellows

- Make sure that the line size of the suction line over the entire length is at least as large as the suction connection (d, 260) of the vacuum pump

In case of very long suction lines it is prudent to use larger line sizes in order to avoid a loss of efficiency. Seek advice from your Busch representative!

If two or more vacuum pumps work on the same suction line, if the volume of the vacuum system is large enough to suck back oil or if the vacuum shall be maintained after switching off the vacuum pump:

- ◆ Provide a manual or automatic operated valve (= non-return valve) in the suction line

(the standard non-return valve that is installed inside the suction connection is not meant to be used for this purpose!)

If the vacuum pump is planned to be used for the suction of gas that contains limited quantities of condensable vapour:

- ◆ Provide a shut-off valve, a drip-leg and a drain cock in the suction line, so that condensates can be drained from the suction line

- Make sure that the suction line does not contain foreign objects, e.g. welding scales

Gas Discharge

The following guidelines for the discharge line do not apply, if the aspirated air is discharged to the environment right at the vacuum pump.

CAUTION

The discharged air contains small quantities of vacuum oil.

Staying in vacuum oil contaminated air bears a risk of damage to health.

If air is discharged into rooms where persons stay, sufficient ventilation must be provided for.

- Make sure that the discharge line fits to the gas discharge (c, 155) of the vacuum pump

In case of using a pipe:

- ◆ Make sure that the pipe will cause no stress on the vacuum pump's connection, if necessary use bellows

- Make sure that the line size of the discharge line over the entire length is at least as large as the gas discharge (c, 155) of the vacuum pump

In case the length of the discharge line exceeds 2 m it is prudent to use larger line sizes in order to avoid a loss of efficiency and an overload of the vacuum pump. Seek advice from your Busch representative!

With unrestricted suction the counter pressure at the gas outlet (c, 155) of the vacuum pump must not exceed 1.3 bar abs 'Absolutdruck (in case of doubt to be verified during commissioning at a suitable time).

- Make sure that the discharge line either slopes away from the vacuum pump or provide a liquid separator or a drip leg with a drain cock, so that no liquids can back up into the vacuum pump

WARNING

Discharge lines made from non-conducting material can build up static charge.

Static discharge can cause explosion of potentially existing oil mist.

The discharge line must be made of conducting material or provisions must be made against static discharge.

Electrical Connection / Controls

- Make sure that the stipulations acc. to the EMC-Directive 89/336/EEC and Low-Voltage-Directive 73/23/EEC as well as the EN-standards, electrical and occupational safety directives and the local or national regulations, respectively, are complied with (this is in the responsibility of the designer of the machinery into which the vacuum pump is to be incorporated; → note in the EC-Declaration of Conformity).
- Make sure that the power supply for the drive motor is compatible with the data on the nameplate of the drive motor (400)
- Make sure that an overload protection according to EN 60204-1 is provided for the drive motor
- Make sure that the drive of the vacuum pump will not be affected by electric or electromagnetic disturbance from the mains; if necessary seek advice from the Busch service

In case of mobile installation:

- ◆ Provide the electrical connection with grommets that serve as strain-relief

Installation

Mounting

- Make sure that the ↘ Installation Prerequisites are complied with
- Set down or mount the vacuum pump at its location

Connecting Electrically

WARNING

Risk of electrical shock, risk of damage to equipment.

Electrical installation work must only be executed by qualified personnel that knows and observes the following regulations:
- IEC 364 or CENELEC HD 384 or DIN VDE 0100, respectively,
- IEC-Report 664 or DIN VDE 0110,
- BGV A2 (VBG 4) or corresponding national accident prevention regulation.

CAUTION

The connection schemes given below are typical. Depending on the specific order or for certain markets deviating connection schemes may apply.

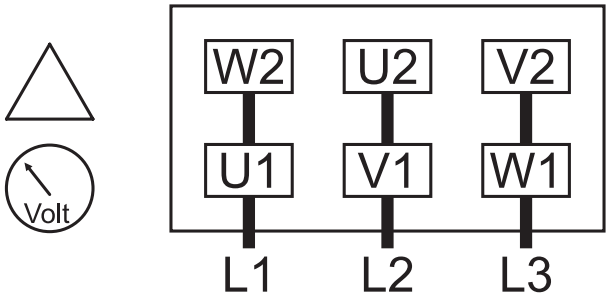
Risk of damage to the drive motor!

The inside of the terminal box shall be checked for drive motor connection instructions/schemes.

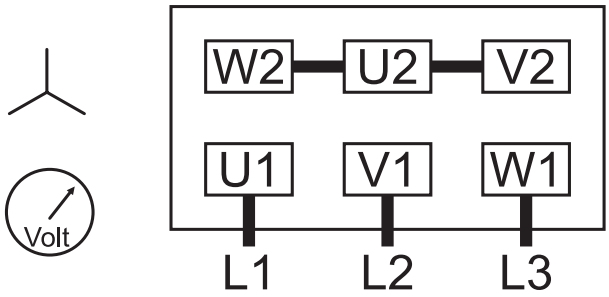
- Electrically connect the drive motor (400)
- Connect the protective earth conductor

Connection Scheme Three-Phase Motor

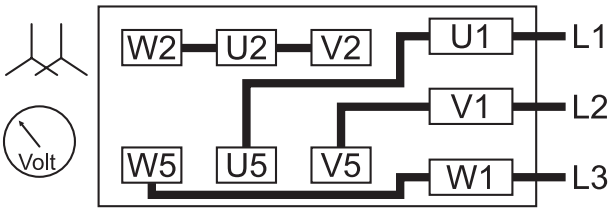
Delta connection (low voltage):



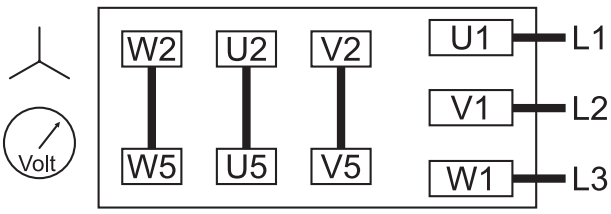
Star connection (high voltage):



Double star connection, multi-voltage motor (low voltage):



Star connection, multi-voltage motor (high voltage):



CAUTION

Operation in the wrong direction of rotation can destroy the vacuum pump in short time.

Prior to starting-up it must be made sure that the vacuum pump is operated in the proper direction.

Version with three-phase motor:

- ◆ Determine the intended direction of rotation with the arrow (a, 431) (stuck on or cast)
- ◆ "Bump" the drive motor (400)
- ◆ Watch the fan wheel of the drive motor (400) and determine the direction of rotation just before the fan wheel stops

If the rotation must be changed:

- ◆ Switch any two of the drive motor wires (three-phase motor)

Connecting Lines/Pipes

In case the suction line is equipped with a shut-off valve:

- ◆ Connect the suction line

- Connect the discharge line

Installation without discharge line:

- ◆ Make sure that the gas discharge (c, 155) is open
- Make sure that all provided covers, guards, hoods etc. are mounted
- Make sure that cooling air inlets and outlets are not covered or obstructed and that the cooling air flow is not affected adversely in any other way

Filling Oil

In case the vacuum pump was treated with conservation oil:

- ◆ Drain the remainders of conservation oil

CAUTION

The vacuum pump is shipped without oil.

Operation without oil will ruin the vacuum pump in short time.

Prior to commissioning it must be made positively sure that oil is filled in.

The vacuum pump is delivered without oil (oil specification → Oil).

- Keep approx. 1.0 litres oil acc. to the table → Oil ready

Note: The amount given in these operating instructions is a guide. The sight glass (m, 83) indicates the actual amount to be filled in.

CAUTION

Filling oil through the suction connection (d, 260) will result in breakage of the vanes (r, 22) and destruction of the vacuum pump.

Oil may be filled through the filling port (l, 88) only.

CAUTION

During operation the oil separator is filled with hot, pressurised oil mist.

Risk of injury from hot oil mist with open filling port.

Risk of injury if a loosely inserted filling plug (l, 88) is ejected.

Remove the filling plug (l, 88) only if the vacuum pump is stopped.

The vacuum pump must only be operated with the filling plug (l, 88) firmly inserted.

- Remove the filling plug (l, 88)
- Fill in approx. 1.0 litres of oil
- Make sure that the level is between the MIN and the MAX-markings of the sight glass (m, 83)
- Make sure that the seal ring (89) is inserted into the filling plug (l, 88) and undamaged, replace if necessary
- Firmly reinsert the filling plug (l, 88) together with the seal ring (89)

Note: Starting the vacuum pump with cold oil is made easier when at this very moment the suction line is neither closed nor covered with a rubber mat.

- Switch on the vacuum pump

In case the suction line is equipped with a shut-off valve:

- ◆ Close the shut-off valve

In case the suction line is not equipped with a shut-off valve:

- ◆ Cover the suction connection (d, 260) with a piece of rubber mat
- Let the vacuum pump run for a few minutes
- Shut down the vacuum pump and wait a few minutes
- Check that the level is between the MIN and the MAX-markings of the sight glass (m, 83)

In case the level has fallen below the MIN-marking:

- ◆ Top-up oil

In case the suction line is equipped with a shut-off valve:

- ◆ Open the shut-off valve

In case the suction line is not equipped with a shut-off valve:

- ◆ Remove the piece of rubber mat and connect the suction line

Recording of Operational Parameters

Version with exhaust filter pressure gauge:

- ◆ Read the scale of the exhaust filter pressure gauge and record it as reference for future maintenance and troubleshooting work Störungsbehebungsarbeiten aufzeichnen (→ Maintenance ↘ Exhaust Filter(s) ↘ Checks during Operation)

As soon as the vacuum pump is operated under normal operating conditions:

- Measure the drive motor current and record it as reference for future maintenance and troubleshooting work

Operation Notes

Use

CAUTION

The vacuum pump is designed for operation under the conditions described below.

In case of disregard risk of damage or destruction of the vacuum pump and adjoining plant components!

Risk of injury!

The vacuum pump must only be operated under the conditions described below.

The vacuum pump is intended for

– the suction

of

– air and other dry, non-aggressive, non-toxic and non-explosive gases

Conveying media with a higher density than air leads to an increased thermal and mechanical load on the vacuum pump and is permissible only after prior consultation with Busch.

Permissible temperature range of the inlet gas: see "Oil", "Ambient temperature range"

In case the vacuum pump is equipped with a gas ballast (optional) water vapour within the gas flow can be tolerated within certain limits (↘ Conveying Condensable Vapours). The conveyance of other vapours shall be agreed upon with Busch.

The vacuum pump is intended for the placement in a non-potentially explosive environment.

Version with float valve (j, 200) and oil return line:

The vacuum pump is thermally suitable for continuous operation.

Version with oil return valve (f, 280):

The vacuum pump is thermally suitable for continuous operation (observe the notes with regard to the oil recirculation, → Product Description ↘ Oil Recirculation and → Installation and Commissioning ↘ Operating Notes ↘ Oil Recirculation).

The vacuum pump is ultimate pressure proof.

CAUTION

During operation the surface of the vacuum pump may reach temperatures of more than 70 °C.

Risk of burns!

The vacuum pump shall be protected against contact during operation, it shall cool down prior to a required contact or heat protection gloves shall be worn.

CAUTION

The gas conveyed by the vacuum pump contains remainders of oil.

Aspiration of process gas over extended periods can be harmful.

The room into which the process gas is discharged must be sufficiently vented.

- Make sure that all provided covers, guards, hoods etc. remain mounted
- Make sure that protective devices will not be disabled
- Make sure that cooling air inlets and outlets will not be covered or obstructed and that the cooling air flow will not be affected adversely in any other way
- Make sure that the installation Prerequisites (➔ Installation and Commissioning ↘ Installation Prerequisites) are complied with and will remain complied with, particularly that a sufficient cooling will be ensured

Oil Return

Only for version with oil return valve (f, 280):

During operation oil accumulates at the bottom of the upper chamber of the oil separator (o, 75), which cannot flow down into the bottom chamber, as long as the vacuum pump runs (for detailed description ➔ Product Description ↘ Oil Recirculation).
At the latest after 10 hours of continuous operation, in case of high pressure difference between suction side and pressure side after a shorter period, the vacuum pump must be shut down for at least 15 minutes, so that the oil can run down from the upper chamber of the oil separator (o, 75) into the bottom chamber. **Note**: This is a good time to check the temperature, the level and the colour of the oil.

Conveying Condensable Vapours

CAUTION

Residual condensates dilute the oil, deteriorate its lubricating properties and can cause a seizure of the rotor.

Apply a suitable operating method to make sure that no condensates remain in the vacuum pump.

In order to use the vacuum pump for the conveyance of condensable vapours, the vacuum pump must be equipped with a shut-off valve in the suction line and with a gas ballast valve.

Version with gas ballast device with ball-cock:

- ◆ Make sure that the ballast valve is open and will remain open during operation

- Close the shut-off valve in the suction line
- Operate the vacuum pump with the suction line shut off for approx. half an hour, so that the operating temperature rises to approx. 75 °C

At process start:

- Open the shut-off valve in the suction line

At the process end:

- Close the shut-off valve in the suction line
- Operate the vacuum pump for another approx. half an hour

Maintenance

DANGER

In case the vacuum pump conveyed gas that was contaminated with foreign materials which are dangerous to health, harmful material can reside in filters.

Danger to health during inspection, cleaning or replacement of filters.

Danger to the environment.

Personal protective equipment must be worn during the handling of contaminated filters.

Contaminated filters are special waste and must be disposed of separately in compliance with applicable regulations.

CAUTION

During operation the surface of the vacuum pump may reach temperatures of more than 70 °C.

Risk of burns!

- Prior to action that requires touching of the vacuum pump, let the vacuum pump cool down, however, if the oil is to be drained, for no more than 20 minutes
- Prior to disconnecting connections make sure that the connected pipes/lines are vented to atmospheric pressure

Maintenance Schedule

Note: The maintenance intervals depend very much on the individual operating conditions. The intervals given below shall be considered as starting values which should be shortened or extended as appropriate. Particularly heavy duty operation, such like high dust loads in the environment or in the process gas, other contaminations or ingress of process material, can make it necessary to shorten the maintenance intervals significantly.

Daily:

- Check the level and the colour of the oil (➔ Checking the Oil)

Weekly:

- Check the vacuum pump for oil leaks - in case of leaks have the vacuum pump repaired (Busch service)

Monthly:

- Check the function of the exhaust filter (p, 122) (➔ Exhaust Filter)
- Make sure that the vacuum pump is shut down and locked against inadvertent start up

In case an inlet air filter is installed:

- ◆ Check the inlet air filter, if necessary clean (with compressed air) or replace

In case of operation in a dusty environment:

- ◆ Clean as described under ↘ Every 6 Months:

Every 6 Months:

- Make sure that the housing is free from dust and dirt, clean if necessary
- Make sure that the vacuum pump is shut down and locked against inadvertent start up
- Clean the fan cowlings, fan wheels, the ventilation grilles and cooling fins

Every Year:

- Make sure that the vacuum pump is shut down and locked against inadvertent start up
- Replace the exhaust filter (p, 122) (↘ Exhaust Filter)

In case an inlet air filter is installed:

- ◆ Clean (with compressed air) or replace the inlet air filter

- Check the inlet screen (261), clean if necessary

Version with gas ballast with sinter metal filter:

- ◆ Clean the sinter metal filter (compressed air)

Every 500 - 2000 Operating Hours (↘ Oil Life):

- Change the oil and the oil filter (h, 100) (↘ Oil and Oil Filter Change)

Version with float valve (j, 200) and oil return line

- ◆ Check the float valve (j, 200) (↘ Oil and Oil Filter Change ↘ Checking the Float Valve)

Checking the Oil

Checking the Level

- Make sure that the vacuum pump is shut down and the oil has collected at the bottom of the oil separator (o, 75)
- Read the level on the sight glass (m, 83)

In case the level has dropped underneath the MIN-marking:

- ◆ Top up oil (↘ Topping up Oil)

In case the level exceeds the MAX-marking:

- ◆ Excessive dilution with condensates - change the oil and check the process
- ◆ If appropriate retrofit a gas ballast (Busch Service) and observe the chapter → Installation and Commissioning ↘ Operation Notes ↘ Conveying Condensable Vapours

Topping up Oil

Note: Under normal conditions there should be no need to top up oil during the recommended oil change intervals. A significant level drop indicates a malfunction (→ Troubleshooting).

Note: During operation the exhaust filter gets saturated with oil. It is therefore normal that the oil level will drop slightly after replacement of the exhaust filter.

CAUTION

Filling oil through the suction connection (d, 260) will result in breakage of the vanes (r, 22) and destruction of the vacuum pump.

Oil may be filled through the filling port (l, 88) only.

CAUTION

During operation the oil separator is filled with hot, pressurised oil mist.

Risk of injury from hot oil mist with open filling port.

Risk of injury if a loosely inserted filling plug (l, 88) is ejected.

Remove the filling plug (l, 88) only if the vacuum pump is stopped.

The vacuum pump must only be operated with the filling plug (l, 88) firmly inserted.

- Make sure that the vacuum pump is shut down and locked against inadvertent start up
- Remove the filling plug (l, 88)
- Top up oil until the level reaches the middle of the sight glass (m, 83)
- Make sure that the level is between the MIN and the MAX-markings of the sight glass (m, 83)
- Make sure that the seal ring (89) is inserted into the filling plug (l, 88) and undamaged, replace if necessary
- Firmly reinsert the filling plug (l, 88) together with the seal ring (89)

Checking the Colour of the Oil

Note: The oil should be light, either transparent, a little foamy or a little tarnished. A milky discolouration that does not vanish after sedation of the oil indicates contamination with foreign material. Oil that is either contaminated with foreign material or burnt must be changed (↘ Oil Change).

Oil Life

The oil life depends very much on the operating conditions. A clean and dry air stream and operating temperatures below 100 °C are ideal. Under these conditions the oil and the oil filter (h, 100) shall be changed every 500 to 2000 operating hours or after half a year.

Under very unfavourable operating conditions the oil life can be less than 500 operating hours. Extremely short life times indicate malfunctions (→ Troubleshooting) or unsuitable operating conditions, though.

Chosing a synthetic oil instead of a mineral oil can extend the oil life. To select the oil best suited for your process please contact your Busch representative.

If there is no experience available with regard to the oil life under the prevailing operation conditions, it is recommended to have an oil analysis carried out every 500 operating hours and establish the change interval accordingly.

Oil and Oil Filter Change

DANGER

In case the vacuum pump conveyed gas that was contaminated with harmful foreign material the oil and the oil filter will be contaminated with harmful material.

Danger to health during the changing of contaminated oil and oil filters.

Danger to the environment.

Wear personal protective equipment during the changing of contaminated oil and oil filters.

Contaminated oil and oil filters are special waste and must be disposed of separately in compliance with applicable regulations.

Draining Used Oil

Note: After switching off the vacuum pump at normal operating temperature wait no more than 20 minutes before the oil is drained.

- Make sure that the vacuum pump is shut down and locked against inadvertent start up
- Make sure that the vacuum pump is vented to atmospheric pressure
- Put a drain tray underneath the drain port (n, 95)
- Remove the drain plug (n, 95) and drain the oil

When the oil stream dwindles:

- Reinsert the drain plug (n, 95)
- Switch the vacuum pump on for a few seconds
- Make sure that the vacuum pump is shut down and locked against inadvertent start up
- Remove the drain plug (n, 95) again and drain the remaining oil
- Make sure that the seal ring (96) is inserted into the drain plug (n, 95) and undamaged, replace if necessary

- Firmly reinsert the drain plug (n, 95) together with the seal ring (96)
- Dispose of the used oil in compliance with applicable regulations

Flushing the Vacuum Pump

WARNING

Degraded oil can choke pipes and coolers.

Risk of damage to the vacuum pump due to insufficient lubrication.

Risk of explosion due to overheating.

If there is a suspicion that deposits have gathered inside the vacuum pump the vacuum pump shall be flushed.

- Make sure that all the used oil is drained
- Make sure that the used oil filter (h, 100) is still in place
- Create 1.0 litres flushing agent from 50 percent oil and 50 percent paraffin or diesel fuel/fuel oil
- Make sure that the drain plug (n, 95) is firmly inserted
- Remove the filling plug (l, 88)
- Fill in the flushing agent
- Firmly reinsert the filling plug (l, 88)
- Close the suction line
- Run the vacuum pump for at least half an hour
- Drain the flushing agent and dispose of it in compliance with applicable regulations

Note: Due to the use of paraffin and even more in case of using diesel fuel/fuel oil, an unpleasant odour can occur after recommissioning. If this is a problem, diesel fuel/fuel oil should be avoided and the vacuum pump be run at idle in a suitable place until the unpleasant odour vanishes.

Checking the Float Valve

(version with float valve and oil return line only)

Note: It is essential that the float valve (j, 200) works properly, so that the vacuum pump will achieve the intended ultimate pressure and no oil will be expelled out of the discharge connection (c, 155).

- Make sure that the vacuum pump is shut down and locked against inadvertent start up
- Prior to disconnecting pipes/lines make sure that the connected pipes/lines are vented to atmospheric pressure
- Remove the discharge line, if necessary
- Remove the exhaust cover (c, 155)
- Remove the oil from the floater chamber with the aid of a suction hose or a wash bottle
- Undo the screws (341) and remove the fan cover (e, 340)

Note: While undoing the banjo fitting of the oil return line (j, 195) a small amount of oil will leak out: keep a cleaning rag ready. Be careful not to lose the sealing rings of the banjo fitting.

- Undo the banjo fitting of the oil return line (j, 195) from the oil separator (o, 75) and bend the oil return line a little bit aside
- Undo the two screws of the flange of the float valve (j, 200) and pull the float valve out of the oil separator (o, 75)
- Check the cleanliness and function of the float valve (j, 200), blow out with compressed air, if necessary
- Make sure that the o-ring on the flange of the float valve is in place and undamaged, replace with a new o-ring, if necessary
- Insert the float valve (j, 200) in the proper orientation into the oil separator (o, 75) and fasten it with two screws and lock washers
- Connect the banjo fitting of the oil return line (j, 195) to the oil separator (o, 75) with the hollow-core screw and two seal rings
- Fasten the fan cover (e, 340) to the vacuum pump with the screws (341)

Only if the exhaust filter (p, 122) is **not** meant to be changed, too:

- ◆ Make sure that the seal (141) under the exhaust cover (c, 155) is clean and undamaged, if necessary replace with a new seal (141)
- ◆ Mount the exhaust cover (c, 155) together with the seal (141), hex head screws (146) and lock washers on the oil separator (o, 75)
- ◆ If necessary connect the discharge line

Replacing the Oil Filter

- Make sure that the oil is drained
- Remove the oil filter (h, 100)
- Apply a drop of fresh oil on the seal ring of the new oil filter (h, 100)
- Mount the new oil filter (h, 100) and tighten it by hand

Filling in Fresh Oil

- Keep 1.0 litres oil acc. to the table → Oil ready

Note: The amount given in these operating instructions is a guide. The sight glass (m, 83) indicates the actual amount to be filled in.

- Make sure that the oil outlet plug (n, 95) is firmly inserted

CAUTION

Filling oil through the suction connection (d, 260) will result in breakage of the vanes (r, 22) and destruction of the vacuum pump.

Oil may be filled through the filling port (l, 88) only.

- Remove the filling plug (l, 88)
- Fill in approx. 1.0 litres of oil
- Make sure that the level is between the MIN and the MAX-markings of the sight glass (m, 83)
- Make sure that the seal ring (89) is inserted into the filling plug (l, 88) and undamaged, replace if necessary
- Firmly reinsert the filling plug (l, 88) together with the seal ring (89)

Exhaust Filter

Checks during Operation

Busch recommends the use of a filter pressure gauge (available as accessory, → Accessories). Without filter pressure gauge the filter resistance shall be assessed on the basis of the drive motor current drawn.

Version with exhaust filter pressure gauge:

- ◆ Remove the suction line from suction connection (d, 260) (unrestricted suction!)
- ◆ Check that the reading on the filter pressure gauge is in the green field
- ◆ Reconnect the suction line to the suction connection (d, 260)

Version without filter pressure gauge:

- ◆ Make sure that the vacuum pump is running
- ◆ Check that the drive motor current drawn is in the usual range

Version with oil return valve (f, 280):

Note: The discharged gas will also contain oil if the vacuum pump is operated without interruption for too long a period (→ Installation and Commissioning ↘ Operation Notes).

- Check that the discharged gas is free from oil

Assessment

If

the reading on the filter pressure gauge is in the red field,

or

the drive motor draws too much current and/or the pump flow rate has dropped,

then the exhaust filter (p, 122) is clogged and must be replaced.

Note: Exhaust filters cannot be cleaned successfully. Clogged exhaust filters must be replaced with new ones.

If

the filter pressure gauge indicates a lower pressure than usual,

or

the drive motor draws less current than usual,

then the exhaust filter (p, 122) is broken through and must be replaced.

If the discharged gas contains oil,

the exhaust filter (p, 122) can either be clogged or broken through and, if applicable, must be replaced.

Change of the Exhaust Filter

DANGER

In case the vacuum pump conveyed gas that was contaminated with harmful foreign material the exhaust filter will be contaminated with harmful material.

Danger to health during the changing of the contaminated exhaust filter.

Danger to the environment.

Wear personal protective equipment during the changing of the contaminated exhaust filter.

Used exhaust filters are special waste and must be disposed of separately in compliance with applicable regulations.

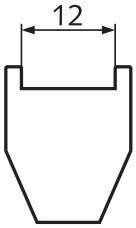
CAUTION

The filter spring (125) can fly out of the exhaust port during removal or insertion.

Risk of eye injury.

Eye protection goggles must be worn while handling filter springs (125).

Note: In order to facilitate the removal and insertion of filter springs (125) it is recommend to make a special tool:



- Make a fork acc. to the sketch from approx. 2 mm steel plate
- Weld the bottom end of the fork to the tip of a medium size slotted head screw driver

Removing the Exhaust Filter

- Make sure that the vacuum pump is shut down and locked against inadvertent start up
- Prior to disconnecting pipes/lines make sure that the connected pipes/lines are vented to atmospheric pressure
- Remove the discharge line, if necessary
- Remove the exhaust cover (c, 155) from the oil separator (o, 75)
- Loosen the screw in the centre of the exhaust filter retaining spring (125), but do not remove it at this time
- With the aid of the special tool press the exhaust filter retaining spring (125) out of the indent and rotate it
- Remove the exhaust filter retaining spring (125) from the oil separator
- Pull the exhaust filter (p, 122) out of the oil separator (o, 75)

Inserting the Exhaust Filter

CAUTION

The non-OEM spares market offers exhaust filters that are geometrically compatible with Busch-vacuum pumps, but do not feature the high retention capacity of genuine Busch-exhaust filters and deteriorate the service life and the efficiency of the vacuum pump due to their increased back pressure.

Increased risk of damage to health.

Adverse effect on efficiency and service life.

In order to keep the emission on the lowest possible level and to preserve efficiency and service life only genuine Busch-exhaust filters shall be used.

- Make sure that the new exhaust filter (p, 122) is equipped with a new o-ring
- Insert the exhaust filter (p, 122) such that its port is properly seated in its receptacle in the oil separator (o, 75)
- Make sure that the tip of the screw in the centre of the exhaust filter retaining spring (125) protrudes the retaining spring by about 2 - 5 revolutions
- With the aid of the special tool insert the exhaust filter retaining spring (125) such that its ends are secured in their receptacles in the oil separator (o, 75) by the protrusions and that the tip of the screw snaps into the indent of the exhaust filter (p, 122)
- Tighten the screw in the exhaust filter retaining spring (125) such that the screw head touches the spring steel sheet
- Make sure that the seal (141) under the exhaust cover (c, 155) is clean and undamaged, if necessary replace with a new seal (141)
- Mount the exhaust cover (c, 155) together with the seal (141), hex head screws (146) and lock washers on the oil separator (o, 75)
- If necessary connect the discharge line

Note: During operation the exhaust filter gets saturated with oil. It is therefore normal that the oil level will drop slightly after replacement of the exhaust filter.

Overhaul

CAUTION

In order to achieve best efficiency and a long life the vacuum pump was assembled and adjusted with precisely defined tolerances.

This adjustment will be lost during dismantling of the vacuum pump.

It is therefore strictly recommended that any dismantling of the vacuum pump that is beyond of what is described in this manual shall be done by Busch service.

DANGER

In case the vacuum pump conveyed gas that was contaminated with harmful foreign material the oil, the oil filter and the exhaust filter(s) will be contaminated with harmful material.

Harmful material can reside in pores, gaps and internal spaces of the vacuum pump.

Danger to health during dismantling of the vacuum pump.

Danger to the environment.

Prior to shipping the vacuum pump shall be decontaminated as good as possible and the contamination status shall be stated in a "Declaration of Contamination" (form downloadable from www.busch-vacuum.com).

Busch service will only accept vacuum pumps that come with a completely filled in and legally binding signed "Declaration of Contamination" (form downloadable from www.busch-vacuum.com).

Removal from Service

Temporary Removal from Service

- Prior to disconnecting pipes/lines make sure that all pipes/lines are vented to atmospheric pressure

Recommissioning

CAUTION

Vanes (r, 22) can stick after a long period of standstill.

Risk of vane breakage if the vacuum pump is started with the drive motor.

After longer periods of standstill the vacuum pump shall be turned by hand.

After longer periods of standstill:

- Make sure that the vacuum pump is locked against inadvertent start up
- Remove the cover around the fan of the drive motor (400)
- Slowly rotate the fan wheel by hand several revolutions in the intended direction of rotation (see stuck on or cast arrow (a, 431))
- Mount the cover around the fan wheel of the drive motor (400)

If deposits could have gathered in the vacuum pump:

- Flush the vacuum pump (→ Maintenance)

- Observe the chapter → Installation and Commissioning

Dismantling and Disposal

DANGER

In case the vacuum pump conveyed gas that was contaminated with harmful foreign material the oil, the oil filter and the exhaust filter(s) will be contaminated with harmful material.

Harmful material can reside in pores, gaps and internal spaces of the vacuum pump.

Danger to health during dismantling of the vacuum pump.

Danger to the environment.

During dismantling of the vacuum pump personal protective equipment must be worn.

The vacuum pump must be decontaminated prior to disposal.

Oil, oil filters and exhaust filters must be disposed of separately in compliance with applicable regulations.

CAUTION

Used oil, used exhaust filters and used oil filters are special waste and must be disposed of in compliance with applicable regulations.

CAUTION

The filter spring (125) can fly out of the exhaust port during removal.

Risk of eye injury.

Eye protection goggles must be worn while handling filter springs.

- Remove the exhaust filter (p, 122) (→ Maintenance ↘ Exhaust Filter)
- Drain the oil
- Remove the oil filter (h, 100)
- Make sure that materials and components to be treated as special waste have been separated from the vacuum pump
- Make sure that the vacuum pump is not contaminated with harmful foreign material

According to the best knowledge at the time of printing of this manual the materials used for the manufacture of the vacuum pump involve no risk.

- Dispose of the used oil in compliance with applicable regulations
- Dispose of special waste in compliance with applicable regulations
- Dispose of the vacuum pump as scrap metal

Troubleshooting

WARNING

Risk of electrical shock, risk of damage to equipment.

Electrical installation work must only be executed by qualified personnel that knows and observes the following regulations:
- IEC 364 or CENELEC HD 384 or DIN VDE 0100, respectively,
- IEC-Report 664 or DIN VDE 0110,
- BGV A2 (VBG 4) or equivalent national accident prevention regulation.

CAUTION

During operation the surface of the vacuum pump may reach temperatures of more than 70 °C.

Risk of burns!

Let the vacuum pump cool down prior to a required contact or wear heat protection gloves.

Problem	Possible Cause	Remedy
The vacuum pump does not reach the usual pressure The drive motor draws a too high current (compare with initial value after commissioning) Evacuation of the system takes too long	The vacuum system or suction line is not leak-tight	Check the hose or pipe connections for possible leak
	In case a vacuum relief valve/regulating system is installed: The vacuum relief valve/regulating system is misadjusted or defective	Adjust, repair or replace, respectively
	Contaminated oil (the most common cause)	Change the oil (➔ Maintenance)
	No or not enough oil in the reservoir	Top up oil (➔ Maintenance)
	The exhaust filter (p, 122) is partially clogged	Replace the exhaust filter (p, 122) (➔ Maintenance)
	The oil filter (h, 100) is clogged (the oil flows through the bypass only, the oil does not get filtered any more)	Replace the oil filter (h, 100) (➔ Maintenance)
	The screen (261) in the suction connection (d, 260) is partially clogged	Clean the screen (261) If cleaning is required too frequently install a filter upstream
	In case a filter is installed on the suction connection (d, 260): The filter on the suction connection (d, 260) is partially clogged	Clean or replace the inlet air filter, respectively
	Partial clogging in the suction, discharge or pressure line	Remove the clogging
	Long suction, discharge or pressure line with too small diameter	Use larger diameter
	The valve disk of the inlet non-return valve is stuck in closed or partially open position	Disassemble the inlet, clean the screen (261) and the valve (257) as required and reassemble
	The oil tubing is defective or leaking The oil return line (j, 195) is broken	Tighten the connections Replace the connections and/or the tubing (replace with identically dimensioned parts only)

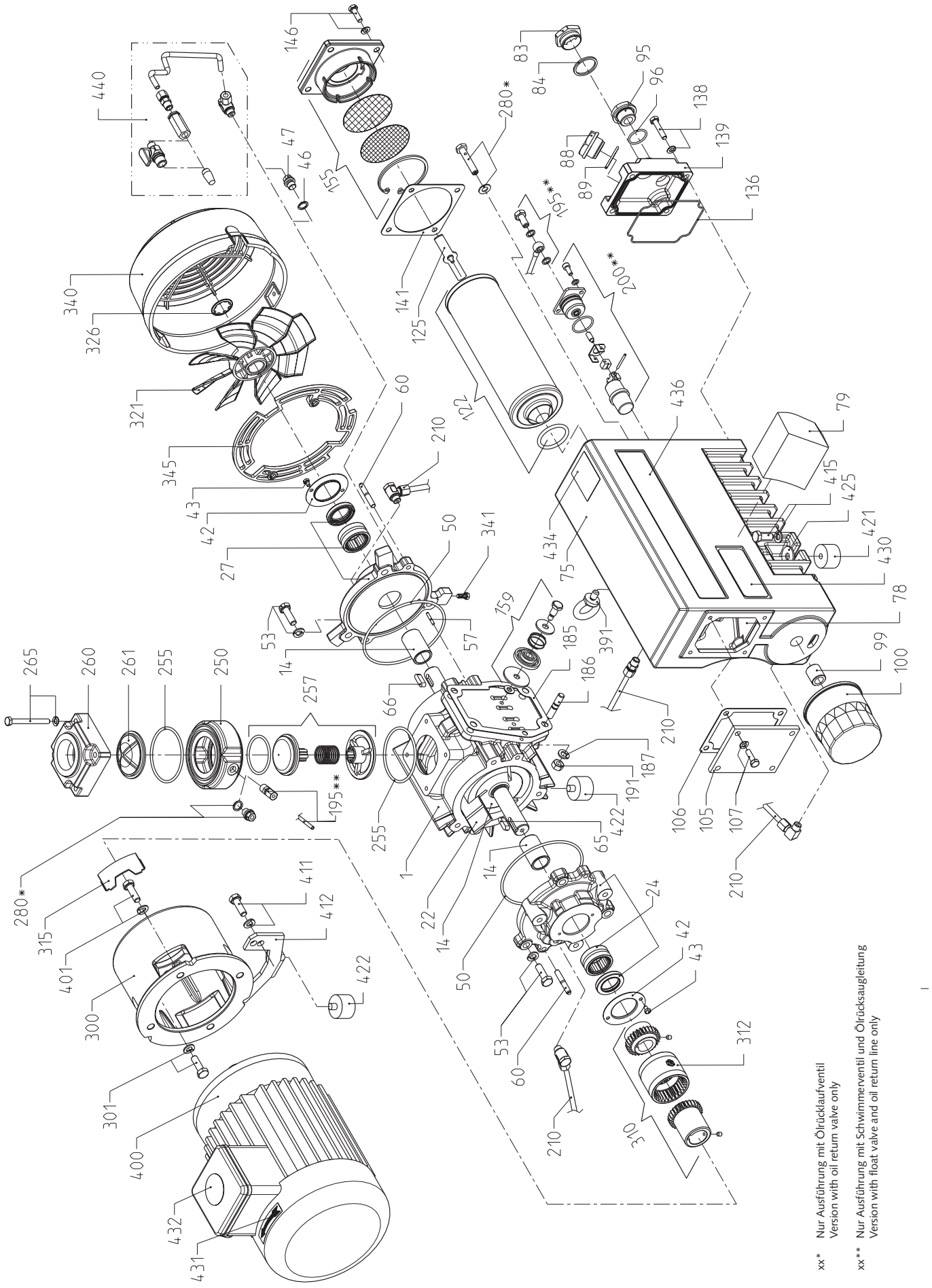
	Version with float valve (j, 200) and oil return line The float valve (j, 200) is stuck in open position	Make the float valve (j, 200) movable, replace if necessary (➔ Maintanance ➘ Oil and Oil Filter Change ➘ Checking the Float Valve)
	A shaft seal is leaking	Replace the shaft seal ring (Busch service)
	An/The exhaust valve (q, 159) is not properly seated or stuck in partially open position	Disassemble and reassemble the exhaust valve(s) (q, 159) (Busch service)
	A vane (r, 22) is blocked in the rotor or otherwise damaged	Free the vanes (r, 22) or replace with new ones (Busch service)
	The radial clearance between the rotor (s, 14) and the cylinder (t, 1) is no longer adequate	Readjust the vacuum pump (Busch service)
	Internal parts worn or damaged	Repair the vacuum pump (Busch service)
The gas conveyed by the vacuum pump smells displeasing	Process components evaporating under vacuum Readily volatile and thus gaseous components of the oil, e.g. additives, particularly right after an oil change. **Note**: This is no indication of a malfunction of the oil separator. The oil separator is able to retain droplets of oil, however no gaseous components of it.	Check the process, if applicable Use a different type of oil, if applicable
The vacuum pump does not start	The drive motor (400) is not supplied with the correct voltage or is overloaded	Supply the drive motor (400) with the correct voltage
	The drive motor starter overload protection is too small or trip level is too low	Compare the trip level of the drive motor starter overload protection with the data on the nameplate, correct if necessary In case of high ambient temperature: set the trip level of the drive motor starter overload protection 5 percent above the nominal drive motor current
	One of the fuses has blown	Check the fuses
	Version with alternating current motor: The drive motor capacitor is defective	Repair the drive (Busch service)
	The connection cable is too small or too long causing a voltage drop at the vacuum pump	Use sufficiently dimensioned cable
	The vacuum pump or the drive motor is blocked	Make sure the drive motor is disconnected from the power supply Remove the fan cover Try to turn the drive motor with the vacuum pump by hand If the unit is still frozen: remove the drive motor and check the drive motor and the vacuum pump separately If the vacuum pump is blocked: Repair the vacuum pump (Busch service)
	The drive motor (400) is defective	Replace the drive motor (Busch service)
The vacuum pump is blocked	Solid foreign matter has entered the vacuum pump	Repair the vacuum pump (Busch service) Make sure the suction line is equipped with a screen If necessary additionally provide a filter
	Corrosion in the vacuum pump from remaining condensate	Repair the vacuum pump (Busch service) Check the process Observe the chapter ➔ Installation and Commissioning ➘ Operating Notes ➘ Conveying Condensable Vapours

	Version with three-phase motor: The vacuum pump was run in the wrong direction	Repair the vacuum pump (Busch service) When connecting the vacuum pump make sure the vacuum pump will run in the correct direction (→ Installation)
	After shutting down the vacuum pump the vacuum system exerted underpressure onto the pump chamber which sucked back excessive oil from the oil separator into the pump chamber When the vacuum pump was restarted too much oil was enclosed between the vanes (r, 22) Oil could not be compressed and thus broke a vane (r, 22)	Repair the vacuum pump (Busch service) Make sure the vacuum system will not exert underpressure onto the shut-down vacuum pump, if necessary provide an additional shut-off valve or non-return valve
	After shutting down the vacuum pump condensate ran into the pump chamber When the vacuum pump was restarted too much condensate was enclosed between the vanes (r, 22) Condensate could not be compressed and thus broke a vane (r, 22)	Repair the vacuum pump (Busch service) Make sure no condensate will enter the vacuum pump, if necessary provide a drip leg and a drain cock Drain condensate regularly
The drive motor is running, but the vacuum pump stands still	The coupling (310) between the drive motor and the vacuum pump is defective	Replace the coupling element (310)
The vacuum pump starts, but labours or runs noisily or rattles The drive motor draws a too high current (compare with initial value after commissioning)	Loose connection(s) in the drive motor terminal box Version with three-phase-motor: Not all drive motor coils are properly connected The drive motor operates on two phases only	Check the proper connection of the wires against the connection diagram (particularly on motors with six coils) Tighten or replace loose connections
	Version with three-phase motor: The vacuum pump runs in the wrong direction	Verification and rectification → Installation and Commissioning
	Standstill over several weeks or months	Let the vacuum pump run warm with inlet closed
	Oil viscosity is too high for the ambient temperature	Use synthetic oil, if necessary use oil of the next lower viscosity class (CAUTION: operation with too low viscosity can cause chatter marks inside the cylinder) Warm up the oil with a heater prior to starting up the vacuum pump, or run the vacuum pump in intervals in order not to let it get too cold
	Improper oil quantity, unsuitable oil type	Use the proper quantity of one of the recommended oils (→ Oil, Oil change: → Maintenance)
	No oil change over extended period of time	Perform oil change incl. flushing and oil filter replacement (→ Maintenance)
	The exhaust filter (p, 122) is clogged and appears black from burnt oil	Flush the vacuum pump Replace the oil filter (h, 100) Replace the exhaust filter (p, 122) Fill in new oil (→ Maintenance) In case the oil life is too short: use oil with better heat resistance (→ Oil) or retrofit cooling
	Foreign objects in the vacuum pump Broken vanes (r, 22) Stuck bearings	Repair the vacuum pump (Busch service)

The vacuum pump runs very noisily	Defective bearings	Repair the vacuum pump (Busch service)
	Worn coupling element (310)	Replace the coupling element (310)
	Stuck vanes (r, 22)	Repair the vacuum pump (Busch service) Use only recommended oils (→ Oil) and change more frequently
The vacuum pump runs very hot (the oil sump temperature shall not exceed 100 °C)	Insufficient air ventilation	Make sure that the cooling of the vacuum pump is not impeded by dust/dirt Clean the fan cowlings, the fan wheels, the ventilation grilles and the cooling fins Install the vacuum pump in a narrow space only if sufficient ventilation is ensured On a vacuum pump with oil-cooler: clean the intermediate spaces of the finned tube
	Ambient temperature too high	Observe the permitted ambient temperatures
	Temperature of the inlet gas too high	Observe the permitted temperatures for the inlet gas
	The exhaust filter (p, 122) is partially clogged	Replace the exhaust filter (p, 122)
	The oil filter (h, 100) is clogged (the oil flows through the bypass only, the oil does not get filtered any more)	Replace the oil filter (h, 100) (→ Maintenance)
	Not enough oil in the reservoir	Top up oil
	Oil burnt from overheating	Flush the vacuum pump Replace the oil filter (h, 100) Replace the exhaust filter (p, 122) Fill in new oil (→ Maintenance) In case the oil life is too short: use oil with better heat resistance (→ Oil) or retrofit cooling
	Mains frequency or voltage outside tolerance range	Provide a more stable power supply
	Partial clogging of filters or screens Partial clogging in the suction, discharge or pressure line	Remove the clogging
	Long suction, discharge or pressure line with too small diameter	Use larger diameter
The vacuum pump fumes or expels oil droplets through the gas discharge The oil level drops	The exhaust filter (p, 122) is not properly seated	Check the proper position of the exhaust filter (p, 122), if necessary insert properly (→ Maintenance)
	The o-ring is missing or damaged	Add the o-ring (→ Maintenance)
	The exhaust filter (p, 122) shows cracks	Replace the exhaust filter (p, 122) (→ Maintenance)
	The exhaust filter (p, 122) is clogged with foreign matter **Note**: The saturation of the exhaust filter with oil is no fault and does not impair the function of the exhaust filter! Oil dropping down from the exhaust filter is returned to the oil circulation.	Replace the exhaust filter (p, 122) (→ Maintenance)

	Version with oil return valve (f, 280): In case the vacuum pump runs for more than 10 hours without interruption, oil can collect in the upper chamber of the oil separator (o, 75) to an extent that it gets expelled together with the discharged gas	Regularly shut down the vacuum pump for short periods of time. Check that the oil return valve (f, 280) functions properly and lets oil run from the upper into the bottom chamber of the oil separator (o, 75) as soon as the vacuum pump is shut down (→ Product Description ↘ Oil Recirculation)
	Version with oil return valve (f, 280): The oil return valve (f, 280) does not work properly or is clogged (proper function is when blowing into the valve it should close, when vacuum is applied, the valve should open; CAUTION: do not let your mouth get in direct contact with the oil return valve, do not inhale through the oil return valve!)	Clean or replace the oil return valve (f, 280)
	Version with float valve (j, 200) and oil return line The float valve (j, 200) is stuck in closed position	Make the float valve (j, 200) movable, replace if necessary (→ Maintanance ↘ Oil and Oil Filter Change ↘ Checking the Float Valve)
	The oil return line (j, 195) is clogged or broken	Clean a clogged oil return line (j, 195) Replace a broken oil return line (j, 195) with an identically dimensioned line, top up oil (if necessary by Busch service)
The oil is black	Oil change intervals are too long The oil was overheated	Flush the vacuum pump Replace the oil filter (h, 100) Replace the exhaust filter (p, 122) Fill in new oil (→ Maintenance) In case the oil life is too short: use oil with better heat resistance (→ Oil) or retrofit cooling
The oil is watery and coloured white	The vacuum pump aspirated water or significant amounts of humidity	Flush the vacuum pump Replace the oil filter (h, 100) Replace the exhaust filter (p, 122) Fill in new oil (→ Maintenance) Modify the operational mode (→ Installation and Commissioning ↘ Operating Notes ↘ Conveying Condensable Vapours)
The oil is resinous and/or sticky	Improper oil type, perhaps in confusion Topping up of incompatible oil	Flush the vacuum pump Replace the oil filter (h, 100) Replace the exhaust filter (p, 122) Fill in new oil (→ Maintenance) Make sure the proper oil is used for changing and topping up
The oil foams	Mixing of incompatible oils	Flush the vacuum pump Replace the oil filter (h, 100) Replace the exhaust filter (p, 122) Fill in new oil (→ Maintenance) Make sure the proper oil is used for topping up

Exploded View



Spare Parts

Note: When ordering spare parts or accessories acc. to the table below please always quote the type and the serial no. of the vacuum pump. This will allow Busch service to check if the vacuum pump is compatible with a modified or improved part.

This parts list applies to a typical configuration of the vacuum pump RA 0025 - 0040 F. Depending on the specific order deviating parts data may apply.

Pos.	Part	Qty	Part no.
1	Cylinder (RA 0025 F)	1	0223 137 428
1	Cylinder (RA 0040 F)	1	0223 137 410
14	Rotor with shaft sleeves (RA 0025 F)	1	0950 138 501
14	Rotor with shaft sleeves (RA 0040 F)	1	0950 138 493
22	Vane (RA 0025 F)	3	0722 000 270
22	Vane (RA 0040 F)	3	0722 000 300
24	Cylinder cover A-side, complete	1	0952 138 010
27	Cylinder cover B-side, complete	1	0952 138 011
42	Supporting washer	2	0391 000 016
43	Hex head screw	4	0410 000 023
46	Seal ring	1	0484 000 029
47	Plug	1	0415 000 002
50	O-ring	2	0486 000 537
53	Hex head screw/lock washer	6	0947 127 451
57	Parallel pin	1	0437 138 870
60	Taper pin	4	0437 000 070
65	Parallel key	1	0434 000 019
66	Parallel key	1	0434 000 019
75	Oil separator (version with float valve and oil return line)	1	0266 137 346
75	Oil separator (version with oil return valve)	1	0266 138 692
78	Expanded metal	1	0534 000 924
79	Demister	1	0534 000 289
83	Sight glass	1	0583 000 001
84	Gasket	1	0480 000 271
88	Plug	1	0710 000 009
89	O-ring	1	0486 000 590
95	Plug	1	0710 000 010
96	O-ring	1	0486 000 505
99	Nipple	1	0461 000 061
100	Oil filter	1	0531 000 002
105	Cover	1	0320 109 603
106	Gasket	1	0480 000 153
107	Hex head screw/lock washer	4	0947 127 445
122	Exhaust filter with o-ring	1	0992 131 342
125	Filter spring	1	0947 000 720
136	Round gasket-service cover	1	0486 114 368
138	Hex head screw/lock washer	4	0947 127 447
139	Service cover	1	0247 113 773
141	Gasket	1	0480 000 112
146	Hex head screw/lock washer	4	0947 127 445
155	Exhaust cover plate, complete	1	0947 125 296
159	Exhaust valve, complete	2	0916 126 769
185	Gasket	1	0480 000 150
186	Stud bolt	4	0412 104 730
187	Spring lock washer	4	0432 000 012
191	Hex nut	4	0420 000 035
195	Oil return line, complete	1	0946 138 688
200	Float valve, complete	1	0947 138 417
210	Oil supply (RA 0025 F), complete	1	0913 000 028
210	Oil supply (RA 0040 F), complete	1	0913 000 026
250	Inlet flange, lower part	1	0246 101 999
255	O-ring	2	0486 000 526
257	Valve insert, complete	1	0916 125 491
260	Inlet flange	1	0246 000 541
261	Screen	1	0534 000 018
265	Hex head screw/lock washer	4	0947 127 453
280	Oil return valve, complete	1	0946 139 037
300	Motor flange	1	0247 107 490
301	Hex head screw/lock washer	3	0947 127 451
310	Coupling, complete, for 3phase motor, motor shaftØ 19 mm	1	0510 000 006
310	Coupling, complete, for 3phase motor, motor shaftØ 24 mm	1	0510 000 008
310	Coupling, complete, for AC motor, motor shaftØ 24 mm	1	0510 000 504
310	Coupling, complete, for AC motor, motor shaftØ 28 mm	1	0510 000 505
310	couplings for other motors	1	on request
312	Coupling sleeve, for AC motor	1	0512 000 003
312	Rubber coupling insert, for AC motor	1	0512 000 109
315	Protection clip	3	0710 109 012
321	Axial flow fan (RA 0025 F)	1	0524 120 370
321	Axial flow fan (RA 0040 F)	1	0524 108 652
326	Locking ring	1	0432 000 367
340	Fan cover	1	0713 000 653
341	Tapping screw	2	0416 120 665
345	Protective grid	1	0713 110 795
391	Eye bolt	1	0416 000 001
400	3phase motor 0.75 kW, 230/400 V, 50 Hz, 1500 min-1, shaftØ 19 mm	1	0612 000 918
400	3phase motor 0.9 kW, 190-210/380-420 V, 50 Hz, 1500 min-1; 1.1 kW, 190-240/380-480 V, 60 Hz, 1800 min-1, shaftØ 24 mm	1	0613 129 386
400	3phase motor 1.1 kW, 230/400 V, 50 Hz, 1500 min-1, shaftØ 24 mm	1	0614 127 186
400	3phase motor 1.1 kW, 208-230/380-460 V, 50/60 Hz, 1500/1800 min-1, shaftØ 24 mm	1	0613 131 774
400	3phase motor 1.3 kW, 190-210/380-420 V, 50 Hz, 1500 min-1; 1.5 kW, 190-240/380-480 V, 60 Hz, 1800 min-1, shaftØ 24 mm	1	0614 129 387

400	3phase motor 1.5 kW, 230/400 V, 50 Hz, 1500 min-1, shaftØ 24 mm	1	0616 127 187
400	AC motor 1.1 kW, 220-400 V, 50 Hz, 1500 min-1, shaftØ 24 mm	1	0613 000 835
400	AC motor 1.8 kW, 220-400 V, 50 Hz, 1500 min-1, shaftØ 24 mm	1	0620 000 340
400	AC motor 2.0 kW, 220-400 V, 60 Hz, 1800 min-1, shaftØ 28 mm	1	0620 000 341
400	other motors	1	on request
401	Hex head screw/lock washer	2	0947 127 451
411	Hex head screw/lock washer	2	0947 127 451
412	Foot	1	0391 107 504
415	Hex head screw/lock washer	1	0947 127 450
421	Rubber foot	1	0561 000 001
422	Rubber foot	2	0561 000 030
425	Washer	1	0431 000 132
430	Nameplate	1	0565 102 562
431	Directional arrow	1	0565 000 003
432	Label before installation	1	0565 104 694
434	Label hot surface	1	0565 531 032
436	Label Busch R 5	1	0565 138 307
440	Gas ballast (optional)	1	0916 000 344
440	Gas ballast, adjustable (optional)	1	0916 111 334
540	Air filter with paper cartridge (not shown, optional)	1	0530 000 002
—	Paper cartridge for air filter (not shown, optional)	1	0532 000 002
540	Air filter with polyester cartridge (not shown, optional)	1	0530 121 867
—	Polyester cartridge for air filter (not shown, optional)	1	0532 121 862
541	Double nipple (not shown, for air filter, optional)	1	0456 000 328
—	Bend (not shown, for horizontal air filter, optional)	1	0456 000 327

Spare Parts Kits

Spare parts kit	Description	Part no.
Service kit	oil filter, exhaust filter and pertinent seals	0992 101 463
Set of seals/gaskets	all necessary seals, except for the seal of the float valve	0990 101 464
Overhaul kit (RA 0025 F)	service kit, set of seals and all overhaul parts, except for the float valve and the seal of the float valve	0993 101 465
Overhaul kit (RA 0040 F)	service kit, set of seals and all overhaul parts, except for the float valve and the seal of the float valve	0993 101 466

Accessories

Accessories	Description	Part no.
Inlet air filter	inlet-side, vertical, with paper cartridge, to separate solids	0945 000 132
Inlet air filter	inlet-side, horizontal, with paper cartridge, to separate solids	0945 000 133
Inlet air filter	inlet-side, vertical, with polyester cartridge, food proof, to separate solids	0945 121 873
Inlet air filter	inlet-side, horizontal, with polyester cartridge, food proof, to separate solids	0945 121 874
Filter pressure gauge	for easy checking of the degree of clogging of the exhaust filter	0946 000 100
Vacuum regulating unit	to adjust the required working pressure; connection R 1¼ inch	0947 000 449
Gas ballast, complete	for the conveying of condensable vapours, with sinter metal filter	0916 000 344
Gas ballast, adjustable, complete	for the conveying of condensable vapours, with sinter metal filter and ball valve	0916 111 334
Motor safety switch	adjustment range: 1.6 – 2.4 A, 3 Ph.	0985 000 248
Motor safety switch	adjustment range: 2.4 – 4.0 A, 3 Ph.	0985 000 249
Motor safety switch	adjustment range: 4.0 – 6.0 A, 3 Ph.	0985 104 496
Motor safety switch	adjustment range: 6.0 – 10.0 A, 3 Ph.	0985 104 497
Motor safety switch	adjustment range: 10.0 – 16.0 A, 3 Ph.	0985 104 498

Oil

Denomination	VM 032	VM 068	VM 100	VE 101	VMH 100	VSL 032	VSL 068	VSL 100
ISO-VG	32	68	100	100	100	32	68	100
Base	Mineral oil	Mineral oil	Mineral oil	Diester	Mineral oil	PAO	PAO	PAO
Density [g/cm^3]	0.872	0.884	0.888	0.96	0.87	0.83	0.83	0.84
Ambient temperature range [°C]	< 5	5 ...20	12 ... 30	12 ... 40	12 ... 30	< 5	5 ...20	10 ... 40
Kinematic viscosity at 40 °C [mm^2/s]	30	68	110	95	94	32	68	96
Kinematic viscosity at 100 °C [mm^2/s]	5	8.5	11.5	9.5	—	6	10	13
Flashpoint [°C]	225	235	260	255	264	240	240	240
Pourpoint [°C]	–15	–15	–15	–30	–15	–60	–55	–50
Part no. 1 l packaging	0831 000 086	0831 102 492	0831 000 060	0831 000 099	0831 133 403	0831 122 575	0831 131 846	0831 122 573
Part no. 5 l packaging	0831 000 087	0831 102 493	0831 000 059	0831 000 100	—	0831 131 845	0831 131 847	0831 122 572
Remark	Standard oil for non-demanding applications	Standard oil for non-demanding applications	Standard oil for non-demanding applications	For thermally and chemically demanding applications	For ultimate pressure critical applications	Food applications (NSF H1)	Food applications (NSF H1)	Food applications (NSF H1)
Filling quantity, approx. [l]	1.0							

EC-Declaration of Conformity

Note: This Declaration of Conformity and the CE-mark affixed to the nameplate are valid for the vacuum pump within the Busch-scope of delivery. When this vacuum pump is integrated into a superordinate machinery the manufacturer of the superordinate machinery (this can be the operating company, too) must conduct the conformity assessment process acc. to the Directive Machinery 98/37/EC for the superordinate machine, issue the Declaration of Conformity for it and affix the CE-mark.

We

Busch Produktions GmbH
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declare that vacuum pumps **RA 0025 - 0040 F**

in accordance with the European Directives

"Machinery" 98/37/EC,

"Electrical Equipment Designed for Use within Certain Voltage Limits" (so called "Low Voltage") 73/23/EEC,

"Electromagnetic Compatibility" 89/336/EEC

have been designed and manufactured to the following specifications:

Standard	Title of the Standard
Harmonised Standards	
EN 12100-1 EN 12100-2	Safety of machinery - Basic concepts, general principles of design - Part 1 and 2
EN 294	Safety of machinery - Safety distance to prevent danger zones being reached by the upper limbs
EN 1012-1 EN 1012-2	Compressors and vacuum pumps - Safety requirements - Part 1 and 2
EN ISO 2151	Acoustics - Noise test code for compressors and vacuum pumps - Engineering method (grade 2)
EN 60204-1	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
EN 61000-6-1 EN 61000-6-2	Electromagnetic compatibility (EMC) - Generic immunity standards
EN 61000-6-3 EN 61000-6-4	Electromagnetic compatibility (EMC) - Generic emission standards

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Lubricants and application temperatures of Busch vacuum pumps

General:
The below-mentioned oil types are suitable for the following pump types of the R5 series:
Vacuum pump RA 0010 / 00100 B / E / F RA 0165- 0305 D

In the operating manuals of the vacuum pump the lubricants of the types VM, VS, VSL and VE (designations used by Busch) are indicated.

VM:	mineral oil
VS/VSL:	synthetic oil
VE:	high-grade synthetic oil

In addition to this list the "Special oils" Busch sheet can be used.

VM100 DILO order No.: 3-690-R201 / 3-690-R203
Ambient temperature: 5 - 30 °C Lubricant recommended by Busch: VM 100
VM 100 is a mineral oil and corresponds to the VC in accordance with DIN 51506. The viscosity class is ISO VG 100 according to DIN 51 519.

ISO VG 100:	specific gravity at +15 °C	0.897 g/cm^3
	cinematic viscosity at 40 °C	112.0 mm^2/s (cSt)
	cinematic viscosity at 100 °C	11.5 mm^2/s (cSt)
	flashpoint	255.0 °C
	pour-point	-12.0 °C

This viscosity corresponds to an oil of the SAE 30 class in accordance with DIN 51511.
Examples for VM 100 lubricants:

Aral:	Motanol 100	Avia:	Avialup VD-L 100
BP:	Energol CS 100 / RC-S 100	Mobil	Rarus 427
Texaco:	Ursa-Öl P 100	Servo Delben:	Anderol 500
Schell:	Talpa-Öl G 100 / Corena P 100	Esso:	Umlauföl 100

VS100/VSL100 DILO order No.: 3-690-R212
Ambient temperature: > 30 °C Lubricant recommended by Busch: VS 100
VS 100 is a synthetic oil and corresponds to the VC in accordance with DIN 51506. The viscosity class is ISO VG 100 according to DIN 51 519.

specific gravity at +15 °C	0,848 g/cm^3
cinematic viscosity at 40 °C	103,00 mm^2/s (cSt)
cinematic viscosity at 100 °C	13,0 mm^2/s (cSt)
flash point	265,0 °C
pour-point	-48,0 °C

This viscosity corresponds to an oil of the SAE 30 class in accordance with the DIN 51511. This oil is particularly used in case of higher suction temperatures or an ambient temperature exceeding +40°C due to its good thermal properties.

Examples for lubricants VS 100:

BP:	Enersyn RC-S 100	Mobil	Rarus 827
Esso:	Compressor Oil RS 32-68	Shell:	Cassida Fluid VP 100

Lubricants and application temperatures of Busch vacuum pumps

VE101 DILO order No.: 3-690-R213
Ambient temperature: > 30 °C Lubricant recommended by Busch: VE 101

VE 101 has similar properties like VS 100.

specific gravity at +15 °C	0.956 g/cm^3
cinematic viscosity at 40 °C	95.0 mm^2/s (cSt)
cinematic viscosity at 100 °C	9.2 mm^2/s (cSt)
flash point	250.0 °C
pour-point	-34.0 °C

This oil is a synthetic oil for high operating temperatures (oil temperature up to 110°C).
The advantage of the VE 101 oil is that it can be used very well for humid processes (drying, removal of ground-air, etc.) as it does only very badly or not at all emulsify with water.

Examples for lubricants VE 101:

Servo Delben: Anderol 500

Ambient temperature below 0°C

Low temperature oil Dilo-order No.: 3-690-R211
Ambient temperature: -10 to +20 °C
We recommend to use a synthetic oil with a pour-point below -50 °C.
This oil should be exchanged at ambient temperatures > 20°C otherwise the indicated final vacuum cannot be reached.

Examples for synthetic oil:
Mobil: Rarus SHC 924 or Rarus 824

Ambient temperature below - 10 °C

At such temperatures the oil should be heated by heating the room or chamber with a heating element or a heating lamp.

Note: According to Busch a heating element can only be installed into the vacuum pumps from a volume of 165 m^3/h as there is not enough space.

Dilo-order numbers for vacuum pump oils:

Application temperatures	Busch designation	Order number	Quantity
5 to 30 °C	VM100	3-690-R201	1-litre
5 to 30 °C	VM100	3-690-R203	5-litres
-10 to +20 °C	----	3-690-R211	1-litre
> 30 °C	VS100, VSL100	3-690-R212	1-litre
> 30 °C	VE101	3-690-R213	1-litre