

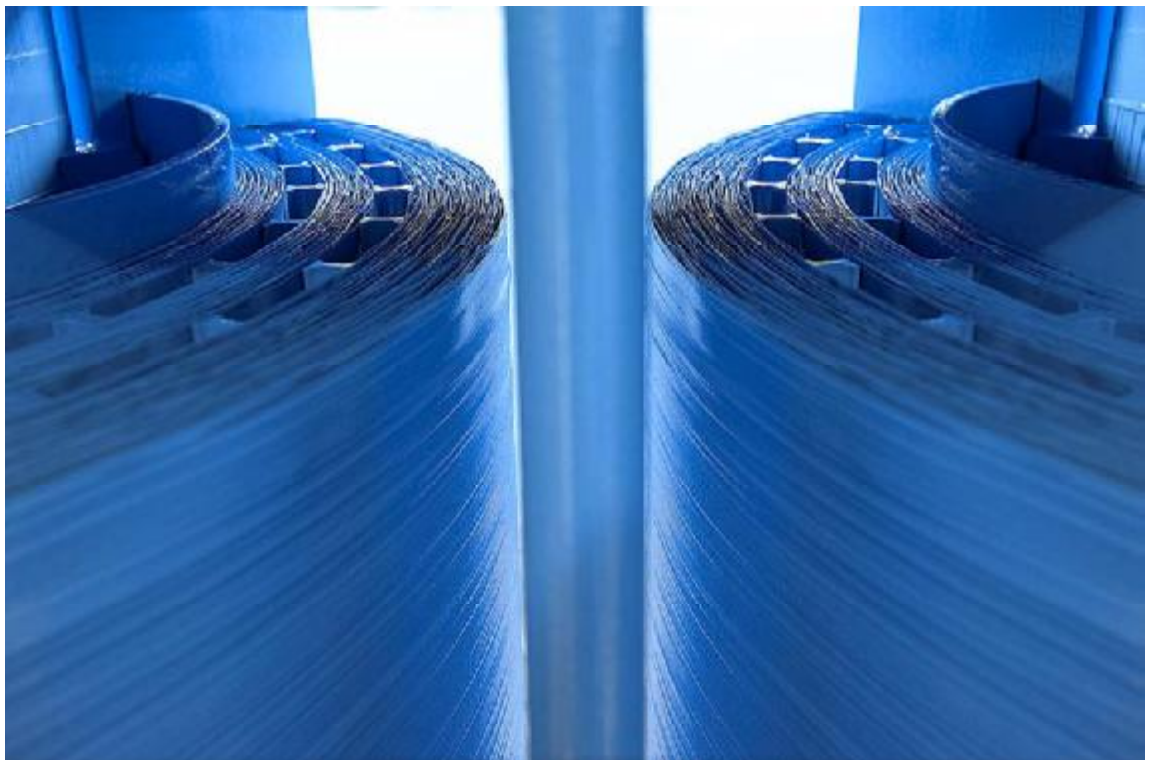


Hans von Mangoldt GmbH & Co. KG
D-52080 Aachen, Germany

Installation and Service Manual for Medium Voltage Filter Reactors

Single and Three-Phase, Iron Core, PolyGap™ Construction

Release date: 06.02.2008





About this Document

This document explains product features and applications as well as conditions and limits for operation and provides guidelines for installation, handling and operation of filter reactors produced by Hans von Mangoldt GmbH & Co. KG.

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1 Important Directions for Use

1.1 Appropriate Use

Hans von Mangoldt GmbH & Co. KG products represent state-of-the-art developments in technology and manufacturing. They are 100% tested prior to shipment to ensure operational safety and reliability. The products may only be used in the manner that is defined as appropriate. If they are used in an inappropriate manner, then situations can develop that may lead to property damage or injury to personnel.

Hans von Mangoldt GmbH & Co. KG, as manufacturer, is not liable for any damages resulting from inappropriate use. In such cases, the guarantee and the right to payment of damages resulting from inappropriate use are forfeited. The user alone carries all responsibility of the risks.

Before using Hans von Mangoldt GmbH & Co. KG products, make sure that all the prerequisites for appropriate use of the products are satisfied:

- Personnel that in any way, shape or form use our products must first read and understand the relevant safety instructions and be familiar with appropriate use.
- The products must remain in their original state. In other words, no structural changes are permitted.
- Do not mount damaged or faulty products or use them in operation.
- Make sure that the products have been installed in the manner described in the relevant documentation.

The products may only be operated under the assembly, installation and ambient conditions as described here (temperature, IP-Class, humidity, etc.) and in the position specified.

1.2 Inappropriate Use

Inappropriate use is defined as using the products outside of the above referenced areas of application or under operating conditions other than described in the document and the technical data specified.

The products may not be used if they are subject to operating conditions that do not meet the specified ambient conditions. This includes, for example, operation under water, extreme temperature fluctuations or extremely high maximum temperatures.



2 Safety Instructions

2.1 General Information

2.1.1 Using the Safety Instructions and Passing them on to Others

Do not attempt to install or commission this device without first reading all documentation provided with the product. Read and understand these safety instructions and all documentation prior to working with the device. If you do not have the documentation for the device, contact Hans von Mangoldt GmbH & Co. KG. Ask for these documents to be sent immediately to the person or persons responsible for the safe operation of the device.

If the device is resold, rented and/or passed on to others in any other form, then these safety instructions must be delivered with the device.



WARNING

Improper use of these devices, failure to follow the safety instructions in this document or tampering with the product may result in material damage, bodily harm, electric shock or even death!



2.1.2 Instructions for Use

Read these instructions before the initial startup of the equipment in order to eliminate the risk of bodily harm or material damage. Follow these safety instructions at all times.

- Hans von Mangoldt GmbH & Co. KG is not liable for damages resulting from failure to observe the warnings provided in this documentation.
- Read the operating, maintenance and safety instructions in a language you fully understand before starting up the machine. If you find that you cannot completely understand the documentation for your product, please ask your supplier to clarify.
- Proper and correct transport, storage, assembly and installation as well as care in operation and maintenance are prerequisites for optimal and safe operation of this device.
- Only assign trained and qualified persons to work with electrical installations. Only those people trained and knowledgeable about the operation of the device may work on this device or within its proximity. The persons are qualified if they have sufficient knowledge of the assembly, installation and operation of the equipment as well as an understanding of all warnings and precautionary measures noted in these instructions. Furthermore, they must be trained, instructed and qualified to switch electrical circuits and devices on and off in accordance with technical safety regulations, to ground them and to mark them according to the requirements of safe work practices. They must have adequate electrical safety training and be trained in first aid.
- Follow all safety regulations and requirements for the specific application as practiced in the country of use.
- The devices referred to in this document have been designed for medium voltage power installations.
- The ambient conditions specified in the product documentation must be observed.
- The information provided in the documentation of the product with regard to the use of the delivered components contains only examples of applications and suggestions.
- The installer must make sure
 - that the delivered components are suited for his individual application and verify the information given in this documentation with regard to the use of the components,
 - that his application complies with the applicable safety regulations and standards and carry out the required measures, modifications and complements.
- Startup of the delivered components is only permitted once it is certain that the installation in which they are installed complies with the national regulations, safety specifications and standards of the application.
- The installer is responsible for compliance with the limiting values as prescribed in the national regulations.
- Technical data, connections and operational conditions are specified in the product documentation or quotation and must be followed at all times.



2.2 Explanation of Warning Symbols and Degrees of Hazard Seriousness

The safety instructions describe the following degrees of hazard seriousness. The degree of hazard seriousness informs about the consequences resulting from non-compliance with the safety instructions:




Warning symbol with signal word	Degree of hazard seriousness according to ANSI Z 535
 DANGER	Death or severe bodily harm will occur.
 WARNING	Death or severe bodily harm may occur.
 CAUTION	Bodily harm or material damage may occur.

Table 1: Hazard classification (according to ANSI Z 535)



2.3 Hazards by Improper Use



**High electric voltage and high working current!
Risk of death or severe bodily injury by electric shock!**

DANGER



Dangerous movements! Danger to life, severe bodily harm or material damage by unintentional product movements!

DANGER



**High electric voltage because of incorrect connection!
High electric voltage because of incorrect electrical spacing!
Risk of death or bodily injury by electric shock!**

WARNING



Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electrical equipment!

WARNING



**Hot surfaces on device components or housing!
Danger of injury! Danger of burns!**

CAUTION



**Risk of injury by improper handling!
Risk of bodily injury by bruising, shearing, cutting or hitting!**

CAUTION



2.4 Instructions with Regard to Specific Dangers

2.4.1 Protection Against Contact with Electrical Parts

Contact with parts conducting voltages above 50 Volts can cause personal danger and electric shock. When operating electrical equipment, it is unavoidable that some parts of the devices conduct dangerous voltage.



DANGER

High electrical voltage! Danger to life, electric shock and severe bodily injury!

- Only those personnel trained and qualified to work with or on electrical equipment are permitted to operate, maintain and repair this equipment.
- Follow general construction and safety regulations when working on electrical power installations.
- Before switching on the device, the equipment grounding conductor must be permanently connected to all electrical equipment in accordance with the connection diagram.
- Do not operate electrical equipment at any time, even for brief measurements or tests, if the equipment grounding conductor is not permanently connected to the mounting points of the components provided for this purpose.
- Before working with electrical equipment, the device must be disconnected from the main voltage or power supply unit. Provide a safeguard to prevent reconnection.
- With electrical installations observe the following:
 - Wait after switching off power to allow capacitors to discharge before beginning to work. Measure the voltage on the capacitors before beginning to work to make sure that the equipment is safe to touch.
 - Never touch the electrical connection points of a component while power is turned on.
 - Install covers and guards properly before switching the device on. Before switching the equipment on, cover and safeguard live parts safely to prevent contact with those parts.
 - Secure built-in devices to protect from direct contact with electrical parts for example by providing an external housing.
 - Follow all applicable standards - international and local - as well as local engineering regulations in the country of installation.
- The operator must observe all the above regulations at any and all times.



2.4.2 Protection Against Dangerous Movements

Dangerous movements can be caused by faulty connection of components of the installation. Some common examples are:

- improper or wrong wiring of cable connections
- incorrect operation of the installation components
- defective components
- errors in power grid

Dangerous movements can occur immediately after equipment is switched on or even after an unspecified time of trouble-free operation.



DANGER

Dangerous movements! Danger to life, risk of injury, severe bodily harm or material damage!

- For the above reasons, ensure personal safety by means of qualified and tested higher-level monitoring devices or by integrating safety precautions into the equipment or its installation. These must be provided for by the user according to the specific conditions within the installation and a hazard and fault analysis. The safety regulations applicable for the installation have to be taken into consideration.

To avoid accidents, bodily harm and/or material damage:

- Keep free and clear of the product's range of motion. Possible measures to prevent people from accidentally entering the component's range of motion: safety fences, safety guards, protective coverings or barriers.
- Fences and coverings must be strong enough to resist maximum possible momentum.
- Mount the emergency stop switch in the immediate reach of the operator. Verify that the emergency stop works before startup. Don't operate the device if the emergency stop is not working.
- Make sure that the installation is switched off before accessing or entering the danger zone.
- Disconnect electrical power to the equipment using a master switch and secure the switch against reconnection for: maintenance and repair work, cleaning of equipment or long periods of discontinued equipment use

2.4.3 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting

Magnetic and electromagnetic fields generated by current-carrying conductors represent a serious personal danger to those with heart pacemakers, metal implants and hearing aids.



WARNING

Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electrical equipment!

- Persons with heart pacemakers and metal implants are not permitted to enter following areas: areas in which electrical equipment and parts are mounted, being operated or commissioned.
- If it is necessary for somebody with a pacemaker to enter such an area, a doctor must be consulted prior to doing so. The interference immunity of present or future implanted heart pacemakers differs greatly, so that no general rules can be provided.
- Those with metal implants or metal pieces, as well as with hearing aids must consult a doctor before they enter the areas described above. Otherwise health hazards may occur.

2.4.4 Protection Against Contact with Hot Parts



CAUTION

**Hot surfaces at products or housings! Danger of injury!
Danger of burns!**

- Do not touch surfaces of product components or housings!
Danger of burns!
- During and after normal operation, temperatures can be higher than 100°C, 212 °F.
- Before accessing the products after having switched them off, let them cool down for a sufficiently long time. Cooling down can require up to 24 hours!
- Wear safety gloves or do not work near hot surfaces.
- For certain applications, the manufacturer of the end product, machine or installation, according to the respective safety regulations, must take measures to avoid injuries caused by burns in the end application. These measures can be, for example: warnings, guards (shielding or barrier), technical documentation.



2.4.5 Protection During Handling and Mounting

In unfavorable conditions, handling and assembling certain parts and components in an improper way can cause injuries.



CAUTION

Risk of injury by improper handling! Bodily injury by bruising, shearing, cutting, hitting!

- Observe the general construction and safety regulations on handling and assembly.
- Use suitable devices for assembly and transport.
- Avoid jamming and bruising by appropriate measures.
- Always use appropriate tools. Use special tools if specified.
- Use lifting equipment and tools in the correct manner.
- If necessary, use suitable protective equipment (for example safety goggles, safety shoes, safety gloves).
- Do not stand under hanging loads.



3 Handling and Transportation

3.1 Supplied Condition

Hans von Mangoldt GmbH & Co. KG products represent state-of-the-art developments in technology and manufacturing. They are 100% tested according to the applicable standards prior to shipment to ensure operating safety and reliability (see also section 7)

The products are delivered in wooden crates or on pallets. Units shipped on pallets are secured to the wood pallet by retaining straps or screws.



CAUTION

Injuries due to uncontrolled movement of the retaining straps when cutting!

- Maintain a sufficient distance and carefully cut the retaining straps.

The products are screwed onto the crates or the pallets in preparation for shipment (see also section 3.3.2).

The products that are mounted on rubber mountings are tightened by a sliding bolt as a transportation lock. The sliding bolts must be removed prior to commissioning (see also section 4.4.2).

The products that are delivered together with standoff insulators must be mounted onto the insulators prior to commissioning. The designed electrical strength of the products exists only when mounted onto the standoff insulators (see also section 4.4.3).

3.1.1 Electrical Insulation

The products are manufactured such that the associated manufacturing process saves energy and raw material to an optimum extent while simultaneously permitting an ideal electrical insulation of all electrically active components. Thus the large life expectancy of the products is ensured.

The products of Hans von Mangoldt GmbH & Co. KG are completely impregnated in one manufacturing-process step. By this process step an optimal electrical insulation is guaranteed. Additionally, good acoustic damping is ensured.

The impregnation process is performed using vacuum-impregnation equipment. In this equipment the impregnation resin is applied evenly onto all components of the product by means of a specific negative pressure. This vacuum is generated prior to impressing the specific amount of resin for each product into the equipment.

When the products leave the vacuum-impregnation equipment the impregnation resin has low viscosity. The hardening process of the resin is performed in a furnace at a specific temperature defined by the resin type. By means of a defined routing of the air flow in the furnace an even distribution of the resin on the upper part of the products can be reached. Simultaneously at the lower part of the products gravitation forms resin beads (Figure 1). These beads can not be prevented because the lowest viscosity of the impregnation resin occurs during the hardening process within the furnace.



CAUTION

Destruction of product components by insulation breakdown! Invalidation of warranty!

- Do not remove impregnation resin beads!
- Insulation breakdown can lead to a destruction of the product!



It is prohibited to remove the resin beads because the electrical insulation of the product might suffer seriously. This again can cause an insulation breakdown immediately or in the long term and thus a failure of the whole product. In any case the life expectancy of the product is dramatically reduced by removing the resin beads.



Figure 1: Insulation resin beads on product

In a subsequent operation the paint film is applied onto the impregnation resin (Figure 2). The paint material is specially formulated for an optimal compatibility between paint and resin and to achieve an optimal insulation level and thermal behavior of the products (see also section 8.4).

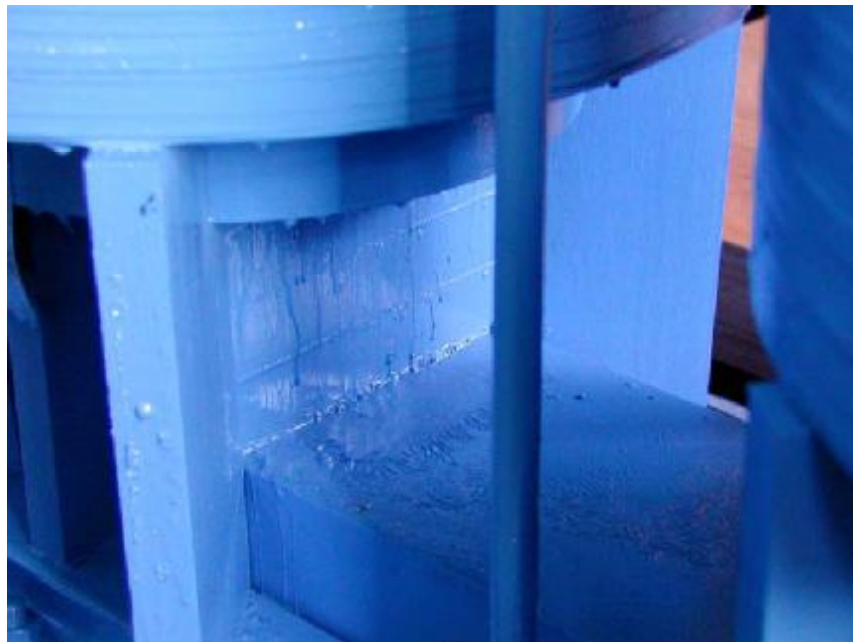


Figure 2: Insulation resin beads after paint finishing

3.2 Identification and Designation

The total scope of a delivery can be seen in the delivery note or waybill. However, the contents of a delivery can be distributed over several packages. After receiving the goods, compare the ordered and the supplied type to confirm receipt of all goods ordered. Submit claim immediately if there is a discrepancy.

The type designation of the product, along with additional product data, is stated on the product nameplate. Using the designation and the serial number, every Hans von Mangoldt GmbH & Co. KG product can be uniquely identified.

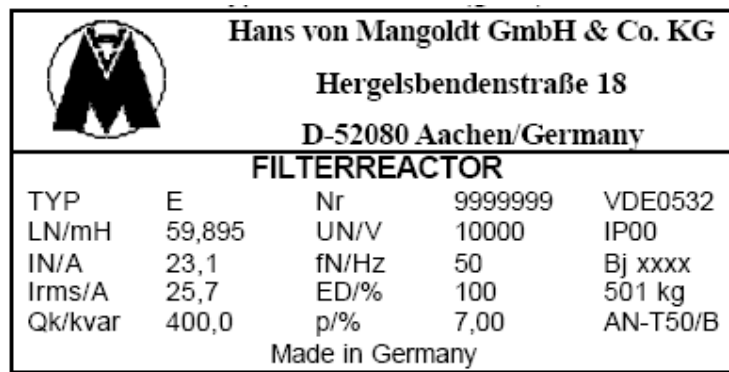


Figure 3: Example of a nameplate

The technical data provided on the type plate of a product may differ depending on the reactor specifications. As an example the nameplate shown in Figure 3 comprises the product data explained in Table 2.

The cooling and temperature class consists of AN for natural convection and T50/B for insulation material of temperature class B and maximum ambient temperature 50 °C (see also section 8.1).


1. Product type	2. Serial / testing number	3. Product standard
4. Nominal inductance	5. Nominal voltage	6. Protection class
7. Nominal current	8. Nominal frequency	9. Production year
10. Rated current	11. Duty cycle	12. Mass
13. Nominal power	14. Detuning factor	15. Cooling / temperature class

Table 2: Fields of the name-plate example

- Before sending questions to Hans von Mangoldt GmbH & Co. KG, always specify the full type identification data and serial number of the products involved.

3.3 Transportation and Storage

3.3.1 General Information



CAUTION

Damages or injuries and invalidation of the warranty due to improper handling!

- Protect the products from moisture and corrosion.
- Avoid mechanical stressing, throwing, tipping or dropping of the products.
- Only use lifting equipment suitable for the weight of the product.
- Use suitable protective equipment and wear protective clothing during transport.

Notes:

- Permitted **transportation temperature range:** -20°C to +80°C.
- Permitted **storage temperature range:** 0°C to +45°C.
- Large or periodic variations of temperature are forbidden.
- Also observe the notes regarding storage and transport on the packages.

3.3.2 Notes for Transportation

To protect the product from dirt, dust etc., Hans von Mangoldt GmbH & Co. KG recommends further transport the product in the original packaging in which it has been delivered

- to the intended installation site and
- to keep it in that way until the actual time of installation.

The products are secured to the crates or pallets in the supplied condition (Figure 4). The transportation screws must be removed prior to lifting the products.

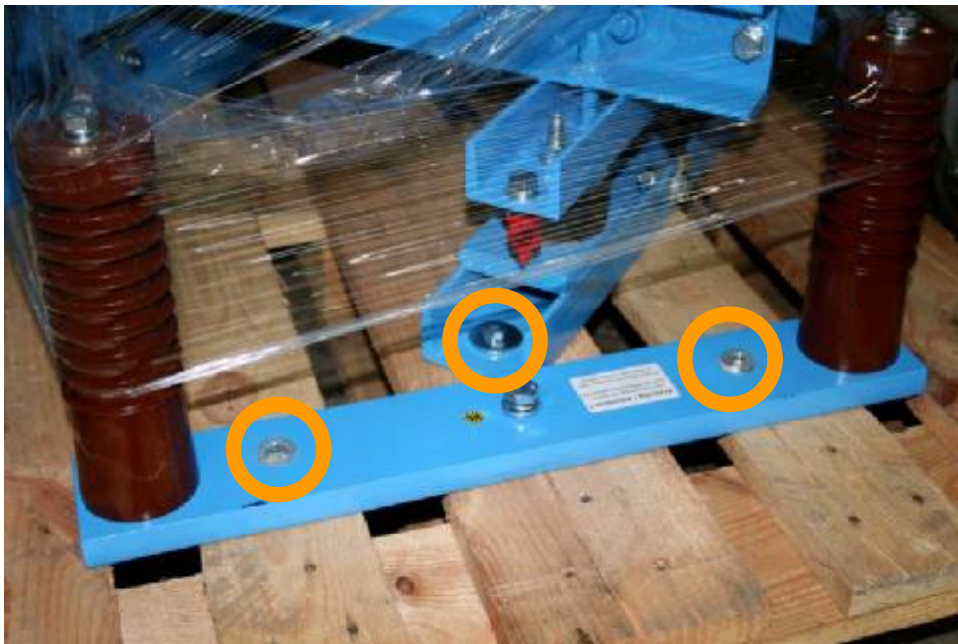


Figure 4: Examples for transportation screws in delivery condition (marked by the circles)

- Secure the products against sliding and tipping before removing the transportation screws.

To lift the product from the transport crate or to install it into the installation, use the transport or lifting eye bolts on the products (Figure 5). The lifting eye bolts comply with the requirements of DIN 580 as a minimum. Before each transport, ensure that the lifting eye bolts are screwed down fully to the stop face and that your selected lifting equipment and lifting method will not overload the lifting eye bolts.

Note: Please note the DIN 580 standard on transport of the products by means of the attached lifting eye bolts. Non-observance of the information in this standard may cause overload of the lifting eye bolts and result in personal injury or damage to products.



Figure 5: Example for lifting bolts at product



4 Installation

4.1 Safety



WARNING

Risk of injuries due to live parts! Risk of injuries due to hot surfaces! Risk of injuries due to lifting of heavy loads!

- Install the products only when they are de-energized and not connected electrically.
- Use suitable lifting equipment and protective equipment and wear protective clothing during transportation.
- Please note the safety information from the preceding chapters, and in particular the notes on transport of products in section 3.3!

Carry out all work with extreme caution to minimize the risk of accidents and damage.

4.2 Mechanical Mounting

To attach the products correctly and safely to the installation, Hans von Mangoldt GmbH & Co. KG recommends the following bolts and washers for product mounting:

- V2a hexagon head screw M12 x ..., DIN 933
- Washer M12-DIN125-A-140HV in material V2a

The material V2a for both screws and washers reduces the danger of overheating of these parts due to induced voltages caused by the stray fields of the products (see also section 8.3).

Note: If other screws and washers than those listed in this recommendation are used, the property class of the screws and the hardness class of the washers must be equivalent to allow for application of the required tightening torque. The values of the tightening torque are listed in the applicable standards.

4.3 Assembly Preparation

Prepare product for assembly as follows:

- Check all components for visible damage. Defective components may not be mounted or used.
- Ensure that dimensions and tolerances for the area or equipment in which the reactor is to be installed are suitable for product attachment.
- Ensure that mounting can be done in a clean, dry and dust-free environment.
- Have all necessary tools and auxiliary material, as well as measuring and testing equipment, readily available.
- Check whether all components, assembly surfaces and threads are clean.
- Remove the transportation screws.
- Log all measurements taken into the commissioning log.



4.4 Assembly

Review the following subsections depending on the design of the product.

After having mounted the product mechanically as prescribed below, proceed with the electrical connections.

4.4.1 Assembly of Products without Rubber Mounting Pads

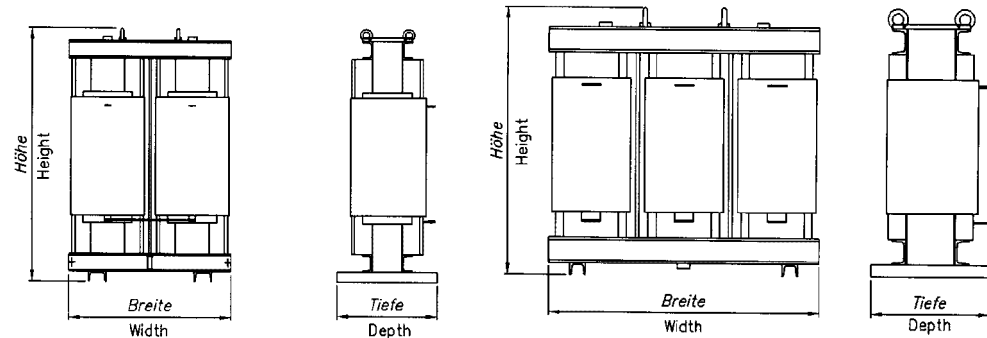


Figure 6: Example drawings for products without rubber mounting

- Fasten the reactor mounting feet securely to the enclosure mounting base.
- Check the fit and accuracy of the reactor installation before you proceed.
- Log all measurements taken in the commissioning log.

4.4.2 Assembly of Products with Rubber Mounting Pads

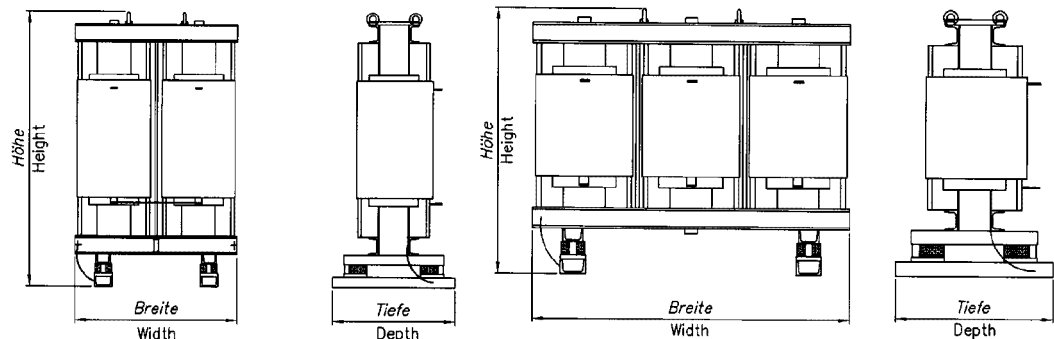


Figure 7: Example drawings for products with rubber mounting pads

Hans von Mangoldt GmbH & Co. KG designs some of the products with rubber mounting pads for anti vibration and acoustic decoupling of the product from the installation.

Each rubber mounting pad is equipped with a transportation safety device (Figure 8). This device must be removed after mounting the products in the installation. Remove the safety bolt from its transportation position and secure it together with its protection sleeve for eventual further transportation of the product.

- Fasten the reactor mounting feet securely to the enclosure mounting base.
- Check the fit and accuracy of the installation before you proceed.
- Remove the safety bolts and the protection sleeves for the rubber mountings. Store both for use in eventual further transportation of the product.
- Log all measurements taken in the commissioning log.



Figure 8: Rubber mounting pad with transportation safety device

4.4.3 Assembly of Products with Standoff Insulators

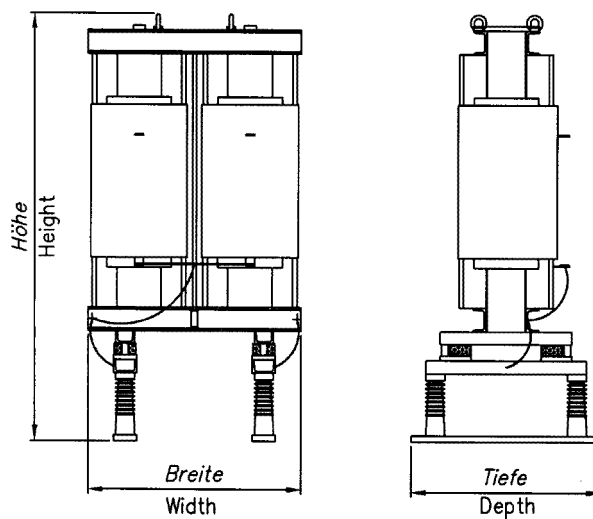


Figure 9: Example drawing for product on standoff insulators

Products with a nominal voltage above 17.5 kV are designed for mounting on standoff insulators. They are also designed as single-phase products. The standoff insulators are designed according to standard IEC 60273. Due to their mechanical construction the insulators are able to carry large forces in axial direction but are not resistant to torsion, thus reactors are shipped without standoff insulators attached.

If the product delivery includes standoff insulators (Figure 10), then these standoff insulators have been dimensioned for the electrical strength of the specific product. The standoff insulators have been tested together with the product in the testing facility.

- Install the standoff insulators only onto the product they have been supplied with and in the intended position.
- Take care not to damage the standoff insulators during assembly. Damaged insulators must be replaced before product is used.
- First, identify the supplied standoff insulators with the product.
- Fasten the insulators with the screws that are delivered together with product or the insulator respectively.
- Check the fit and accuracy of the connection between insulator and product before you proceed.
- Fasten the mounting base of the standoff insulators to the reactor mounting base (Figure 11).
- Check the fit and accuracy of the connection before you proceed.



- Log all measurements taken in the commissioning log.

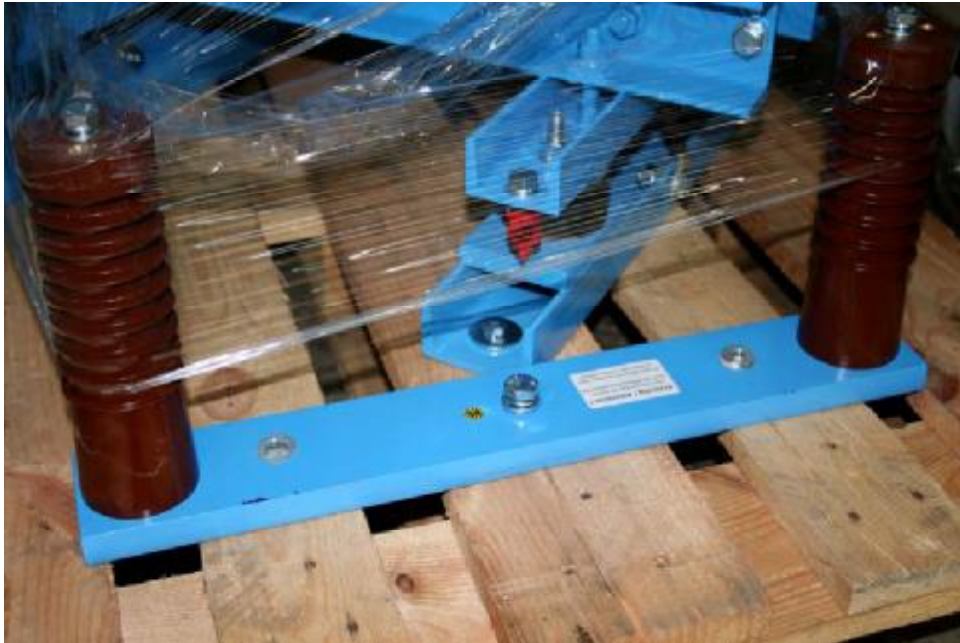


Figure 10: Standoff insulator in delivery condition



Figure 11: Example for products with standoff insulators after assembly

Note: Products with standoff insulators may also have rubber mounting pads. In this case remove the safety devices of the rubber mounting pads as described in section 4.4.2.



4.4.4 Assembly of Products on Carriages

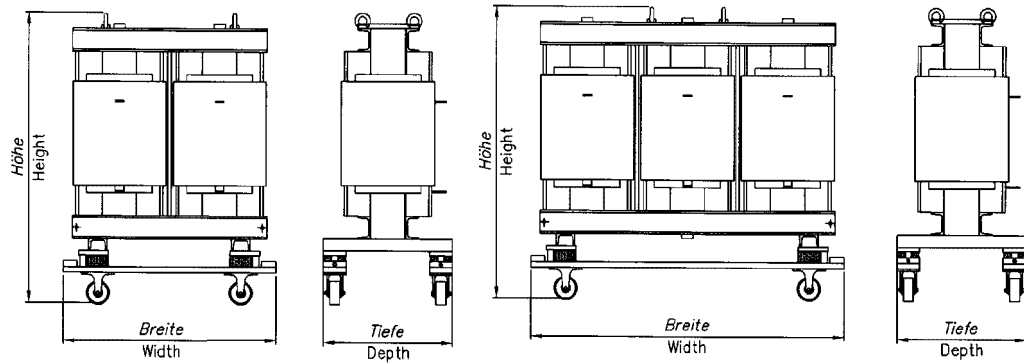


Figure 12: Example drawings for products on carriages (and on rubber mounting pads)

- Pull the product onto the carriage to its final position in the installation.
- Secure the product against unintentional movement by fastening the carriage to the intended mounting base.
- Check the fit and accuracy of the connection before you proceed.
- Log all measurements taken in the commissioning log.

4.5 Electrical Connection

Complete the electrical connection of the products according to the information in section 6.

Note: The terminal diagrams included in this manual are used to generate the system circuit diagrams. The system circuit diagrams for the installation are the sole responsibility of the equipment manufacturer or system integrator and should be used for connecting the reactor into the piece of equipment.



4.6 Commissioning



DANGER

High electric voltage and high working current! Risk of death or severe bodily injury by electric shock!

- Only those personnel trained and qualified to work with or on electrical equipment are permitted to operate, maintain and repair this equipment.
- Follow general construction and safety regulations when working on electrical power installations.
- Before switching on the device, the equipment grounding conductor must be permanently connected to all electrical equipment in accordance with the connection diagram.
- Do not operate electrical equipment at any time, even for brief measurements or tests, if the equipment grounding conductor is not permanently connected to the mounting points of the components provided for this purpose.
- If the topology of the installation or power grid has changed, the electrical utilization of the products must be checked prior to reconnection
- Never touch the electrical connection points of a component while power is turned on.
- Install the covers and guards provided with the equipment properly before switching the device on. Before switching the equipment on, cover and safeguard live parts safely to prevent contact with those parts.
- Protect all products against direct contact with live parts.
- The operator must observe all the above regulations at all times.

After the electrical connection is completed and verified you may proceed to commission the products.

- Recheck the electrical load of the product during normal operation and verify it is within the limits stated on the quotation and product nameplate.
- If possible check the maximum load operation.
- Recheck the thermal load of the components of the installation.
- Log all measured data in the commissioning log.



4.7 Deactivation and Dismantling



WARNING

Risk of injuries due to live parts! Risk of injuries due to hot surfaces! Risk of injuries due to lifting of heavy loads!

- Do not work on any product that has not been properly mounted or while products are operating.
- Do not take any measurements while the product is operating.
- Protect the product against unauthorized operation.
- Wait after switching off power to allow capacitors to discharge before beginning to work. Measure the voltage on the capacitors before beginning to work to make sure that the equipment is safe to touch.
- Do not work on hot surfaces.
- Before dismantling, secure the product and power supply against falling or movement before disconnecting the mechanical connections.
- Only use lifting equipment suitable for the weight of the product.

- Observe the instructions of the installation procedures.
- Switch off the installation or at least the part of the installation in which the product is located.
- Protect the product against unauthorized operation.
- Wait after switching off for electrical components of the installation to discharge. Then disconnect the electrical connections.
- Before dismantling the products let them cool adequately.
- Secure the product and the connections against falling and unintentional movement prior to disconnecting the mechanical fixations.
- Store the product properly.
- Document all executed measures in the commissioning report and the installation maintenance plan.

4.8 Waste Disposal

The products are manufactured such that the associated manufacturing process saves energy and raw material to an optimum extent while simultaneously permitting recycling and utilization of incidental waste.

Hans von Mangoldt GmbH & Co. KG regularly tries to use environmentally friendly raw materials and supplies. The products do not contain any dangerous substances which could be released with proper use. Under normal operating conditions, negative effects on the environment should not be expected.

We guarantee that our products include no substances according to chemical ban regulations. Furthermore, our products are free of mercury, asbestos, PCBs and chlorinated hydrocarbons.

Basically, the products contain steel, aluminum, copper, and insulation material.

The products can be recycled due to the high metal content. To reach optimum metal recovery, disassembly into individual components is necessary. These materials can be easily recycled.

High-quality products need optimal packaging. The packaging material consists of paper, wood and polystyrene. They can be easily recycled.


For ecological reasons, the return transport of product or packaging is not necessary.

5 Maintenance

The products of Hans von Mangoldt GmbH & Co. KG can operate within specified conditions, without wear for their normal service life. However, operation under unfavorable conditions can lead to limitations in their useable life.

- Increase product life expectancy with regular preventive maintenance measures. Follow the information in the maintenance schedule of the equipment manufacturer and the service measures described below.
- Log all maintenance measurements in the installation maintenance plan.

5.1 Measures

	Risk of injuries due to live parts! Danger of injury due to hot surfaces!
DANGER	<ul style="list-style-type: none">• Do not work on products that are not securely mounted or while they are operating.• Do not perform any maintenance measures when the installation is running.• Switch off the installation or at least that part of the installation that can be accessed during maintenance work.• Wait after switching off power to allow capacitors to discharge before beginning to work• During maintenance work, protect the system against restarting and unauthorized use.• Do not work on hot surfaces.

Hans von Mangoldt GmbH & Co. KG recommends the following maintenance measures, based on the maintenance plan of the installation manufacturer:

- Visual inspection:
According to the guidelines in the installation maintenance plan, but at least annually.
Regularly check the visual appearance of the product. Especially take notice of discoloration because discoloring might be an indication of thermal overloading of the product.
- Check the mechanical and electrical connections:
According to the guidelines in the installation maintenance plan, but at least annually.
- Remove dust, chips and other dirt from product components:
Depending on the degree of soiling, but at least annually.
Soiling that causes malfunctioning of the product must be removed immediately. Take precautions to prevent damage to the product insulation. For example, use pressurized air (see also 8.1.6).

5.2 Troubleshooting

Possible causes for malfunctioning can be limited to the following areas:

- electrical or thermal overload
- electrical connection
- mechanical damage
- mechanical mounting

In the case of malfunctioning contact the installer.



6 Connection Techniques



DANGER

High electric voltage and high working current! Risk of death or severe bodily injury by electric shock!

- Only personnel trained and qualified to work with or on electrical equipment are permitted to operate, maintain or repair this equipment.
- Follow general construction and safety regulations at all times when working on electrical power installations.
- Before switching on the device, the equipment grounding conductor must be permanently connected to all electrical equipment in accordance with the connection diagram.
- Do not operate electrical equipment at any time, even for brief measurements or tests, if the equipment grounding conductor is not permanently connected to the mounting points of the components provided for this purpose.
- Before working with electrical parts, the device must be disconnected from the main supply voltage. Provide a safeguard to prevent reconnection.
- If the configuration of the installation or power grid has changed, the electrical utilization of the products must be evaluated prior to reconnection.
- After switching off power wait to allow for capacitors to discharge before beginning to work. Measure the voltage on the capacitors before beginning to work to make sure that the equipment is safe to touch.
- Never touch the electrical connection points of a component while power is turned on.
- Before switching the equipment on, cover and safeguard live parts safely to prevent contact with those parts. Install covers and guards properly before switching the device on.
- For all products, all protective covers, insulators, or shields to prevent direct contact with live parts must be secured.
- The operator must observe all the above regulations at all times.

Before working on the system, always use a suitable measuring instrument (e.g. multimeter, circuit analyzer) to determine whether parts are still under a residual voltage (e.g. due to the residual energies of capacitors in filters, drive devices, etc.). Always allow the discharge times of capacitors elapse before working on the equipment.

The connection between the ground-reference lug and the grounding conductor must be made before any other connections.

Route and properly secure and support all cables prior to energization. Use proper methods to support the cables to minimize mechanical stress on the cables and connections. Be sure the cable supports can withstand the mass of the connection cables as well as the forces during short-circuit operation. The standoff insulators are not designed nor intended to withstand these forces.

The terminals of the products are made of copper bars according to DIN 46206. Note that all terminals are made of copper bars regardless of the winding material (copper or aluminum).

Note: The terminal diagrams of the product documentation are used to generate the system circuit diagrams. System circuit diagrams are the sole responsibility of the installer or system integrator and should be consulted for connecting the product and equipment to the electrical system.

6.1 Bolting at Electrical Connection

The electrical connection must be professionally secured using properly tightened bolts. Inappropriate electrical connection of the products can lead to a breakdown of the electrical strength and may result in the complete destruction of the products.

The minimum electrical spacing on the electrical connection must be maintained by bolting the connection cables or busbars as depicted in the drawings in Figure 13 to Figure 15. The cable lug or busbar is positioned on the top of the product terminal. At the beginning of the winding, the position of the bolt head is defined by the beginning of the winding being on top or on the bottom of the coil. If the beginning of the winding terminal is at the bottom of the coil the bolt head is on the top side of the terminal (Figure 13). If the beginning of the winding is at the top of the coil the bolt head is positioned underneath the terminal (Figure 14). At the end of the winding the bolt head is always positioned on the top side of the terminal. (Figure 15). The length of the bolt should be as short as possible. For the testing purposes, a maximum length of 50 mm is assumed.

At the beginning of the winding the copper terminal extends outside of the coil (Figure 13 and Figure 14). At the end of the winding the terminal is directly on the coil surface (Figure 15).

WICKELANFANG / BEGINNING OF WINDING

WICKELANFANG / BEGINNING OF WINDING

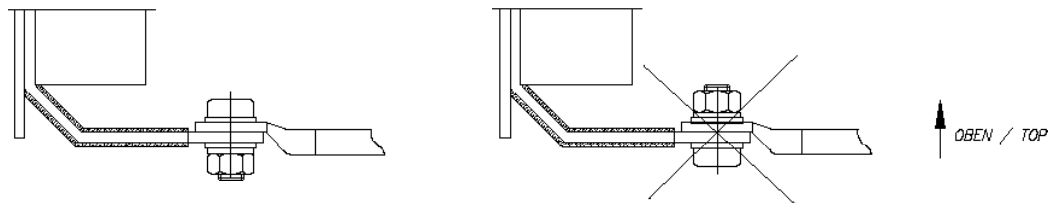


Figure 13: Drawing of bolted electrical connection; beginning of winding at the bottom of the coil

WICKELANFANG / BEGINNING OF WINDING

WICKELANFANG / BEGINNING OF WINDING

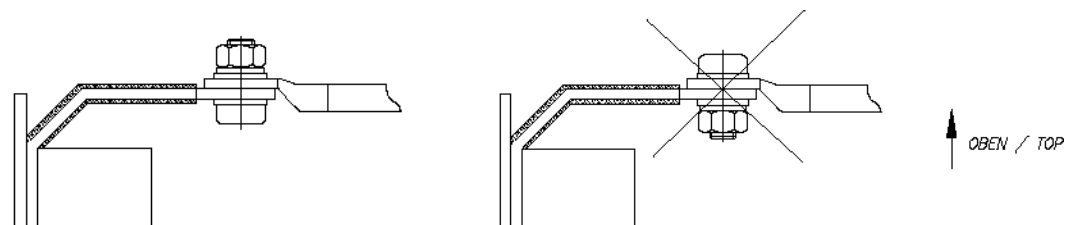


Figure 14: Drawing of bolted electrical connection; beginning of winding at the top of the coil

WICKELEND / END OF WINDING

WICKELEND / END OF WINDING

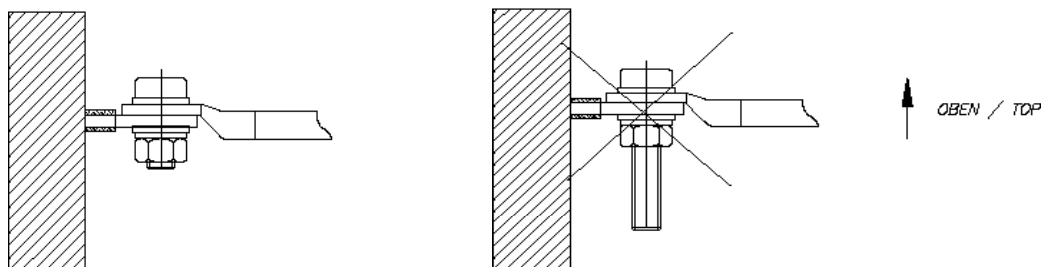


Figure 15: Drawing of bolted electrical connection; end of winding

Hans von Mangoldt GmbH & Co. KG strongly suggests the use of bolts, nuts and washers listed in Table 3 for the electrical connection on all phases.

Ø connection (mm)	Screw max. length in mm	Washer	Nut	Spring washer
11	M10, DIN6912 max. length 50	M10, DIN125	M10, DIN934	M10, DIN127
14	M12, DIN6912 max. length 50	M12, DIN125	M12, DIN934	M12, DIN127

Table 3: Suggested bolting parts for electrical connection

- Bolt the electrical connection as depicted in Figure 13 to Figure 15 on the page to the left.
- Use the bolting parts suggested in Table 3 by Hans von Mangoldt GmbH & Co. KG. If you utilize parts other than those suggested, be certain to use identical dimensions in order to keep the electrical spacing intact.

6.2 Connection Types for Single-Phase Products and Nominal Voltage below 17.5 kV

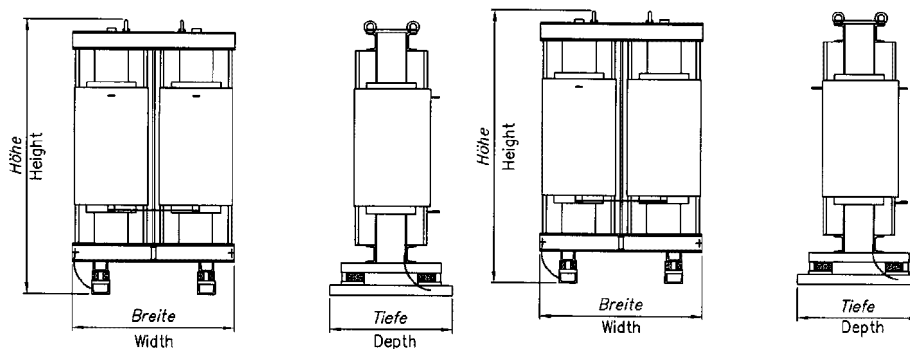


Figure 16: Example drawings for connection on one side (left) and diagonal (on both sides, right)

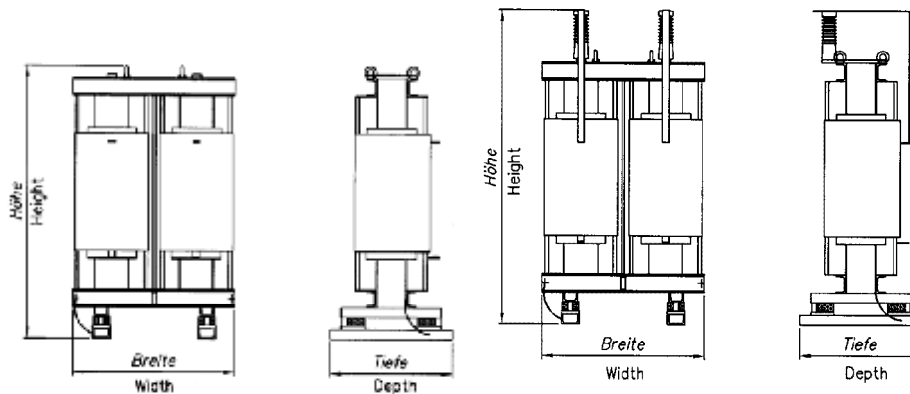


Figure 17: Example drawings without bridge and connection on one side (left) and on top of core (right)

For single-phase products the winding is divided onto both legs of the core. The product is then either provided with a coil interconnection busbar [bridge] (Figure 16) or without bridge (Figure 17). If a bridge is provided, both parts of the winding are either connected in series (standard) or parallel. If no bridge is provided the bridging must be supplied by the installer. In this case it is possible to connect the product in either series or parallel as desired or specified.

Note: The inductance in series connection will be four times the inductance in parallel connection.

The ground connection is always made on the mounting feet of the product. The supporting beams are connected internally to ground. The other terminals of the products are either directly in front of the coil (Figure 16 or Figure 17 left) or on top of the core (Figure 17 right, Figure 20 right). For both cases it is possible to have both terminals (winding beginning and end) either on one side of the product (Figure 16 left) or diagonal (one end on each side of the product (Figure 16 right)).

As standard, Hans von Mangoldt GmbH & Co. KG utilizes connection in front of the coil and on one side of the product with bridge in series connection.

- If you require a different positioning of the terminals, it is necessary to define and specify the type of connection in the design phase.

The markings are according to DIN EN 60445. The connection diagram is depicted in Figure 18. The terminals are marked by "1.1" (beginning of winding, Figure 20 right) and "2.2" (end of winding) if the bridge is provided. Otherwise the marking is "1.1" and "1.2" on one part and "2.1" and "2.2" on the second part of the winding. The ground terminal is marked with its symbol (IEC 60417-5019).

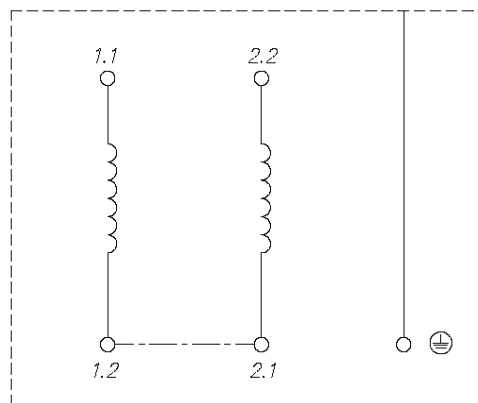


Figure 18: Connection diagram for single-phase products

- Always connect ground conductor first.
- Check if the electrical bridge between the coils is properly installed.
- Connect the supply cables to the terminals.
- Check that there is no mechanical stress on the terminals.
- Check the fit and accuracy of the connection before you proceed.
- Use two wrenches (above and below terminal) when securing terminal screws.
- Log all measurements taken in the commissioning log.

6.3 Connection Types for Single-Phase Products and Nominal Voltage above 17.5 kV

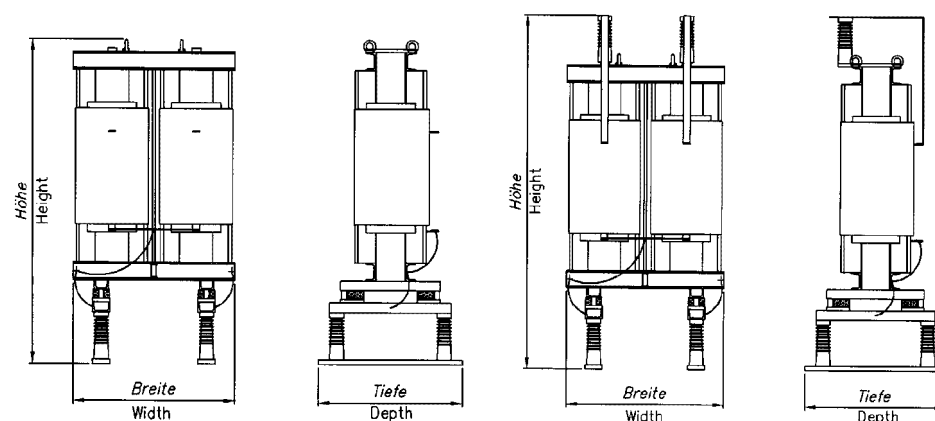


Figure 19: Example drawings for products on standoff insulators and connection in front of coil (left) and on top of core (right)

Products with a nominal voltage above 17.5 kV are mounted on standoff insulators. The insulators are included in the product shipment (see section 4.4.3).

The products with nominal voltage above 17.5 kV are designed with standoff insulators. These products are always provided with a connection bridge between both parts of the winding. The core and upper beams are connected with the bridge. Thus the electrical potential of the core is half the nominal voltage of the product and all passive components above the standoff insulators are electrically connected to have the same potential. In this way the electrical strength of the product is achieved within a small overall product volume.

- Do not disconnect the components from the bridge or the electrical strength of the product will fail.

The ground connection of the product is located on the mounting feet below the standoff insulators. The other terminals of the products are either directly in front of the coil (Figure 19 left, Figure 20 left) or on top of the core (Figure 19 right). For both cases it is possible to have both terminals (winding beginning and end) either on one side of the product or diagonal.

The marking of the terminals is described in section 6.1 and the connection plan is depicted in Figure 18.



Figure 20: Examples for connected product on standoff insulators (left) and marking of terminal on top of core (right)

- Always connect ground conductor first.
- Confirm that the bridge is connected to the core and the supporting beams above the standoff insulators.
- Connect the supply cables to the terminals .
- Check that there is no mechanical stress on the terminals.
- Check the fit and accuracy of the connection before you proceed.
- Log all measurements taken in the commissioning log.

6.4 Connection Types for Three-Phase Products

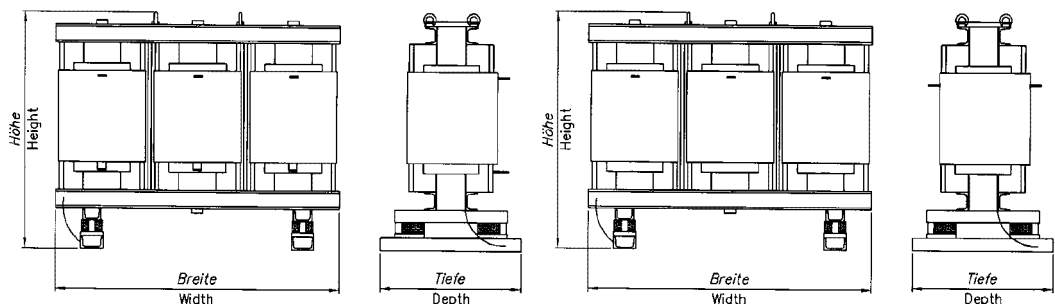


Figure 21: Example drawings for connection type in front of coil for three-phase products

The ground connection is always on the mounting feet of the product. The core and supporting beams are connected to ground. The other terminals of the products are either directly in front of the coil (Figure 22) or on top of the core (Figure 22). The terminals (winding beginning and end) can either be

on one side of the product (Figure 22 left) or diagonal (one end on each side of the product, Figure 22 right and Figure 22)

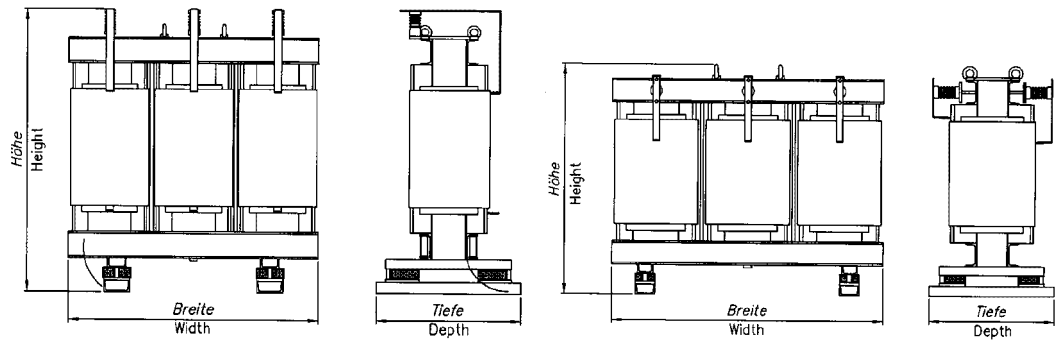


Figure 22: Example drawings for connection type on top of core for three-phase products

As standard, Hans von Mangoldt GmbH & Co. KG utilizes connection in front of the coil and on one side of the product.

- If you require a different positioning of the terminals, it is necessary to define and specify the type of connection in the design phase.

The terminals are marked by U1, U2, V1, V2, W1, and W2 as specified in DIN EN 60445. This marking designates the phases with U, V, and W and the beginning of each winding with 1 and the end of each winding with 2. The ground terminal is marked with its symbol (IEC 60417-5019). The connection plan is depicted in Figure 23.

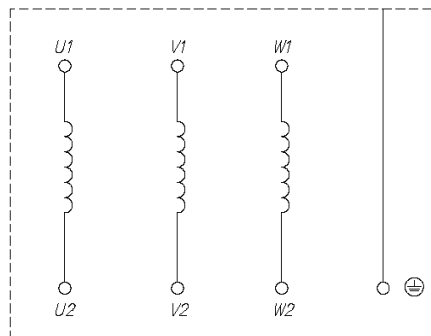


Figure 23: Connection plan for three-phase products



Figure 24: Example for three-phase product with connection in front of coil after assembly

- Always connect ground conductor first.
- Connect the supply cables to the terminals.
- Check that there is no mechanical stress on the terminals.
- Check the fit and accuracy of the connection before you proceed.
- Log all measurements taken in the commissioning log.

6.5 Electrical Connection with Taps

Products with taps allow for an adjustment in the installation (Figure 25). The tap values are stated relative to the nominal inductance values (e.g. $\pm 5\%$ of L_N defines two taps with inductance of 95% and 105% of the nominal inductance).

- If you require taps, be certain to define and specify the number of taps and their values during the design phase.



Figure 25: Examples for taps on products

The taps are marked according to DIN EN 60445. For three-phase products the markings are the winding letter and the numbers 3 to the maximum terminal count of that winding (e.g. U3, U4). For single-phase products the number of the coil is followed by a dot and the numbers 3 up to the maximum terminal number. All other terminals are marked as described in sections 6.1 to 6.4. The connection plans for one- and three-phase products with two taps are depicted as examples in Figure 26.

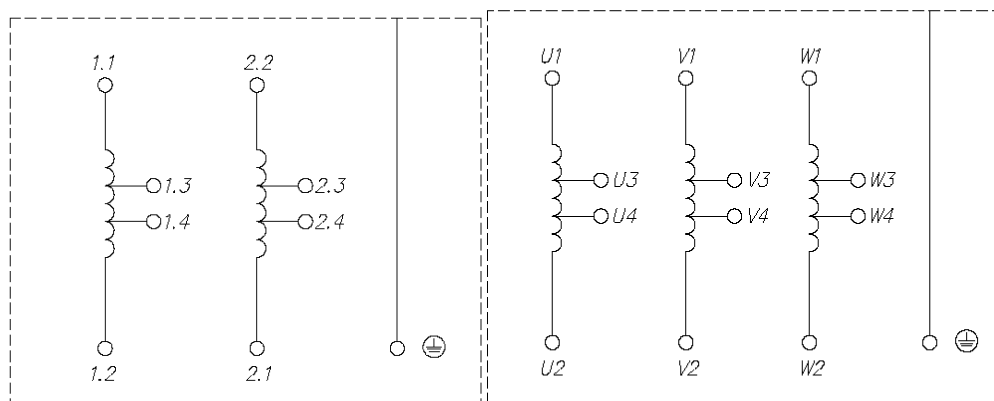


Figure 26: Connection plans for single-phase (left) and three-phase (right) products with two taps



- Always connect ground conductor first.
- Only connect the tap terminals that you require to the installation lines or cables.
- Check that there is no mechanical stress on the terminals.
- Check the fit and accuracy of the connection before you proceed.
- Log all measurements taken in the commissioning log.

6.6 Connection of Thermal Sensor



CAUTION

Damage of the product in spite of temperature sensor logging! Danger of injury due to hot surfaces!

- Temperature sensors in medium-voltage products do not guarantee against thermal overloading of the products.
- Do not use a temperature sensor as over-load detection!
- Do not work on hot surfaces.

- A thermal sensor does not protect the product against overheating (see also section 8.5).

The terminals of the thermal sensor are located on the upper part of the product. They are marked with T1 and T2. All other terminals and their markings are described in sections 6.1 to 6.5. The connection diagram for the sensor is depicted in Figure 27.

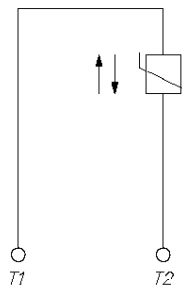


Figure 27: Connection diagram for thermal sensor

- Always connect ground conductor first.
- Next connect the thermal sensor to the temperature logging device.
- Connect the supply cables to the terminals.
- Check that there is no mechanical stress on the terminals.
- Check the fit and accuracy of the connection before you proceed.
- Log all measurements taken in the commissioning log.



7 Testing

7.1 Factory Testing

Hans von Mangoldt GmbH & Co. KG products represent state-of-the-art developments in technology and manufacturing. They are 100% tested according to the applicable standards prior to delivery to ensure operating safety and reliability.

All medium-voltage products manufactured by Hans von Mangoldt GmbH & Co. KG must pass the following routine tests prior to shipment:

- Measurement of winding resistance according to IEC 60076-1
- Measurement of inductance according to DIN EN 60289 / VDE 0532 Part 289
- Induced voltage withstand test according to DIN EN 60289 / VDE 0532 Part 289
- Separate source voltage withstand test according to IEC 60076-3
- Measurement of quality factor according to DIN EN 60289 / VDE 0532 Part 289
- Power loss measurement according to DIN EN 60289 / VDE 0532 Part 289

When required, the following type tests, as well as others are available for a premium:

- Temperature-rise test according to DIN EN 60289 / VDE 0532 Part 289
- Lightning impulse voltage withstand test according to IEC 60076-3, IEC 60722

The test data is maintained by Hans von Mangoldt GmbH & Co. KG via electronic-data processing. For each product identified by its serial or testing number the test data can be stored and later be retrieved. Thus a test report is always available, even after the testing.

- If you require a test report with your delivery, please contact Hans von Mangoldt GmbH & Co. KG during the design phase.
- If you require a type test, please contact Hans von Mangoldt GmbH & Co. KG during the design phase.

Note: Occasionally, due to unusual reactor ratings, there may be tests that cannot be performed according to a specified or under full load conditions. Please review section 7.2.



7.2 Deviation of Tests

Some of the tests described in section 7 cannot be carried out for all products in all circumstances. In this case the standards allow deviations which have to be agreed upon by the producers (here Hans von Mangoldt GmbH & Co. KG) and the customer. If a test cannot be carried out, Hans von Mangoldt GmbH & Co. KG tries to substitute that test by an equivalent test.

The following deviations can occur with medium-voltage products of Hans von Mangoldt GmbH & Co. KG during the testing:

- The induced voltage withstand test may not possible due to the high amount of power needed:

According to DIN EN 60289 / VDE 0532 Part 289 a lightning impulse voltage withstand test can be carried out instead of the induced voltage withstand test.

- The temperature-rise test may not be able to be carried out with the given current spectrum:
The testing facility is capable of performing test with specific magnitudes of individual harmonic current up to the 13th harmonic and up to a total capacity of 960KVA. In some cases, it may not be possible to simulate all harmonic currents as defined in a customer specification. In this case the temperature-rise test can be carried out with reduced load or reduced harmonics. The end temperature of the product, according to the customer harmonic spectrum, is then extrapolated on the basis of the measurements with the reduced load or harmonics respectively (see IEC 60076-11). **Note:** This method leads to realistic results if the reduction of the applied load is small.
- The characteristic curve for the lightning impulse voltage withstand test cannot be generated:
According to IEC 60076-3, IEC 60722 in the case of low inductance or high capacitance the characteristic time constraints provided in the standards cannot be generated during the lightning impulse voltage withstand test. In this case the test is carried out with the signal curves that can be generated.
- Lightning impulse voltage withstand test on products with taps:
The test along the winding will only be done for the highest tap. Thus the entire winding is tested and the insulation stress is reduced due to the reduced number of tests.

7.3 Testing by Customer

Since all products undergo a standardized testing procedure, high-voltage tests on the customer side are not required. Components could be damaged if they undergo several high-voltage tests. This might lead to premature aging and thus to a reduced life expectancy of the products.



CAUTION

Destruction of product components by improperly executed high-voltage test! Invalidation of warranty!

- Avoid repeated testing!
- Observe the regulations of IEC 60076 and IEC 60289!



8 Application Notes

8.1 Operating Conditions

8.1.1 Altitude

The performance data specified for the products applies for site elevation of 0 m to 1,000 m above sea level.

If you choose to use the products in areas with values beyond this range, the electrical strength of the product is reduced (see also DIN VDE 0101).

- Ensure that the product data are not exceeded by your application.
- If you require a different site elevation, this information must be defined during the design phase.

8.1.2 Ambient Temperature

The performance data specified for the products applies for ambient temperatures ranging from 0 °C to a maximum temperature that defined by the product specification and as designated on the product nameplate. Typical maximum ambient temperatures are 40 °C, 45 °C, 50 °C or 55 °C. The maximum allowable ambient temperature for the product is stated in the quotation and on the product nameplate (see also section 3.2).

If you choose to use the products in areas with values beyond the specified range of the products, the performance data of the products are reduced.

- The product data depends greatly on the type of cooling (see also section 8.4).
- Ensure that the product data are not exceeded by your application.
- Ensure that no large or periodic variations of temperature exist. They reduce the life expectancy of the product due to premature aging of the insulation material.
- Hans von Mangoldt GmbH & Co. KG designs the products for the specified ambient temperature. Be certain to specify your ambient temperature during the design phase.

8.1.3 Temperature Classes of the Insulation System

Hans von Mangoldt GmbH & Co. KG designs the products on the basis of a material temperature class according to IEC 60076-11. The permitted average temperature rise in the active parts of the products is given in Table 4.

Short symbol according to IEC60085	Temperature of the insulation system (°C)	Permitted average temperature rise of the winding at rated current (K)
A	105	60
E	120	75
B	130	80
F	155	100
H	180	125


Table 4 : Excerpt from IEC60076: Permitted temperature rise of the winding

The design of the product ensures that the temperature rise of the active parts of the products stays below the permitted thermal limits of the insulation materials. The thermal behavior of the products is guaranteed by temperature-rise type tests of equivalent products (see also section 7).



- Ensure that the product specifications and nameplate ratings are not exceeded by your application.
- The temperature class of a product is stated on the nameplate (see also section 3.2).
- Note that Hans von Mangoldt GmbH & Co. KG designs the products according to a temperature class of the insulation material. Define and specify the required temperature class of the insulation material or the product during the design phase.
- If you require a temperature-rise test as type test on a specific product, define and specify it during the design phase.

8.1.4 Air Humidity

 CAUTION	Destruction of the product by condensing or icing! Invalidation of the warranty due to improper ambient conditions!
	<ul style="list-style-type: none"> • Protect the product against moisture and corrosion. • Condensation or ice build-up is prohibited!

Make sure that under all circumstances condensation and ice build-up on any product component is prevented. Condensation and icing lead to premature aging of the insulation materials and therefore to a reduction of the life expectancy of the product.

Ambient climatic conditions are defined into different classes according to DIN EN 60721-3-3. They are based on observations made over long periods of time throughout the world and take into account all influencing quantities that could have an effect, such as the air temperature and humidity.

Based on this standard, Hans von Mangoldt GmbH & Co. KG recommends class 3K4 for continuous operation of the products. This class (3K4) is defined in Table 5.

Low air temperature	+5 °C
High air temperature	+40 °C
Low relative air humidity	5 %
High relative air humidity	95 %
Low absolute air humidity	1 g/m ³
High absolute air humidity	29 g/m ³
Speed of temperature change	0.5 K/min

Table 5 : Excerpt of class 3K4 of climatic conditions according to DIN EN 60721-3-3

- Hans von Mangoldt GmbH & Co. KG can accommodate requirements for either lower or higher ambient temperature rating (see also section 8.1.2).
- Ensure that the product specifications are not exceeded by your application.
- Define and specify the ambient temperature in the design phase.

8.1.5 Strengthened Mechanical Structure

As standard procedure, Hans von Mangoldt GmbH & co. KG does not define an earth-quake protection class for the products. It is possible to strengthen the mechanical structure of the products to protect against mechanical stress. These products can for example be applied for naval installations or for earth quake regions.

- If you need a strengthened mechanical structure, define and specify it during the design phase.

8.1.6 Compatibility with Foreign Material

All products of Hans von Mangoldt GmbH & Co. KG are developed and tested according to the state-of-the-art.

However, since it is impossible to follow the continuing further development of every material with which our products could come into contact, reactions with the materials that we use cannot be ruled out in every case. For this reason, we recommend that you carry out a test for compatibility among new detergents, etc. and our housing and device materials. Hans von Mangoldt GmbH & Co. KG cannot assure nor be held responsible for compatibility of its product with detergents, etc.

Under all circumstances make sure that no residual material that influences the electrical strength remains on the products. Hans von Mangoldt GmbH & Co. KG recommends to abstain from using detergents and instead use pressurized air for cleaning.

8.2 Protection Class

The protection classes according to IEC 60529 apply for the products. The degree of protection is defined by the abbreviation IP (International Protection) and two reference numbers specifying the degree of protection. The first code number describes the protection class against contact and penetration of foreign substances; the second code number describes the protection class against water penetration.

The products of Hans von Mangoldt GmbH & Co. KG use protection class IP00 as standard.

- If you require a protection class higher than IP00, contact Hans von Mangoldt GmbH & Co. KG during the design phase.
- The installer must assure that, in each and every installation, the products are not subjected to ambient conditions outside of the applicable degree of protection according to IEC 60529.
- Products with a low degree of protection (ie: IP00) are not suited for cleaning procedures with high pressures, vapors or water jets.

8.3 Minimum Electrical Spacing

The products of Hans von Mangoldt GmbH & Co. KG are designed in such a way, that the minimum electrical spacing with regard to electrical strength and induced voltages exist within the products themselves. The product testing according to IEC 60076 and IEC 60289 at the factory site guarantees the accuracy of the internal spacing within the products (see also section 7).

Hans von Mangoldt GmbH & Co. KG cannot maintain the proper minimum electrical spacing between the products and other components of the installation. The installer is responsible for ensuring the minimum electrical spacing between installed components.

8.3.1 Minimum Electrical Spacing due to Electrical Strength



WARNING

Risk of injury due to live parts! Damage to the products and invalidation of warranty due to incorrect installation design!

- Ensure adequate electrical spacing in the installed equipment!
- Due to flashover, passive components of the installation might carry high voltages!


If the product is placed inside a housing or enclosure at the installation site the minimum electrical spacing defined in the regulations in the country of installation must be fulfilled. In Europe the standards DIN VDE 0101 or IEC 60071-1 apply. An excerpt of the minimum electrical spacing according to this DIN standard is listed in Table 6.

Highest voltage of active components (kV, RMS value)	Rated lightning impulse voltage 1.2/50 μ s (kV, peak value)	Induced over-voltage (kV, RMS value)	Minimum electrical spacing conductor-ground and conductor-conductor for indoor installation (mm)	Minimum electrical spacing conductor-ground and conductor-conductor for outdoor installation (mm)
3,6	40	10	60	120
7,2	60	20	90	120
12	75	28	120	150
17,5	95	38	160	160
24	125	50	220	220
36	170	70	320	320

Table 6: Excerpt minimum electrical spacing according to IEC 60071-1 (induced over-voltages according to IEC 60076-3)

- **Note:** The installer must assure that the delivered components are suitable for his/her individual application and must verify the information given in this document with regard to the use of the components. The installer must make sure that his application complies with the applicable safety regulations and standards in the country of installation and must carry out the required measures, modifications and complements.

8.3.2 Minimum Electrical Spacing due to Electromagnetic Fields



Risk of injury due to life parts! Risk of injuries due to hot surfaces!

CAUTION

- Ensure adequate electrical spacing in the installed equipment!
- Accommodate the electromagnetic stray field of the products when designing the spacing!
- Avoid electrically and magnetically conducting components or parts within the electromagnetic stray field!
- Dimension the shielding sufficiently!

When positioning electrically or magnetically conducting components or parts (for example housing, enclosure, shielding, mounting hardware, screws, etc.), keep in mind that the stray field of the active components influences them directly. Thus these components or parts can carry induced or coupled currents, which might lead to a steep temperature rise in the originally inactive parts. Additionally high voltages might be induced.

If you utilize electromagnetic shielding, take care that the shielding can thermally carry the induced currents.

- Use warning symbols as defined by the applicable standards on shielding and housings that heat up or might carry induced voltages.
- Consider the electromagnetic stray field when you dimension the minimum electrical spacing.

8.4 Cooling System

During operation, the products of Hans von Mangoldt GmbH & Co. KG experience losses resulting from laws of physics. The losses lead to a temperature rise of the products over and above the ambient temperature. The final operating temperature of the products stabilizes when the amount of losses that the cooling medium dissipates correlates to the amount of losses produced in the product. Thus, the end temperature depends on the cooling medium and the type of cooling.

Hans von Mangoldt GmbH & Co. KG designs the product, so that the end temperature corresponds to the temperature class of the insulation system (see also section 3.1.1). The cooling medium and the type of cooling are the basis for the product design. Our standard practice is to consider that the reactor cooling medium is air, and cooling is achieved by natural convection.



Forced air cooling is an option instead of natural convection forced cooling. If forced cooling is applied the flow rate of the cooling medium and the amount of loss that is dissipated rises. Thus the power density of the products with forced cooling can be higher than products cooled by natural convection.

Hans von Mangoldt GmbH & Co. KG does not supply fans for forced cooling. The installer is responsible for the design and operation of fans and installations for forced cooling.

The type of cooling is stated on the nameplate with the symbol according to DIN EN 60076-11. (see also section 3.2). The applied symbols are given in Table 7.

cooling medium	type of cooling	symbol according to DIN EN 60076-11
air	natural convection	AN
air	forced cooling	AF

Table 7: Excerpt of cooling types according to DIN EN 60076-11

- Define and specify the type of cooling during the design phase.
- If you use forced air cooling, define and specify the characteristics of your cooling system (for example flow rate of air etc.).
- Beware that the dissipated loss might lead to a rise of ambient temperature even for natural convection. Take this physical effect into account when specifying your ambient temperature and designing your installation.

8.5 Temperature Sensor

Hans von Mangoldt GmbH & Co. KG designs the product to reach a specific end temperature that is defined by the material class of the product. The basis for the design is the characteristic data of the customer application. Therefore a temperature sensor is available as an option. It is not part of the standard design (see also section 8.7).



CAUTION

Damage of the product in spite of temperature sensor logging! Danger of injury due to hot surfaces!

- Temperature sensors in medium-voltage products do not guarantee against destruction of the products!
- Do not use a temperature sensor as over-load detection!
- Do not work on hot surfaces.

Due to the high electrical strength of medium-voltage products the temperature sensor cannot be positioned on the winding. Instead, it is positioned on the middle core leg of the reactor (Figure **Fehler! Unbekanntes Schalterargument.**). The position of the sensor does not allow for the detection of a steep temperature rise in the winding itself. It only senses the temperature trend in the core of the product. Therefore a temperature rise of the coils is only detected with a large delay that might lead to destruction of the product before switch-off.

There are different types of temperature sensors e.g. positive or negative temperature coefficients and with either a normally open (N.O.) or a normally closed (N.C.) contact. If you need the available sensor specifications please contact Hans von Mangoldt GmbH & co. KG.

- If you require a redundant (ie: alarm plus switch) temperature sensor, be sure to define and specify the sensor in the design phase.
- For the connection diagram of the thermal sensor, see section 6.



Figure Fehler! Unbekanntes Schalterargument.: Temperature sensor at the middle core leg of a three-phase product

8.6 Painting

The standard painting process of the medium voltage reactors consists of a blue (RAL5012) 2K epoxy resin coating.

It is prohibited to provide an additional painting. The applied paint film and its thickness is specially adjusted to the electromagnetic characteristics and the thermal design of the products.

If you require a different color, contact Hans von Mangoldt GmbH & Co. KG during the design phase.

8.7 General Specification

In the design phase you will receive a quotation from Hans von Mangoldt GmbH & Co. KG with the characteristic data of the product. Note that this data is computed prior to the product manufacturing and testing. Therefore slight differences between the pre-computed and the real product data may occur.

In order to clarify the data given in the quotation these data are defined in Table 8.

SYMBOL	UNIT	DESCRIPTION
U_N	Volts	nominal voltage
f_N	Hz	nominal frequency
Q_{cn}	kvar	nominal power of the capacitor
U_{cn}	Volts	nominal voltage of the capacitor
N_c	kvar	detuned reactive power
C_v	μF	capacitance in wye / 3 x in delta connection
p	%	detuning factor
L_N	mH	nominal inductance
I_1	Amps	fundamental component of the nominal current spectrum
I_v	Amps	harmonic component of order v of the nominal current spectrum
I_{rms}	Amps	root-mean square of the nominal current spectrum
I_{th}	Amps	thermal limiting current
I_{Lin}	Amps	limit of linearity with $L = 0.95 L_N$
$N_v(I_1)$	Watts	power loss of the fundamental component of the current
$N_v(I_{rms})$	Watts	Total power loss of the nominal current spectrum
ED	%	duty rating
Temperature class		maximum ambient temperature and material temperature class
Terminals		design of the terminals
Coil material	kilogram	coil material (AL / CU) and if necessary mass of the coil material
Weight	kilogram	total weight of the product

Table 8: Design data given in quotations

There are quantities that can be derived directly from the design data of the quotations. These quantities are listed in Table 9.



Symbol	unit	description	calculation formulae
f_R	Hz	detuning frequency	$f_R = \frac{10 \cdot f_N}{\sqrt{p}}$ (p in %)
X_{L_v}	Ohms	reactance at harmonic order v	$X_{L_v} = 2 \cdot \pi \cdot f_v \cdot L_v$
Q_v	VAr	reactive power at harmonic order v	$Q_v = I_v^2 \cdot X_{L_v}$
G_v		Quality Factor rating at harmonic order v	$G_v = \frac{Q_v}{N_v(I_v)} = \frac{X_{L_v}}{R_{eq,v}}$

Table 9: Derived quantities

8.7.1 HvM Standard Design

Hans von Mangoldt GmbH & Co. KG applies a standard design if the customer does not specify the characteristics of the customer's application. This HvM standard design is based on the long-term empirical knowledge that Hans von Mangoldt GmbH & Co. KG has acquired in the field of power compensation and filter technology.

The basic design specifications of HvM standard designs are stated in the following overview:

- I_1 is based on L/C at $U = 1.06 U_N$. This defines an over-load of 6 %.
- Harmonics defined by $U_3 = 0.5 \%$, $U_5 = 5.0 \%$ and $U_7 = 5.0 \%$ based on U_N
- I_{rms} : Root-mean square of the currents I_1 , I_3 , I_5 and I_7
- Thermal current $I_{th} = 1.05 I_{rms}$
- Limit of linearity $I_{lin} \geq 1.2 \cdot [I_1 + I_3 + I_5 + I_7]$ with $L = 0.95 L_N$
- Tolerance of inductance: $\pm 3 \%$ of L_N
- Natural convection with isolation class B at maximum ambient temperature $40 \text{ }^\circ\text{C}$ (AN-T40/B)
- IP 00 for indoor use; reactors must be mounted inside of a suitable enclosure
- Terminal connection in front of coil on one side of the product
- On rubber mounting pads for anti-vibration

8.7.2 Customer-Specific Design

If you know the current spectrum of your installation or if you wish a different design, Hans von Mangoldt GmbH & Co. KG will design the products specifically for your requirements by taking the data specified by you into account.

- Define and specify your design criteria during the design phase.

If you would like help with the specifications of the product for your application, you can find a standardized data sheet on our website (www.mangoldt.com).

If you need further information feel free to contact our service and sales personnel whose contact information is also on the web pages or in section 9.



9 Service and Support

9.1 Before Contacting Us

For quick and efficient help, please have the following information ready:

- Detailed description of the failure and circumstances.
- Information on the nameplate of the affected products, especially type codes and serial numbers.
- Your phone/fax numbers and e-mail address, so we can contact you in case of further questions.

9.2 Establishing Contact

Our headquarters in Aachen, Germany can assist you in all kinds of inquiries. Contact us at:

Hans von Mangoldt GmbH & Co. KG
Hergelsbendenstraße 18
D-52080 Aachen, Germany
Phone: +49-241-16607 – 0
Fax: +49-241-16607 – 21
Email: info@mangoldt.com

<http://www.mangoldt.com>

Please visit our website where you can find additional technical information, regional contact information and a current version of this manual (data in this document may become obsolete).