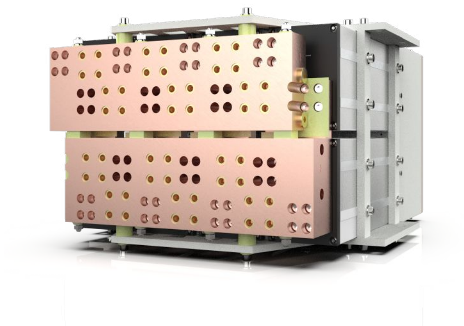
Operating Manual

MF and HF DC
Transformer rectifier units
for resistance welding



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1 General

This operating manual contains important information on safety, handling, assembly, and installation of medium-frequency transformer-rectifier units (hereinafter referred to as MFDC-units) for resistance welding designed and manufactured by EXPERT Transformatorenbau GmbH. Additionally, basic information on intended use, sizing, design, and function is given.
The following European Union Directives apply to the product and its intended use:

- 73/23/EEC Electrical equipment for use within certain voltage limits (the "Low-Voltage Directive")
- 89/336/EEC Electromagnetic compatibility
- 89/392/EEC Safety of machines (the "Machinery Directive")
- 93/68/EEC CE-marking (electrical safety label)

Furthermore, national regulations for the design, operation and safety of electrical equipment must be followed.
The user must be given the necessary safety instructions (see Section 2).
This operating manual is intended for the following groups of users:

- Personnel engaged on project work and design engineering
- Personnel for installation and commissioning
- Personnel responsible for maintenance and repair
- Personnel in transportation and storage departments

2 Safety instructions

2.1 General notes

- Correct and safe operation requires proper transport, storage, assembly and installation as well as careful operation and maintenance.
- MFDC rectifiers units are intended for installation in machines and systems in commercial areas. The specific safety regulations and provisions for the application in question must be considered.
- Operation of MFDC rectifiers units is only permitted with effective protective measures against indirect contact with electrically conductive parts in the event of a fault. This also applies to short-term operation for inspection and test purposes.
- Before switching on the MFDC rectifiers units, live parts must be safely covered to prevent contact.
- Before starting installation or maintenance work, the machine or system must be brought into a condition that permits safe working (e.g., base position).
- The machine or plant section in which the work is to be carried out must be disconnected from the mains supply. Under certain conditions, reverse voltages may occur. In such cases, the primary and secondary sides must be disconnected. Attention must be paid to hazardous moving parts from adjacent system parts. In the event of such hazards, the adjacent system parts must also be disconnected.
- **Attention:** Power modules based on semiconductors (thyristors, IGBT etc.) do not realize a galvanic isolation of the circuit even if the control is switched off! In any case the mains supply must be disconnected!
- The mains switch must be secured against accidental reconnection. Equipment must be marked with a warning sign, e.g., "DO NOT SWITCH ON! - Repair work -" with details of the repair period and the name of the responsible employee.
- The absence of voltage on all lines must be checked with a suitable measuring or testing device (e.g., voltage tester, voltmeter) on the MFDC rectifiers unit.
- Adjacent live parts must be covered.
- Machines or plants may only be entered in the prescribed manner (e.g., by opening the safety doors).
- The cooling water supply must be interrupted.

2.2 Protection against direct or indirect contact with electrically conductive parts

2.2.1 Protection against direct contact

The operation of MFDC-units in resistance welding equipment will cause those certain components as parts of the welding circuit or the workpiece are subjected to a electrical potential as high as the no-load secondary voltage of the MFDC-unit.
In general, these voltages are below the permissible limit for contact voltages.
The regulation DIN VDE 0100 part 410 defines following limits for contact voltages:

- AC (50 - 60Hz) equipment U_L = 25V
- DC equipment U_L = 60V

⚠	**Danger from excessively high contact voltage** If the secondary coils of one or more MFDC-units are connected in series, higher voltages can be generated than those permissible for contact. If cascading results in excessive voltages, the user must take suitable safety precautions against direct contact, e.g. by covering or closing the cladding.

The maximum permissible contact voltages defined in DIN VDE 0100 Part 410 apply to applications in dry rooms.
Touching “live” parts with the whole of a wet hand can result in a perceptible electric shock even at voltages below 10V.
This fact must be considered in the design of welding guns, particularly those operated manually.
All metal parts that can conduct electricity and can be touched must have an earth connection. Gun arms with potential should have additional insulating sleeves, wrappings, or similar, so that for instance when two people are working on the machine there is no possibility of the two gun arms coming into contact.
In addition to this the operating personnel should also wear suitable gloves.

⚠	Touching “live” parts with the whole of a wet hand can result in a serious electric shock even at AC or DC voltages below 10V. Manual guns with potential must be properly covered.

2.2.2 Protection against indirect contact in case of fault

The transformers in EXPERT MFDC-units meet the requirements for Safety Category 1 of DIN VDE 0551 Part 1 l.
As protection against excessively high contact voltages in the event of a fault (protection against indirect contact), additional safety precautions must be taken in accordance with EN 62135-1 (DIN VDE 0545, Part 1) such as connecting the secondary circuits to earth and installing r.c.d..
All the housing parts of the MFDC must be electrical connected via the primary side earth connection to the main earth connection.

⚠	**Safety precautions against indirect contact** The secondary circuits of the MFDC-unit should not be connected to the main earth because of the many different switching possibilities and the applicability of different safety devices that may be present in the unit in the state in which it is delivered. The user must identify and take the suitable safety precautions necessary under EN 62135-1 (DIN VDE 0545, Part 1).

The exception to this is the MFDC-units that, on account of existing general or the customer’s specific standards, are already fitted in the factory with an internal earth connection, e.g. MFDC-units for welding guns complying with ISO 10656 or special MFDC-units for suspension-point equipment. This internal earth connection is usually constructed to be detachable and is identified as MPE.
Please note in any case the data on the information plates of the MFDC-units and the instructions in the data sheet.

⚠	**Avoidance of compensation currents** If the necessary safety precautions have been taken by means of a direct connection between the secondary circuit and the earth lead, the user must ensure that no compensation (leakage) currents via the earth lead connection can be caused in complex welding lines by potential displacement during the welding. The earth conductor must not conduct electricity when the unit is in operation!

Leakage currents can also occur, for instance, if several welding current sources are welding simultaneously on one single workpiece or if welding work is being done with an MFDC that is already grounded to an additionally earthed workpiece.
When the welding station is being taken into operation, suitable measurements as current and voltage measurements should be used to check that the earth lead is not carrying any current during the welding work.

⚠	Leakage currents must always be avoided because they can in an extreme case interrupt the internal earth lead connection. **An interruption in the earth lead connection nullifies the safety precautions and can put human lives in danger.**

If balancing currents are unavoidable due to the direct connection of the secondary circuit to the protective conductor, the protective conductor connection can be removed in most MF-TGE.
In this case, however, another protective measure permitted under EN50063 must be installed as an alternative.

⚠	For systems with residual current protective devices according to EN 60947-2 in TN or TT networks (rated residual current ≤ 30mA), MF-TGE can be supplied with built-in residual current protection resistor. The residual current resistance must be checked optically and electrically cyclically (at least twice a year) for perfect condition. It must be ensured that the RCD protective device is suitable for the application.

2.3 Protection against the exposure of electromagnetic fields

During resistance welding, depending on the amount of the welding current, strong magnetic fields might occur. Due to the current level, the highest magnetic fields occur mainly around the secondary lines.
This must be considered in the design of resistance welding devices and the corresponding workplaces.
To avoid excess of electromagnetic radiation, metrological proof must be provided if necessary.
In addition to the formation of magnetic fields, welding also produces conducted and radiated interference emissions from electromagnetic waves in a wide frequency range, depending on the type and functioning of the power setting.
For this purpose, the specifications according to the EMC Directive apply.

	**Danger due to the influence of electromagnetic fields** Persons with medical auxiliary units (such as pacemakers, etc.) must not be in the area of the welding equipment and their supply lines! There is a risk of malfunctions, which may lead to death or serious damage to health.

Additional notes:

- When setting up welding machines or systems, the limit values for electromagnetic radiation must be observed (see Appendix Standards).
- If necessary, suitable protective devices must be provided (e.B. shielding) or the operating stations must be set up at an appropriate distance.
- In the area of the welding machine or system, the information of magnetically stored data carriers (e.B sound and video tapes, EC cards, etc.) can be deleted or changed.
- The magnetic fields that occur during welding can damage motor-driven precision mechanical products such as wristwatches.
- In the immediate vicinity of the welding circle, currents can be induced in metallic objects (including jewelry, e.B. rings or chains). Depending on the strength of the magnetic field, this can lead to local heating in the metal parts (risk of burns).
- The EMC/EMC guidelines for resistance welding equipment have not yet been defined in full detail, or there are uncertainties in the guidelines for welding circuits. Therefore, please note the new publications in the relevant literature.

3 Technical specifications

3.1 General

The common resistance welding processes such as point, projection and seam welding are characterized by the fact that the welding energy is not continuously but pulsed into the welding point. The required welding times are usually much less than one second. Due to the process, there are variable break times between the welding impulses.

This operating mode (*pulsed operation*) makes it possible to overload the MFDC unit during the current phase, i.e. in contrast to the permissible continuous currents of an MFDC unit, significantly higher pulse currents can flow for a short time without thermally overloading the MFDC unit. This makes it possible to produce cost- and weight-optimized devices tailored to the specific application. On the other hand, however, this means that the targeted overload must be precisely defined to ensure safe operation.

An essential feature for the intermittent operation is the percentage duty cycle *X* i.e., the sum of all current times in relation to the cycle time *T*. The ratio can take a value between 0 and 1 and is expressed as a percentage. In addition, the length of the individual welding pulses is also decisive for the overload capacity. The behavior in case of overload is shown in type-related diagrams.

The technical data of the are contained in the respective data sheets.

The devices are subject to technical changes in the sense of technical progress. If necessary, the current documentation must be requested.

3.2 Type plate information

Following type plate information of EXPERT MFDC unit contain the characteristic values that are important to the user.

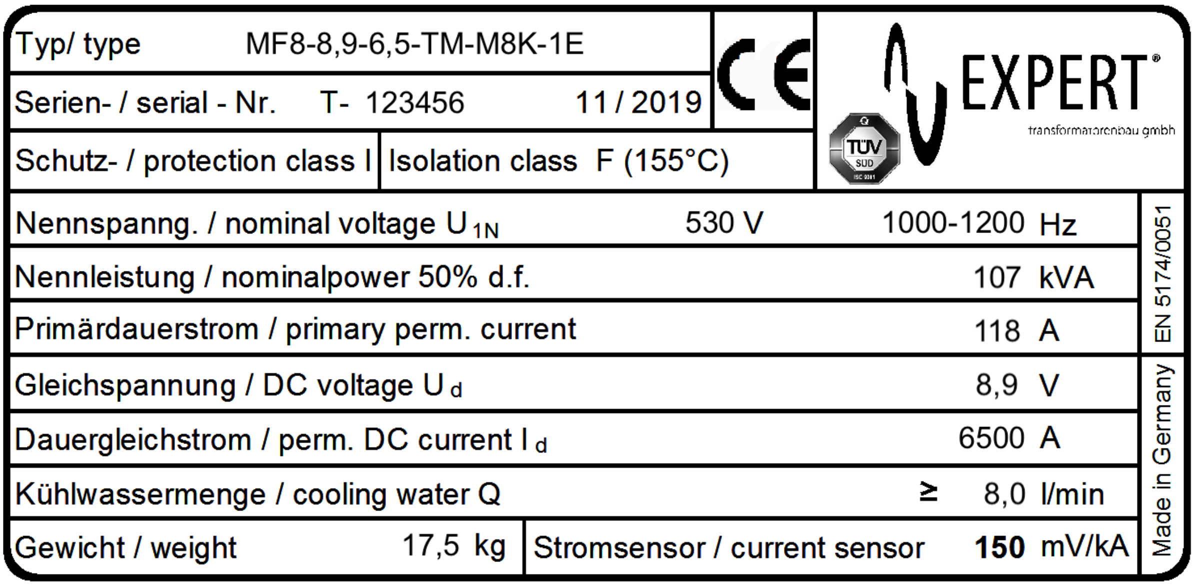


Bild 3-1 Type plate of an Expert MFDC unit

4 Intended use

EXPERT MFDC units are specially developed and manufactured for resistance welding technology. The general design and technical design are carried out in accordance with currently valid regulations, standards, and specifications. In addition, applicable type-bound standards are considered.

⚠	**Danger due to improper use** Improper use can cause personal injury, property damage and hazards to the environment. Due to high short-circuit currents and the associated high welding energies, there is a risk of material evaporation. Use the MFDC unit only as intended.

4.1 Areas of application for MFDC units

MFDC units consist of a transformer and a rectifier. The transformer is built in a fully encapsulated design *(cast resin filling)* i.e., the windings are optimally protected against moisture, contamination and the effect of dynamic current forces. Depending on the design, the rectifier is open or covered (please refer to the corresponding datasheet). In the case of open designs, care must be taken to ensure that the rectifier is protected against contamination. MFDC units are components that are usually designed in protection class IP00 on the primary and secondary sides (*open clamping points*). The design of the individual types can be seen from the specific data sheets.
The MFDC units must not be used in potentially explosive atmospheres. Please note the permissible environmental conditions.

⚠	**Protection class** The MFDC units may only be used and operated in those areas that correspond to the specified degree of protection (according to the data sheet). These MFDC units may not be used for operation in potentially explosive atmospheres.

4.2 Materials for resistance welding, resistance welding process

<u>Definition resistance welding (DIN 1910 part 5):</u>

The heat required for welding is generated by current flow over the electrical resistance of the welding zone (*resistance heat, Joule's heat*). Welding is done with or without force and with or without welding consumable.
Regarding the above definition, the minimum requirement of a material to be welded is that it must be electrically conductive. Furthermore, the material must be weldable in the kneadable state.

<u>Suitable materials:</u>

- uncoated steel sheet in different material thicknesses (often up to 3.0mm)
- coated steel sheet e.g., galvanized
- Chrome-nickel steel
- Non-ferrous metals e.g., aluminum, copper and silver

⚠	**Danger from the use of incorrect materials** The use of non-weldable or non-recommended materials can cause physical damage or damage to machines as a result of unpredictable reactions when the welding energy is introduced into the material.

4.3 Dimensioning of MFDC units

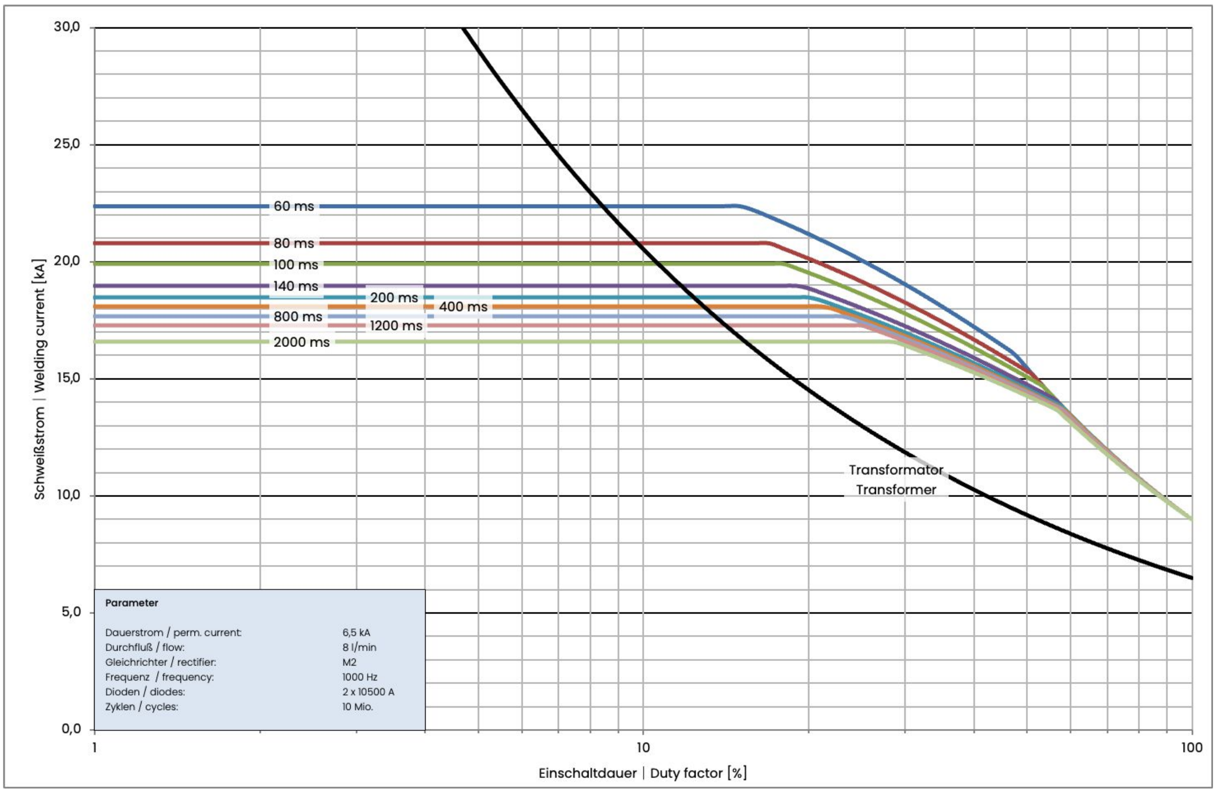
Following points have to be discussed separately:

- Thermal dimensioning – here the MFDC unis is designed in such a way that no overload due to overheating occurs in the required application
- Short-circuit dimensioning – here the maximum machine short-circuit current between the welding electrodes (or corresponding tools) is determined

Both values are independent of each other and must be determined for each application.

4.3.1 Thermal dimensioning

Basis is the load diagram with the welding current I_s as a function of the relative duty cycle X and the welding time t_S. Load diagrams are part of the documentation. Due to the different thermal time constants, the diode and transformer loads must be considered separately. If you have any questions, please contact one of the addresses given at the end. Please also note the instructions of the manufacturers of MF inverters and welding controls.



Picture 4.1 Load diagram of an MFDC-unit

⚠	**Risk of overload** Use outside the permitted working range can lead to hazards to persons (explosive bursting of the diodes). The thermal monitors installed in the TGE cannot guarantee universal protection against device overload due to incorrect dimensioning, even if connected correctly.

4.3.2 Short-circuit current dimensioning

For a better understanding, two important parameters should be noted:

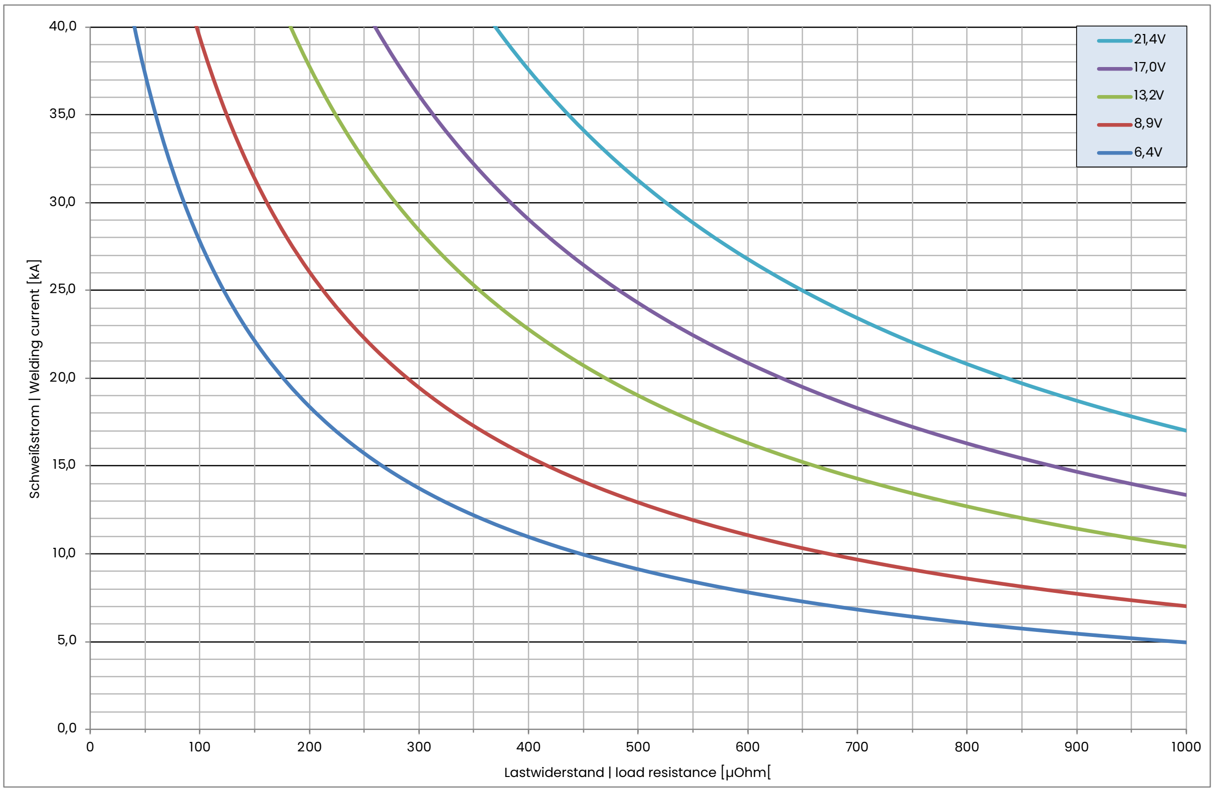
4.3.2.1 Short-circuit current of the MFDC unit

The short-circuit current is the maximum current that can be achieved at the rated primary voltage when short-circuiting the secondary side by a lossless bridge (Z=0). If the internal resistance of the MFDC unit were equal to 0, the short-circuit current would be infinite. The value of the short-circuit current is type related. The short-circuit current serves only as a reference value and has little practical relevance.

4.3.2.2 Short-circuit current of the machine

When connecting MFDC units to a welding equipment with a load (impedance) Z the current will be limited by this load. In the case of using DC currents as for MFDC-units the current is mainly limited by the ohmic resistance. The inductive part of the impedance may be skipped. (Latter will change when going to processes with very short pulses and fast rise times.)
With resistance welding the total resistance of the secondary circuit is considerably greater than that of the material being welded between the electrodes. The maximum attainable welding current I_{Smax}. is therefore usually similar to the short-circuit current of the machine.
The output characteristic of an MFDC-unit is in the form of

$$I_{S_{max}} = f(R, L).$$



Picture 4.2 Output characteristic $I_{S_{max}} = f(R, L)$ of an MFDC-unit

Remark:	It should be noted that the specified currents are the maximum currents achievable in the pulsed mode at a certain projection, which are limited only by the impedance of the external circuitry. The analysis is independent of the thermal conditions in the MFDC-unit. Depending on the current level, correspondingly long break times must be provided for cooling down according to the thermal capacity of the unit!

With the help of this type-dependent characteristic curve, the maximum achievable welding current $I_{S_{max}}$ can be determined as a function of the resistance R_L of the load circuit (i.e. the sum of all resistors connected to the MFDC-unit on the secondary side).
Conversely, these load diagrams are also suitable for the approximate determination of the resistance of the secondary circuit by measuring the maximum achievable welding current and then taking the value for R_L from the load diagram of the MFDC-unit in use.
The load diagram thus facilitates the selection of a suitable MFDC-unit with respect to the maximum secondary current if the resistance of the welding circuit is referred to.
The following principle applies:
The maximum achievable current increases proportionally to the level of the driving voltage (output DC voltage of the MFDC-unit).
When selecting the MFDC-unit, it should be noted that a welding current reserve of at least 30% is considered to compensate for e.g., wear on secondary cables and clamping points, which lead to an increase in resistance in the welding circuit. Additional power reserves are also required, for example, for secondary connections via adjacent welding points or when using stepper functions.

⚠	The load diagrams are calculated from the data of the respective MFDC units. Voltage drops of the mains supply are not considered. If these voltage drops are larger than 5% due to long mains supply lines, etc., additional welding power reserves must be considered.

4.4 Parallel/series connection of MFDC units

In principle, the secondary side parallel or series connection of several MFDC units is possible. Due to the decoupling of the circuits by the rectifier diodes, for example, no balancing currents flow during parallel connection. Depending on the number of identical units connected in parallel, the available current increases with the factor of units connected in parallel.
When using interconnected transformer rectifier units, a suitable converter and a suitable welding control must be selected due to the wide range of control and monitoring functions.
In any case, please consult the manufacturer of your control and inverter system.

4.5 General requirements for welding inverters and controls

EXPERT MFDC units are designed for operation on commercially available control and inverter systems. The technical data (power, voltage, frequency, pulse duration) of the converter must meet the welding task. Please also note the relevant documents of the welding converter and control manufacturers.

⚠	Please only use CE-compliant inverters and controls specially designed for resistance welding to operate EXPERT MFDC units.

4.6 Force effects in the welding circuit, secondary connections

When designing welding equipment for resistance welding, the force effects, and the resulting mechanical stresses because of the high welding currents must be considered when designing the secondary circuits.
Due to the magnetic field, attractive forces act on current-flowing parallel conductors in the same direction of current and *repulsive* forces in the opposite direction of current.
In the case of a closed welding circle, the direction of action of the forces during welding is such that the conductors forming the welding circle always want to occupy a larger area. Depending on the current level, very large force effects can occur.
If, for example, two parallel bus bars of $l = 1m$ length, which are laid at a distance from are flowed through $a = 0{,}05m$ by a current, $I = 25kA$ for example, a force *F* distributed over the length *l* results according to the following relationship:

$$F = 2{,}0 \cdot I^2 \cdot \frac{l}{a} \cdot 10^{-7} N$$

For this example, the electromagnetic force is $2{,}5\ kN$.
Since these forces occur dynamically with each weld, care must be taken in the design of the welding circuit to ensure that no leverage effects occur, for example when using rigid busbars. Leverage increases the already considerable current forces. Due to the flow behavior of copper, this can lead to a gradual deformation of the secondary connections and busbars up to breakage.

⚠	**Connection of the MFDC unit** MFDC units are to be connected on the secondary side with flexible welding cables or lamellar belts. As a result, leverage effects are largely avoided. When using busbars, these must be **additionally** mechanically supported at least at the beginning and end in accordance with the current forces that occur.

Due to the variety of welding systems *(mechanical design, operating parameters, and operating conditions)*, no general specifications for the design of welding circuits can be given. The general guidelines for the design of high current circuits taking into account dynamic current forces must be taken into account.
It is ensured that the electrodynamic forces are within the permissible range when operating within the working range specified in the data sheet.
The user must take appropriate design measures to ensure that no additional forces can act on the MFDC unit, such as e.g., force feedback of welding cylinders, forces caused by the particular weight of machine components, force feedback in the event of robot collision and the like.

⚠	**Risk of mechanical damage** An MFDC unit is a complex electrotechnical device that is operated with high voltage. To avoid unacceptably high contact voltages, protective measures such as e.g., a direct ground connection, are carried out. In the event of the action of large additional external forces, it cannot be ruled out that mechanical damage to the MFDC unit may also lead to an interruption of the protective conductor or damage to other functional parts of the protective measure before the system is switched off via this. In this case, the protective measure becomes ineffective and there is a risk of the occurrence of inadmissibly high contact voltages on system components and thus danger to the life of the operating personnel!

4.7 Connection to mains supply

MFDC units are intended exclusively for operation on suitable MF inverters. These are connected to the 3 phases of the mains supply. The inverter increases the frequency of the supply voltage required for the MFDC unit (e.g. 500V/1000Hz) on the output side.
For the sizing of the mains connection, the operating instructions of the MF inverter manufacturers must be followed!
Due to the typical pulsed operation for resistance welding and the associated load, the responsible electricity company should be consulted in the planning of resistance welding systems in any case!

5 Design and function of an MFDC unit

5.1 Design of an MFDC transformer rectifier unit

EXPERT MFDC units have a characteristic design regardless of type. The secondary winding and the rectifier are directly cooled by water. The primary winding and the iron core are cooled indirectly. The cooling water connection is directly bound with the potential of the secondary circuit of the MFDC unit. The secondary voltage difference is between the cooling water inlet and outlet.

⚠	**Danger due to potential-bound cooling water connections** When simultaneously touching or bridging cooling water inlet and outlet with metallic objects, e.g., tools, this can lead to very high short-circuit currents. There is a risk of injury due to burns or metal splashes.

5.2 Auxiliary circuits

The MFDC units can be equipped with monitoring devices *(e.g., temperature, welding current, secondary circuit, voltage monitoring).*
The integration of such auxiliary circuits into the MFDC unit avoids that sensitive cables and sensors must be additionally attached to the secondary circuit. The risk of contamination and damage does not exist in this case.

5.2.1 Temperature surveillance

Bimetal domes with double contact interruption are used as temperature monitors. The contacts are funtioning as openers.
Typical design:

Mechanical life:	10^4 (VDE testing class 1)	
Insulation voltage:	1,5 kV	
Maximum ambient temperature:	+ 180 °C (during operation)	
Nominal voltage:	250V AC / 50-60Hz	
Rated current:	2,5 A	at $cos\varphi = 1$ or
	1,6 A	at $cos\varphi = 0{,}6$
Switching cycles:	10.000	

The contact design is current-insensitive, i.e., the response temperature is independent of the current load. As standard, three temperature monitors with 2 x *150°C* response temperature for the transformer and 1 x 80°C for the rectifier are installed per MFDC unit.
On request, PTC temperature sensors, temperature measuring resistors or thermocouples can also be installed to monitor the transformer temperature. Due to the compact mass of the MF-TGE, operational temperature changes are associated with correspondingly large time constants. This means that the temperature response is very slow. Built-in temperature monitors therefore only signal an overload of the MFDC unit or a lack of sufficient cooling. The temperature monitors are not able to react or trigger short term overload such as overvoltage, shock load and the like.

5.2.2 Current sensing, constant current regulation

Optional, most EXPERT MFDC units can be supplied with built-in toroid measurement coils. These are air induction coils arranged concentrically around the secondary conductor. In these coils, a measuring voltage directly proportional to the change in welding current is induced.
The standardized measuring voltage is 150 mV/kA at a load resistance of 1kΩ *(input resistance of the evaluation electronics),* measured at full sine.
For the measurement of DC pulses, an electronic processing of the measurement signal emitted by the measuring coil is required (integration and RMS value formation).

Commercially available medium-frequency welding controls contain special electronic assemblies for this purpose. These signals are used in the welding controls for current control or to monitor the welding process.
EXPERT MFDC units with toroid measuring coils can be connected to all medium-frequency systems with standard calibration for current-actual value acquisition.
The toroid measuring coils used have a basic accuracy of ±1.5%, after installation the calibration accuracy for the standard types is ±3.0%.
The measurement coil is usually connected by plug-in or terminal connections on the primary side of the MFDC unit.

5.2.3 Integrated sensing leads for Fault Voltage Circuit Breaker

The direct connection of the secondary winding of MFDC unit with the protective conductor as a possible protective measure according to VDE 0545 Part1 (*EN50 063*) leads to compensatory currents via the protective conductor connection in some systems. In this case, another protective measure must be applied.
For this reason, various suppliers offer quick shutdown systems for secondary circuit monitoring. The principle is based on the FU procedure.
This means that when a threshold value of a fault voltage is reached, the system is switched off via an evaluation electronics.
The necessary test leads on the secondary circuit of the MF-TGE are installed in the MF-TGE at the customer's request and routed to the outside via suitable plug-in systems or connection terminals. To protect against interruptions in the fault voltage measuring line, this is usually designed as a double line and flowed through by a quiescent current.

5.2.4 Voltage monitoring

Modern welding controls are optionally equipped with adaptive controls. This requires a voltage measurement either in the MFDC unit or externally. EXPERT MFDC units can be supplied with integrated voltage measuring cables for such applications.
The connections are also installed in the MFDC unit upon the customer's request and realized via suitable plug-in systems or terminals on the primary side.

6 Transport and storage

The MFDC units are inspected and properly packed before shipping. Upon arrival, the MFDC unit must be inspected for any transport damage. Any damage that has occurred must be reported immediately to the carrier or the forwarding company. Later complaints can no longer be considered.

6.1 Transport

Due to the high weight in relation to the volume, the transport of TGE must be carried out with suitable aids. In case of improper transport, the device may tilt or fall. There is a risk of injury. We recommend when ordering to request our special cardboard packaging, which is equipped with handles and thus allows safe handling This packaging is also suitable as storage packaging.

⚠	**Danger due to improper transport!** Use only suitable transport aids! Don't stay under floating loads! There is a risk of injury from squeezing, shearing, cutting, bumping! The MFDC unit itself can also be damaged.

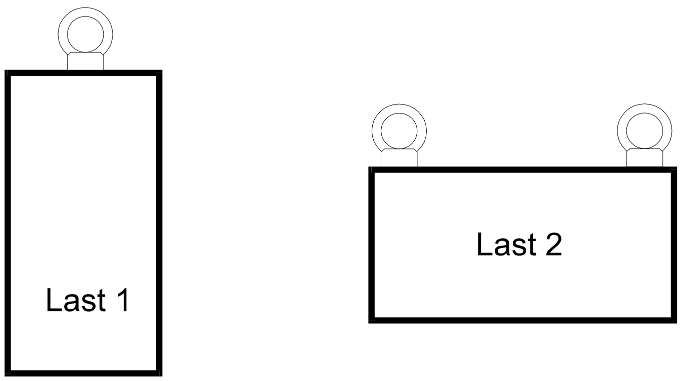
General protective measures:

- Use appropriate transport facilities.
- Prevent entrapment and crushing by taking appropriate precautions.
- Lifting devices (*observe permissible payload*) and use tools professionally.
- use suitable protective equipment (e.B. safety shoes, protective gloves).
- Do not stop under floating loads.
- Eliminate any leaking coolant immediately (*risk of slipping*).

Transport aids:

Proper transport is usually only possible with suitable aids such as hoists, cranes, forklifts and transport trolleys. If hoists are used for transport, the eye bolts may only be attached to the attachment holes provided for this purpose.

⚠	Load on the eye bolts: Note the maximum loads for eye bolts according to DIN 580.



Picture 6.1 Hoist points

DIN 580 specifies the maximum permissible loads for eye bolts. There are two basic ways to lift the transported goods (*see Picture 6.1*).

- with one eyebolt (Last 1)
- with two or more eye bolts (Last 2).

It should be noted that the load information always refers only to a eye bolt.

Thread	Last 1 in kg	Last 2 in kg
M8	140	95
M10	230	170
M12	340	240
M16	700	500

Table 6.2 Excerpt Maximum load values for eye bolts according to DIN 580

6.2 Storage

If an MFDC unit is exposed to strong external magnetic fields, e.g., in the immediate vicinity of induction furnaces, solenoids, etc., these fields can induce voltages in the windings of the MFDC unit. Depending on the nature and structure of the MFDC units, it cannot be ruled out that these induced voltages may assume unacceptably high values. Storage in the influence of large alternating magnetic fields is therefore not permitted.
The following general conditions apply to the storage of EXPERT MFDC units.

Storage conditions:

Permissible bearing height above N.N.:	no restriction
Permissible ambient temperature:	- 25 to +60 °C, (emptied water circuit)
Permissible relative humidity:	20 to 85% (no condensation)
Stack height:	max. 2 MFDC units flat over each other

Danger of frost damage!
When water-cooled MFDC units are stored below freezing, cracks can occur on the cooling pipe. Be sure to completely empty the entire water circuit of the MFDC units (blowout).

7 Installation, electrical connection, and commissioning

Failure to follow the information below may lead to the exclusion of the warranty by EXPERT Transformatorenbau GmbH in the event of damage.

⚠	**Requirements for assembly personnel:** The electrical connection (assembly) as well as the subsequent commissioning may only be carried out by electrical personnel!

7.1 Installation and electrical assembly

Please note the following information:

- When handling and assembling MFDC units, hazards occur due to the relatively high weight.

⚠	**Danger due to improper handling!** There is a risk of bodily injury from squeezing, shearing, cutting, pushing!

- The installation locations and fasteners must be designed for their weight.
- Suitable assembly and transport equipment must always be used.
- Lifting devices and tools must be used professionally. The permissible payload must be observed.
- Make sure that the connections remain accessible to the primary, secondary, and auxiliary circuits.
- The nameplate should be readily visible, or the technical data should be repeated in a visible place.
- The cooling water connection must be carried out professionally. The cooling water connection points on the MF-TGE may have potential differences. To avoid a short circuit via the water connections, only non-conductive hoses, or pipes with a length of at least 0,5 m and an electrical resistance of at least 1MΩ/m maybe used. The specific resistance of the water column should be at least 20 Ωm.
- Check the cooling water connection for tightness and function.
- The electrical connection may only be carried out by an electrician. Explanation of the term "specialist":
- Anyone who has knowledge and experience as well as knowledge of the relevant standards for the work assigned to him based on his professional training is a specialist. A passed professional vocational training as a skilled worker, master craftsman, technician or Dipl.-Ing. are regarded as proof of the required professional training. A specialist must also be familiar with the standards applicable to the respective field of activity and have sufficient experience in a particular field of work to be able to assess transferred work and identify hazards. Furthermore, the specialist is trained, instructed, or entitled to switch on and off, ground and mark circuits and devices in accordance with the provisions. She has adequate equipment and is trained in first aid.
- The connection surfaces of the primary and secondary conductors must be flat and clean.

- The primary-side connection pins/contact pins shall be tightened with a torque wrench. Depending on the order request, threaded or contact pins are loosely enclosed with most TGE types.
- Tightening torques are shown in Table 7.1-7.3 recommended
- All live parts must be covered and thus secured against direct contact.
- In the case of screw connections, the following tightening torques must be observed and checked:

Thread	M5	M6	M8	M10	M12	M16	M18	M20
Torque / Nm	5,75	9,9	24	48	83	200	275	390

Table 7.1 Torques for housing mounting

Thread	Cu-flange / Cu-bar	Cu-flange/ Cu flexible	Contact piece/ Cable lug
M5	5,5	5,5	5,5
M6	9	9	8
M8	23	23	20
M10	45	45	42
M12	85	85	80
M16	160	160	150
M18	220	220	200
M20	250	250	220

Table 7.2 Screw connections for electrical connections with different material pairing (specification in Nm for screws and nuts strength 8.8)

Kontact pin	Torque / Nm
M6	6,0 +0,5
M8	15,0 ±1,0

Table 7.3 Torques for mounting contact pins for clamp transformers with plug-in system from Multi-Contact

There is currently no standard regulation for maximum permissible torques of Cu screw connections. The tightening torques listed in Tables 7.1 to 7.3 were determined experimentally. Make sure that there are no overstresses on the Cu screw connections. Tightening too tightly can lead to deformations due to the flow behavior of copper.

7.2 Permissible environmental conditions

MFDC units are usually delivered as components to be processed on the primary and secondary sides in protection class IP54 or IP00. The information on the respective data and dimension sheets is valid.
Use in potentially explosive atmospheres is not permitted.
The following environmental conditions apply to operation:

Permissible guaranteed installation height:	1000m N.N.
Permissible ambient temperature:	+ 5 to + 40 °C
Cooling water temperature:max.	30°C (flow)
Permissible relative humidity:	30 to 95 %

8 Notes on operating MFDC units

8.1 Cooling water quality

If the cooling water quality is insufficient, the function of the MF-TGE can be significantly restricted. The use of a closed circulation cooling, in which treated water is recooled, is advantageous in any case. In order not to increase the low specific electrical conductivity of the cooling water, it is advisable to install an ion exchanger in the cooling circuit for larger systems. In the cooling pipes, metal ions e.B. iron, copper, etc. are released into the cooling water, which increase the specific electrical conductivity of the cooling water.
In addition, the metal ions contained in the cooling water in the cooling circuit of the MF-TGE (copper tube) can form local corrosion sources according to their position in the galvanic voltage series.
Since the secondary circuit is flowed directly through by the cooling water, it should have a low electrical conductance to avoid potential carryovers.

Cooling water requirements:

- mechanically pure, filter fineness approx. 100 microns
- natural water, optically clear, without turbidity, no sediment

pH-value:	7-8
spec. electr. conductivity:	max. 800 µS / cm
Water hardness:	max. 6 °DH
Iron:	< 0,3 mg/l
Copper:	< 0,2 mg/l
Zinc:	< 0,2 mg/l
Magnesium:	< 30 mg/l
Calcium:	< 80 mg/l
Sulfates:	< 150 mg/l
Chlorides:	< 50mg/l
Nitrides:	< 1,5 mg/l
Nitrates:	< 40 mg/l
Phosphates:	< 1,0 mg/l
Ammonia:	must not be detectable
Aggressive carbonic acid:	must not be detectable
Cooling water temperature (entrance):	approx. 18 °C to approx. 30 °C

- If appropriate inhibitors are added to the cooling water to avoid corrosion and limescale deposits, we recommend organic inhibitors, as these only slightly increase the specific electrical conductivity of the cooling water.

⚠	**Danger of overheating of the MFDC unit!** If there is too much contamination or deposits in the cooling pipes, the heat loss cannot be sufficiently transferred to the cooling water. The specified amount of cooling water (see data sheet) must be adhered to.

⚠	**Condensation!** The cooling water inlet temperature at the MFDC unit should be approx. 18 °C to a maximum of 30 °C. If the cooling water inlet temperature is significantly lower than the ambient temperature, there is a risk of condensation.

8.2 Cooling water quantity, differential pressure of the cooling circuit

Water-cooled MF-TGE are designed in such a way that almost all the heat generated in the windings and in the rectifier, part must be dissipated via the cooling water. The heat dissipation by convection via the housing is negligible.
In our data and dimension sheets, the necessary amount of cooling water is shown in relation to the corresponding load curves.
Additional pressure losses occur in the external cooling circuit *(hose lines, fittings,*etc.).
The differential pressure between the flow and return of the cooling circuit shall be determined by the user in such a way that the amount of cooling water noted in the MF-TGE data sheet is achieved. To control the amount of water, we recommend the installation of a flow measuring device.
Depending on the amount of the self-loss power of the MF-TGE, the outlet temperature of the cooling water is about 15 - 35 K higher than the inlet temperature.
If the possible cooling conditions cannot be met, operation with reduced load is possible. The maximum load parameters must then be agreed individually on the basis of the cooling conditions. In this case, please contact us.

⚠	**Water supply!** The cooling water inlet temperature at the MF-TGE must not exceed 30 °C. Series connection of cooling circuits of several MF-TGE is not permitted. The pressure in the cooling system must not exceed 8 bar higher than the external pressure (atmosphere).

9 Maintenance

Regular maintenance of welding equipment significantly influences the quality of the welded joints to be produced and the reliability of the systems. The risk of machine and plant failures can thus be reduced.
Due to their compact and fully encapsulated design, EXPERT MFDC units do require only little maintenance.

9.1 Primary and secondary connections

The maintenance intervals depend on the dynamic load on the terminal connections and the degree of utilization of the machines. We recommend maintenance cycles of 4 to 6 weeks. The nature of the connection points *(corrosion and strength of the connections)* as well as the welding cables themselves must be inspected for wear or damage. Welding spatter adhesions partially form shunts at the secondary connection points of the MF-TGE. These must be removed regularly. Care must be taken to ensure that there is no damage to the MF-TGE.

- Before starting the work, the safety instructions in section must be observed.
- The MF-TGE must be activated and secured against reactivation.
- In the event of damage to the primary or secondary lines (e.B. insulation or other defects), the connection cables must be replaced.
- The tightening torques of the primary and secondary connections shall be checked.
- The effectiveness of the protective measures against indirect contact in the event of a fault must be checked with suitable measuring instruments (e.B. nature and function of the protective conductor connections, function FI protection circuit or similar).

9.2 Rectifier

The high-current diodes used are subject to a high specific load during resistance welding in pulsed operation due to the temperature change processes. The permissible load results from the respective type-specific load diagram.
If these limit conditions are followed, statistical lifetime values of approx. 10 million load cycles (welding points) can be expected for the diodes for standard components.
Special applications with specifically higher diode load and thus also lower statistical service life are possible. A reduced load can increase the statistical service life accordingly. In this context, please note the information on the load diagrams contained in the documentation. For further information, please contact EXPERT customer service.
To prevent a failure in the production plant, we recommend replacing the MFDC unit before reaching its useful life and having a preventive inspection with rectifier change carried out.
Due to the special installation conditions for high-current diodes, we do not recommend self-repair. Improperly installed diodes do not reach their possible service life and can be destroyed in extreme cases after a few welds.

9.3 Cooling circuit

The frequency of the maintenance measures described here depends on the quality of the cooling water used.
Due to deposits in the cooling channels of the MFDC unit, the cooling capacity can be drastically reduced. As a result, the MFDC unit is thermally overloaded (*e.g. triggering of temperature monitoring*).
In addition, deposits reduce the hydraulic cross-section in the cooling channels. As a result, the pressure loss in the MFDC unit increases.
Carrying out the cleaning work of the cooling circuit:

- Before starting the work, the ones in section observed.
- The cooling water supply of the MFDC unit shall be interrupted.

- The hoses for the cooling water connection of the MFDC unit must be removed.
- The cooling circuits of the MFDC unit are flushed with suitable solvents for the degradation of lime and scale residues. The safety and instructions for use of the solvent manufacturer must be observed. In the case of heavy deposits, it may be necessary to repeat these rinsing processes several times or to extend the exposure time.
- For the removal of deposits from the cooling circuits, commercially available agents e.B. based on citric acid or similar are suitable.

10 Literature

10.1 Standards and regulations

DIN EN 294	Safety of machinery; safety distances to prevent danger zones from being reached by the upper limbs
DIN EN 62135-1	Resistance welding equipment - Part 1: Safety requirements for design, manufacture, and installation
DIN EN 60204	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
DIN ISO 669	Resistance welding - Resistance welding equipment - Mechanical and electrical requirements
DIN EN 50240	Elektromagnetische Verträglichkeit (EMV) - Produktnorm für Widerstandsschweißeinrichtungen
DIN EN ISO 5826	Resistance welding equipment - Transformers - General specifications applicable to all transformers
DIN EN ISO 5828	Resistance welding equipment - Secondary connecting cables with terminals connected to water-cooled lugs - Dimensions and characteristics
DIN EN ISO 7284	Resistance welding equipment - Particular specifications applicable to transformers with two separate secondary windings for multi-spot welding as used in the automobile industry
DIN EN ISO 8205	Resistance welding equipment - Water-cooled secondary connection cables I
DIN VDE 0100-410	Low-voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shockg
DIN VDE 0100-600	Low-voltage electrical installations - Part 6: Verification

10.2 DVS-Richtlinien und –Merkblätter

DVS 2903	Electrodes for resistance welding
DVS 2904	Controls for spot, projection, and seam welding machines
DVS 2907	Recommendations for the selection and comparison of resistance spot, projection, and seam welding equipment as well as resistance spot and seam welding equipment
DVS 2917	Operation and maintenance of resistance welding machines
DVS 2937-1	Resistance welding with industrial robots