Installation instructions

Liquid ring compressor vacuum pump
VacuStar WR 2500 / WR 3100 / WR4000

Prior to installing the machine and putting it into operation you must have read and understood these instructions. These instructions are only valid together with the operating instructions, they do not replace them!

FruitlandManufacturing™  www.fruitlandmanufacturing.com  1-800-663-9003
# Contents

1 **General** .......................................................................................................................... 5  
1.1 Information about the installation instructions ................................................................. 5  
1.2 Pictogram explanation ........................................................................................................ 6  
1.3 Limitation of liability ......................................................................................................... 7  
1.4 Copyright protection ......................................................................................................... 7  
1.5 Spare parts ......................................................................................................................... 7  
1.6 Warranty conditions ....................................................................................................... 7  
1.7 Customer service ............................................................................................................. 7  
1.8 Declaration of incorporation ............................................................................................ 7  
2 **Safety** ............................................................................................................................. 8  
2.1 Intended use ....................................................................................................................... 8  
2.2 Intended use ....................................................................................................................... 9  
2.3 Acceptance and monitoring ............................................................................................. 9  
2.4 Operator’s responsibility ................................................................................................. 9  
2.5 Requirements placed upon the specialised staff ......................................................... 9  
2.6 Personal protective equipment ...................................................................................... 9  
2.7 Occupational safety and special risks ............................................................................ 10  
3 **Technical data** .............................................................................................................. 10  
3.1 Dimensions of VacuStar WR 2500 / WR 3100 ............................................................... 10  
3.2 Dimensions of VacuStar WR 4000 ............................................................................... 11  
3.3 Connection variants for suction and pressure line ...................................................... 11  
3.4 Technical data ................................................................................................................. 13  
4 **Design and function** ..................................................................................................... 15  
4.1 Design .............................................................................................................................. 15  
4.2 Function .......................................................................................................................... 15  
5 **Transport and storage** ................................................................................................. 18  
5.1 Safety notes for transport ............................................................................................ 18  
5.2 Transport ......................................................................................................................... 18  
5.3 Storage ............................................................................................................................ 19  
6 **Installation** .................................................................................................................. 20  
6.1 Safety .............................................................................................................................. 20  
6.2 Typical installation ......................................................................................................... 21  
6.3 Necessary work .............................................................................................................. 22  
6.4 Liquid ring compressor vacuum pump VacuStar WR .................................................... 22  
6.5 Compensators ............................................................................................................... 23  
6.6 Lines and containers ..................................................................................................... 24
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.7</td>
<td>Safety equipment</td>
<td>26</td>
</tr>
<tr>
<td>6.7.1</td>
<td>Safety valve</td>
<td>26</td>
</tr>
<tr>
<td>6.7.2</td>
<td>Monitoring the end temperature</td>
<td>26</td>
</tr>
<tr>
<td>6.7.3</td>
<td>Non-return valve</td>
<td>27</td>
</tr>
<tr>
<td>6.7.4</td>
<td>Vacuum suction filter</td>
<td>27</td>
</tr>
<tr>
<td>6.7.5</td>
<td>Protection against contact</td>
<td>27</td>
</tr>
<tr>
<td>6.7.6</td>
<td>Display and monitoring equipment</td>
<td>27</td>
</tr>
<tr>
<td>6.8</td>
<td>Additional components of the system</td>
<td>29</td>
</tr>
<tr>
<td>6.8.1</td>
<td>Safety tank</td>
<td>29</td>
</tr>
<tr>
<td>6.9</td>
<td>Safety dome</td>
<td>29</td>
</tr>
<tr>
<td>6.10</td>
<td>Cooling water system</td>
<td>29</td>
</tr>
<tr>
<td>6.11</td>
<td>Drive</td>
<td>31</td>
</tr>
<tr>
<td>6.11.1</td>
<td>V-belt drive</td>
<td>31</td>
</tr>
<tr>
<td>6.11.2</td>
<td>Articulated shaft drive</td>
<td>32</td>
</tr>
<tr>
<td>6.11.3</td>
<td>Drive via flexible coupling and hydraulic motor</td>
<td>32</td>
</tr>
<tr>
<td>7</td>
<td>Start-up</td>
<td>33</td>
</tr>
<tr>
<td>7.1</td>
<td>Safety during start-up</td>
<td>33</td>
</tr>
<tr>
<td>7.2</td>
<td>Start-up</td>
<td>34</td>
</tr>
<tr>
<td>7.3</td>
<td>Switching off</td>
<td>36</td>
</tr>
<tr>
<td>7.4</td>
<td>Inspections to be performed</td>
<td>36</td>
</tr>
</tbody>
</table>

Declaration of incorporation .......................................................... 37
Declaration of Conformity ................................................................. 38
Index ................................................................................................. 39
General

1 General

1.1 Information about the installation instructions

These installation instructions provide important information about installation and start-up of the machine. A precondition for safe operation is the observance of all specified safety and handling instructions.

Furthermore, all local accident prevention regulations and general safety regulations valid for the application area of the machine must be observed.

You must have read and understood the installation instructions before you start installing the machine and put it into operation! They are a product component and must be kept in direct proximity of the machine, well accessible to the personnel at all times. All safety instructions of the operating instructions must additionally be observed.
1.2 Pictogram explanation

Warning notes

Warning notes are identified by icons in these operating instructions. The warning notes are marked by signal words expressing the extend of the hazard. It is absolutely essential to observe the notes and to proceed with caution in order to prevent accidents as well as bodily injuries and property damage.

**DANGER!**
… points to an immediately dangerous situation, which will lead to death or serious injuries if it is not avoided.

**WARNING!**
… points to a potentially dangerous situation, which may lead to death or serious injuries if it is not avoided.

**ATTENTION!**
… points to a potentially dangerous situation, which may lead to minor or light injuries if it is not avoided.

**CAUTION!**
… points to a potentially dangerous situation, which may lead to property damage if it is not avoided.

Safety note ATEX!
Only for machines with Ex-approval. This icon shows the special conditions that must be observed according to the approvals when conveying explosive gases and gas mixtures.

Hints and recommendations

**NOTE!**
… highlights useful hints and recommendations as well as information for an efficient and trouble-free operation.
1.3 Limitation of liability

See operating instructions "VacuStar WR 2500 / WR 3100 / WR 4000" for information about limitation of liability.

1.4 Copyright protection

See operating instructions "VacuStar WR 2500 / WR 3100 / WR 4000" for information about copyright protection.

1.5 Spare parts

See operating instructions "VacuStar WR 2500 / WR 3100 / WR 4000" for information about spare parts.

1.6 Warranty conditions

The warranty conditions are included in the sales documentation as a separate document.

1.7 Customer service

Our customer service can be contacted for any technical advice. Information about the responsible contact person can be retrieved by telephone, fax, E-mail or via the Internet at any time. Please refer to the manufacturer's address on page 2.

1.8 Declaration of incorporation

2 Safety

2.1 Intended use

The compressor vacuum pumps of the VacuStar WR model range have been developed for installation in a superordinate system. The manufacturer of the overall system must assess the new risks resulting from the installation. These risks must be included in the operating instructions of the system.

The VacuStar WR is exclusively intended for the compression or extraction of filtered air or filtered water vapour saturated air.

The VacuStar WR in the explosion proof design complies with Directive 94/9/EC (ATEX) and is suitable for conveying explosive gases and gas mixtures of explosion group IIB, temperature class T5 from explosive zone 1 and zone 2 areas.

No explosive atmosphere is allowed in the area around the VacuStar WR. The vacuum pump may only be opened when it is stopped and when there is no explosive atmosphere around it.

Machine identification:

II 2G c k IIB T5 (i): Zone 1 and Zone 2 inside, no explosive atmosphere outside.

In temperature class T5, the gas temperature is limited to 95 °C, and must be secured.

Device category, temperature class and explosion group of all attachments that are not contained in the scope of delivery of CVS engineering GmbH (such as temperature sensors and pressure switches) must comply with the requirements of the Directive 94/9/EC.
2.2 Intended use

The intended use is chiefly defined by the data in "Table 1: General data" (page 13).

If explosive gases and gas mixtures are conveyed, the following guidelines must be observed:
- 94/9/E6 (ATEX 95), Requirement on equipment
- 99/92/E6 (ATEX 137), Assembly, installation and operation of equipment

All specifications in these installation and operating instructions have to be strictly complied with (technical data, ATEX regulations, etc.)

Any types of claims due to damage arising from improper use are excluded. The operator alone shall be responsible for any damage arising from improper use.

2.3 Acceptance and monitoring

The VacuStar WR itself is not subject to any acceptance and monitoring obligation.

2.4 Operator's responsibility

See operating instructions "VacuStar WR 2500 / WR 3100 / WR 4000" for information about the responsibility of the operating company.

2.5 Requirements placed upon the specialised staff

The installation instructions specify the following qualification requirements for the different fields of activity:

- **Specialised staff**
  are due to their technical training, knowledge and experience and their knowledge of the pertinent regulations able to carry out the work assigned to them and to independently recognize potential hazards.

- **Electrical specialists**
  are, due to their technical training, knowledge and experiences and their knowledge of the relevant standards and regulations, able to work on electrical systems and to independently recognize possible hazards.

2.6 Personal protective equipment

See "VacuStar WR 2500 / WR 3100 / WR 4000" operating instructions for information about personal protective equipment.
2.7 Occupational safety and special risks

Observe all safety instructions in the operating instructions "VacuStar WR 2500 / WR 3100 / WR 4000", Chapter "Occupational safety and special risks".

3 Technical data

3.1 Dimensions of VacuStar WR 2500 / WR 3100

![Fig. 1: Dimensions of VacuStar WR 2500 / WR 3100, shown WR 3100]

a  VacuStar WR 2500  

b  VacuStar WR 3100
3.2 Dimensions of VacuStar WR 4000

Fig. 2: Dimensions of VacuStar WR 4000

1. Foot arrangement "outward"
2. Foot arrangement "inward"
3. Cell ventilation connection G1 ½"
4. WR 4000 cell ventilation connection G2"
5. Process water connection G1 ½"

3.3 Connection variants for suction and pressure line

CVS engineering offers the following connecting flanges:

<table>
<thead>
<tr>
<th>Type 1</th>
<th>Type 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>WR 2500/3100</td>
<td>WR 4000</td>
</tr>
<tr>
<td>950075-00</td>
<td>950076-00</td>
</tr>
<tr>
<td>WR 2500/3100</td>
<td>WR 4000</td>
</tr>
<tr>
<td>950080-00</td>
<td>950081-00</td>
</tr>
</tbody>
</table>

Fig. 3: Connecting flanges
The horizontal and vertical flange arrangements can be combined with each other.

<table>
<thead>
<tr>
<th>B-side</th>
<th>A-side</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WR2500</strong></td>
<td><strong>WR2500</strong></td>
</tr>
<tr>
<td><strong>WR3100</strong></td>
<td><strong>WR3100</strong></td>
</tr>
<tr>
<td><strong>WR4000</strong></td>
<td><strong>WR4000</strong></td>
</tr>
<tr>
<td><strong>Pressure connection</strong></td>
<td><strong>Suction connection</strong></td>
</tr>
<tr>
<td>R: 950 080-00</td>
<td>R: 950 080-00</td>
</tr>
<tr>
<td>L: 950 075-00</td>
<td>L: 950 075-00</td>
</tr>
<tr>
<td>950081-00</td>
<td>950081-00</td>
</tr>
<tr>
<td>950076-00</td>
<td>950076-00</td>
</tr>
<tr>
<td><strong>Suction connection</strong></td>
<td><strong>Pressure connection</strong></td>
</tr>
<tr>
<td>R: 950 075-00</td>
<td>R: 950 075-00</td>
</tr>
<tr>
<td>L: 950 080-00</td>
<td>L: 950 080-00</td>
</tr>
<tr>
<td>950076-00</td>
<td>950076-00</td>
</tr>
<tr>
<td>950081-00</td>
<td>950081-00</td>
</tr>
</tbody>
</table>

**Fig. 4: Connection variants for suction and pressure line**

- **A** Drive side
- **B** Opposite side
- **R** Sense of rotation, viewed on the drive shaft right (clockwise)
- **L** Sense of rotation, viewed on the drive shaft left (anticlockwise)

**Example:**

Machine rotating clockwise (R)

**A-side:**
- Suction connection vertical → No. 950 075-00

**B-side**
- Pressure connection horizontal → No. 950 080-00
3.4 Technical data

<table>
<thead>
<tr>
<th>General data</th>
<th>Unit</th>
<th>WR 2500</th>
<th>WR 3100</th>
<th>WR 4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal operating vacuum ¹)</td>
<td>[mbar]</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Angular momentum on the drive shaft</td>
<td>[kgm²]</td>
<td>1.40</td>
<td>1.80</td>
<td>3.9</td>
</tr>
<tr>
<td>Weight without water filling</td>
<td>[kg]</td>
<td>175</td>
<td>192</td>
<td>298</td>
</tr>
<tr>
<td>Permissible misalignment lateral</td>
<td>[°]</td>
<td>22 (see Fig. 1, Fig. 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permissible misalignment in longitudinal direction</td>
<td>[°]</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process liquid</td>
<td>–</td>
<td></td>
<td>Water–glycol mixture</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: General data

<table>
<thead>
<tr>
<th>Permissible working range</th>
<th>Unit</th>
<th>WR 2500</th>
<th>WR 3100</th>
<th>WR 4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input speed</td>
<td>[1/min]</td>
<td>800...1600</td>
<td>800...1300</td>
<td></td>
</tr>
<tr>
<td>Suction temperature ¹)</td>
<td>[°C]</td>
<td>–20...+60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outlet temperature</td>
<td>[°C]</td>
<td>max. 65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geodetic height ¹)</td>
<td>[m]</td>
<td>0...1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum operating vacuum ⁴)</td>
<td>[mbar]</td>
<td>130</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum final overpressure with direct drive ³)</td>
<td>[bar]</td>
<td>1.5</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Maximum final overpressure with V-belt drive ³)</td>
<td>[bar]</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

¹) Consult CVS for suction temperature and/or altitudes outside the permissible working range.
²) Excess pressure = 0 bar, suction and ambient temperature = 20 °C
³) Vacuum = 0 mbar, suction and ambient temperature = 20 °C
⁴) Process water temperature = 20 °C

Table 2: Permissible working range
### VacuStar performance characteristics

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>WR 2500</th>
<th>WR 3100</th>
<th>WR 4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation speed</td>
<td>[1/min]</td>
<td>1600</td>
<td>1300</td>
<td>1300</td>
</tr>
<tr>
<td>Maximum intake volume flow</td>
<td>[m³/h]</td>
<td>2500</td>
<td>3100</td>
<td>4063</td>
</tr>
<tr>
<td>Coupling power</td>
<td>[kW]</td>
<td>73</td>
<td>88</td>
<td>117</td>
</tr>
<tr>
<td>Intake volume flow</td>
<td>[m³/h]</td>
<td>2016</td>
<td>2427</td>
<td>3521</td>
</tr>
<tr>
<td>Coupling power</td>
<td>[kW]</td>
<td>61</td>
<td>76</td>
<td>107,5</td>
</tr>
<tr>
<td>Pressure operation, excess pressure: 0,5 bar</td>
<td>[kW]</td>
<td>77</td>
<td>94</td>
<td>131,5</td>
</tr>
<tr>
<td>Intake volume flow</td>
<td>[m³/h]</td>
<td>1936</td>
<td>2469</td>
<td>3496</td>
</tr>
<tr>
<td>Sound pressure level at 7 m distance at 400 mbar / 0,5 bar excess pressure</td>
<td>[dB(A)]</td>
<td>70</td>
<td>72</td>
<td>73</td>
</tr>
</tbody>
</table>

1) Excess pressure = 0 bar, suction and ambient temperature = 20 °C
2) Vacuum = 0 mbar, suction and ambient temperature = 20 °C
3) Process water temperature = 20 °C
4) Water vapour saturated air = 55 °C

**Table 3: Performance characteristics**

### VacuStar process water circulation

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>WR 2500</th>
<th>WR 3100</th>
<th>WR 4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissipated heat in vacuum operation</td>
<td>[kW]</td>
<td>48 / 42</td>
<td>60 / 52</td>
<td>81 / 72</td>
</tr>
<tr>
<td>Dissipated heat in pressure operation</td>
<td>[kW]</td>
<td>55 / 47</td>
<td>68 / 59</td>
<td>95 / 84</td>
</tr>
<tr>
<td>Dissipated heat in vacuum operation</td>
<td>[kW]</td>
<td>65 / 48</td>
<td>72 / 65</td>
<td>99 / 89</td>
</tr>
<tr>
<td>Maximum process water inlet temperature</td>
<td>[°C]</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH value</td>
<td>–</td>
<td>5…8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe dimension</td>
<td>[Zoll]</td>
<td>R1 ½</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiator surface $A_{radiator}$</td>
<td>[m²]</td>
<td>0,16</td>
<td>0,32</td>
<td>0,43</td>
</tr>
<tr>
<td>Water supply volume in the reservoir (at least)</td>
<td>[l]</td>
<td>ca. 300</td>
<td>ca. 400</td>
<td>ca. 550</td>
</tr>
<tr>
<td>Total volume water reservoir (at least)</td>
<td>[l]</td>
<td>ca. 450</td>
<td>ca. 600</td>
<td>ca. 800</td>
</tr>
<tr>
<td>Process water circulating quantity in vacuum operation at 400 mbar</td>
<td>[l/min]</td>
<td>70…90</td>
<td>70…90</td>
<td>70…90</td>
</tr>
</tbody>
</table>

1) Excess pressure 0 bar
2) Vacuum 0 mbar
3) Based on a radiator of a specific cooling capacity $P_{spec} = 3.5$ kW / (m² • °C)
4) Heat to be dissipated for operation with water vapour saturated air on request

**Table 4: Process water circulation**
4 Design and function

4.1 Design

Fig. 5: Design

1 Drive shaft
2 Connection process water
3 Connection cell ventilation
4 Connecting flange for pressure or suction connection (flange DIN 28459-125)
5 Process water draining
6 Rating plate
7 Rotation arrow
8 Thread for eye bolt
9 Fixing foot
10 Process water indicator
11 Liquid supply for slide ring seals

4.2 Function

VacuStar

The liquid ring pump works according to the positive displacement principle. At a sufficiently high speed, a rotating liquid ring is formed in the casing. In conjunction with the impeller, cells form that are separated from each other and steadily grow (sucking) or shrink (compressing) with each revolution.

Lubrication

All moving parts are without contact. The lubrication of the machine is limited to the impeller bearing. The bearings are fitted with a permanent grease filling.

Cooling

The unit is cooled by the process water and/or the liquid ring. A radiator in the process water circulation dissipates the heat to the environment.
Shaft sealing

Installation instructions Liquid ring compressor vacuum pump VacuStar WR

Design and function

Maintenance-free slide ring seals separate the working space from the bearings and/or the atmosphere.

Sense of rotation

The unit is always driven from the A-side. The machine is optionally available with clockwise or anticlockwise sense of rotation.

Connecting flanges

Location (A-side or B-side) and direction (horizontal or vertical) of suction and pressure flange are variable. Fig. 4 (page 12) shows a diagram of the flange allocations.

Drive

The machine can be driven via:

- Articulated shaft
- V-belt
- Flexible coupling

See page 31.

Process water circulation and cell ventilation

In addition to the drive and the suction and pressure lines, other components are required to operate a liquid ring pump (see page 21, Fig. 7).

- Water circulation with reservoir and radiator. The air flowing through the VacuStar absorbs humidity from the liquid ring, and is 100% saturated when it exits. Only the water drops are separated in the reservoir. The steam component is dissipated to the environment.
Typical process water loss calculation:

1. Type: WR 3100
2. Intake pressure: 400 mbar
3. Intake volume flow according to Tab. 3: 2427 m³/h
4. Process water outlet temperature: 50 °C
5. Water loss for intake pressure and process water outlet temperature according to Fig. 4: 2.1 l/h per 100 m³/h intake air

\[
\text{Process water loss} = 2.1 \cdot \frac{2427}{100} = 50.97 \text{ l/h}
\]

In operation with cell ventilation, the process water loss is increased as a function of the additional air throughput.

Cell ventilation:
- As the vacuum increases, the amount of process water that is removed from the working space decreases due to the decreasing air mass. At a higher vacuum, auxiliary air is fed through a ventilation line. This maintains a safe operation.
5 Transport and storage

5.1 Safety notes for transport

DANGER!
Danger by falling down or tilting of the machine!

The weight of the machine may injure a person and cause serious bruising!
Therefore:
- Depending on the dead weight and size of the machine, use a pallet on which the machine can be moved by means of a fork lift.
- For lifting the machine, use suitable lifting gear (slings, etc.) that is designed for the weight of the machine.
- Avoid stress on individual components when you position the slings.
- Only use attachment points with eye bolts provided for that purpose.

Also observe all safety instructions in the "VacuStar WR 2500 / WR 3100 / WR 4000" operating instructions, Chapter "Occupational safety and special risks".

5.2 Transport

The machine, which is fastened on a base plate, must be transported with a fork lift or suitable straps. The lifting gear must be designed for the weight of the machine.

For future transports:
- Seal all open connections with protective caps (prevents penetration of dirt and water)
- Secure against vibrations
- Drain all process and operating media
- Securely fasten the machine prior to transport (e.g. screw it onto a pallet)
- Transport and put down machine with a fork lift or secure it with straps and lift it with suitable lifting gear.
5.3 Storage

Storage of packages

Store packages under the following conditions:

- Do not store outdoors.
- Store dry and dust free.
- Do not expose to aggressive media.
- Protect against solar irradiation.
- Avoid mechanical vibrations.
- Storage temperature: -10…+60 °C
- Relative humidity: max. 95%, non-condensing
- If storage lasts longer than 3 months, regularly check the general condition of all parts and of the packaging. If necessary, brush up or recondition the preservation.
6 Installation

6.1 Safety

Safety

**WARNING!**
Risk of explosion!
Only use components that are suitable for the zone in which the unit is used when you install the unit in an explosive atmosphere. An equipotential bonding must be installed between the equipment and the vehicle.

The safety equipment described in our operating instructions and installation instructions are mandatory for a safe operation of the machine in explosive areas.

Electrical system

**DANGER!**
Mortal danger due to electric current!
There is mortal danger in case of contact with live components.
Activated electrically driven components can start to move uncontrolled and cause severest injuries.

Therefore:
- Switch off the electric power supply before commencing any work and secure against restarting.
- Only skilled electricians are allowed to carry out any work on the electric systems, on electric components and connections.

Dirt and lying about items

**CAUTION!**
Risk of tripping from dirt and objects lying around!
Contamination and discarded items can lead to slipping and tripping, resulting in substantial injuries.

Therefore:
- Always keep the working area clean.
- Remove objects that are not required.
- Mark tripping points with yellow-and-black tape.

Also observe all safety instructions in the "VacuStar WR 2500 / WR 3100 / WR 4000" operating instructions, Chapter "Occupational safety and special risks".
6.2 Typical installation

Fig. 7: Typical installation

- 1 Compressor / vacuum pump
- 2 Dehydration
- 3 Compensator
- 4 Pressure gauge
- 5 Thermometer / temperature switch
- 6 Safety valve
- 7 Non-return valve for VacuStar
- 8 Process water reservoir
- 9 Changeover four-way cock
- 10 Safety tank
- 11 Vacuum meter
- 12 Vacuum suction filter
- 13 Safety dome with float valve
- 14 Vehicle tank
- 15 Cell ventilation from atmosphere
- 16 Cell ventilation from reservoir
- 17 Process water radiator
- 18 Process water cooling in the main flow
- 19 Process water cooling in the bypass flow
- 15.1 Non-return valve
- 15.2 Sound absorber
- 15.3 Air filter
- 16.1 Reservoir – radiator pipe
- 16.2 Radiator – reservoir pipe
- 18.1 Reservoir – radiator pipe
- 18.2 Circulating pump
- 18.3 Radiator – reservoir pipe
- 18.4 Reservoir – VacuStar pipe

Fig. 7 shows the example of a complete system with all possible pipe variants.
Installation

Cell ventilation:
- Variant I: Ventilation from the atmosphere (15.1, 15.2, 15.3)
- Variant II: Ventilation from the reservoir (16)

Process water cooling:
- Variant I: Cooling in the bypass flow (18.1, 18.2, 18.3, 18.4)
  Cooling in the bypass flow should always be preferred!
- Variant II: Cooling in the main flow (16)

6.3 Necessary work

Installation requires the following activities:
- Installing all components on the vehicle side.
- Installing VacuStar with suction and pressure lines.
- Installing safety and monitoring equipment.
- Connecting the VacuStar with the process water circulation.
- Connecting the drive with VacuStar. Observe sense of rotation and speed range.

6.4 Liquid ring compressor vacuum pump VacuStar WR

Possible step attachment
- Four screws at the machine feet secure the VacuStar to the vehicle.
- To adjust the unit in the best possible way to the installation conditions, the machine feet can be rotated clockwise or anticlockwise by one screw pitch. See page 10, Fig. 1, Fig. 2.

Checking the function before the installation
- Check the rotor shaft function. Rotating the rotor shaft with your hand must be possible.

Requirements placed upon installation point and attachment
- The attachment points on the vehicle must be of adequate carrying capacity and stiffness.
- The attachment points for the machine feet must be on the same level.
Installation instructions Liquid ring compressor vacuum pump VacuStar WR

Requirements placed upon the installation point

- Protected against dirt, gravel impact and splashing water.
- Sufficient space for a protection against contact.
- Sufficient space for the connections of the suction and pressure lines.
- Good readability of the instruments.
- Accessible for maintenance and repair work (e.g. for replacing the air filter, or for checking the safety and non-return valve).

Assembly

Use the following screws for securing the VacuStar WR:

<table>
<thead>
<tr>
<th>Type</th>
<th>Screw</th>
<th>Strength</th>
<th>Tightening torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>WR 2500 / 3100</td>
<td>M16</td>
<td>8.8</td>
<td>190 Nm</td>
</tr>
<tr>
<td>WR 4000</td>
<td>M24</td>
<td>8.8</td>
<td>680 Nm</td>
</tr>
</tbody>
</table>

*Table 5: Retaining screws*

6.5 Compensators

Compensators in suction and pressure lines

Vacuum- and pressure-proof compensators must be installed in the suction and pressure lines to delimit the socket forces and to isolate the impact sound. Selection according to the protection pressure and - with ATEX - the explosion pressure shock resistance. Temperature resistance up to 100 °C.
6.6 Lines and containers

Suction and pressure line

As required, the suction line and the pressure line can be installed at the A-side or at the pressure side and in vertical or horizontal direction (see page 10, Fig. 1, Fig. 2).

Fig. 4 (see page 12) shows the allocations of the flanges for all possible combinations.

The lines must satisfy the following requirements:

- Corrosion-proof
- Pressure resistance or explosion pressure shock resistance for ATEX
- Nominal diameter according to the following table:

<table>
<thead>
<tr>
<th>VacuStar</th>
<th>DN suction and pressure line</th>
</tr>
</thead>
<tbody>
<tr>
<td>WR 2500</td>
<td>DN 125 (5&quot;)</td>
</tr>
<tr>
<td>WR 3100</td>
<td>DN 125 (5&quot;)</td>
</tr>
<tr>
<td>WR 4000</td>
<td>DN 125 (6&quot;)</td>
</tr>
</tbody>
</table>

Table 6: DN suction and pressure line

- The lines must not exert any reaction force on the compressor. Support the lines adequately.
- Lay the suction line to the compressor such that is ascending. The condensate must be able to be drained.
- Remove dirt, welding remainders, rust, etc. before you put the unit into operation.

Process water line

Depending on the pipe routing, a line cross-section of R1/2"…R2" results.

To avoid overfilling the machine, a solenoid valve (flow when the VacuStar is started, stop when it is switched off) is installed in the process water inlet.
Installation instructions Liquid ring compressor vacuum pump VacuStar WR

Cell ventilation

Variant I (see page 21, Chapter 6.2): The ventilation line is fed with air from the reservoir. Connection at the upper part of the reservoir, descending to the VacuStar.

Variant II (see page 21, Chapter 6.2): The ventilation line is fed from the atmosphere. Installing a sound absorber is necessary to reduce the flow noise. Process water delivery must be prevented by installing a non-return valve.

<table>
<thead>
<tr>
<th>VacuStar</th>
<th>Inside diameter up to a line length of 2.5 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>WR 2500</td>
<td>at least 27 mm</td>
</tr>
<tr>
<td>WR 3100</td>
<td>at least 52 mm</td>
</tr>
<tr>
<td>WR 4000</td>
<td>at least 68 mm</td>
</tr>
</tbody>
</table>

*Table 7: Inside diameter*

Reservoir

There must always be a water supply available in the machine. This is required for generating the liquid ring during the start and to ensure the lubrication of the slide ring seal.

Variant I (see page 21, Chapter 6.2): The liquid level is above the line connection of the VacuStar.

1. At minimum water content in the reservoir and open process water line, the water level must not be below the connection of the VacuStar lines.
2. A solenoid valve must be installed in the process water inlet to avoid overfilling the machine at standstill.

**CAUTION!**

The slide ring seal will be damaged when the machine runs dry, without liquid. Before it is started, the liquid ring pump must always be filled approximately half with liquid.

Variant II (see page 21, Chapter 6.2): The liquid level is below the line connection of the VacuStar.

1. Depending on the line routing, installing a water circulation pump in the process water line may be necessary to support the circulation. Please contact CVS for the rating of the pump.
6.7 Safety equipment

The following safety equipment must be installed:

- Safety valve
- Monitoring the compression end temperature
- Non-return valve always at the suction side
- Vacuum suction filter
- Protection against contact.

6.7.1 Safety valve

Risk of explosion

DANGER!

Risk of injury from explosion!
Explosion can cause the most serious injuries!
Therefore:
- Install the safety valve properly. Observe the manufacturer's instructions.
- Use the safety valve only as intended.
- Never block the safety valve.

The German accident prevention regulations require a non-lockable safety valve to be installed after the compressor at the pressure side. This valve must be selected such that it prevents the pressure to exceed the highest permissible operating pressure by more than 10%. It must be identified with a TÜV component test number and be equipped with a manual venting element.

Assembly
1. Install the safety valve immediately after the pressure pipe joint.
2. The nominal opening pressure must not exceed the maximum permissible final overpressure (see Tab. 2) or the permissible system pressure (whichever is the lower).

6.7.2 Monitoring the end temperature

A suitable measuring instrument must be installed that switches the machine off when the maximum permissible temperature is reached.

Assembly
1. Install the temperature sensor in the line after the pressure pipe joint.
2. Connect the temperature sensor to the superordinate vehicle controller.
6.7.3 Non-return valve

When a vacuum is applied and the machine is stopped, the non-return valve prevents the air and the process water from flowing back into the suction line.

The non-return valve must be installed immediately before the suction flange.

6.7.4 Vacuum suction filter

An adequate filter (filter mesh < 0.5 mm) is required to prevent solid matters from being sucked in.

Assembly

Install a vacuum filter in the suction line before the machine. Observe the flow direction.

CAUTION!
For explosion-proof machines, use only filters that are resistant to the explosion pressure shock. Such filters can be purchased from CVS for the WR2500 and WR3100.

6.7.5 Protection against contact

Rotating or hot parts of the system must be equipped with a protection against contact.

Please note that the German accident prevention regulations do not allow a maximum surface temperature of 80 °C to be exceeded.

Observe DIN EN 294, for example, for the distances and the layout of the protective grid.

6.7.6 Display and monitoring equipment

CAUTION!
All display and monitoring devices in a system that is used for conveying explosive material must comply with the Directive 94/9/EC (ATEX) with respect to equipment category, temperature class and explosion group.

Vacuum meter, pressure gauge, temperature sensor and flow monitor must be installed for the safety of the VacuStar.
The process water supply in the reservoir must also be monitored. We also recommend the installation of a speed counter.

<table>
<thead>
<tr>
<th>Designation</th>
<th>Monitored parameter</th>
<th>Place of installation</th>
<th>Measuring range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum meter</td>
<td>Operating vacuum</td>
<td>Intended location, immediate in front of the inlet</td>
<td>0…1000 mbars</td>
</tr>
<tr>
<td>Pressure gauge</td>
<td>Positive working pressure</td>
<td>Immediately after the pressure pipe joint of the VacuStar</td>
<td>0…2.0 bars</td>
</tr>
<tr>
<td>Temperature sensor</td>
<td>Compression end temperature</td>
<td>After the pressure flange</td>
<td>Up to approximately 120 °C</td>
</tr>
<tr>
<td>Flow monitor</td>
<td>Process water inlet</td>
<td>Water feed line in front of the process water connection of the VacuStar WR</td>
<td>–</td>
</tr>
<tr>
<td>Water level indicator</td>
<td>Water level in machine at standstill</td>
<td></td>
<td>Only for visual inspection</td>
</tr>
<tr>
<td>Speed counter (option)</td>
<td>Speed</td>
<td>Drive shaft WR 2500 / WR 3100/ WR 4000</td>
<td>800…1600 min⁻¹</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>800…1300 min⁻¹</td>
</tr>
</tbody>
</table>

Table 8: Display and monitoring equipment
6.8 Additional components of the system

6.8.1 Safety tank

Requirements

The safety tank protects the VacuStar from sucking in liquids. It must comply with the following requirements:

- Passing air must not hit the liquid surface directly
- Sufficiently large settling chamber
- Drain cock at the deepest point of the tank

Assembly

Install the safety tank at the deepest point of the system.

Functional check

The functional check of the safety tank must satisfy the following requirements:

- The separated water must remain in the safety tank during suction operation.
- In atmospheric suction (pressure operation), the liquid ring pump must not suck in more than 1 litre of liquid per hour.

6.9 Safety dome

Requirement

The safety dome on the vehicle tank must be equipped with a float valve and a baffle.

The baffle prevents the liquid from being entrained when the liquid sloshes.

6.10 Cooling water system

CAUTION!

- The maximum permissible cooling water temperature is 60 °C.
- When dimensioning the components, you must take extreme temperatures in the summer and coolant additives into account. See page 14, Table 4.
The following figure shows a diagram of the radiator arrangement. See also page 21, Fig. 7.

1 Process water inlet from the reservoir
2 Process water outlet to the reservoir

**Assembly**

Observe the following points during installation:

- Operate the radiator in the bypass flow if possible.
- Ask CVS engineering for the circulating cooling water quantity.
- Install the radiator stress-free on rubber elements.
- Install the cooling water pump at the lowest point.
- Use hoses that are temperature-resistant up to 100 °C.
- Add antifreeze compound for ambient temperatures below 0 °C.
- Recommended cooling water cycling volume flow 5200 l/h at 0.2 bar pressure loss.

**NOTE!**

To avoid contamination in the VacuStar we recommend to install a coarse filter in the process water circulation.
6.11 Drive

CAUTION!
Drive and coupling of a system that is used for conveying explosive material must comply with the Directive 94/9/EC (ATEX) with respect to equipment category, temperature class and explosion group.

CAUTION!
– Selection and design are within the responsibility of the system builder.
– Do not apply any axial forces to the compressor shaft when you attach drive components.
– Pull couplings or other connecting components onto the shaft, do not knock them on.
– Check speed and sense of rotation.

The compressor is driven via:
1. V-belt
2. Articulated shaft
3. Flexible coupling

where drives such as lorry P.T.O, electric motors, hydraulic motors or diesel engine are possible.

6.11.1 V-belt drive

CAUTION!
The maximum permissible lateral force (FQ) on the compressor shaft due to belt-pull must not exceed the following values:
WR 2500 / WR 3100  FQ= 9300 N
WR 4000  FQ= 12500 N

Observe the ratings, installation instructions and inspection intervals from the manufacturer.
The following belt pulleys can directly be installed on the shaft end of the VacuStar:

<table>
<thead>
<tr>
<th>VacuStar V-belt drive</th>
<th>Unit</th>
<th>WR 2500</th>
<th>WR 3100</th>
<th>WR 4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belt profile</td>
<td>–</td>
<td></td>
<td>XPB</td>
<td></td>
</tr>
<tr>
<td>Smallest pulley diameter</td>
<td>[mm]</td>
<td>280</td>
<td>315</td>
<td></td>
</tr>
<tr>
<td>Number of belts in pressure operation</td>
<td>–</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Permissible final overpressure in pressure operation</td>
<td>[bar]</td>
<td>1.0</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Number of belts in vacuum operation</td>
<td>–</td>
<td>5</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

*Table 9: Belt pulleys*

**Assembly**

1. Select V-belt drive according to Table (Table 9).
2. Align the V-belt pulleys exactly to each other.
3. Install V-belt pulley (e.g. with Taper-Lock clamping bushes) and V-belt with pretension according to the manufacturer specifications.

**6.11.2 Articulated shaft drive**

**CAUTION!**

Observe the ratings, installation instructions and inspection intervals from the manufacturer.

Keep the bending radius of the articulated shafts as small as possible, max. 15°.

**6.11.3 Drive via flexible coupling and hydraulic motor**

**CAUTION!**

Observe the ratings, installation instructions and inspection intervals from the manufacturer.

The hydraulic motor is installed to the compressor via an intermediate flange. The power is transmitted via a flexible coupling.

Components that match the machine type can be ordered from CVS.
# 7 Start-up

## 7.1 Safety during start-up

| WARNING!  
Risk of injury due to improper start-up and operation |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Improper start-up and operation can lead to serious bodily injuries or property damage.</td>
</tr>
<tr>
<td>Therefore:</td>
</tr>
<tr>
<td>– Have all work during initial operation exclusively performed by the manufacturer's employees or by his authorized representatives or by trained personnel.</td>
</tr>
<tr>
<td>– Start-up and operation may only be performed by adequately qualified personnel who have been authorized and instructed by the operator.</td>
</tr>
<tr>
<td>– Before the start of any work, ensure that all covers and protective devices are correctly installed and function correctly.</td>
</tr>
<tr>
<td>– Never override any protective equipment during operation.</td>
</tr>
<tr>
<td>– Pay attention to tidiness and cleanliness in the working area! Loosely stacked or scattered components and tools are accident sources.</td>
</tr>
</tbody>
</table>

Also observe all safety instructions in the "VacuStar WR 2500 / WR 3100" operating instructions, Chapter "Occupational safety and special risks".
7.2 Start-up

Inspection before the initial start-up

The following points must be checked prior to initial start-up:

1. Check VacuStar and overall system
2. Check the pipes for continuity and residues (remove blanks if there are any)
3. Check the operating data on the rating plate.
4. Check whether the rotor shaft can be rotated by hand.
5. Check the function of the water stop valve (water supply and/or cell ventilation).
6. Check the sense of rotation (switch briefly on/off). Observe the arrow for the sense of rotation.
7. Fill in process water (clean drinking water) up to the maximum mark on the reservoir. Bleed the circuit. Add antifreeze according to manufacturer’s specifications.

**CAUTION!**

Risk of damaging the slide ring seal!

The slide ring seal will be damaged when the machine runs dry, without liquid.

Therefore:

- Before the unit is started, the liquid ring pump must always be approximately half full (shaft centre) with liquid (refer to Fig. 5, No. 10).

8. Check the function of the safety valve (see page 26 ff, Chapter 0.).
9. Check the retaining screws. (see page 22, Chapter 6.4)

Start-up

Proceed as follows during start-up:

1. Open shut-off devices (if installed)
2. Start the VacuStar drive.
3. Check the operating data.
4. Check the function of the installed cell ventilation.

The machine must run smoothly when the suction valve is closed.
Inspections during operation

The following inspections have to be carried out during operation:

1. The liquid level in the reservoir must not be lower than the minimum mark during operation.
2. Always turn the four-way cock until it hits the stop. Intermediate positions are not permitted.
3. Check whether pressure or vacuum builds up.
4. Pay attention to abnormal noises and leaks during operation. If necessary, switch off machine.
5. Drain the condensate at the safety trap. Vessel may not be in a state of vacuum when condensate is drained.

Checking the operating data:

1. The speed must be between:
   - 800...1600 min⁻¹ (WR 2500 / WR 3000), resp.
   - 800...1300 min⁻¹ (WR 4000).
2. The cooling water outlet temperature (return flow to radiator) may be max. 60 °C.
3. Check positive working pressure at the pressure gauge (permissible pressure refer to rating plate).
4. Check the operating vacuum at the vacuum meter (permissible vacuum refer to rating plate).

CAUTION!
The following points must be observed when explosive gases and gas mixtures are conveyed:

- Prior to every machine start and during operation:
  - Check the process liquid levels (machine and reservoir)
  - Check for leaks
  - Listen for abnormal noise during the suction process. Switch off the machine if necessary.
  - Check the machine at regular intervals (daily) for signs of overheating and exceptional deformations. If necessary, switch off the machine or do not put it into operation.
7.3 Switching off

To switch off the VacuStar, proceed as follows:

① Switch off the drive to the VacuStar
② Close the shut-off valves (if installed)
③ Drain the safety tank. Vessel may not be in a state of vacuum when condensate is drained.

7.4 Inspections to be performed

pH value of the process water

④ Depending on the conveyed medium, the steady water delivery can lead to an increased concentration of harmful substances and thus to a change in the pH value.
④ The permissible pH value (see page 14, Table 3) must be checked (using litmus paper, for example) at regular intervals according to the operation experience.
Declaration of incorporation

(according to Directive 2006/42/EC, Annex II, Part 1 Clause B)

Manufacturer: CVS engineering GmbH
Grossmattstraße 14
D-79618 Rheinfelden / Germany

Documentation representative: Rolf Jäger
Grossmattstraße 14
D-79618 Rheinfelden / Germany

The manufacturer herewith declares that the "incomplete machine" model "VacuStar WR" complies with the requirements of Directive 2006/42/EC up to the interface(s) described in the enclosed installation guide, operating instructions, data sheets and technical documentation.

The manufacturer undertakes to forward the special technical documentation in respect of the incomplete machine to national authorities at their request.

The special technical documentation belonging to the machine according to Appendix VII Part B has been compiled.

The special technical documentation according to Appendix VII B of the directive is available for a possible inspection by the responsible supervisory body.

Start-up of the incomplete machine is not permitted until it has been determined that the machine or machinery into which this incomplete machine has been integrated or of which it constitutes a component complies with the basic safety requirements and provisions of Directive 2006/42/EC.

Machine design: Liquid ring pump for aspirating filtered air or water vapour for pressure and vacuum operation
Suitable for direct drive via flexible coupling by means of V-belt or articulated.

Machine models: VacuStar WR 2500, VacuStar WR 3100, VacuStar WR 4000

Applied harmonised standards:

- DIN EN ISO 12100-1/-2
  Safety of machinery – Basic concepts, general principles for design
  Part 1: Basic terminology
  Part 2: Technical principles

- DIN EN ISO 14121-1
  Safety of machinery – Risk assessment
  Part 1: Principles

- DIN EN 1012 Part 1 / 2
  Compressors and vacuum pumps - Safety requirements
  Part 1: Air compressors
  Part 2: Vacuum pumps

In case of conversion or alterations on the device as a whole or on individual components, this declaration shall become invalid with immediate effect

Rheinfelden, this 27st day of July 2010
p.p. Rolf Jäger
Head of Design and Development
Declaration of Conformity

as per EU directive 94/9/EG (ATEX)

Manufacturer: CVS engineering GmbH
Grossmattstraße 14
79618 Rheinfelden / Germany

We herewith declare that the liquid ring compressor vacuum pump of the series VacuStar WR comply with the regulations of directive 94/9/EG (ATEX) for devices and protection systems for the proper use in explosive environments.

Device group, category, gas group, temperature class, zone:

II 2G c k IIB T5 interior zone 1, 2; exterior atmosphere

The conformity evaluation process was performed as per the directive 94/9/EG (ATEX). For the Type VacuStar WR 2500 and WR 3100 the corresponding documentation is stored under EX9 08 12 63947 002 and for the Type VacuStar WR 4000 under EX9 11 63947 003 in the following location:

TÜV Product Service GmbH
Unternehmensgruppe
TÜV Süddeutschland
Gottlieb – Daimler – Strasse 7
70794 Filderstadt, Germany

Design: Liquid ring compressor vacuum pump for pressure- and suction mode, suitable to drive with elastic coupling, V-belt drive or articulated shaft.

Series: VacuStar WR 2500, VacuStar WR 3100, VacuStar WR 4000

The following harmonised standards apply:

DIN EN ISO 12100-1 Safety of machinery April 2004
DIN EN ISO 12100-2 Safety of machinery April 2004
DIN EN 1012-1 Compressors and vacuum pumps February 2010
DIN EN 1012-2 Compressors and vacuum pumps Safety requirements
DIN EN 14121-1 Safety of machinery- risk assessment December 2007
DIN EN 1127-1 Explosion prevention and protection February 2008
DIN EN 13463-1 Non-electrical equipment intended July 2007
DIN EN 13463-5 Non-electrical equipment intended for use in potentially explosive atmosphere March 2004
DIN EN 13463-8 Non-electrical equipment intended January 2004

The following non-harmonised standard was applied:

TRT 006 Technical guideline tank, Explosion and shock proof June 2002

The respective installation instructions / operating instructions contain important safety relevant notes and instructions for the startup of the above-mentioned mechanical devices as per directive 94/9/EG.

Changes and repairs on these devices are prohibited, unless expressly permitted in writing by the manufacturer.

The mentioned devices are intended for the installation in a superior machine (upstream). The risks associated with the installation must be evaluated by the manufacturer of the new machine.

Rheinfelden, January 21, 2011

i.V. Rolf Jäger
Design and Development Manager
Index

1 Declaration of incorporation.................................37
A Acceptance..........................................................9
Articulated shaft drive..........................................32
ATEX .........................................................8, 9, 23, 24, 27, 31, 35, 38
C Cell ventilation..................................................16, 25
Compensators....................................................23
Connecting flanges..............................................16
Contact person......................................................7
Cooling..............................................................15
Cooling water system.........................................29
Copyright protection...........................................7
Customer service................................................7
D Danger pictograms............................................10
Dangers............................................................10
Declaration of Conformity....................................38
Declaration of incorporation................................7
Design...............................................................15
Dimensions........................................................10
Dirt .................................................................20
Display equipment..............................................27
Drive ...............................................................31
E Electrical specialist............................................9
F Function............................................................15
I Inspection
   during operation...........................................35
   Lubricating oil..............................................36
   prior to initial start-up ..................................34
Installation and assembly.................................20
Installing VacuStar WR......................................22
Intended use......................................................8
L Liability..................................................................7
Lubrication........................................................15
M Monitoring equipment.....................................27
N Non-return valve..............................................27
O Occupational safety..........................................10
Operating instructions.......................................5
Operator............................................................9
P Personnel..........................................................9
Pictograms
   in the operating instructions............................6
   Pressure line..................................................11, 24
   Process water circulation..............................11, 24
   Process water delivery...................................17
   Process water line...........................................24
   Proper operation..........................................19
   Protection against contact............................27
   Protective equipment.................................19
R Reservoir..........................................................25
S Safety...............................................................8
   Safety dome................................................29
   Safety equipment..........................................26
   Safety tank...................................................29
   Safety valve................................................26
   Shaft sealing................................................16
   Sound absorber - oil separator......................29
   Spare parts..................................................7
   Specialised staff..........................................19
   Start-up.......................................................33
   Storage.......................................................19
   Suction line................................................11, 24
   Switching off...............................................36
Index

T
Technical data.............................................. 10, 13
Transport..................................................... 18
Typical installation........................................ 21

V
Vacuum suction filter........................................ 27
V-belt drive................................................... 31

W
Warranty.......................................................... 7