

Installation and Operating Instructions

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Vacuum Pumps
R 5 KB/KC 0040 D

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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.

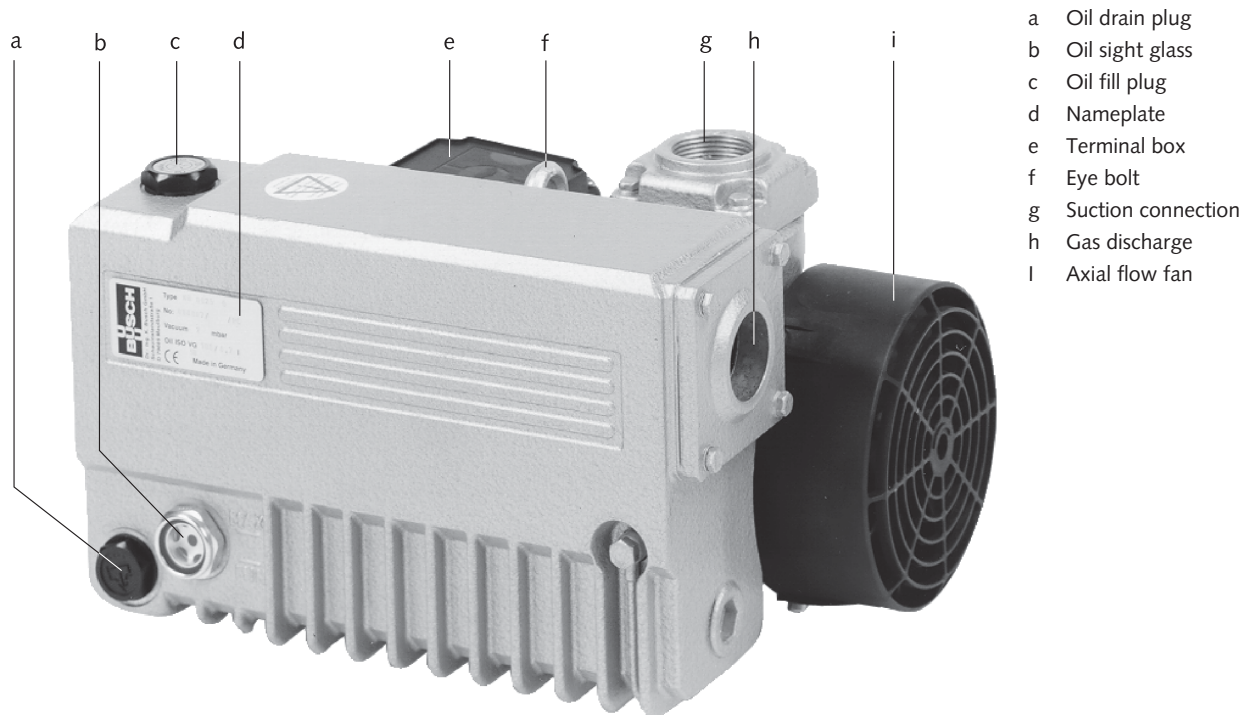
For the purpose of these instructions, "handling" the vacuum pump means the transport, storage, installation, commissioning, influence on operating conditions, maintenance, troubleshooting and overhaul of the vacuum pump.

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	40 / 48
Ultimate pressure	hPa (=mbar) abs.	KB 0040 D: 2 KC 0040 D: 20
Motor nominal rating (50Hz/60Hz)	kW	1.5
Motor nominal speed (50Hz/60Hz)	min ⁻¹	3000 / 3600
Sound pressure level (EN ISO 2151) (50Hz/60Hz)	dB (A)	69 / 71
Operating temperature (50Hz/60Hz)	°C	80 / 85
Ambient temperature range	°C	12 ... 30
Ambient pressure		Atmospheric pressure
Oil quantity	l	0.8
Weight approx. (50Hz/60Hz)	kg	~29



- a Oil drain plug
- b Oil sight glass
- c Oil fill plug
- d Nameplate
- e Terminal box
- f Eye bolt
- g Suction connection
- h Gas discharge
- i Axial flow fan

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

In case the vacuum pump is equipped with a gas ballast (optional) water vapour within the gas flow can be tolerated within certain limits (→ page 8: 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.

The vacuum pump is thermally suitable for continuous operation (100 percent duty).

The vacuum pump is ultimate pressure proof.

Principle of Operation

The vacuum pump works on the rotating vane principle.

A circular rotor is positioned centrally on the shaft of the vacuum pump (i.e. drive motor shaft).

The rotor rotates in an also circular, fixed cylinder, 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, 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 in the suction connection.

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

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 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 (→ page 8: Conveying Condensable Vapours).

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

In order to improve the operating characteristics the outlet of the pump chamber is equipped with a spring loaded valve.

Oil Circulation

The vacuum pump requires oil to seal the gaps, to lubricate the vanes 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.

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 through the oil supply lines 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 as oil mist. Oil that separates before the exhaust filter accumulates at the bottom of the bottom chamber of the oil separator.

Oil that is separated by the exhaust filter accumulates at the bottom of the upper chamber of the oil separator.

The flow resistance of the exhaust filters 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 oil return line to the suction connection (KC 0040 D):

Therefore the oil that accumulates in the upper chamber is sucked through the oil return line right to the suction connection.

Version with oil return line to the B-cover (KB 0040 D):

Therefore the oil that accumulates in the upper chamber is sucked through the oil return line right to the cylinder chamber.

Cooling

The vacuum pump is cooled by

- radiation of heat from the surface of the vacuum pump incl. oil separator
- the air flow from the fan wheel of the drive motor
- the process gas
- the air flow from the fan wheel (i) on the shaft of the vacuum pump

Start Controls

The vacuum pump comes without start controls. 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 (→ page 3: Product Description) and the installation prerequisites (→ page 5: 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 installation and 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 state-of-the-art methods. Nevertheless, residual risks may remain. These operating instructions highlight 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 → page 2: Technical Data.



CAUTION

The vacuum pump emits noise of high intensity.

Risk of damage to the hearing.

Persons staying in the vicinity of a non noise insulated vacuum pump over extended periods shall wear ear protection.

Transport

Note: Also a vacuum pump, that is not topped up with oil contains residues of oil (from the test run). Always transport and store the vacuum pump in upright position. Do not put the vacuum pump on its side nor put it upside down.

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.

- Make sure that the eyebolt (f) is in faultless condition (replace a damaged, e.g. bent eyebolt with a new one)
- Make sure that the eyebolt (f) is fully screwed in and tightened by hand
- Attach lifting gear securely to the eyebolt (f) 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 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 without ball-valve, with sinter metal filter:

- ◆ Close the sinter metal filter of the gas ballast device 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 without ball-valve, with sinter metal filter:

- ◆ Close the sinter metal filter of the gas ballast 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 (→ page 5)

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 2006/42/EC are complied with (in the responsibility of the designer of the machinery into which the vacuum pump is to be incorporated; → page 21: 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: 12 ... 30 °C
- ◆ Fit the vacuum pump with a temperature switch and control the vacuum pump such that it will start automatically when the oil sump temperature falls below the allowed temperature
- 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 the base for placement / mounting base is even
- 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 (b) will remain easily accessible

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

- ◆ Make sure that the drain port (a) and the filling port (c) will remain easily accessible
- Make sure that enough space will remain for the removal and the reinsertion of the exhaust filter

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 (g) 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 an expansion joint
- Make sure that the line size of the suction line over the entire length is at least as large as the suction connection (g) 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 discharged gas must flow without obstruction. It is not permitted to shut off or throttle the discharge line or to use it as a pressurised air source.

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 gas 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 (h) 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 an expansion joint
- Make sure that the line size of the discharge line over the entire length is at least as large as the gas discharge (h) 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!

- 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-conductive material can build up static charge.

Static discharge can cause explosion of potentially existing oil mist.

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

Electrical Connection / Controls

- Make sure that the stipulations acc. to the EMC-Directive 2004/108/EC and Low-Voltage-Directive 2006/95/EC as well as the EN-standards, electrical and occupational safety directives and the local or national regulations, respectively, are complied with (this is the responsibility of the designer of the machinery into which the vacuum pump is to be incorporated; → page 21: 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
- 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 (→ page 5) are complied with
- Set down or mount the vacuum pump at its location

Connecting Electrically



WARNING

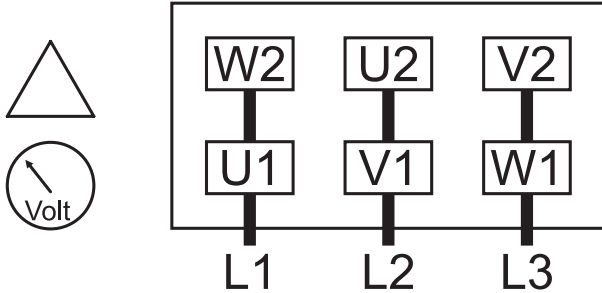
Risk of electrical shock, risk of damage to equipment.

Electrical installation work must only be executed by qualified personnel that knows and observes the following regulations:

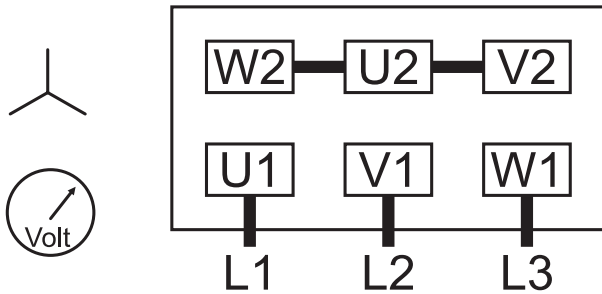
- IEC 364 or CENELEC HD 384 or DIN VDE 0100, respectively,
- IEC-Report 664 or DIN VDE 0110,
- BGV A2 (VBG 4) or corresponding national accident prevention regulation.

- Electrically connect the drive motor
- Connect the protective earth conductor

Delta connection (low voltage):



Star connection (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 (clockwise rotating field).

- Determine the intended direction of rotation with the arrow (stuck on or cast)
- "Bump" the drive motor
- Watch the fan wheel of the drive motor 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

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 (h) 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 → page 20: Oil).

- Keep approx. 0.8 litres oil acc. to the table Oil (→ page 20) ready

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



CAUTION

Filling oil through the suction connection (g) will result in breakage of the vanes and destruction of the vacuum pump.

Oil may be filled through the filling port (c) 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 (c) is ejected.

Remove the filling plug (c) only if the vacuum pump is stopped.

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

- Remove the filling plug (c)
- Fill in approx. 0.8 litres of oil
- Make sure that the level is between the MIN and the MAX-markings of the sight glass (b)
- Make sure that the seal ring is inserted into the filling plug (c) and undamaged, replace if necessary
- Firmly reinsert the filling plug (c) together with the seal ring

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 (g) 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 (b)

In case the level has dropped 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

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

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 (→ page 10: Checks during Operation)

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

In case the vacuum pump is equipped with a gas ballast (optional) water vapour within the gas flow can be tolerated within certain limits (→ page 8: 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.

The vacuum pump is thermally suitable for continuous operation (100 percent duty).

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.



CAUTION

The vacuum pump emits noise of high intensity.

Risk of damage to the hearing.

Persons staying in the vicinity of a non noise insulated vacuum pump over extended periods shall wear ear protection.

- 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 (→ page 5: Installation Prerequisites) are complied with and will remain complied with, particularly that a sufficient cooling will be ensured

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.

- 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 (the oil shall still be warm when being drained)
- 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 (→ page 9: 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 (→ page 10: 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 replace

In case of operation in a dusty environment:

- ◆ Clean as described under → page 9: 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 (→ page 10: Exhaust Filter)

In case an inlet air filter is installed:

- ◆ Replace the inlet air filter
- Check the inlet screen, clean if necessary

Version with gas ballast with sinter metal filter:

- ◆ Clean the sinter metal filter (compressed air)

Every 500 - 2000 Operating Hours:

(→ page 9: Oil Life):

- Change the oil (→ page 10: Oil Change)

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
- Read the level on the sight glass (b)

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

- ◆ Top up oil (→ page 9: 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 Conveying Condensable Vapours (→ page 8)

In case the level exceeds the MAX-marking despite proper use of the gas ballast:

- ◆ Clean the sinter metal filter (compressed air)

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 (→ page 13: 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 (g) will result in breakage of the vanes and destruction of the vacuum pump.

Oil may be filled through the filling port (c) 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 (c) is ejected.

Remove the filling plug (c) only if the vacuum pump is stopped.

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

- Make sure that the vacuum pump is shut down and locked against inadvertent start up
- Remove the filling plug (c)
- Top up oil until the level reaches the middle of the sight glass (b)
- Make sure that the seal ring is inserted into the filling plug (c) and undamaged, replace if necessary
- Firmly reinsert the filling plug (c) together with the seal ring

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 (→ page 10: Oil Change).

In case the oil appears to be contaminated with water or other condensates despite proper use of the gas ballast:

- ◆ Clean the sinter metal filter (compressed air)

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 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 (→ page 13: Troubleshooting) or unsuitable operating conditions, though.

Choosing a synthetic oil instead of a mineral oil can extend the oil life. To select the oil best suited oil 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 Change



DANGER

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

Danger to health during the changing of contaminated oil.

Danger to the environment.

Personal protective equipment must be worn during the changing of contaminated oil.

Contaminated oil is 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 (the oil shall still be warm when being 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 (a)
- Remove the drain plug (a) and drain the oil

When the oil stream dwindles:

- Reinsert the drain plug (a)
- 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 (a) again and drain the remaining oil
- Make sure that the seal ring is inserted into the drain plug (a) and undamaged, replace if necessary
- Firmly reinsert the drain plug (a) together with the seal ring
- 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
- Create 0.8 litres flushing agent from 50 percent oil and 50 percent paraffin or diesel fuel/fuel oil
- Make sure that the drain plug (a) is firmly inserted
- Remove the filling plug (c)
- Fill in the flushing agent
- Firmly reinsert the filling plug (c)
- 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.

Filling in Fresh Oil

- Keep 0.8 litres oil acc. to the table Oil (→ page 20) ready

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

- Make sure that the drain plug (a) is firmly inserted



CAUTION

Filling oil through the suction connection (g) will result in breakage of the vanes and destruction of the vacuum pump.

Oil may be filled through the filling port (c) only.

- Remove the filling plug (c)
- Fill in approx. 0.8 litres of oil
- Make sure that the level is between the MIN and the MAX-markings of the sight glass (b)
- Make sure that the seal ring is inserted into the filling plug (c) and undamaged, replace if necessary
- Firmly reinsert the filling plug (c) together with the seal ring

Exhaust Filter

Checks during Operation

Busch recommends the use of a filter pressure gauge (available as accessory, → page 20: 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 the suction connection (g) (unrestricted suction!)
- ◆ Make sure that the vacuum pump is running
- ◆ Check that the reading on the filter pressure gauge is in the green field
- ◆ Reconnect the suction line to the suction connection (g)

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
- 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 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 is broken through and must be replaced.

If the discharged gas contains oil,

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

Change of the Exhaust Filter



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.



The filter spring 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.

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 (h) from the oil separator
- Loosen the screw in the centre of the exhaust filter retaining spring, but do not remove it at this time
- Press the exhaust filter retaining spring out of the indent and rotate it
- Remove the exhaust filter retaining spring from the oil separator
- Pull the exhaust filter out of the oil separator

Inserting the Exhaust Filter



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 is equipped with a new o-ring
- Insert the exhaust filter such that its port is properly seated in its receptacle in the oil separator

- Make sure that the tip of the screw in the centre of the exhaust filter retaining spring protrudes the retaining spring by about 2 - 5 revolutions
- Insert the exhaust filter retaining spring such that its ends are secured in their receptacles in the oil separator by the protrusions and that the tip of the screw snaps into the indent of the exhaust filter
- Tighten the screw in the exhaust filter retaining spring such that the screw head touches the spring steel sheet
- Make sure that the seal under the exhaust cover (h) is clean and undamaged, if necessary replace with a new seal
- Mount the exhaust cover (h) together with the seal and hex head screws on the oil separator
- 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



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.



In case the vacuum pump conveyed gas that was contaminated with harmful foreign material the oil 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 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
- ◆ Slowly rotate the fan wheel by hand several revolutions in the intended direction of rotation (see stuck on or cast arrow)
- ◆ Mount the cover around the fan wheel of the drive motor

If deposits could have gathered in the vacuum pump:

- ◆ Flush the vacuum pump (→ page 8: Maintenance)
- Observe the chapter Installation and Commissioning (→ page 5)

Dismantling and Disposal



DANGER

In case the vacuum pump conveyed gas that was contaminated with harmful foreign material the oil 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 and exhaust filters must be disposed of separately in compliance with applicable regulations.



CAUTION

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



CAUTION

The filter spring 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 (→ page 10: Exhaust Filter)
- Drain the oil
- 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 (VGB 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 (→ page 8: Maintenance)
	No or not enough oil in the reservoir	Top up oil (→ page 8: Maintenance)
	The exhaust filter is partially clogged	Replace the exhaust filter (→ page 8: Maintenance)
	The screen in the suction connection (g) is partially clogged	Clean the screen If cleaning is required too frequently install a filter upstream
	In case a filter is installed on the suction connection (g): The filter on the suction connection (g) 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 and the valve as required and reassemble
	The oil tubing is defective or leaking The oil return line is broken	Tighten the connections Replace the connections and/or the tubing (replace with identically dimensioned parts only)
	A shaft seal is leaking	Replace the shaft seal ring (Busch service)
An/The exhaust valve is not properly seated or stuck in partially open position	Disassemble and reassemble the exhaust valve(s) (Busch service)	

	A vane is blocked in the rotor or otherwise damaged	Free the vanes or replace with new ones (Busch service)
	The radial clearance between the rotor and the cylinder is no longer adequate	Readjust the vacuum pump (Busch service)
	Internal parts are worn or damaged	Repair the vacuum pump (Busch service)
	<p>Version with oil return line to the suction connection (KC 0040 D):</p> <p>The oil return line starts in an area vented to atmospheric pressure. Particularly on small model pumps, a fairly large amount of air is sucked through the oil return line, which may prevent the ultimate pressure from reaching 20 mbar abs.</p> <p>In order to exclude this possible cause:</p> <p>either</p> <p>temporarily disconnect the oil return line from its connection near the exhaust opening and close it</p> <p>or</p> <p>squirt oil through the gas discharge (h)</p>	
The gas conveyed by the vacuum pump smells displeasing	<p>Process components evaporating under vacuum</p> <p>Readily volatile and thus gaseous components of the oil, e.g. additives, particularly right after an oil change.</p> <p>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.</p>	<p>Check the process, if applicable</p> <p>Use a different type of oil, if applicable</p>
The vacuum pump does not start	The drive motor is not supplied with the correct voltage or is overloaded	Supply the drive motor with the correct voltage
	The drive motor starter overload protection is too small or trip level is too low	<p>Compare the trip level of the drive motor starter overload protection with the data on the nameplate, correct if necessary</p> <p>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</p>
	One of the fuses has blown	Check the fuses
	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	<p>Make sure the drive motor is disconnected from the power supply</p> <p>Remove the fan cover</p> <p>Try to turn the drive motor with the vacuum pump by hand</p> <p>If the vacuum pump is blocked:</p> <p>Repair the vacuum pump (Busch service)</p>
	The drive motor is defective	Replace the drive motor (Busch service)
The vacuum pump is blocked	Solid foreign matter has entered the vacuum pump	<p>Repair the vacuum pump (Busch service)</p> <p>Make sure the suction line is equipped with a screen</p> <p>If necessary additionally provide a filter</p>
	Corrosion in the vacuum pump from remaining condensate	<p>Repair the vacuum pump (Busch service)</p> <p>Check the process</p> <p>Observe the chapter Conveying Condensable Vapours (→ page 8)</p>
	The vacuum pump was run in the wrong direction	<p>Repair the vacuum pump (Busch service)</p> <p>When connecting the vacuum pump make sure the vacuum pump will run in the correct direction (→ page 6: Installation)</p>

	<p>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</p> <p>When the vacuum pump was restarted too much oil was enclosed between the vanes</p> <p>Oil could not be compressed and thus broke a vane</p>	<p>Repair the vacuum pump (Busch service)</p> <p>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</p>
	<p>After shutting down the vacuum pump condensate ran into the pump chamber</p> <p>When the vacuum pump was restarted too much condensate was enclosed between the vanes</p> <p>Condensate could not be compressed and thus broke a vane</p>	<p>Repair the vacuum pump (Busch service)</p> <p>Make sure no condensate will enter the vacuum pump, if necessary provide a drip leg and a drain cock</p> <p>Drain condensate regularly</p>
<p>The vacuum pump starts, but labours or runs noisily or rattles</p> <p>The drive motor draws a too high current (compare with initial value after commissioning)</p>	<p>Loose connection(s) in the drive motor terminal box</p> <p>Not all drive motor coils are properly connected</p> <p>The drive motor operates on two phases only</p>	<p>Check the proper connection of the wires against the connection diagram</p> <p>Tighten or replace loose connections</p>
	<p>The vacuum pump runs in the wrong direction</p>	<p>Verification and rectification → page 5: Installation and Commissioning</p>
	<p>Standstill over several weeks or months</p>	<p>Let the vacuum pump run warm with inlet closed</p>
	<p>Oil viscosity is too high for the ambient temperature</p>	<p>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)</p> <p>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</p>
	<p>Improper oil quantity, unsuitable oil type</p>	<p>Use the proper quantity of one of the recommended oils</p> <p>(→ page 20: Oil change: → page 8: Maintenance)</p>
	<p>No oil change over extended period of time</p>	<p>Perform oil change incl. flushing</p> <p>(→ page 8: Maintenance)</p>
	<p>The exhaust filter is clogged and appears black from burnt oil</p>	<p>Flush the vacuum pump</p> <p>Replace the exhaust filter</p> <p>Fill in new oil</p> <p>(→ page 8: Maintenance)</p> <p>In case the oil life is too short: use oil with better heat resistance (→ page 20: Oil) or retrofit cooling</p>
	<p>Foreign objects in the vacuum pump</p> <p>Broken vanes</p> <p>Stuck bearings</p>	<p>Repair the vacuum pump (Busch service)</p>
<p>The vacuum pump runs very noisily</p>	<p>Defective bearings</p>	<p>Repair the vacuum pump (Busch service)</p>
	<p>Stuck vanes</p>	<p>Repair the vacuum pump (Busch service)</p> <p>Use only recommended oils (→ page 20: Oil) and change more frequently</p>

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 is partially clogged	Replace the exhaust filter
	Not enough oil in the reservoir	Top up oil
	Oil burnt from overheating	Flush the vacuum pump Replace the exhaust filter Fill in new oil (→ page 8: Maintenance) In case the oil life is too short: use oil with better heat resistance (→ page 20: 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
The vacuum pump fumes or expels oil droplets through the gas discharge The oil level drops	Long suction, discharge or pressure line with too small diameter	Use larger diameter
	The exhaust filter is not properly seated	Check the proper position of the exhaust filter, if necessary insert properly (→ page 8: Maintenance)
	The o-ring is missing or damaged	Add or replace resp. the o-ring (→ page 8: Maintenance)
	The exhaust filter shows cracks	Replace the exhaust filter (→ page 8: Maintenance)
	The exhaust filter 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 (→ page 8: Maintenance)
The oil return line is clogged or broken	Clean a clogged oil return line Replace a broken oil return line 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 exhaust filter Fill in new oil (→ page 8: Maintenance) In case the oil life is too short: use oil with better heat resistance (→ page 20: Oil) or retrofit cooling

<p>The oil is watery and coloured white</p>	<p>The vacuum pump aspirated water or significant amounts of humidity</p> <p>Version with gas ballast: The filter of the gas ballast is clogged</p>	<p>Flush the vacuum pump Replace the exhaust filter Fill in new oil (→ page 8: Maintenance) Modify the operational mode (→ page 8: Operating Notes → Conveying Condensable Vapours)</p> <p>Version with gas ballast with sinter metal filter: Clean the sinter metal filter (compressed air)</p>
<p>The oil is resinous and/or sticky</p>	<p>Improper oil type, perhaps in confusion Topping up of incompatible oil</p>	<p>Flush the vacuum pump Replace the exhaust filter Fill in new oil (→ page 8: Maintenance) Make sure the proper oil is used for changing and topping up</p>
<p>The oil foams</p>	<p>Mixing of incompatible oils</p>	<p>Flush the vacuum pump Replace the exhaust filter Fill in new oil (→ page 8: Maintenance) Make sure the proper oil is used for topping up</p>

EC-Declaration of Conformity

Note: This Declaration of Conformity and the CE-mark affixed to the nameplate are valid for the machine within the Busch scope of delivery. This Declaration of Conformity is issued under the sole responsibility of the manufacturer.
When this machine 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 for the superordinate machine or plant, issue the Declaration of Conformity for it and affix the CE-mark.

We

Busch Produktions GmbH
Schauinslandstr. 1
79689 Maulburg
Germany

Declare that the vacuum pumps **KB/KC 0040 D**

with a serial number from **D1601...** to **D1752...**

has (have) been manufactured in accordance with the European Directives:

- 'Machinery' 2006/42/EC
- 'Electromagnetic Compatibility' 2014/30/EU
- 'RoHS' 2011/65/EU, restriction of the use of certain hazardous substances in electrical and electronic equipment

and following the standards.

Standard	Title of the Standard
EN ISO 12100: 2010	Safety of machinery –General principles for design –Risk assessment and risk reduction
EN ISO 13857: 2008	Safety of machinery - Safety distances to prevent hazard zones being reached by the upper and lower limbs
EN 1012-1: 2010 EN 1012-2: 1996 + A1: 2009	Compressors and vacuum pumps - Safety requirements - Part 1 and Part 2
EN ISO 2151: 2008	Acoustics - Noise test code for compressors and vacuum pumps - Engineering method (grade 2)
EN 60204-1: 2006	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
EN 61000-6-2: 2005	Electromagnetic compatibility (EMC) - Generic immunity standards. Immunity for industrial environments
EN 61000-6-4: 2007 + A1: 2011	Electromagnetic compatibility (EMC) - Generic immunity standards. Emission standard for industrial environments
EN ISO 13849-1:2015 ⁽¹⁾	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design

Manufacturer	Person authorized to compile the technical file
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