# Instruction Handbook

## Electron Beam Evaporator

**Types: EV M – 6**
**EV M – 8**
**EV M – 10**

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*This instruction handbook is an integral part of the electron beam evaporator and must be kept readily at hand for the operating personnel at all times.*
*The safety instructions contained in it must be obeyed.*
*If the machine is resold, the instruction handbook must always be delivered with it as well.*

**Liability**

The manufacturer's liability for the electron beam evaporators EV M – 6, EV M – 8 and EV M – 10 is based on the principles of German law.
The manufacturer accepts no liability for damage and losses due to:

- improper use;
- operation by unauthorised personnel;
- failure to follow safety regulations;
- failure to heed the information in the instruction handbook.

**Translation**

If the machine is sold to a country in the EEA, this instruction handbook must be translated into the language of the country in which the machine is to be used.
Should the translated text be unclear, the original instruction handbook (German) must be consulted or the manufacturer contacted for clarification.

**Copyright**

# 1 Table of Contents and Figures

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## 1.3 Manufacturer's Declaration

# Manufacturer's Declaration

pursuant to

- **EC Low Voltage Directive 2006/95/EG**
- **EC Directive EMV 2004/108/EG**
- **EC Machinery Directive 98/37/EC, Annex II B**

We hereby declare that the design of the

**Description:** **Electron Beam Evaporator**

**Types:** **EV M – 6, EV M – 8 and EV M – 10**

as delivered complies with the above regulations and following DIN EN standards.

Harmonised standards pursuant to the directives:

| Directive/ Standard | Title | Edition | Remarks |
|---|---|---|---|
| DIN EN 62079 | Preparation of instructions - Structuring, content and presentation | 2001 | Harmonised standard |
| | | | |
| **2006/95/EG** | **EC Directive: Low Voltage** | **2006** | |
| DIN EN 60204-1 | Safety of machinery - Electrical equipment of machines - Part 1: General requirements | 2007 | Harmonised standard |
| DIN EN 60204-11 | Safety of machinery - Electrical equipment of machines - Part 11: Requirements for HV equipment for voltages above 1000 V a.c. or 1500 V d.c. and not exceeding 36 kV | 2001 | Harmonised standard |
| | | | |
| **2004/108/EG** | **EC Directive: EMC** | **2004** | |
| DIN EN 61000-6-4 | Electromagnetic compatibility - Generic emission standard - Industrial environment | 2007 | Harmonised standard |
| DIN EN 61000-6-2 | Electromagnetic compatibility - Generic immunity standard - Industrial environment | 2007 | Harmonised standard |
| **98/37/EG** | **EC Directive: Machinery** | **1998** | |
| DIN EN 12100-1 | Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology | 2006 | Harmonised standard |

| | | | |
|---|---|---|---|
| DIN EN 12100-2 | Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles and specifications | 2003 | Harmonised standard |
| DIN EN 563 | Safety of machinery - Temperatures of touchable surfaces - Ergonomics data to establish temperature limit values for hot surfaces | 1995, 1999 | Harmonised standard |

**The standards EN 12100-1 and 2 refer additionally to the following applicable standards:**

DIN EN 294**); DIN EN 349**); DIN EN 418**); DIN EN 811**); DIN EN 894-1**); DIN EN 954-1*); DIN EN 1037; DIN EN 1050; DIN EN 1088

***)** Safety-related control elements must correspond at least to safety category 2 according to EN 954-1.

****)** These must be complied with by the manufacturer of the complete plant (issuer of the declaration of conformity).

Unauthorised changes to the machine invalidate this declaration.

**Operation of this machine is forbidden until the complete plant is found to be in conformity with the regulations of all relevant, applicable EC directives.**

Unterensingen, 14 May 2009

Signature

.....

Title / Name / Position

# 2 Overview and Intended Use

## 2.1 Overview

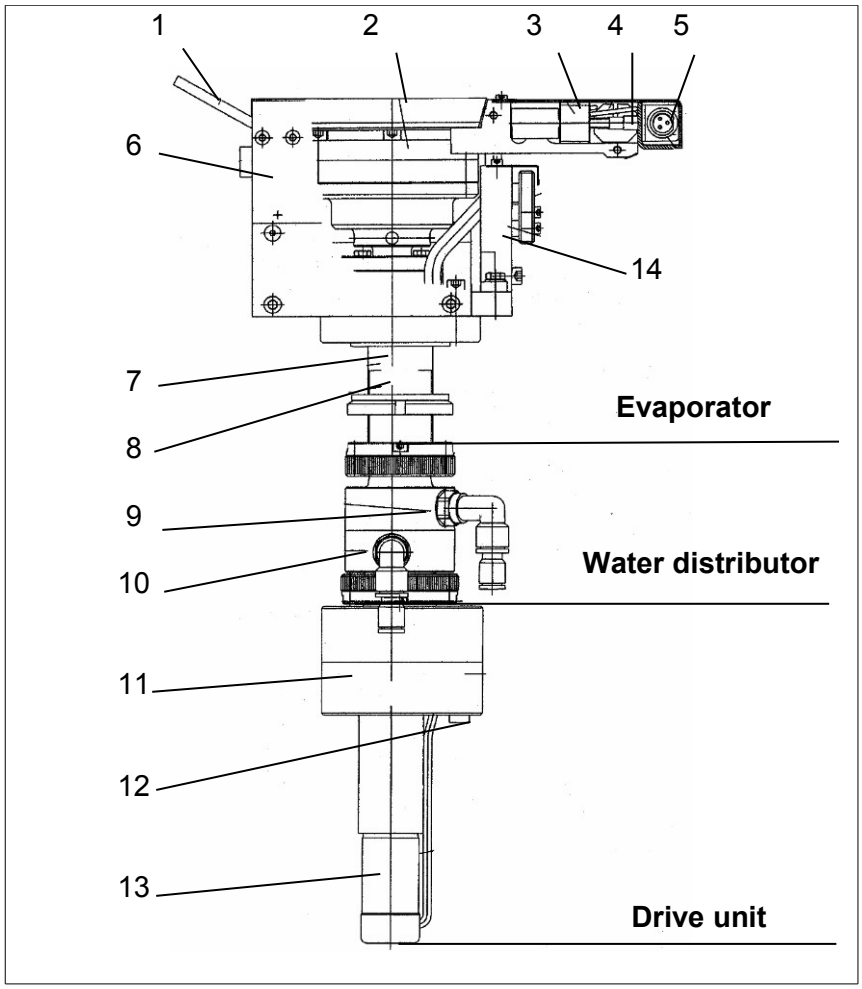



*Fig. 2-1 Overview (Example)*

| The EV M – 6, 8 and 10 electron beam evaporators consist of the following main components: | |
|---|---|
| 1 Crucible cover | 8 Rotary feedthrough |
| 2 Crucible | 9 Water outlet |
| 3 Y-coil | 10 Water inlet |
| 4 X-coil | 11 Positioning unit |
| 5 Magnet current connection | 12 Drive socket |
| 6 Magnet (concealed shunt) | 13 Motor |
| 7 Feedthrough | 14 Filament block |

## 2.2 Intended Use

The EV M – 6, 8 and 10 electron beam evaporators are multi-hearth electron beam sources; they were developed, designed and built for medium to large vacuum coating systems and are intended for use in production, research and development.

Typical applications are optical coating or laboratory-scale coatings with a variety of different materials or materials requiring sequential or continual rotation of the crucible.
The EV M – 6, 8 and 10 electron beam evaporators are designed for direct or contact-cooled crucibles with a varying number of pockets.
The directly cooled crucibles permit intensive cooling for high coating rates.
Contact-cooled crucibles allow easier and quicker crucible changes without mechanical work.

Apart from rotation, the compact (Ø 32 mm) hollow-shaft rotary feedthrough also serves cooling of the crucible.
The hollow shaft is driven directly by a DC motor with gear.

An optical position recognition system guarantees precise crucible position recognition with feedback to a controller.


*The EV M – 6, 8 and 10 electron beam evaporators are intended solely for the purpose described above. Any other use or modification of the EV M – 6, 8 and 10 electron beam evaporators without the written consent of the manufacturer is deemed improper. The manufacturer accepts no liability for resultant damage. The risk is borne solely by the operator.*
*The EV M – 6, 8 and 10 electron beam evaporators may only be put into operation when it has been ensured that all safety equipment is operative and that the EV M – 6, 8 and 10 electron beam evaporators comply with EU directives.*

Proper use of the machine in accordance with its intended use includes compliance with the manufacturer's operating, maintenance and repair instructions.

***Notice** on application of the EMC Directive 89/336/EC in the **manufacturer's declaration**:*
*If DIN EN 61000-6-4 (Electromagnetic compatibility - Generic emission standard - **Industrial environment**) was applied, the machine may not be used in residential, commercial and light industrial environments and small businesses unless it also conforms to the standard*
*DIN EN 61000-6-3 (Generic emission standard - Residential environment).*

## 2.3 Technical Specifications

### 2.3.1 Product Data

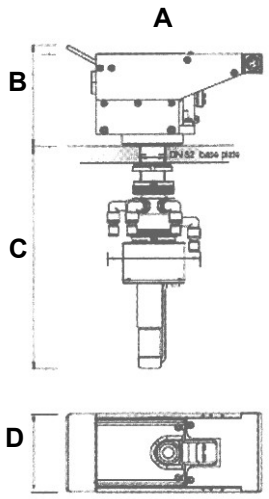
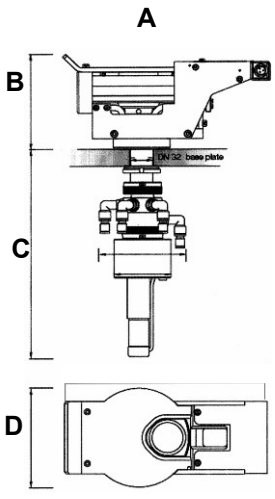
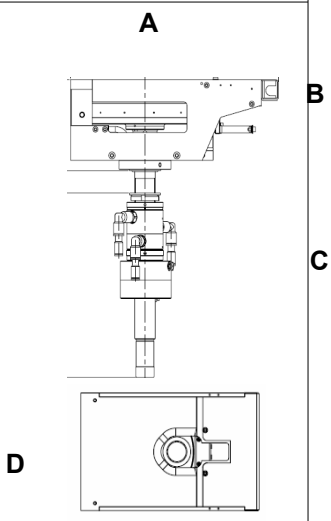

*The materials/media needed for operation of the electron beam evaporator in compliance with its intended use are procured and used by the operator of the electron beam evaporator. Proper handling of these materials/media and the related dangers are the sole responsibility of the operator. The operator must supply his operating personnel with information and instructions on dangers and disposal. The safety data sheets of the material/media manufacturers must be observed.*

| | |
|---|---|
| **Processable Products** | Substrate |
| **Operating Conditions** | |
| Bake out temperature: | Max. 100°C (water off)<br>Max. 140°C (water on) |
| **Water** | |
| Flow rate: | 6 - 10 l / min. |
| Pressure: | 4 - 6 bar |
| Temperature: | Max. 40°C |
| Hardness: | pH 6 - 8 |

*Make sure that the water pressure at the water inlet does not exceed 6 bar. Magnetically controlled flow valves can lead to peaks in the water pressure. It must be ensured that chemical contamination in the water does not obstruct the water flow in any way and also does not attack solder joints, which could lead to leaks.*

| | |
|---|---|
| **Material** | |
| Crucible: | OFHC-Cu 99.99%<br>(ASTM-F-68-99) |
| Filament block: | Stainless steel (special configuration Mo or Ta)<br>W 99.95%; $Al_2O_3$ |
| Pole shoe: | Nickel-plated |
| **Connections** | |
| High voltage: | 2 x 10 $mm^2$, Cu |
| X / Y magnet coil: | 3-pin FISCHER plug |
| Cooling water: | 8/10 mm PE hose |

## 2.3.2 Production Data, Dimensions and Weights

| Model | EV M - 6 | EV M - 8 | EV M - 10 |
|---|---|---|---|
| |  |  |  |
| Max. power | 6 kW | 10 kW | 10 kW |
| Acceleration voltage | 4 – 10 kV | 4 – 10 kV | 4 – 10 kV |
| Filament current | 50 A @ 10 VAC | 50 A @ 10 VAC | 50 A @ 10 VAC |
| Beam deflection | 270° magnetic | 270° magnetic | 270° magnetic |
| Magnet system | STD (150°C) | STD (150°C) | STD (150°C) |
| X-deflection | ± 3 A (150 Hz) | ± 3 A (150 Hz) | ± 3 A (100 Hz) |
| Y-deflection | ± 3 A (150 Hz) | ± 3 A (150 Hz) | ± 3 A (100 Hz) |
| Beam diameter, focussed | 3 mm | 3 mm | 3 mm |
| Max. vacuum evaporation rate[1] | 12 000 A/min | 25 000 A/min | Ag>15 000A/min@8kW<br>Ti >42 000A/min@6kW<br>Al >12 000A/min@10kW |
| Crucible rotation | yes | yes | yes |
| Emission current | max. 600 mA | max. 1000 mA | max. 1200 mA |
| Working pressure | $<10^{-3}$ mbar;$>10^{-8}$ mbar | $<10^{-3}$ mbar;$>10^{-8}$ mbar | $<10^{-3}$ mbar;$>10^{-8}$ mbar |
| Cooling Water<br>T<40°C<br>p= 4-6 bar; | 6 l / min | 8 l / min | 10 l / min |
| Feedthroughs | - / 2 x Ø 8/10 mm PE | - / 2 x Ø 8/10 mm PE | - / 2 x Ø 8/10 mm PE |
| Outside diameter of feedthrough | 32 mm | 32 mm | 32 mm |
| Weight | 12 kg | 15 kg | 30 kg |
| Part no. | 1-61 00 00 | 1-61 10 00 | 1-61 60 00 |
| Dimensions | A = 256 mm<br>B = 136 mm<br>C = 298 mm<br>D = 106 mm | A = 287 mm<br>B = 136 mm<br>C = 298 mm<br>D = 144 mm | A = 327 mm<br>B = 110 mm<br>C = 298 mm<br>D = 202 mm |
| 1 = for aluminium, distance between EB gun and substrate = 250 mm | | | |

## 2.3.3 General Specifications

**Ambient Temperature Range:**

| | |
|---|---|
| Minimum temperature: | + 5°C |
| Maximum temperature: | + 40°C |

**Ambient Conditions:**

| | |
|---|---|
| Sound pressure level: | $L_{PA}$ = 66 dB (A) |

**Luminance**(on evaporation of tungsten)

| | |
|---|---|
| Measured directly at the sight glass | Approx. 44 000 Lux |

**Magnetic Field Measurements**

- Maximum in front of the vacuum chamber, operation: Approx. B = 0.6 mT = 600 µT (base level 0.001)
- Maximum in the vacuum chamber, crucible change, maintenance: Approx. B = 60 mT = 60 000 µT (base level 0.001)

– The permanent magnetic field at and around the vacuum chamber lies below "exposure range 2".
– The magnetic field in the vacuum chamber is significantly higher, but still just below "exposure range 1".

**Access for wearers of cardiac pacemakers must be prohibited, especially during handling work in the vacuum chamber.**

**Coatings**
None. All outside surfaces are metallic.

# 3 Safety

## 3.1 Notes / Explanations

***Instruction handbook mandatory***
*Marked with a book symbol.*

***Notices***
*Marked with a hand symbol.*


***Warnings***
*Marked with a stop sign.*

***Dangers***
*Marked with a warning triangle.*

***Danger of electric shock***
*Marked with this symbol.*

***Danger of burns***
*Marked with this symbol.*

***Danger of crushing***
*Marked with this symbol.*

***Danger from magnetism***
*Marked with this symbol.*

*Dangers for people with **cardiac pacemakers** are marked with this symbol.*


*Caution. Special packaging for transport by air.*

***Danger from x-rays***
*Marked with this symbol.*

***Danger from UV radiation***
*Marked with this symbol.*


***Protective conductor connection***
*Marked at the connection points with this symbol.*

### 3.1.1 Machine Identification

The information in this instruction handbook only applies to the electron beam evaporators whose type designations are given on the title page.
The types are stamped into the housing. The type is coded in the serial number.
It is important that the type designation is stated correctly when consulting us.
We can only process your query properly and quickly if this information is correct.

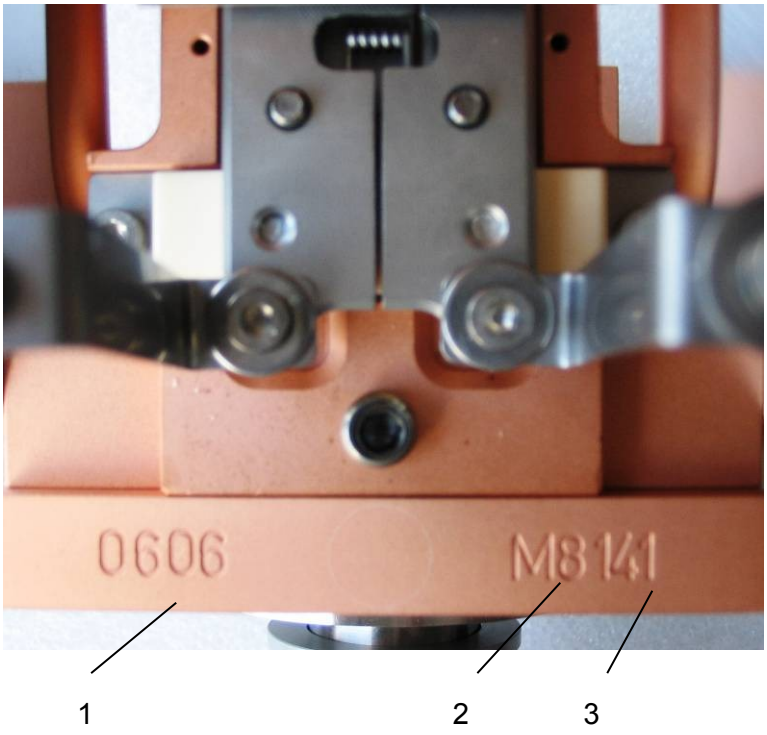



*Fig. 3-1 Example of Identification Marking*

1 Month/Year
2 Type
3 Consecutive number

## 3.2 Integrated Safety Systems

The integrated safety systems must be checked at regular intervals (**d**= daily, **w** = weekly, **m** = monthly, ½ **y** = half-yearly, **y** = yearly).
The test methods that are to be applied are:
**V** = visual inspection, **F** = function test, **M** = measurement.

**The operator must implement the following in the overall plant:**

**Mains Isolator (Main Switch)**
The electron beam evaporator is connected to the main power supply system. The electron beam evaporator is connected to and disconnected from the power supply with the main switch for this power supply system.

| Test | |
|---|---|
| Interval | Method |
| **y** | **F** |

*When the main switch is switched off for cleaning, maintenance and repair work, it must be locked with a padlock to prevent unauthorised switching on.*

**Emergency Stop System**
The electron beam evaporator is integrated in a master emergency stop system that immediately puts the electron beam evaporator into a safe operating state when actuated.

| Test | |
|---|---|
| Interval | Method |
| **m** | **F** |

**Safety Systems**
- Discharge rod
- Safety switch at the vacuum chamber for the evaporator
- Safety latch for interlocks
- Flow controller
- Vacuum monitor
- Stop valve for the cooling water supply

| Test | |
|---|---|
| Interval | Method |
| **m** | **F** |

**Machine Control System**
The machine control system is equipped internally with a three-phase, five-wire supply system with current-carrying mid-point conductor and **separate ground conductor** (with YELLOW/GREEN insulation).

| Test | |
|---|---|
| Interval | Method |
| **y** | **V, F, M** |

The operating and maintenance personnel are trained in the use of the machine at its point of installation by personnel from FERROTEC GmbH. Should you have any questions or be uncertain about anything, please contact FERROTEC GmbH.

*It is strictly forbidden to render any of the safety systems inoperative or to modify their action.*

*This instruction handbook is an integral part of the electron beam evaporator and must be kept readily at hand for the operating personnel at all times. The safety instructions contained in it must be obeyed.. If the electron beam evaporator is resold, the instruction handbook must always be delivered with it as well.*

*The type, scope and action of the safety systems were arranged with the operator.*

## 3.3 Interfaces on the Electron Beam Evaporator

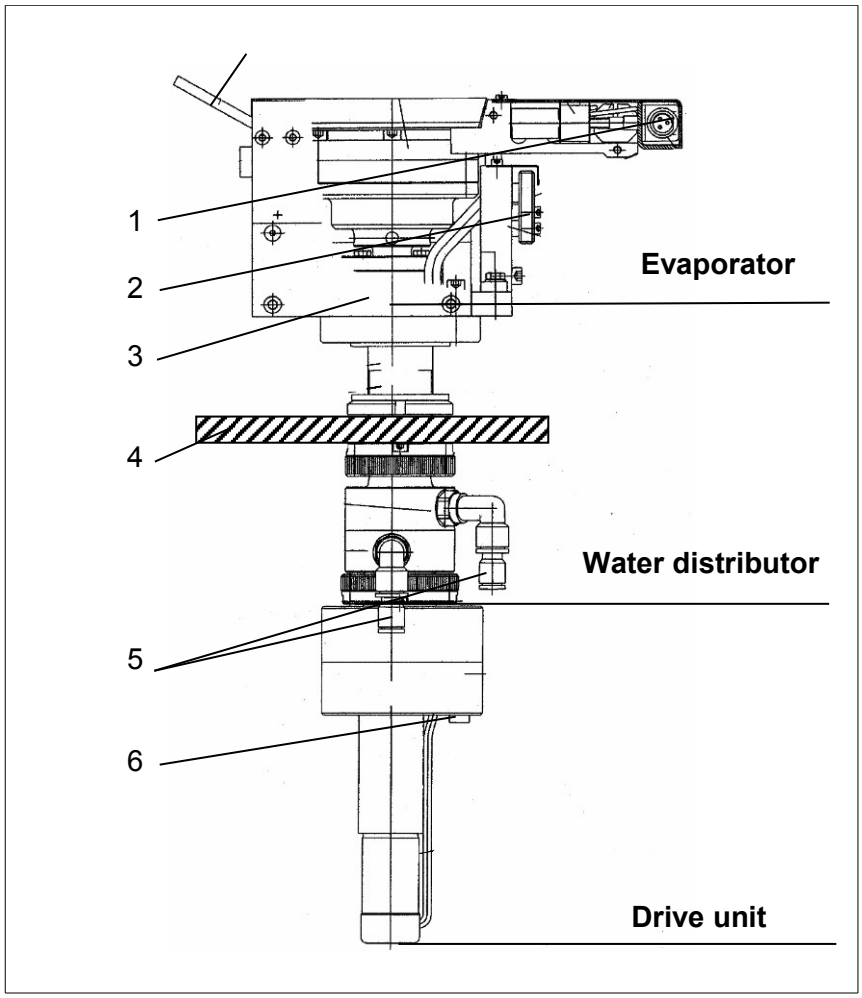



*Fig. 3-2* *Interfaces on the Electron Beam Evaporator (using the EV M – 10 as example)*

**There are the following interfaces on the electron beam evaporator:**

1 Deflection
2 Cathode connection
3 Evaporator
4 Feedthrough to the vacuum system
5 Cooling water inlet (not illustrated)
6 Drive unit connection
7 Electric power supply (main switch) and controls (not illustrated)

## 3.4 Safety Precautions (by the Operator)

The operator must:
- instruct his operating and maintenance personnel in the use of the **safeguards** of the electron beam evaporator and
- ensure the safety precautions are being observed.
- The operator must ensure that access to the danger zone of the machine by unauthorised persons (not operating and maintenance personnel) is prevented.

This instruction handbook must be kept in a safe place for future reference. The frequency of inspections and checks must be observed.
The work described in this instruction handbook is explained in such a way that
-the chapters on operation and modes of operation can be understood by an **instructed person** and
-those on transport, installation and assembly, maintenance and troubleshooting by a **skilled person**.

The chapters on **transport, installation and assembly, maintenance and troubleshooting** are intended **for skilled persons only**. Work described in these chapters may only be carried out by such skilled persons.

**Instructed Person**
A person familiarised with and, if applicable, trained in his or her particular duties by a skilled person and advised of the risks of improper conduct and about the necessary safeguards and safety precautions.

**Skilled Person**
A person with relevant technical training, know-how, experience and knowledge of applicable standards to enable him or her to assess the work assigned to him or her and to perceive potential risks.

**Definitions based on EN 60204-1.**

## 3.5 Responsibilities of the Operator

*In the EEA (European Economic Area) national implementation of the framework directive 89/391/EEC and corresponding individual directives, in particular the directive 89/655/EEC concerning the minimum safety and health requirements for the use of work equipment by workers at work, as amended, are to be observed and adhered to. In Germany the Plant Safety Ordinance of October 2002 must be observed (translation of the above-mentioned directive into national law).*

The operator must (where necessary) obtain any local **operating permits** required and observe the provisions contained therein.

In addition to this he must observe local laws and regulations on
- personnel safety (accident prevention regulations)
- safety of work materials and tools (safety equipment and maintenance)
- disposal of products (laws on wastes)
- disposal of materials (laws on wastes)
- cleaning (cleaning agents and disposal)
- environmental protection.

**Connections:**
Before starting the electron beam evaporator the operator must ensure that:
- only specifically trained personnel are used for installation and start-up if this work is done by the operator himself.

***Lighting***
*The operator must ensure that there is adequate and uniform lighting in all areas of use of the electron beam evaporator. The recommended illumination is 300 Lux (maintenance value; ASR 7/3 applies in Germany).*

## 3.6 Safety Inspections and Tests

Factory inspections and tests by the manufacturer.

1. Airborne noise measurement
   - According to the Machinery Directive, Annex 1 (point 1.7.4/ff.)
     (upwards of 70 dB: test certificate)

2. Tests and inspections in terms of DIN EN 60204-1 (Edition Nov. 98) and DIN EN 60204-11 (Edition 2001):
   - Check whether the electrical equipment corresponds to the technical documentation (chap. 19.1)
   - Continuous connection of the protective conductor system (chap. 19.2)
   - Insulation resistance tests (chap. 19.3)
   - Voltage tests (chap. 19.4)
   - Protection against residual voltage (chap. 19.5)
   - Function tests (chap. 19.6)
     The functions of the electrical equipment, particularly those concerning safety and protective measures, were tested.

# 4 General Warnings

## 4.1 Dangers

The safety systems and safety instructions described in this handbook must be heeded accordingly.
The machine is operated from the control unit in combination with the GENIUS controller, the CARRERA high voltage power supply and the overall plant.

*Pay attention to the **danger of electric shock** when carrying out adjustment, maintenance and repair work!*
*Before touching the electron beam evaporator, discharge it with the **grounding rod**.*

*There is a **danger of burns** at heated parts, especially at the crucible. Wear suitable protective gloves.*

***Danger from X-rays***
*The German x-ray ordinance (RöV1) - dated 8 January 1987 and amended of 30 April 2003 (BGBl. I S. 604) - refers to components that work with acceleration voltages under 10 kV and are therefore deemed sources of x-ray interference (5.1, Art. 2, RöV). Prerequisite for work with these x-ray sources are stainless steel chambers (wall thickness at least 5 mm) and window glass with a minimum thickness of 10 mm. The x-radiation outside the chamber is therefore less than 1 Microsievert per hour and therefore below the limit value for special safety precautions. The vacuum chamber must be mark with a sign stating that x-ray radiation is generated inside. The high voltage is not allowed to be extended above 10 KV.*

*It is advisable to have direct eye contact with the filament when working with the machine for the first time and after every maintenance job.*

*Pay attention when observing the work process to the **dangers** from **UV radiation** and the **dazzling** that can occur.*
*Wear protective goggles with suitably protective glasses (e.g.*

*welder's goggles).*

*Pay attention to the **dangers** from **magnetism** when using and handling the electron beam evaporator.*

*People with cardiac pacemakers (and with insulin pumps and people with active or passive prostheses and ferromagnetic or conductive foreign bodies) must keep clear of the electron beam evaporator!*
*The limits of how close they may approach the machine must be clearly marked.*

*When working with the electron beam evaporator (at the crucible when the vacuum chamber is open), pay attention to the **danger of crushing** when the crucible is rotated.*

## 4.2 Operating Areas and Danger Zones at the Machines

The **operating area** is defined by the operator (overall plant).

The **danger zone** during adjustment and maintenance work is the immediate area around the electron beam evaporator.

*The danger zone during adjustment, maintenance and repair work extends 1 m around the electron beam evaporator. The area needed to open the switch cabinet doors must be taken into account.*
*Keep the danger zone around the machine free of objects. Lay cables in such a way that they cannot be tripped over!*
*The operator must ensure that access to the **danger zones** by unauthorised persons is prevented.*

The danger zones may only be entered for cleaning, maintenance and repair work by skilled personnel under compliance with applicable safety regulations.

## 4.3 Operating and Maintenance Personnel

The operating and maintenance personnel are those people responsible for the transport, assembly, installation, operation, adjustment and cleaning of the machine as well as for troubleshooting.

1. The machine may only be operated by trained and authorised personnel.
2. The different responsibilities in the operation of the machine must be clearly defined and observed so that no confusion with respect to responsibilities arises, thus endangering safety.
3. Whenever any work (operation, maintenance, repair, etc.) is carried out, the shutdown procedure specified in this instruction handbook must be followed.
4. The operating personnel may not apply any working methods that impair the safety of the machine.
5. The operating personnel are co-responsible for ensuring that no unauthorised person works with or on the machine.
6. The operating personnel must immediately report any changes in the machine that impair its safety to the responsible executive.
7. The machine may only be operated when it is in perfect working order.
8. The operating personnel must be equipped with personal protective equipment as required by law and appropriate for the materials being processed.
9. The operator must regularly remind his operating personnel to wear personal protective equipment.

## 4.4 Spare and Wearing Parts

Spare parts and accessories that have not been supplied by us have also not been tested and approved by us. The fitting and/or use of such products could therefore negatively affect the design characteristics of your machine. FERROTEC GmbH accepts no liability for damages arising from the use of non-original parts and non-original accessories.
Standard parts can be bought through the specialised trade.
The spare parts list is to be found in the technical reference material.

The so-called tool kit contains two spare filaments, Viton O-rings and an assortment of small parts.
We recommend you keep a supply of the following spare parts in stock (e.g. when minimisation of downtimes is imperative):

| Quantity | Description | Part Number | | |
|---|---|---|---|---|
| | | EV M 6 | EV M 8 | EV M 10 |
| 1 | Filament block | 1-700310 | 1-700310 | 1-700310 |
| 1 | Filament set (5 pieces) | 1-703000 | 1-703000 | 1-703000 |
| 1 | Ceramic insulator | 1-700317 | 1-700317 | 1-700317 |
| 1 | Screw set, complete | 1-703022 | 1-703022 | 1-703022 |
| 1 | Filament clamp long | 1-700314 | 1-700314 | 1-700314 |
| 1 | Filament clamp short | 1-700315 | 1-700315 | 1-700315 |
| 1 | O-ring set | 1-931100 | 1-931103 | 1-931101 |
| 1 | Magnet current deflection system | 1-610800 | 1-611800 | 1-616800 |
| | | | | |

## 4.5 Shutdown Procedure

*The shutdown procedure may only be initiated by skilled personnel according to the definition in DIN EN 60 204 (see also chap. 3.5).*


*The following shutdown procedure must be followed before any cleaning, repair or maintenance work is carried out.*

1. *Switch off the high voltage power supply.*
2. *Vent the vacuum chamber.*

3. *Ground all high voltage feedthroughs with the discharge rod.*
4. *For maintenance and repair work, switch off the machine:*
   - *Switch the mains isolator (main switch) on the electric switch cabinet on to "0".*
   - *Lock the main switch with a padlock so that it cannot be switched back on again.*
   - *Make sure the machine is dead.*
   - *Ground the high voltage feedthroughs and high voltage conductors (supply line) with the discharge rod.*

5. *Shut off the cooling water supply:*
   - *Close the stop valve.*
   - *Lock the stop valve so that it cannot be opened again by mistake.*

*Close the open switch cabinet before cleaning so that water and dust cannot get inside it.*

*There is a danger to life and limb of the personnel if this procedure is not followed!*

# 5 Installation

## 5.1 Delivery Package

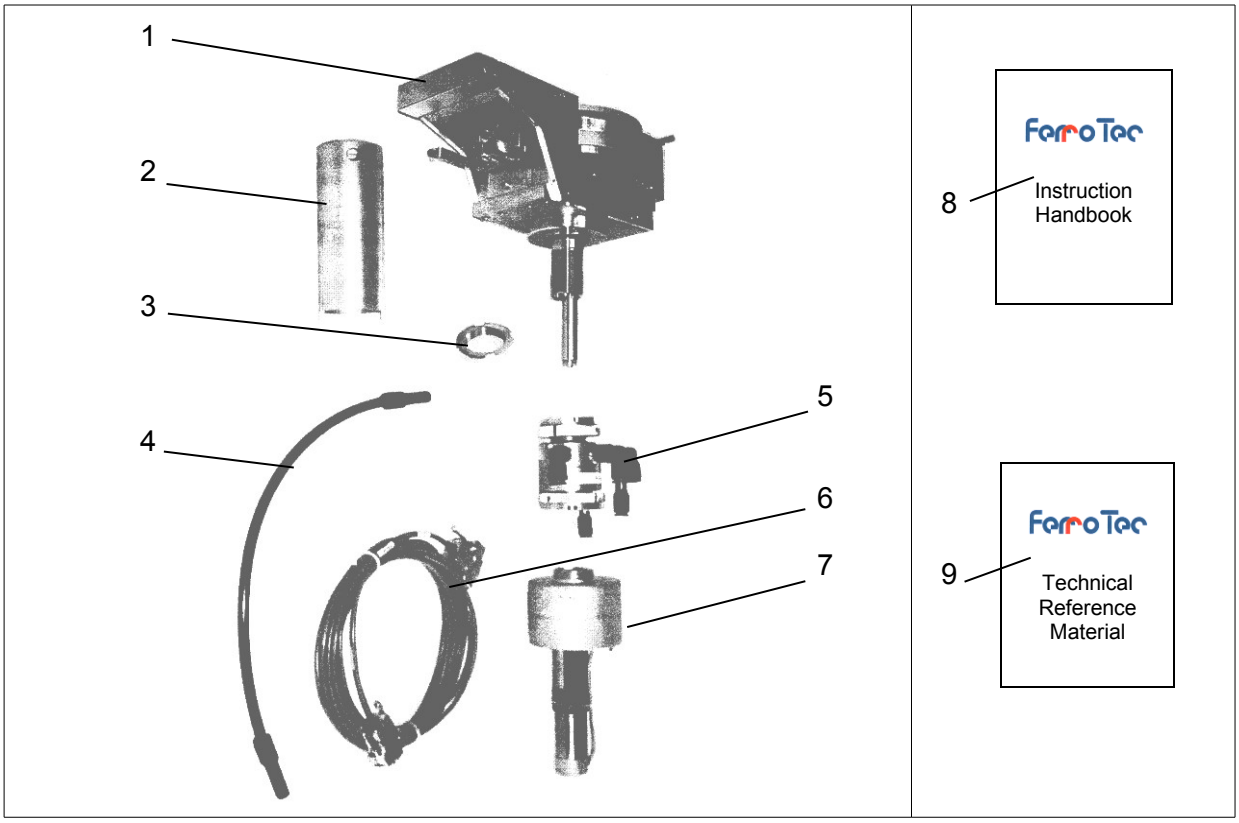



*Fig. 5-1 Delivery Package*

**The delivery package consists of:**

1 Base unit (evaporator and bottom feedthrough)
2 Pipe spanner
3 Grooved nut and spacer
4 Water hose
5 Water distributor
6 Drive cable
7 Drive unit
8 Instruction handbook
9 Technical reference material and tool kit (see fig. 5-2)

*A detailed specification of the delivery package is to be found in the acknowledgement of the order.*

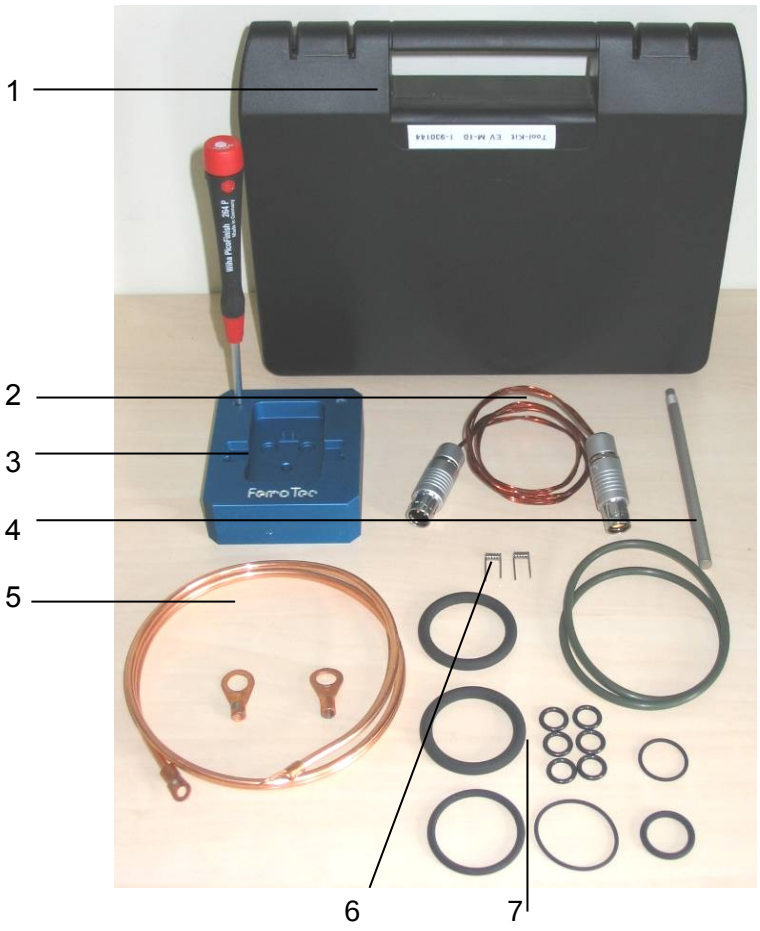



*Fig. 5-2 Tool Kit*

**The tool kit consists of:**

1 Case
2 Magnet current cable 0.25 mm² (incl. 3-pin Fischer plug)
3 Assembly tool with Allen key
4 Assembly rod
5 High voltage cable 1 x 10 mm
6 Filament
7 O-ring set

## 5.2 Transport and Packaging

Machines, devices and other equipment from FERROTEC GmbH are carefully inspected and packed before shipment.
Nevertheless, it is still possible that they might become damaged during transit.

### 5.2.1 Delivery (Also of Spare and Replacement Parts)

**Receiving Inspection:**
- Check the shipment against the packing list to ensure that it is complete!

**If the Packaging is Damaged**
- Check the shipment itself for damage (visual inspection)!

**Complaints**
If the shipment was damaged during transit:
- Immediately contact the last carrier!
- Keep the packaging material (for possible inspection or return shipment)!

**Packaging for Return Shipment**
Use the original packaging material as far as possible.
If it is no longer available:
- Use the services of a packaging company with skilled personnel.
- Consult FERROTEC GmbH should you have any questions on the packaging and protection of the machine for shipment.

## 5.3 Intermediate Storage

The freight packaging of the electron beam evaporator and spare and replacement parts is designed for a storage period of three months from delivery.

**Storage Conditions**
Closed and dry room with a room temperature of +5°C to +40°C.

## 5.4 Transport to Point of Installation (by Operator)

*Take the **weight** of the **transport unit** into account during transport (see technical specifications). The transport unit can tip over during transport. Pay attention to the **centre of gravity**.*

| | EV M - 6 | EV M - 8 | EV M - 10 |
|---|---|---|---|
| Weights (complete) | 12 kg | 15 kg | 30 kg |

With dismounted crucible and drive, the individual weights are under 15 kg.

*Pay attention to the **dangers** from **magnetism** when using and handling the electron beam evaporator.*

*People with cardiac pacemakers (and with insulin pumps and people with active or passive prostheses and ferromagnetic or conductive foreign bodies) may not be used to transport and install the electron beam evaporator.*

## 5.5 Additional Equipment (by Operator)

The following additional components must be installed together with the electron beam evaporator.
We presume that these components and modules are available on installation of the electron beam evaporator.

- **Power Supply**

We recommend the high voltage power supplies in the CARRERA series together with a GENIUS controller from FERROTEC GmbH.

- **High Voltage Feedthrough**

A dual terminal high voltage feedthrough (or two separate feedthroughs) must be designed for a filament current of 50 A at a maximum voltage of 10 kV. The FERROTEC high voltage dual terminal feedthrough is ideal for most high vacuum applications.

This pluggable and O-ring sealed unit is compatible with every hole with a diameter of 25 mm / 32 mm.

We recommend the dual high voltage feedthrough CF-40 for metallically sealed systems. It consists of a metal-ceramic unit with brass contact connectors on the atmosphere side.

*In all cases in which a FERROTEC high voltage feedthrough is not used the operator alone is responsible for reliable and safe connection of external and internal high voltage cables.*

- **Magnet Current Feedthrough**

A magnet current feedthrough is needed to supply the magnet current to the x and y-coils. The connector of the FERROTEC magnet current feedthrough is compatible with the evaporator unit and ideal for most high vacuum installations.
This O-ring sealed unit is available for holes 25 mm / 32 mm in diameter.
We recommend use of the FERROTEC controller GENIUS with integrated "Gun Rotation Card" (GRC). This controller contains the motor control and automatically evaluates the position signals of the evaporator.

*In all cases in which a FERROTEC drive unit is not used the operator is responsible for reliable and safe use of the crucible adjustment; this applies particularly to operation under high voltage.*

- **Sight Glass**

The vacuum chamber sight glass makes it possible to observe the evaporator/electron beam from outside. The sight glass should also grant a free view of the melting crucible. A chamber light would be advantageous for suitable mirror adjustment. The glass must be at least 10 mm thick to protect you against the x-rays arising during evaporation.
Should you be in doubt, contact your nearest FERROTEC representative immediately.

- **Interlock**

For safe and reliable use of the electron beam evaporator, a series of interlocks is needed to protect the life and health of the users and to secure the operability of the machine.

- **Chamber**

The status of the chamber door must be monitored by a chamber switch. If, for example, the chamber is open for inspection, maintenance work or a substrate change, a user could possible touch an unprotected high voltage line that is still live.

For this reason an interlock must be installed to ensure that all parts conducting high voltage are switched off when the chamber is open.

- **Vacuum Pressure**

A vacuum switch should be installed to ensure that the evaporation process is only enabled at a pressure below 1 x $10^{-3}$ mbar.

- **Water**

A flow controller must be installed in the water return line to ensure a minimum flow is maintained during operation. We recommend the FERROTEC flow controller. The recommended water flow rate is 6-10 l/min.

- **Crucible Position**

If the crucible is not in the right position, the emission current must be interrupted by a safety circuit to prevent damage to the crucible.

We recommend you use the "pocket-in-position" signal supplied by the evaporator positioning unit and processed automatically in the GENIUS controller for this.

- **Interlock Switches**

Please use only volt-free make-contacts for all interlock switches so that faults due to defective cables are also detected. Should you have any questions in this regard, please contact FERROTEC Service for further support.

## 5.6 Assembly, Installation

Assembly and initial start-up must be carried out by skilled personnel from FERROTEC GmbH or the customer's skilled personnel who have been especially trained for this work.

Consult the instruction handbook and technical reference material supplied for assembly and installation of the electron beam evaporator.

### 5.6.1 Assembly

- **Evaporator**

The evaporator must be mounted on the base plate in such a way that it is aligned to the substrate for homogenous coating and is electropositively grounded. A hole 32 - 34 mm in diameter with vacuum-side ground surface for an O-ring gasket is needed in the base plate. The maximum thickness allowed for the base plate is 38.5 mm.

---

*The evaporator must be electropositively grounded with a cross-section of at least 20 $mm^2$.*

---

- **Sight Glass**

Make sure you can see the electron beam hitting the crucible through a sight glass. Protect your sight glass against coating by the evaporation material with, for example, a mirror or a protective screen.

---

*The window glass must be at least 10 mm thick to protect against x-rays. Obey your local radiation protection regulations in this regard.*

---

- **Screen**

The screen plate must be mounted at least 30 mm above the top edge of the gun. It must not block the view through the sight glass.

- **Magnet**

The distance between the evaporator and any magnetisable materials should be at least 50 mm.

*Check the chamber bottom for magnetic properties. The evaporator must not be mounted on a magnetic base plate.*

If the magnetic field is weakened by mounting of the evaporator on a magnetic base plate, this will cause a malfunction in the beam deflection that cannot be detected by the safety equipment. The electron beam will then, for example, not be directed into the crucible, but at the chamber roof.
This can cause **damage** to all components.

*If the base plate is made of magnetic steel, you can avoid a magnetic short circuit by placing 10 mm spacers under the evaporator base plate. Proceed carefully when using the machine for the first time and check whether the electron beam also lands in the middle of the crucible when working with high voltage.*

- **Water Line**

The cooling water lines must be suitable for a flow of 8 l/min. at 20°C (room temperature) and a pressure of 4-6 bar. A flow controller must be installed in the **outlet circuit** so that it can also detect a leak in the water system of the evaporator. The cooling water outflows should not have any reflux. It must be ensured that chemical contamination in the water does not obstruct the water flow in any way and also does not attack solder joints, which could lead to leaks.

*Make sure that the water pressure at the water inlet does not exceed 6 bar. Magnetically controlled flow valves can lead to peaks in the water pressure.*

- **High Voltage**

Place the high voltage feedthrough in such a way that the length of the necessary supply line does not exceed 150 - 200 mm. Excessively long supply lines exacerbate the problem of adequate HV shielding, while supply lines that are too short conduct too much heat from the filament block to the HV feedthrough. The high voltage cables should be laid in parallel and with a minimum distance of 10 mm from the floor. All high voltage conductors must be protected against ion bombardment. This can be achieved with a cover (e.g. of stainless steel) that is adequately grounded.

*Do **not** use magnetic material for shielding. If stainless steel has to be used, use a non-magnetic material that is not thicker than 0.5 mm.*

- **Magnet Current**

The magnet current cables must be suitable for a current of 3 A, i.e. have a cross-section of at least 0.25 $mm^2$. The magnet current cables may **not** be grounded. The cable insulation must be vacuum compatible. Please work with Kapton or Teflon insulation for high voltage applications. Magnet current cables must be laid as far away as possible from high voltage cables. **Never** lay magnet current cables parallel to high voltage cables!

- **Grounding**

The evaporator must be grounded with a cable with a cross-section of at least 20 $mm^2$. Use the chamber bottom as grounding point. Keep the grounding lines as short as possible and do not form ground circuits.

- **Safety**

All necessary safety switches must be installed and operative before you start the evaporator. Please also obey the instructions in the instruction handbooks for the power supplies.

## 5.6.2 Installation

- **Base Plate**

– The evaporator should be mounted on a well-grounded base plate. Select the position of the evaporator and corresponding feedthroughs carefully. The holes for the feedthroughs should be selected in such a way that the feedthroughs can be connected easily.
– Select the location of the evaporator in relation to the location of the substrate. A hole 32 - 34 mm in diameter with a vacuum-side sealing face is needed for this.
– Select the location for the high voltage feedthrough near the evaporator, but not in front of the filament block.
– Select the location for the magnet current feedthrough near the evaporator so that the magnet current cables are kept as short as possible.
– Select a location for the feedthrough for the screen. The screen plate must be mounted at least 30 mm above the highest point of the gun and may not block the view of the selected crucible.
– Prepare **grounding points** at which you can ground the evaporator and accessories.
– Prepare holders for fastening of **shielding plates**. The shielding plates must be grounded.
– Finish all mechanical work on the base plate and holes for the feedthroughs.

- **Evaporator**

Install the evaporator in the following steps A – D
(see also fig. 5-1).

**A** Unscrew the water distributor with drive unit from underneath the evaporator by unscrewing the large nut on the top side of the water distributor. Unscrew the drive unit by unscrewing the nut of the water distributor above it. Remove the nut and washer from the base unit. Clean the O-rings carefully. Proceed in exactly the same way with the threads of the feedthrough, base plate and holes for the feedthroughs. Use acetone or other alcoholic solutions for this if possible.

Do not use a lubricant or fat. Do not, however, remove the grease on the drive shaft of the evaporator.

**B** Carefully clean all parts of the vacuum unit and all associated elements. Use acetone, methanol or other alcoholic solutions to clean dirt on the surface. Pass the feedthrough through the base plate. Make sure that the filament block (beam exit) points in the direction you want. The O-ring of the feedthrough seals the evaporator on the vacuum-side surface of the base plate. Fit the spacer and nut on the feedthrough from underneath the base plate. Fasten the nut with the pipe spanner delivered with the evaporator.

**C** Push the water distributor carefully on to the drive shaft. Align the water distributor so that the small O-rings on the top side are flush with the corresponding pipe ends of the feedthrough.

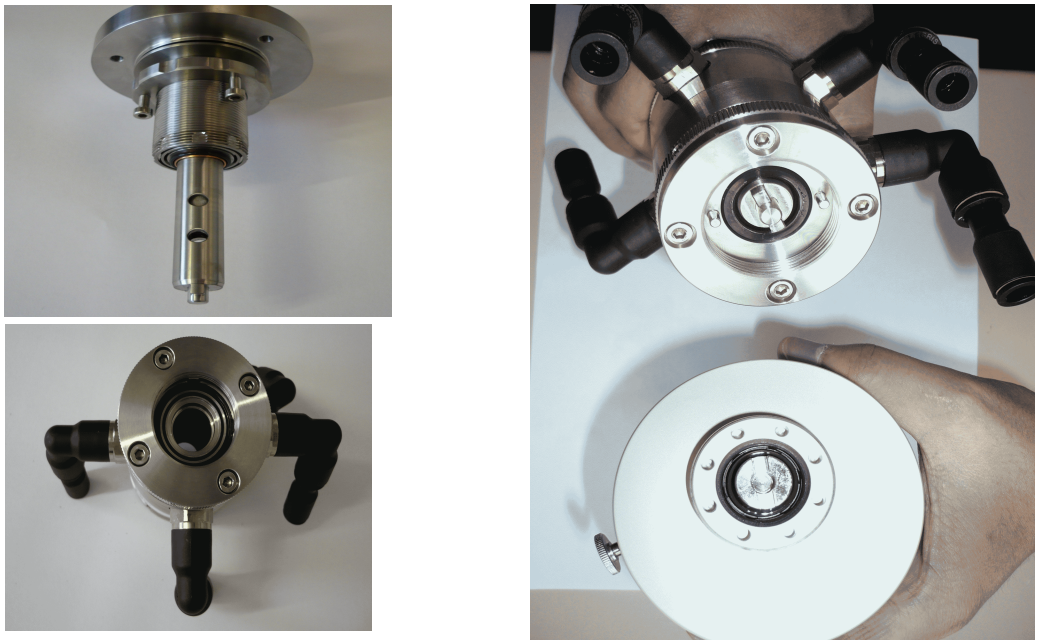


*Fig. 5-3 Installation Water Distributor – Shaft*

Then screw the water distributor on to the feedthrough with the top union nut of the distributor.

**D** Connect the drive unit to the water distributor from below and fasten loosely with the bottom groove on the water distributor. Turn the crucible until the stud at the end of the crucible shaft catches in the groove of the motor-side shaft. Fasten the drive unit with the bottom union nut of the water distributor. See fig. 17 for alignment of the crucible position. Install the feedthroughs for the magnet current, high voltage and screen.

- **Cooling Water**

Connect all water connections and make sure that none of the connections leak. Connect the supply line to the connection marked "CR IN" (**C**rucible **In**). Use the water hose to connect the crucible outlet "CR OUT" with the plug connection for the top part of the source (marked "MAGNET") in series.
Connect the cooling water outlet to the second plug connector of the magnet connection (marked "MAGNET", direction-independent).
For a higher flow rate or better cooling at high powers (> 5 kW), please use an additional cooling circuit for the crucible and for the top part of the source.
The evaporator needs a cooling water flow of at least 6 l/min.
**Never run the evaporator without suitable cooling.**

For these reasons the evaporator should be equipped with a flow safety switch mounted in the outlet. A sieve filter should also be fitted in the inlet. The flow controller should be set so that it responds at a flow rate less than 6 l/min.
You can obtain such a switch from FERROTEC.

*To avoid damage to the evaporator, it is more important to guarantee an adequate flow of water than to worry about the temperature of the cooling water in the outlet. Luke warm water (max. 40°C) does not damage the evaporator.*

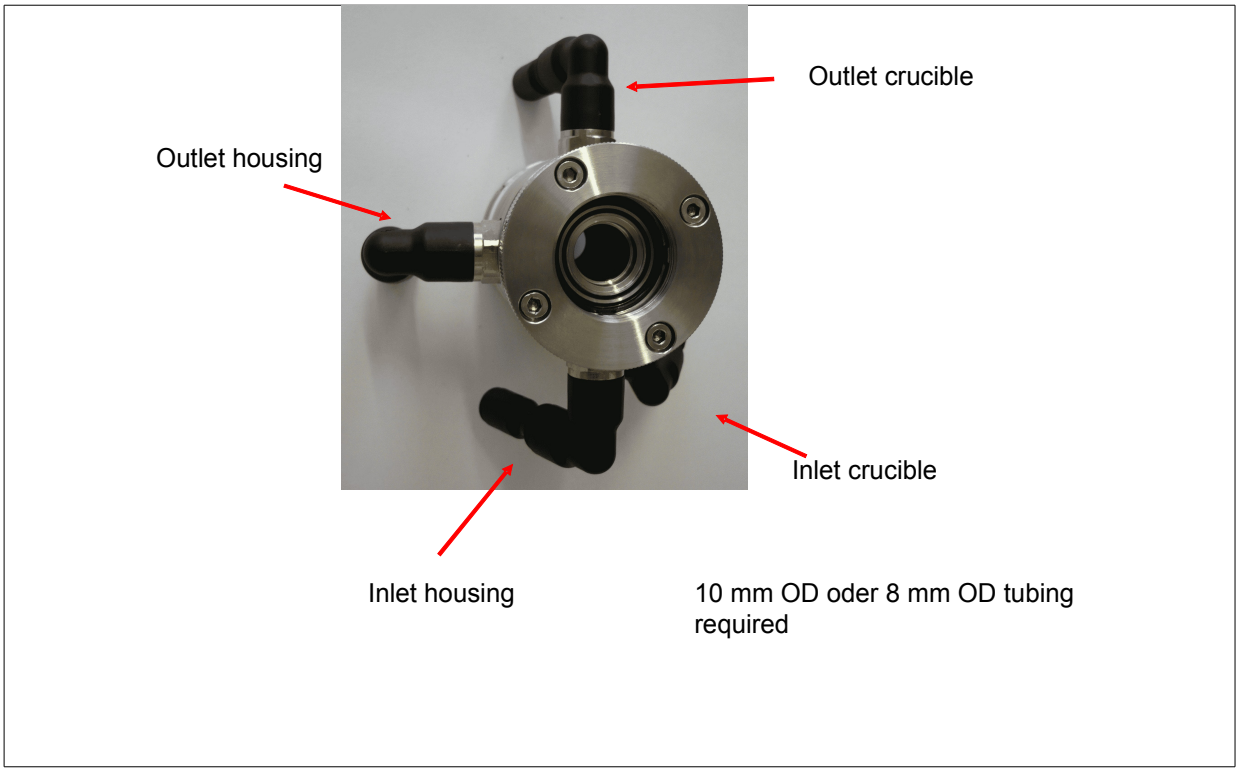



*Fig. 5-4 Cooling Water Connection*

- **Magnet current cable**

Connect the magnet current feedthrough to the magnet current socket on the evaporator with the help of the magnet current cable from the tool kit. The maximum current needed is ± 3 A.

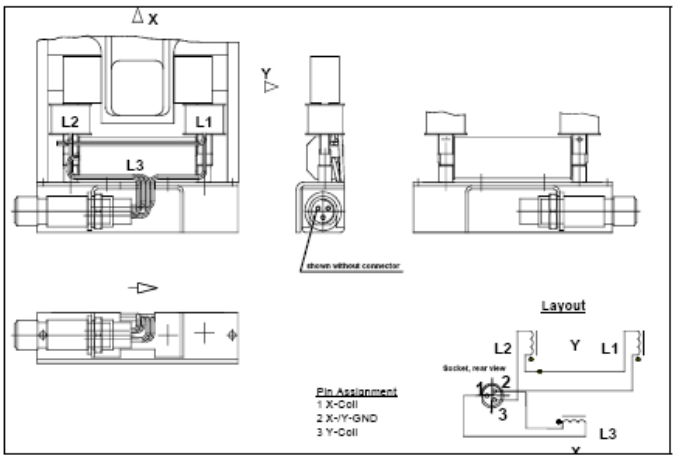



*Fig. 5-5 Connection Diagram for Magnet Current Socket*

If you do not have a standard cable from FERROTEC, use Teflon or Kapton-coated cables with a minimum cross-section of 0.25 $mm^2$.
Magnet current cables should be laid as far away as possible from and never parallel to high voltage cables.

*Magnet current cables should be replaced once a year to avoid unforeseeable short circuits as a result of worn-out cable insulation. Even Teflon-insulated cables become brittle over time as a result of the constant bombardment with ions and the effects of heat.*

- **High Voltage Cable**

Connect the high voltage feedthrough to the connection terminals of the filament block. Bright copper wire (10 $mm^2$; contained in the tool kit) has a good conductivity and guarantees sufficient stiffness. The high voltage supply line should be kept as short as possible; preferably approx. 200 mm. Lay the supply line parallel to and with a minimum distance of 10 mm from the base plate.

- **Shielding**

Install grounded shielding plates in a wide area surrounding the evaporator to protect the (high voltage conducting) parts underneath against the constant bombardment with ions and against coating. The shielding plates should have a minimum distance of 10 mm from the high voltage cables and the feedthroughs. Use non-magnetic stainless steel plates by preference.

*Make sure that the space underneath the shielding plate can be pumped down.*

- **Shutter**

Install the shutter. Adjust the shutter in "closed" state to protect the substrate reliably against coating.

- **Interlocks**

Check all interlocks for the power supply for correct mode of operation.

- **External Cables**

Connect the HV and magnet current cables to the power supplies as described in their instruction handbooks.

- **Additional Components**

If the vacuum chamber also has ungrounded resistance heaters, ground a connection point of the heater or current feedthrough. Make sure by grounding at other components that no high voltage potential is passed to the outside. Ungrounded components can become charged with high voltage potential during operation of the evaporator. This voltage can possibly also reach the outside through connected feedthroughs. Arcs caused by short circuits across insulating layers or parts can also damage the equipment.
Electron beam evaporators work with very high currents with regard to grounding. They are able to charge ungrounded components with dangerously high currents. Potential-free components, e.g. a resistor and its connected feedthroughs or connected cables, can be charged electrically to such an extent that touching them can be **fatal**.

---

*Remember that although many components work with small voltages, they can when working with **high voltage** be charged to its potential. Therefore switch off the high voltage and ground all electric feedthroughs / lines with a **grounding rod** before coming close to them (< 50 mm).*

---

- **Final Inspection**

Check the complete system to make sure that all lines are connected and properly tight and that **no** HV and magnet current cables are grounded.
Check also that all interlocks are connected, especially:

**water interlock**
**safety interlock**

# 6 Function and Operation

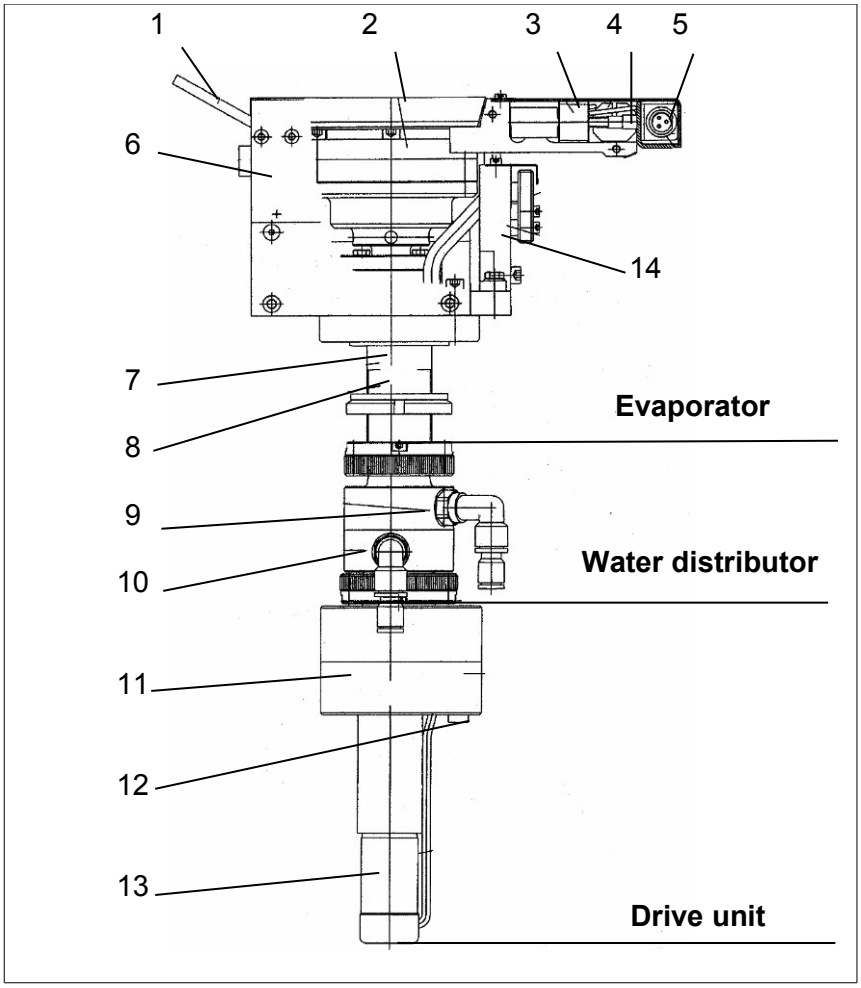



*Fig. 6-1 Overview (Example)*

| **The EV M – 6, 8 and 10 electron beam evaporators consist of the following main components:** | | | |
|---|---|---|---|
| 1 | Crucible cover | 8 | Rotary feedthrough |
| 2 | Crucible | 9 | Water outlet |
| 3 | Y-coil | 10 | Water inlet |
| 4 | X-coil | 11 | Positioning unit |
| 5 | Magnet current connection | 12 | Drive socket |
| 6 | Magnet (concealed shunt) | 13 | Motor |
| 7 | Feedthrough | 14 | Filament block |

The **mode of operation** of a

FERROTEC electron beam evaporator with a FERROTEC – CARRERA high voltage power supply and FERROTEC – GENIUS deposition controller is described below.

**Bidirectional Deflection; Definition**
It is presumed that the x/y magnet deflection is already integrated in the deposition controller as in the GENIUS.

See the following fig. 6-1 for definition of x (longitudinal) and y (lateral) direction.

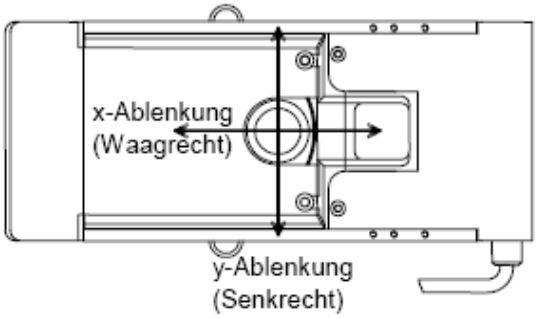



*Fig. 6-2 Definition of Beam Deflection*

All FERROTEC electron beam evaporators are defined according to this logic. For further information, see the instruction handbooks for the power supplies.

***Warning***

- ***Never** touch (vacuum) parts connected to the HV cables before you have discharged them with the **grounding rod**.*
- *When you work on the vacuum chamber, check **beforehand** whether the **mains power switch** for the high voltage is off and the power supply has been disconnected reliably.*
- *Always check whether **all safety switches** are connected and in working order before trying to operate the **evaporator**.*
- ***Never** bypass the **safety switches**!*
  *Work on the vacuum chamber presupposes that the complete high voltage power supply including the supply l ine outside the chamber is properly installed, protected against touch, switched off and interlocked.*

*You can also obtain TÜV-tested grounding rods from FERROTEC.*

## 6.1 Initial Start-Up

Make sure that you have a free view of the position of the electron beam and of the heating spiral (filament) through the sight glass.

- **Crucible Liner**

Select a pocket and turn the crucible to the selected position. Use a crucible liner if necessary.

| Material | Use |
|---|---|
| Melting | Generally you will obtain significantly higher vacuum evaporation rates at the same operating power with a crucible liner than with evaporation without liner. Crucible liners are also advantageous for high-grade materials such as, for example, gold. |
| Non melting | Crucible liners have no special benefits if melting or subliming materials are not used. In this case the crucible liners reduce the volume of the pocket, possibly cause contamination during vacuum evaporation and demand additional care by the user to avoid damage. |

***Indium***
*Always use a $TiB_2$ crucible liner for indium because this material alloys even with a water-cooled crucible, thereby damaging the evaporator.*

- **Evaporation Material**

Fill the crucible of your choice with the evaporation material. If you have a free choice for your first work cycle, choose aluminium. This material evaporates excellently at emission currents of 150 mA and higher.
If you are restricted to only a small quantity of material (e.g. ultra-pure material), use the material with the best evaporation rate.
If you are restricted to a material with a very high rate/emission current ratio, e.g. magnesium fluoride, start evaporation carefully with 5 - 20 mA.

The crucible should generally not be filled with material by more than 2 mm above the crucible edge and at least one-third of the crucible volume should remain filled during the process.

- **Magnetic Shunt**

Install so-called magnetic shunts above the permanent magnet of the evaporator according to the high voltage mainly used in the process.

| | |
|---|---|
| 2 shunts | high voltage < 7kV |
| 1 shunt | 7 kV < high voltage < 9 kV |
| No shunt | high voltage > 9 kV |

*The x-position of the beam depends on the high voltage used during the process.*

- **Pump Down**

Pump the vacuum chamber down to a pressure of less than 5 x $10^{-4}$ mbar.

- **Water**

Switch on the water cooling system. Make sure the flow rate in the cooling circuit is not less than 6 l/min.
Use the remote control if possible to control the process you can observe through the sight glass.

- **High Voltage**

Switch on the filament heater and high voltage.

- **Limits**

Set the LIMITS for the deflection currents for the electron beam. Increase the emission current slowly until the electron beam can be seen in the crucible.

*If you cannot find a fluorescent beam impact point, **do not increase the emission current**, but change the LIMITS accordingly.*
*If this does not help you find the beam, switch off your power supply and go through all the installation steps again. Also consult the troubleshooting guide (see chap. 9 "Troubleshooting").*

As long as your x-deflection current is not set correctly, you will not find your beam spot exactly in the middle of the crucible.
Look for fluorescent luminous phenomena, caused by secondary excitation, behind the electron beam.
As long as the emission current remains under 50 mA in the case of aluminium (without crucible liner), there is not enough energy available to heat the evaporation material sufficiently.
**Do not exceed an emission current of 50 mA.**

*Only direct the electron beam at an adequately full crucible. The energy density of the beam is so strong that it can melt through any material, which can result in damage to components accompanied by vacuum or water leaks.*
*Switch the current off immediately if the edge of the anode plate near the filament becomes glowing red. Air the vacuum chamber and inspect the parts of the filament block (see setting of the filament block in chap. 8 "Maintenance").*

If the filament block is aligned correctly, no signs of heating should be seen on the anode plate.

- **Electron Beam**

Adjust the deflection current until the electron beam can be seen exactly in the middle of the evaporation material.

- **Dynamic Deflection**

Adjust the AMPLITUDE setpoint until the width of the electron beam in x and y-direction fits the evaporation material. Also consult the documentation delivered with your controller in this regard.
Adjust the other parameters for beam deflection (FREQUENCY, WAVEFORM, ...) to your requirements.

- **Evaporation**

Increase the emission current to bring the evaporation material to evaporate.
As soon as the material evaporates, adjust the emission current to obtain the required rate of evaporation.

*Use a thickness/rate monitor or controller to control evaporation.*

*Observe the position and deflection of the electron beam constantly during the evaporation process.*
*The beam should never strike outside the adequately filled crucible.*

# 7 Operation

*The system may only be operated by skilled personnel who are qualified and trained to operate it.*

## 7.1 System Overview

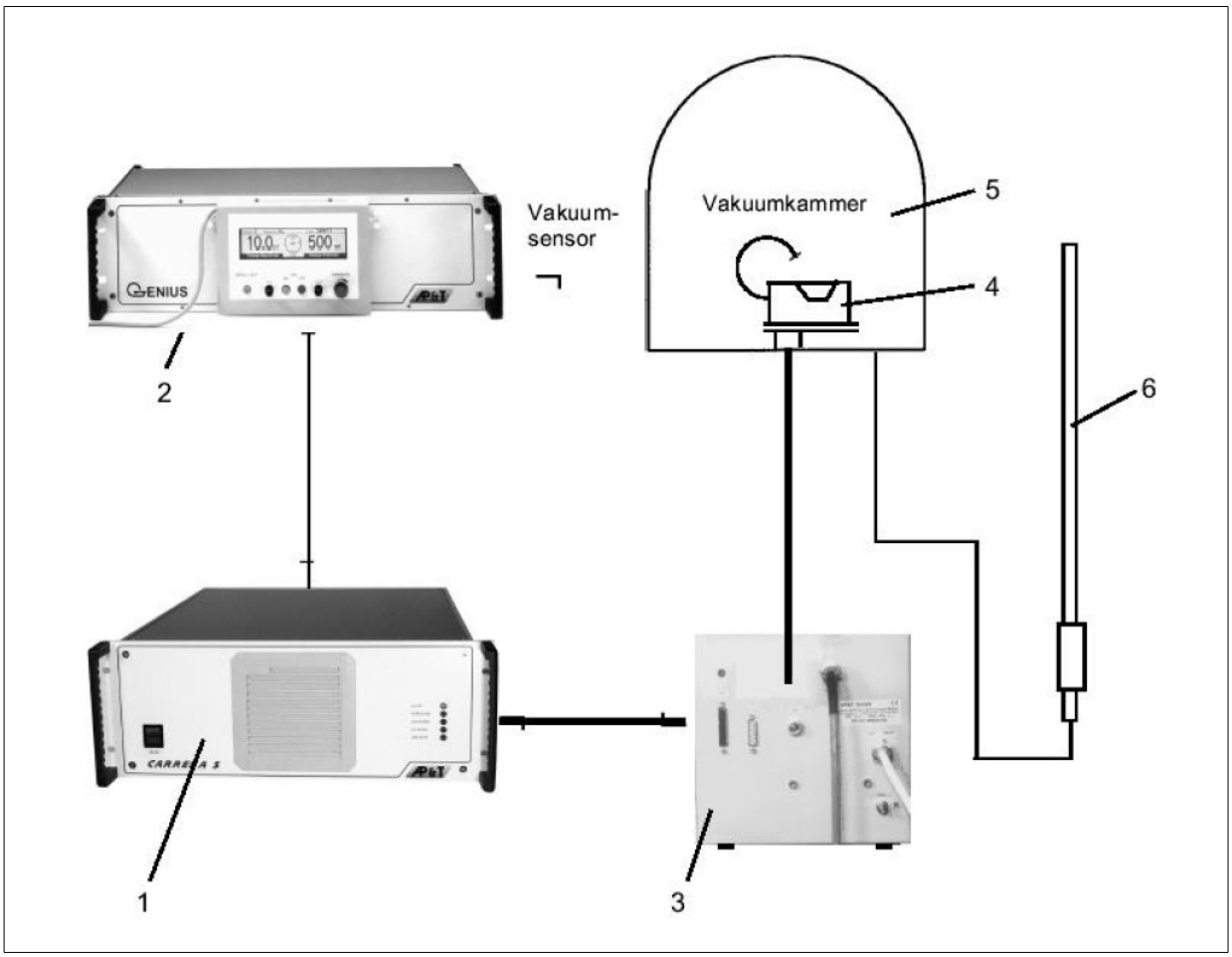



*Fig. 7-1 System Overview*

**System Overview**

1 High voltage power supply
2 Controller
3 Filament power supply
4 Electron beam evaporator
5 Vacuum chamber (by operator)
6 Grounding rod

*The components shown in fig. 7-1 are needed to operate the electron beam evaporator. They come with their own instruction handbooks, which must be followed.*

## 7.2 Modes of Operation

*The modes of operation are described in the separate instruction handbooks of the components making up the system.*

# 8 Cleaning / Maintenance

*The chapter **Cleaning / Maintenance** is intended for skilled personnel only. Maintenance, cleaning and repair work may only be carried out by skilled personnel.*

**Skilled Person**
A person with relevant technical training, know-how, experience and knowledge of applicable standards to enable him or her to assess the work assigned to him or her and to perceive potential risks.

**The above definition is based on EN 60204-1.**

*The operating and maintenance personnel are trained in the use of the electron beam evaporator at its point of installation by personnel from FERROTEC GmbH.*
*Should you have any questions or be uncertain about anything, please contact FERROTEC GmbH.*

For trouble-free operation of the electron beam evaporator it is absolutely essential that it is cleaned and serviced at regular intervals.

*Maintenance and cleaning of **vendor components** (e.g. drive motor) are described in their manufacturer's separate **instruction handbooks**. They are contained in the technical reference material.*

*Pay attention to the **dangers** from **magnetism** when using and handling the electron beam evaporator.*

*People with cardiac pacemakers (and with insulin pumps and people with active or passive prostheses and ferromagnetic or conductive foreign bodies) may not be used to clean and service the electron beam evaporator.*

*The shutdown procedure may only be initiated by skilled personnel according to the definition in DIN EN 60 204 (see also chap. 3.5).*


*The following shutdown procedure must be followed before any cleaning, repair or maintenance work is carried out.*

1. *Switch off the high voltage power supply.*
2. *Vent the vacuum chamber.*

3. *Ground all high voltage feedthroughs with the discharge rod.*
4. *For maintenance and repair work, switch off the machine:*
   - *Switch the mains isolator (main switch) on the electric switch cabinet on to "0".*
   - *Lock the main switch with a padlock so that it cannot be switched back on again.*
   - *Make sure the machine is dead.*
   - *Ground all high voltage feedthroughs with the discharge rod.*

5. *Shut off the cooling water supply:*
   - *Close the stop valve.*
   - *Lock the stop valve so that it cannot be opened again by mistake.*

*Close the open switch cabinet before cleaning so that water and dust cannot get inside it.*
*There is a danger to life and limb of the personnel if this procedure is not followed!*

*The times specified in this instruction handbook are based on one-shift operation (8 hours/day, 22 days/month, 12 months/year).*

| | | | | | |
|---|---|---|---|---|---|
| ***D*** | = | *Daily* | *½ Y* | = | *Half-yearly* |
| ***W*** | = | *Weekly* | *Y* | = | *Yearly* |
| ***M*** | = | *Monthly* | *W.Hr.* | = | *Work hours* |
| *¼ Y* | = | *Quarterly* | *MIH* | = | *Manufacturer's instruction handbook* |

## 8.1 Complete Daily Cleaning

*The shutdown procedure must be followed before any cleaning, maintenance or repair work is carried out (see chap. 4.5).*
*Do not use sharp objects or tools to clean the machine unless they are explicitly intended for this purpose.*

## 8.2 Maintenance

*During maintenance work beware of the **danger of electric shock!***

*During cleaning and maintenance work on the electron beam evaporator (on the crucible when the vacuum chamber is open) beware of the **danger of crushing** when turning the crucible.*

*The electric motor at the gun must be serviced according to its manufacturer's instructions. These instructions are contained in the technical reference material.*

### 8.2.1 Function Test Plan

| | Interval for One-Shift System | | | | |
|---|---|---|---|---|---|
| | **W** | **M** | **½ Y** | **y** | **MIH** |
| Emergency stop system (emergency stop buttons) | | **X** | | | |
| Mains isolator (main switch) | | | | **X** | |
| Check all electric terminal and plug connections | | | **X** | | |
| Settings on the safety circuit-breakers | | | | **X** | |
| Push buttons and switches on the switch cabinet | | **X** | | | |
| Check all plug, screw and clamped joints for firmness and tighten if necessary | | | | **X** | |
| Check pneumatic components for working order and leaks | **X** | | | | |
| Function check of the electric drives | | | | | **X** |
| Check the cooling water system for working order | | **X** | | | |

### 8.2.2 Inspections

1. Carry out a visual inspection of the switch cabinet.
   Check:
   - the wiring for kinks, abrasions and burns,
   - the covers and insulation for damage,
   - the switch cabinet doors for ease of movement.

2. Carry out a function test of all subassemblies in setting mode and in manual mode.

If all the functions work properly, the **machine is handed over** to the operating personnel.

## 8.3 General Maintenance Instructions

***Warning***

- *Never touch (vacuum) parts connected to the HV cables before you have discharged them with the grounding rod.*
- *When you work on the vacuum chamber, check beforehand whether the mains power switch for the high voltage is off and the power supply has been disconnected reliably.*
- *Always check whether all safety switches are connected and in working order before trying to operate the evaporator. Never bypass the safety switches!*

*Work on the vacuum chamber presupposes that the complete high voltage power supply including the supply line outside the chamber is properly installed, protected against touch, switched off and interlocked. You can also obtain TÜV-tested grounding rods from FERROTEC.*

## 8.3.1 Evaporator Unit

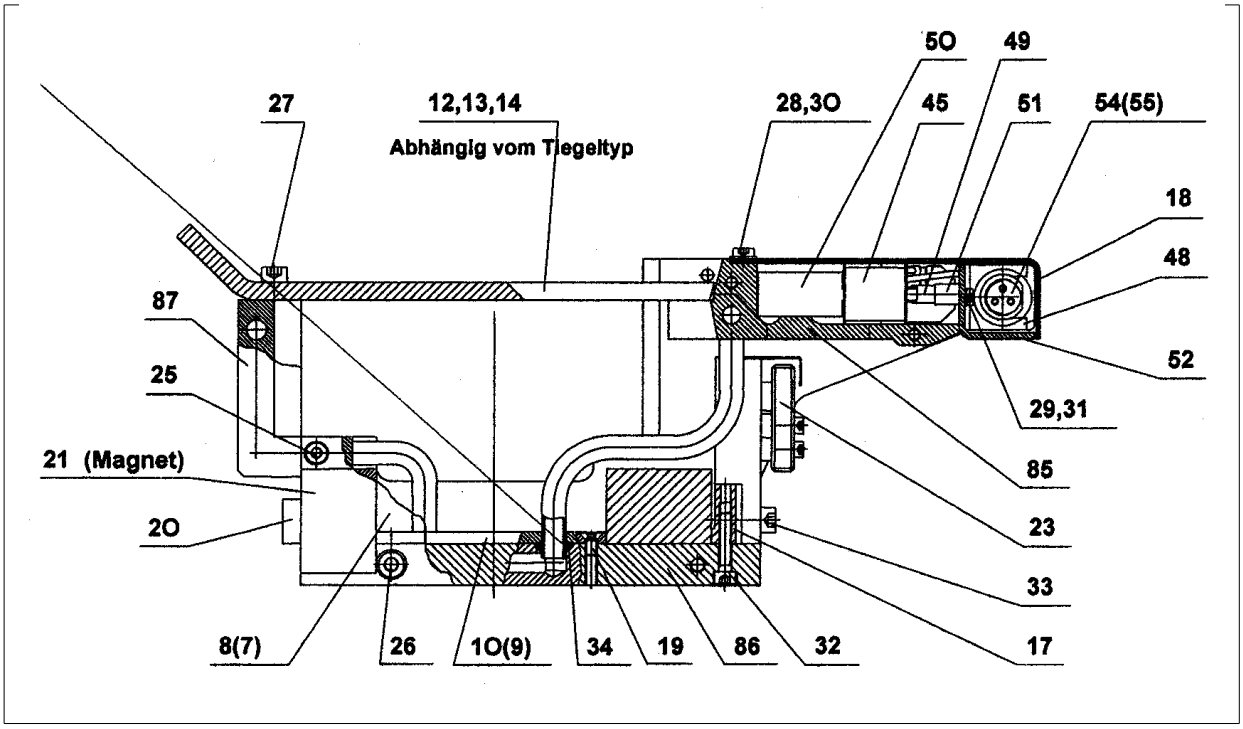
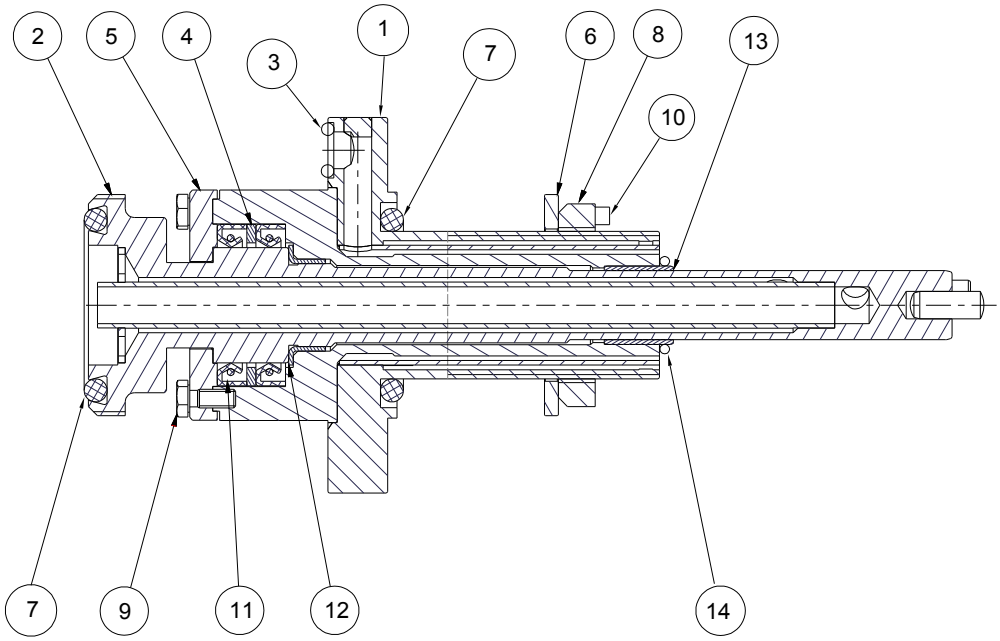



*Fig. 8-1 Evaporator Unit*

| *Item* | *Qty.* | *Description* | *Part No.* | *Part No.* | *Part No.* |
|---|---|---|---|---|---|
| 8-1 | 1 | Evaporator | 1-610000 | 1-611100 | 1-616000 |
| 7 | 1 | Pole piece, left | | | |
| 8 | 1 | Pole piece, right | 1-610909 | | |
| 9 | 1 | Pressure lug, left | 1-610110 | | |
| 10 | 1 | Pressure lug, right | | | |
| 12 | 1 | Cover plate ( 1-Pocket ) | 1-610707 | 1-611707 | 1-616704 |
| 12a | 1 | Cover plate ( 1-Pocket – special shape ) | 1-610708 | 1-611708 | -- |
| | 1 | Cover plate ( 2-Pocket ) | 1-610703 | -- | -- |
| | 1 | Cover plate ( 3-Pocket ) | 1-610704 | -- | -- |
| | 1 | Cover plate ( 4-Pocket ) | 1-610102 | 1-611702 | 1-616701 |
| | | Cover plate ( 5-Pocket ) | -- | 1-611709 | -- |
| | 1 | Cover plate ( 6-Pocket ) | 1-610701 | 1-611701 | 1-616702 |
| | 1 | Cover plate ( 8-Pocket ) | 1-610706 | 1-611706 | 1-616703 |
| | 1 | Cover plate ( 8-Pocket – soldered ) | -- | -- | 1-616705 |
| | 1 | Cover plate ( 12-Pocket ) | 1-610705 | 1-611712 | |
| 17 | 1 | Filamentblock-stop-plate | 1-610103 | 1-611103 | |
| 18 | 1 | Coil cover | 1-610104 | 1-611104 | |

| | | | | | |
|---|---|---|---|---|---|
| 26 | 4 | Allen head screw M5x8 DIN 7984-A2 | | | |
| 27 | 2 | Allen head screw M5x16 DIN 912-A4 | | | |
| 28 | 2 | Allen head screw M4x8 DIN 7984-A2 | | | |
| 29 | 2 | Allen head screw M3x8 DIN 7984-A2 | | | |
| 30 | 2 | Washer 4.3 DIN 125 | | | |
| 31 | 2 | Washer 3.2 DIN 433-A2 | | | |
| 32 | 4 | Allen head screw M4x8 DIN 912-A2 | | | |
| 33 | 1 | Allen head screw M4x8 DIN 912-A2 | | | |
| 34 | 4 | O-ring 8.00-2.00 70 NBR/769 | | 0-601 124 | |
| 48 | 1 | Box holder | | 1-610 805 | |
| 49 | 1 | X-magnet coil | | 1-610 803 | |
| 50 | 2 | Y-magnet coil | | 1-610 804 | |
| 51 | 2 | Spacer | | 1-610 806 | |
| 52 | 1 | Front plate | | 1-610 807 | |
| 54 | 1 | Magnet current socket, 3-pin | | 1-610 808 | |
| 55 | 1 | Magnet current plug, straight 3-pin | | 1-610 809 | |
| 85 | 1 | Top part, soldered | | 1-611 111 | |
| 86 | 1 | Base plate, soldered | | 1-611 101 | |
| 87 | 1 | Cooling block, soldered | | 1-611 112 | |
| | | | | | |

## 8.3.2 Rotary Feedthrough

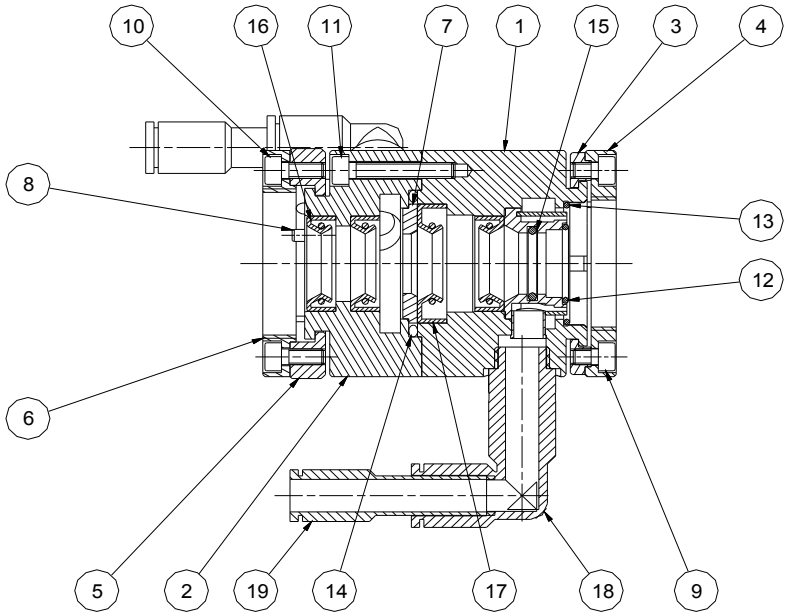



**The rotary feedthrough consists of the following components**

| Position | Amount | Description | Partnumber |
|---|---|---|---|
| 1 | 1 | Feedthrough | 1-610301 |
| 2 | 1 | Shaft , complete | 1-610310 |
| 3 | 2 | O-Ring 8,00-2,00 70NBR/769 | 0-601124 |
| 4 | 1 | Spacer | 1-610302 |
| 5 | 1 | Flange, split | 1-610303 |
| 6 | 1 | Washer | 1-610304 |
| 7 | 2 | O-Ring 32 x 5 70NBR/769 | 0-601786 |
| 8 | 1 | Knurled Nut | 1-786504 |
| 9 | 4 | Hexscrew M4x12 DIN 933-A2 | |
| 10 | 3 | Allenscrew M4x 16 DIN 912 A2 | |
| 11 | 2 | Shaft Seal Ring 25 x 35 x 7 72 NBR/902 st.steel spring | 1-040905 |
| 12 | 1 | Clamp Bushing Dia. 15/15 long | 1-610306 |
| 13 | 1 | Bushing Dia. 18/8 long | 1-610305 |
| 14 | 1 | O-Ring 17 x 1,5 70NBR/769 | 0-601077 |

## 8.3.3 Water Distributor

*Fig. 8-3 Water Distributor (Example)*

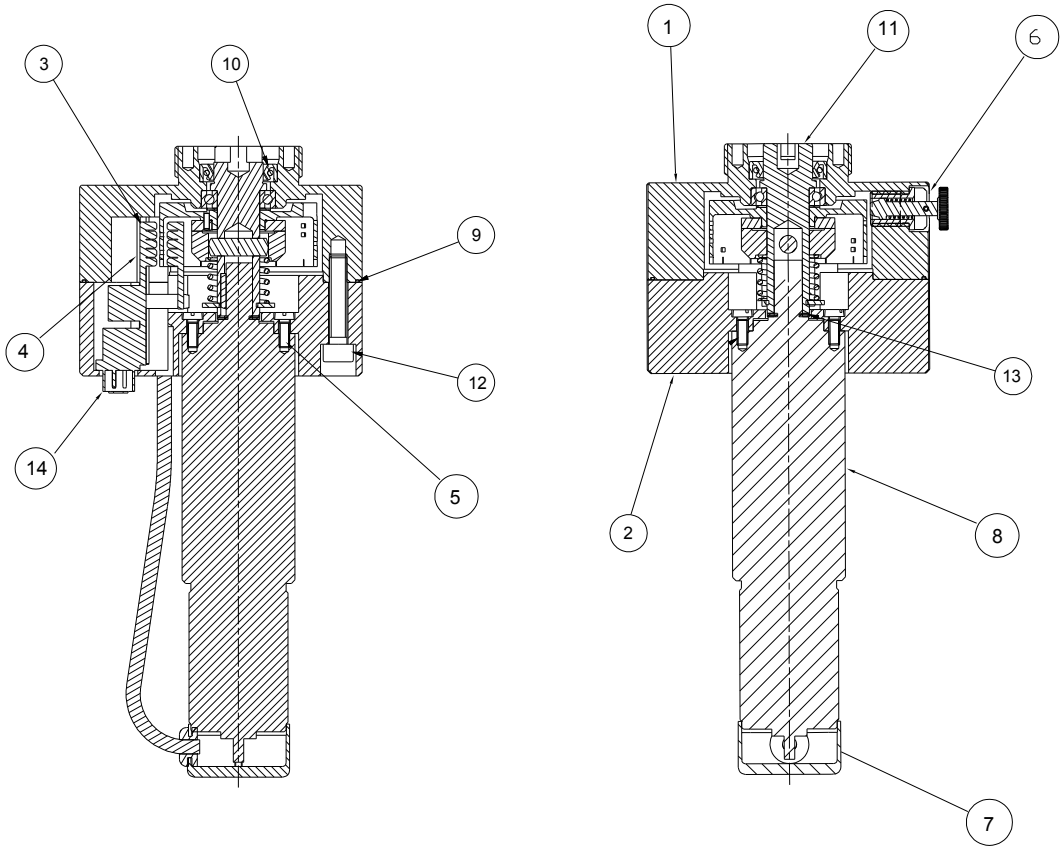



***The water distributor consists of the following components:***

| Position | Amount | Description | Partnumber |
|---|---|---|---|
| 1 | 1 | Housing Top | 1-610501 |
| 2 | 1 | Housing Bottom | 1-610502 |
| 3 | 1 | Flange split Top | 1-610503 |
| 4 | 1 | Knurled nut Top | 1-610504 |
| 5 | 1 | Flange split Bottom | 1-610505 |
| 6 | 1 | Knurled nut Bottom | 1-610506 |
| 7 | 1 | Guide Washer | 1-610507 |
| 8 | 2 | Dowel pin 3m6x10 DIN 7-A2 | |
| 9 | 1 | Allenscrew m4x6 DIN 912-A2 | |
| 10 | 8 | Hexscrew M4x10 DIN 912-A2 | |
| 11 | 3 | Hexscrew M4x22 DIN 912-A2 | |
| 12 | 2 | O-Ring 17 x 1,5 70NBR/769 | 0-601077 |
| 13 | 1 | O-Ring 28 x 1,5 70NBR/769 | 0-601089 |
| 14 | 1 | O-Ring 31 x 3 70NBR/769 | 0-601365 |
| 15 | 1 | O-Ring 15 x 2,65 70NBR/769 | 0-100564 |
| 16 | 3 | Shaft Seal Ring BA 15x24x7 72NBR/902 st. steel spring | 1-040906 |
| 17 | 1 | Shaft Seal Ring BA 15x30x7 72NBR/902 st. steel spring | 1-040907 |
| 18 | 4 | Elbowjack 1/4", Ø10 | 1-041110 |
| 19 | 4 | Reduction 10/8 | 1-041106 |

## 8.3.4 Drive Unit

*Fig. 8-4 Drive Unit*




***The drive unit consists of the following components:***

| Position | Amount | Description | Partnumber |
|---|---|---|---|
| 1 | 1 | Housing Top | 1-610401 |
| 2 | 1 | Housing Bottom | 1-610402 |
| 3 | 2 | Guide PCB | 1-610403 |
| 4 | 1 | Positiondetector PCB | 1-610411 |
| 5 | 4 | Hexscrew M3x8 DIN 84-4.8 gal Zn | |
| 6 | 1 | Decoder Lock Assembly | |
| 7 | 1 | Cover | |
| 8 | 1 | Motor and Gearbox | 1-040610 |
| 9 | 1 | O-Ring 76x1 70NBR/769 | 0-601997 |
| 10 | 1 | Shaft Seal Ring BA 14x22x4 72NBR/902 ss spring | 1-040910 |
| 11 | 1 | Shaft complete - 1-, 2-, 3-, 4-, 6-, 8- Hearth | 1-610405 |
| 11a | 1 | Shaft complete - 1-, 2-, 3-, 4-, 6-, 12- Hearth | |
| 12 | 3 | Hexscrew M5x25 DIN 912-8.8 gal Zn | |
| 13 | 3 | Distance washer 6x12x0,5 DIN 988 gal Zn | |
| 14 | 2 | Standoff | |

## 8.3.5 Crucible Configuration

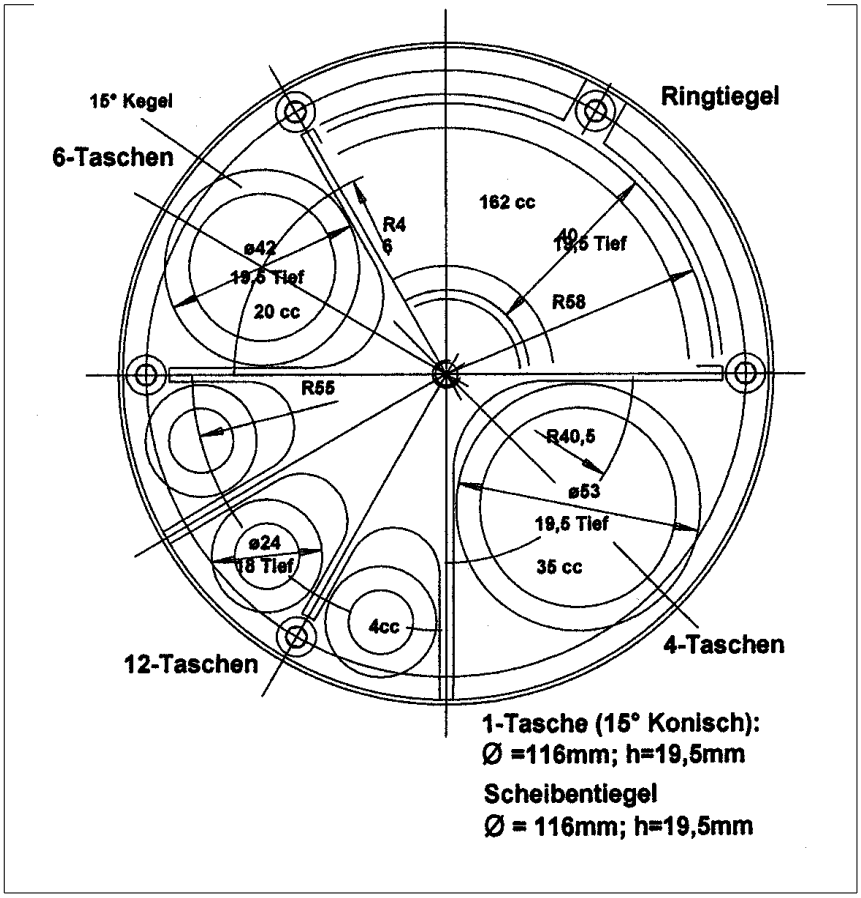



*Fig. 8-5 Crucible Configuration (Example)*

**The crucible configuration consists of the following components:**

| Quantity | Crucible | Part Number | | |
|---|---|---|---|---|
| | **Directly Cooled Crucible** | **EV M 6** | **EV M 8** | **EV M 10** |
| 1 | 4-pocket crucible (8 kW) | 1-610902 | 1-611902 | 1-616623 |
| 1 | 6-pocket crucible (8 kW) | 1-610903 | 1-611903 | 1-616625 |
| 1 | 8-pocket crucible (6 kW) | 1-610904 | 1-611914 | 1-616626 |
| 1 | 12-pocket crucible (3 kW) | | 1-611912 | |
| 1 | 1-pocket crucible (10 kW) | | 1-611901 | |
| 1 | Ring crucible (10 kW) | | 1-611904 | |
| | | | | |
| 1 | Viton O-ring 115.0-4.0 70NBR/769 | | 1-601664 | |
| | **Directly Cooled Crucible, Welded** | | | |
| 1 | 4-pocket crucible (10 kW) | 1-610922 | 1-611922 | 1-616630 |
| 1 | 6-pocket crucible (10 kW) | 1-610923 | 1-611923 | 1-616631 |
| Further crucibles, also special designs, on request! | | | | |

## 8.4 General Maintenance Instructions for the Individual Components

| Components | Checks and Maintenance Work | Interval |
|---|---|---|
| Filling | Make sure there is enough material in the crucible of the evaporator for a complete process. | **Periodically** |
| Cleaning | Remove old evaporation residues from the crucible to prevent uncontrolled melting of the material. | **Periodically** |
| Water | Check the water flow rate and the function of the water interlock at the evaporator controller. | **D** |
| Insulators | Check the insulator of the filament block and the ceramic of the HV feedthrough for unwanted deposits of conductive material. This is especially important when metals are vaporised.<br>Replace the ceramic insulator when it is coated over more than 50% of its length. | **After 20 W.Hr.** |
| Evaporator | To simplify cleaning, dismount the crucible. Switch off the water cooling. Remove the cover plate. Use the assembly tool (see tool kit, part 18) to remove the complete crucible. To remove only the top part of the crucible, unscrew the retaining screws on the top side of the crucible in the case of directly cooled crucibles and lift off the top part.<br>If the surface is contaminated, sandblast the corresponding parts.<br>Protect seals, threads and other sensitive parts with adhesive tape during sandblasting.<br>Clean the seals carefully with alcohol or acetone. | **Y or after 500 to 2500 W.Hr.** |
| HV supply cable, magnet current cable | Replace eroded HV cables. Replace the magnet current cables to avoid, for example, short circuits due to brittle insulation.<br><br>Pay particular attention to replacement of the evaporation material:<br>Always clean the crucible thoroughly to prevent contamination of the new material. | **Y or after 500 to 2500 W.Hr.** |

| | | |
|---|---|---|
| Permanent magnet | Field Direction<br>Particular attention must be paid to the permanent magnet! If the permanent magnet has been taken out from underneath the cover plate, make sure when fitting it again that it is fitted in correct position. The magnet has a groove in it to aid orientation.<br>If the evaporator is operated with an incorrectly positioned magnet or a magnet with changed field intensity, the electron beam cannot be directed at the crucible correctly and can therefore damage other components.<br><br>Temperature<br>Do not expose the permanent magnet to temperatures above 150°C.<br><br>Storage<br>Do not store the permanent magnet in the direct vicinity of other magnetic components. Short the permanent magnet, best with the help of a U-channel iron.<br><br>Replacement<br>If the permanent magnet is damaged, e.g. by peeling, fracture or sudden impact, high temperatures or suspected demagnetisation, you should replace the permanent magnet with a new magnet. | **Y**<br>**or after**<br>**500 to**<br>**2500 W.Hr.** |

### 8.4.1 Maintenance Filament Block

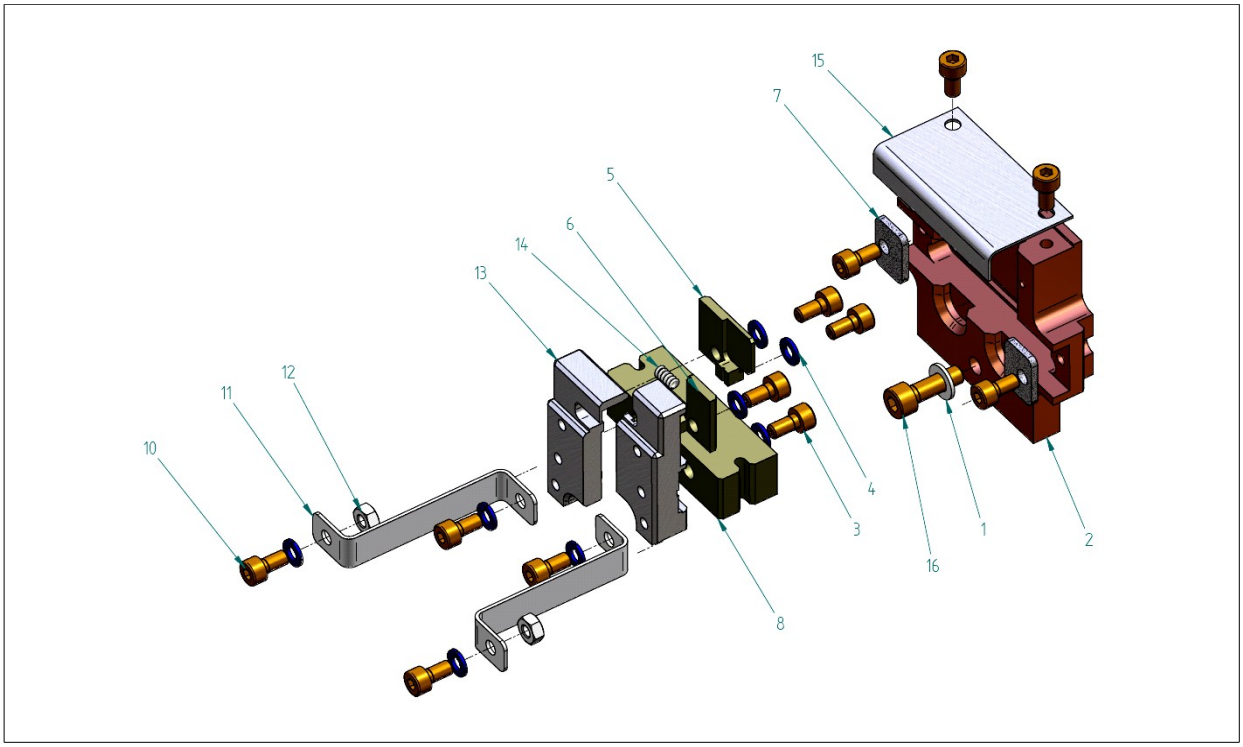



*Fig. 8-6 Filament Block Assembly (Example)*

**The filament block consists of the following components:**

| item | Description | Part Number |
|---|---|---|
| 1 | Plain washer | set of |
| 2 | Base element | 1 - 70 03 11 |
| 3 | Screws M 4 x 10 | set of |
| 4 | Plain washer | set of |
| 5 | Jaw, wide | 1 - 70 03 14 |
| 6 | Jaw, narrow | 1 - 70 03 15 |
| 7 | Lug | 1 - 70 03 16 |
| 8 | Ceramic Insulator | 1 - 70 03 17 |
| 9 | Cathode block, right | 1 - 70 03 13 |
| 10 | Screw M 4 x 10 | set of |
| 11 | Power supply connection distribution box | 1 - 70 07 11 |
| 12 | Nut M4 | set of |
| 13 | Cathode block, left | 1 - 70 03 12 |
| 14 | Filament | 1 - 70 30 00 / 1 - 70 30 05 ( 5 pc) |
| 15 | Anode plate | 1 - 70 05 02 |
| 16 | Screw M 5 x 16 8 10 (pieces) | 1 - 70 30 36 |
| | Screw set | 1- 70 30 22 |
| | Mounting gauge<br>( included in the Tool Kit) | 1 - 70 03 18 |

| | | |
|---|---|---|
| Filament block  | There are two methods for replacement of the filament. Both are described in detail further below. The first only describes replacement of the filament, while the second also describes testing and replacement of the ceramic insulator.<br><br>Note that all screws of the evaporator can be removed with a metric Allen key. | **Y or after 500 to 2500 W.Hr.** |

- *Never touch (vacuum) parts connected to the HV cables before you have discharged them with the grounding rod.*
- *When you work on the vacuum chamber, check beforehand whether the mains power switch for the high voltage is off and the power supply has been disconnected reliably (see also "Shutdown Procedure").*
- *Always check whether all safety switches are connected and in working order before trying to operate the evaporator.*
- *Never bypass the safety switches!*

*Work on the vacuum chamber presupposes that the complete high voltage power supply including the supply line outside the chamber is properly installed, protected against touch, switched off and interlocked.*

*You can also obtain TÜV-tested grounding rods from FERROTEC.*

### 8.4.2 Filament Change

*When a used filament has been removed, it must be replaced with a new one. Heating to operating temperature causes the filament to deform, resulting in re-crystallisation in the wire. This crystallised structure reacts very sensitively to changes in the shape, e.g. as happens when loosening the filament clamps. This can cause microscopically small cracks along the filament wire, which in turn has unforeseeable consequences for electrical conductivity and process stability.*

*The filament must be replaced exactly according to schedule.*

- Get the assembly tool and template ready.
- Dismount the filament block.

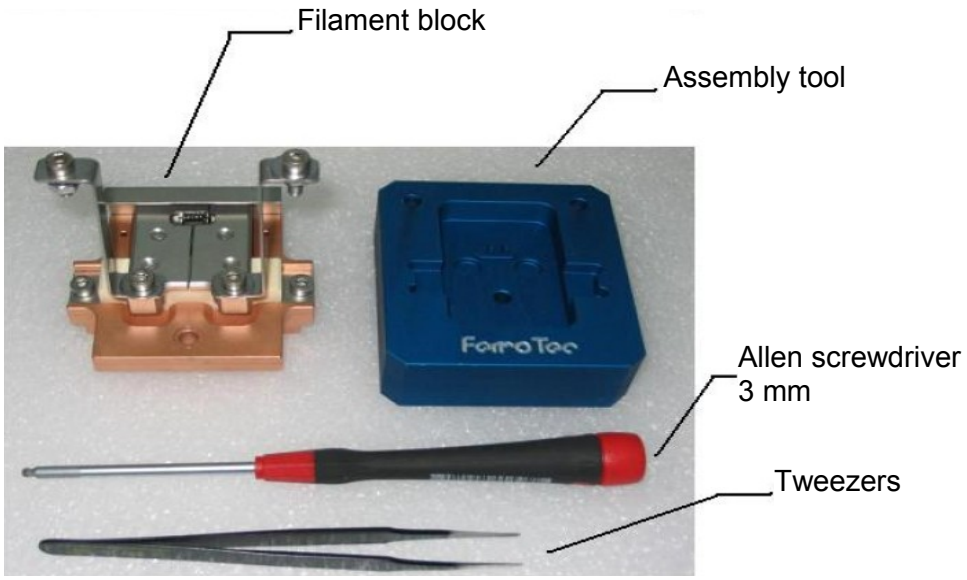



*Fig. 8-7 Filament Block and Accessories*

- Disconnect the filament current connectors.
- Dismount the anode plate.

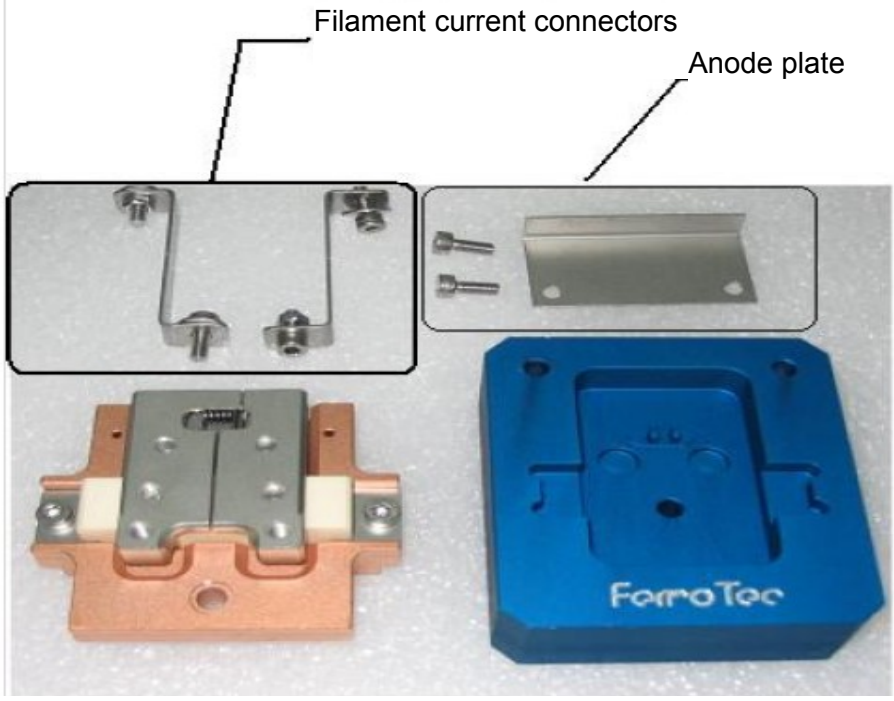



*Fig. 8-8 Anode Plate and Filament Current Connectors*

- Dismount the clamping pieces.
- Remove the filament holder and place it in the assembly tool with the ceramic insulator at the top.

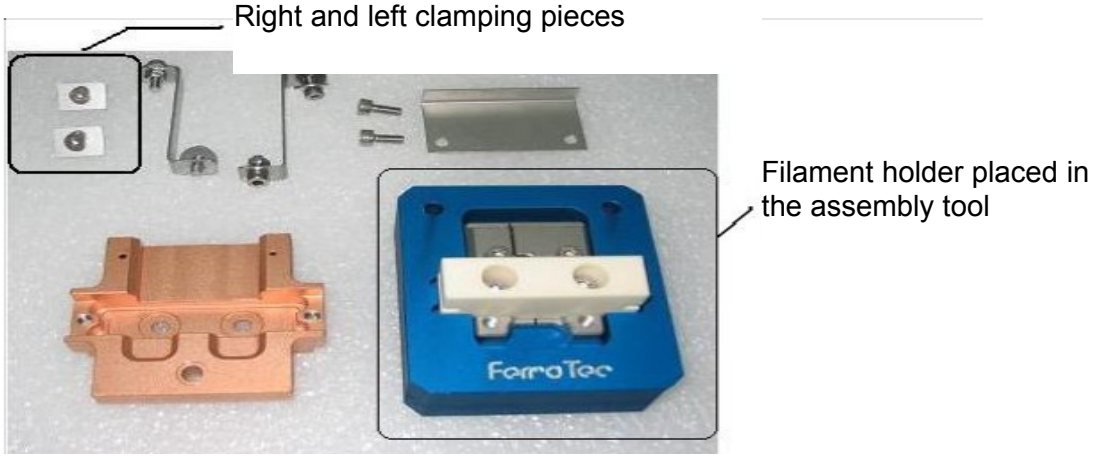



*Fig. 8-9 Clamping Pieces and Assembly Tool*

- Dismount the right and left filament clamps.
- Remove the filament.


*Fig. 8-10 Fastenings and Clamps*

- Pick up a new filament with the tweezers.
- Place it on the bottom part of the clamping pieces.
- Make sure that the spiral lies against the projections of the assembly tool.

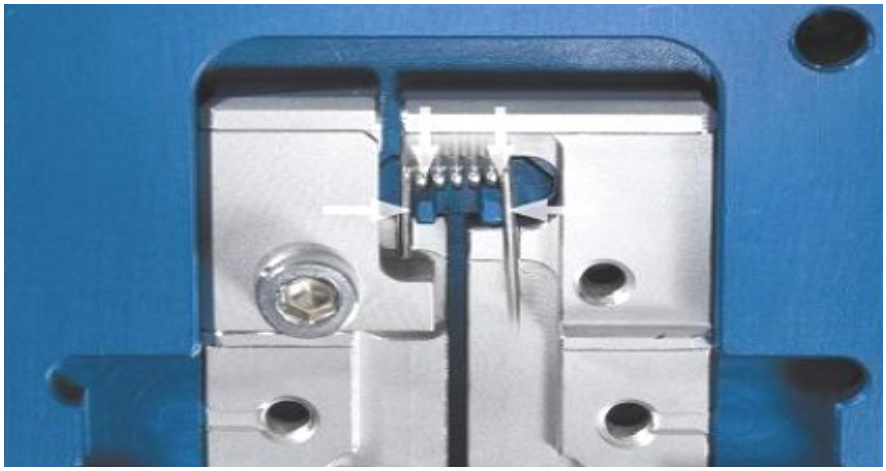


*Fig. 8-11 Filament Adjustment*

- The filament is now correctly adjusted and can be fixed with the filament clamps.
- You can then assemble the filament block again.
- Proceed in reverse order to disassembly.

### 8.4.3 Rotary Feedthrough and Positioning Unit

**Rotary Feedthrough**

The rotary feedthrough should only be dismounted by trained and experienced personnel to ensure it does not develop leaks.

Should you have any leak or rotation problems with the rotary feedthrough, we advise you to send the complete unit to your nearest service partner or directly to FERROTEC GmbH.

**Drive and Positioning Unit**

If motorised rotation is not possible, but the crucible can be turned by hand without resistance, there is no frictional connection between crucible shaft and drive shaft. Install the drive unit as described in the chapter "Installation".
If the position recognition system does not work, i.e. the controller does not receive a "pocket-in-position" signal, check the following possible sources of the fault:

- Defective control cable
  Check that the cable matches the pin configuration given in the table below.
- Defective control components
  Check the components and replace them if necessary.
- Calibration pin locked in decoding cylinder
  Check the correct procedure for crucible calibration.

| PIN NO. EV M-6 Sub D 9 pin | GENIUS X118 Sub D 15 pin | FUNKTION |
|---|---|---|
| 1 | 9 | Tiegel in Position |
| 2 | 4 | Position 8, Bit 4 ($2^3$) |
| 3 | 3 | Position 4, Bit 3 ($2^2$) |
| 4 | 2 | Position 2, Bit 2 ($2^1$) |
| 5 | 1 | Position 1, Bit 1 ($2^0$) |
| 6 | 5 | COM |
| 7 | 8 | +15 V |
| 8 | 6 | Motorspannung (+) |
| 9 | 7 | Motorspannung (-) |

*Fig. 8-12 Pin Configuration*

### 8.4.4 Crucible Calibration

Crucible calibration is necessary during initial start-up, after changing the crucible and after all other events that make recalibration necessary, e.g. change in the position of the crucible after a blockage.
Calibration defines the exact position of the crucible defined as crucible no. 1.

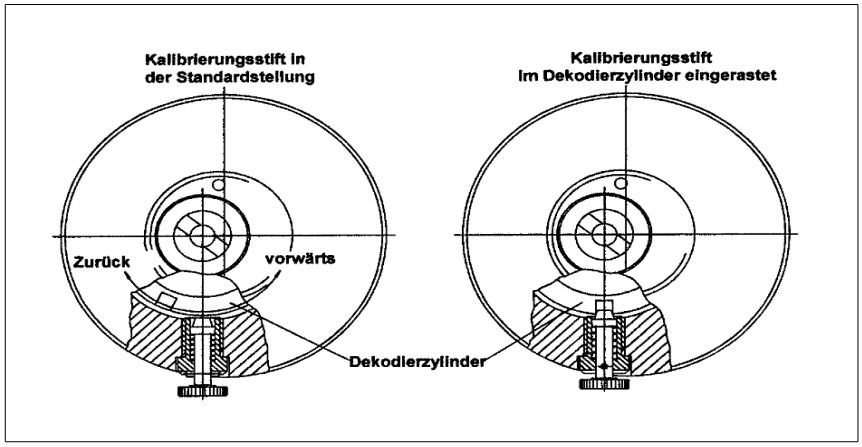



*Fig. 8-13 Crucible Calibration*

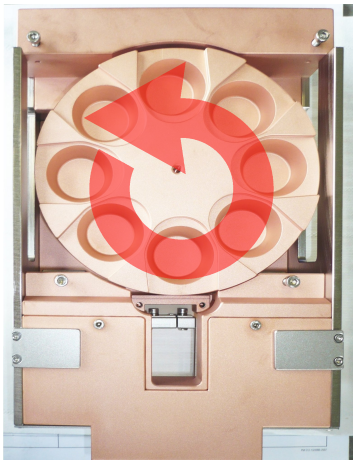
The following description of crucible calibration relates to operation with a GENIUS controller.
The GENIUS menu commands are shown in English and italicised.
Please also consult the instruction handbook for the controller in this regard:

- Log into Service mode (Auto/Manual-User Level) and select crucible no. 1:


- In the menu "Options-System Setup-Source Type" select evaporator type no. 1:

- Select the number of pockets in the menu "Options-System Setup-Pockets".
- Select the speed of rotation under "Options-System Setup-Speed", where 100% represents the maximum speed in anticlockwise direction.

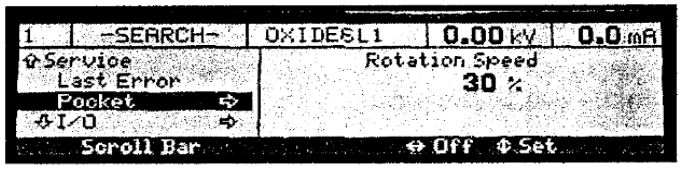
*Set the speed in normal operation on a negative value so that the crucible turns anticlockwise. This stops the crucible from being turned off the shaft by the motor torque in the event of a blockage in the vacuum area, thereby resulting in the risk of a water leak. Also switch off path optimisation in the GENIUS menu for this.*



### 8.4.5 Calibration

- Adjust the calibration pin at the drive unit so that it can catch in the groove in the decoding cylinder as shown in fig. 8-9. For this the calibration pin must be turned 90° out of its standard setting. The pin must catch in the groove in the decoding cylinder by spring force during a crucible rotation so that it can lock it.

- Activate crucible control by moving the right joystick in the menu "Options-Service-Pocket" as shown in the illustration below.


- Stop rotation of the crucible with the controller when crucible no. 1 is positioned correctly.

- Turn the calibration pin from locked position back to its standard position. The decoding cylinder with the top part of the crucible also turns when this is done.

- All other crucible positions are detected automatically by the optical recognition system in the drive unit on the basis of the setting "Options-System Setup-Pockets" by data transfer of the corresponding bit pattern.

- You can then select all crucibles directly with the menu "Set Pockets".

## 8.5 Inspection of the Machine

After completing cleaning, maintenance and repair work:

- Check that the protective conductor connections are firm.
- Check that the work has been carried out properly and fully.

*After checking and replacing spare and wearing parts make sure that all safety systems are in working order..*

- If all the functions work properly, the electron beam evaporator is **handed over** to the **operating personnel**.

# 9 Troubleshooting


*The situations and information on faults, their causes and correction in this chapter are described in such a way that they can be understood by skilled persons (see definition in chapter 3.4 "Safety Precautions") with training in*
- *electrical engineering/electronics*
- *mechanical engineering/maintenance.*

*These technicians must be equipped with the proper tools and test materials.*
*The shutdown procedure (see chap. 4.5) must be carried out before all maintenance and repair work.*
*If the measures described below do not prove successful, please contact FERROTEC GmbH.*

## 9.1 Fault Finding

The following fault finding guide deals with problems that can be caused both by the electron beam evaporator and by the power supplies/controllers.
It is not always clear whether a fault is of a mechanical or electronic nature. Some parts of the fault finding guide have therefore been taken from the fault descriptions for the power supply.

- *Never touch (vacuum) parts connected to the HV cables before you have discharged them with the grounding rod.*
- *When you work on the vacuum chamber, check beforehand whether the mains power switch for the high voltage is off and the power supply has been disconnected reliably.*
- *Always check whether all safety switches are connected and in working order before trying to operate the evaporator.*
- *Never bypass the safety switches!*

- *Work on the vacuum chamber presupposes that the complete high voltage power supply including the supply line outside the chamber is properly installed, protected against touch, switched off and interlocked.*

*You can also obtain TÜV-tested grounding rods from FERROTEC.*

| **Fault** | **Cause** | **Remedy** |
|---|---|---|
| Filament does not light up,<br>magnet current and HV switched on | Filament broken. | Replace filament |
| | HV cables without contact to filament block | The measured resistance at the filament block and at the feedthrough must be ¼ Ohm. If the resistance is higher, one of the cables is not connected firmly enough. Check the contact points. |
| | Filament short circuit | Check the HV cables. Check the cathode block after short circuits at the filament. |
| No emission current, filament only glows, FPS LED ON, HV switched on | Emission current not enabled, HV LED at Genius remote control permanently on | Check crucible positioning and feedback |
| No beam spot visible, filament lights up bright, HV switched on | Beam deflection defective | Check the electromagnetic deflection; especially the x-deflection |
| | | Check the permanent magnet |
| | | Check the magnetic properties in the surroundings of the evaporator |

| | | |
|---|---|---|
| Maximum emission current cannot be reached | Partial short circuit at the filament | Replace the filament and make sure it is adjusted correctly |
| | Limitation by the controller | Increase the emission current/filament current limit |
| Evaporation material sticks to the crucible | Inadequate cooling | Check the flow rate of the water; min. 6 l/min. |
| | Crucible too full or too empty | The crucible should not be overfilled. Do not keep full with less than 1/3 of the crucible volume. |

*Information on troubleshooting on vendor components is to be found in the separate manufacturer instruction handbooks. They are contained in the technical reference material.*

# 10 Emergencies

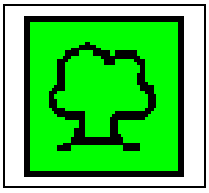
In the event of an emergency:

- Press the emergency stop button on the master control unit. The emergency stop button is released by pulling out or turning anticlockwise/clockwise.

- Switch off the main switch if necessary.

# 11 Dismantling / Disposal

**Dismantling**
Dismantling may only be performed by skilled personnel.
Make sure the shutdown procedure is followed before beginning dismantling work.



**Disposal**
The machine is primarily made of copper (except for the electrical equipment) and must be disposed of in accordance with local environmental protection regulations.

Oils and cleaning agents must be disposed of in accordance with local regulations and the instructions in the manufacturers' safety data sheets.

Contaminated cleaning tools (brushes, cloths, etc.) must also be disposed of in accordance with the manufacturer's instructions.