

## Industry X-ray Unit

### ERESCO MF4 Type Series

Digital control unit ERESCO MF4 *control*

Operating manual



## 6. Edition

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Changes and improvements compared to the previous edition:

- Exchange of Fig. 5 – Chapter 2 Installation,
- Exchange of Fig. 7 – Chapter 6 Fuses and pin assignment and values corrected
- Addition of ERESKO 300MF4-R
- Addition of Global Tech Support

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## 1 Safety Information

X-ray units that are used in industrial materials testing radiography **basically** require approval according to Section 3 of the current German X-ray ordinance. Relevant national regulations must be observed in all countries.

### 1.1 Used Safety Symbols

In this Operating Manual and within the system, the following symbols are used to indicate information and warnings:



**Danger:** Danger by electric current



**Danger:** Danger by ionizing rays (X-ray radiation)



**Caution:** Warning of a Danger zone



Indication of unauthorised entry or intervention



**Caution:** Danger of crushing



**Caution:** Laser radiation hazard,



Indication of special information, following instructions



Symbol for "hazardous waste segregation"



### Important note

This product contains a battery that cannot be disposed of as unsorted municipal waste in the European Union. See the product documentation for specific battery information. The battery is marked with this symbol, which may include lettering to indicate cadmium (Cd), lead (Pb), or mercury (Hg). For proper recycling return the battery to your supplier or to a designated collection point.

### What do the markings mean?

Batteries and rechargeable batteries must be marked (either on the battery or the rechargeable battery or on the packaging, depending on the size) with the "separate collection symbol". In addition, the marking must include the chemical symbols for specific levels of toxic metals as follows:

- Cadmium (Cd) over 0.002%
- Lead (Pb) over 0.004%
- Mercury (Hg) over 0.0005%



### The risks and your role in reducing them

Your participation is an important part of the effort to minimize the impact of batteries and rechargeable batteries on the environment and on human health. For proper recycling you can return this product or the batteries or rechargeable batteries it contains to your supplier or to a designated collection point.

Some batteries or rechargeable batteries contain toxic metals that pose serious risks to human health and to the environment. When required, the product marking includes chemical symbols that indicate the presence toxic metals: Pb for lead, Hg for mercury, and Cd for cadmium.

**Cadmium** poisoning can result in cancer of the lungs and prostate gland. Chronic effects include kidney damage, pulmonary emphysema, and bone diseases such as osteomalacia and osteoporosis. Cadmium may also cause anemia, discoloration of the teeth, and loss of smell (anosmia).

**Lead** is poisonous in all forms. It accumulates in the body, so each exposure is significant. Ingestion and inhalation of lead can cause severe damage to human health. Risks include brain damage, convulsions, malnutrition, and sterility.

**Mercury** creates hazardous vapors at room temperature. Exposure to high concentrations of mercury vapor can cause a variety of severe symptoms. Risks include chronic inflammation of mouth and gums, personality change, nervousness, fever, and rashes.

## 1.2 Radiation Protection Information

Dear Customer:



You received equipment for X-ray generation from our company. It contains the radiating unit with the built-in X-ray tube which constitutes the actual X-ray generating source.

Our company is legally obliged to point out to the customer those measures that serve radiation protection. Therefore, we recommend the following steps to you.



1. Carefully read the Operating Manual, in particular the descriptions pertaining to functions of the control units and display units.



2. Take advantage of equipment-specific protective devices, e.g. door switches and light barriers that can guard off-limit areas.

3. Never choose a beam cone angle in excess of what is absolutely necessary for an economical inspection. Not only is the operator's radiation dose kept to a minimum this way. The quality of the test results is improved as well.

In practical terms this means that the beam cone should always be restricted to the film format or the fluorescent screen format by applying a beam limiting diaphragm of a highly absorbent material such as lead in sufficient thickness. This diaphragm can be either provided by the supplier or by the customer.

4. Frequently, the cheapest and most convenient radiation protection is achieved by keeping the distance from the radiation source as large as possible. In case of mobile X-ray units, make use of the full length of the connecting cable between the radiating unit and the control.

All automated **GE Sensing & Inspection Technologies** controls render operator-guided monitoring of the operating values unnecessary during radiation time. Therefore, immediately after HV switch-on, the operator can further increase the distance from the X-ray tubehousing or the radiating unit. The benefit of this measure is even enhanced by a slow HV increase from zero to the preselected value within approximately five seconds.

5. During film exposures, always cover the back of the film with an additional lead sheet. The general radiation level is considerably lowered this way. The film is protected from contrast-reducing scattered radiation.



6. Always remember that X-radiation is generated as long as the amber pilot light of the control is on or flashing and the warning lamp is active.

7. Never forget to remove the key from the control during non-operational intervals. Keep it in a safe place to prevent its use by unauthorized personnel.

8. Always exploit existent shielding facilities. Often structural features can be used to great advantage.

Our broadly automated control units make monitoring during the exposure time dispensable. The operator can therefore immediately increase the distance after switching-on the high voltage. The effect of this measure is increased since after switch-on (approx. 6 sec./100kV) the high voltage is slowly increased from zero to the preselected value in the case of all **GE Sensing & Inspection Technologies** control units.

9. Always remember to cover the rear side of the film with an additional lead plate when taking shots. By doing so, you substantially reduce general radiation level and additionally protect the film against stray radiation that reduces contrast.
10. Please always remember that so long as X-ray radiation is being generated, the yellow signal lamp on the control unit lights or flashes or if necessary the warning lamp or optionally the flash lamp works.
11. Never forget to remove the key of control unit and to secure the unit against unauthorised users during working breaks.



### 1.3 Safety notes



- Carefully read these Operating Instructions and the corresponding instruction of individual components before you begin working with the unit.
- All persons that have to do with the installation, initial operation, operation, maintenance and servicing of the unit must be qualified accordingly and must exactly observe this Operating Instructions.

**It concerns your safety!**

- Unauthorised conversion and changes to this unit are prohibited for safety reasons.

### 1.4 Danger Posed by this System



This unit is provided with a device for generating high voltage and X-ray radiation.



Legal provisions for the operation of an X-ray tube and legal radiation protection provisions have to be observed and upheld.



There is danger of sustaining injuries in case of improper operation or manipulation of the components.

### 1.5 Authorised Users

- Only authorised persons are allowed to operate the unit. Operators must be at least 18 years old, valid for the Federal Republic of Germany. Relevant national regulations must be observed outside the Federal Republic of Germany.
- The operator is liable for injuries occurring within the working area to third party.
- Responsibilities for different activities on the unit must be clearly determined and observed. Unclear delegation of authority is a safety risk.



- The operating company must make the operating instructions accessible to the operator and ensure that the operator has read and understood them.
- Work on the unit's electrical equipment may only be carried out by electricians trained by **GE Sensing & Inspection Technologies**.

## 1.6 Personal Protective Clothing

Always wear the specified protective clothing at the installation site!

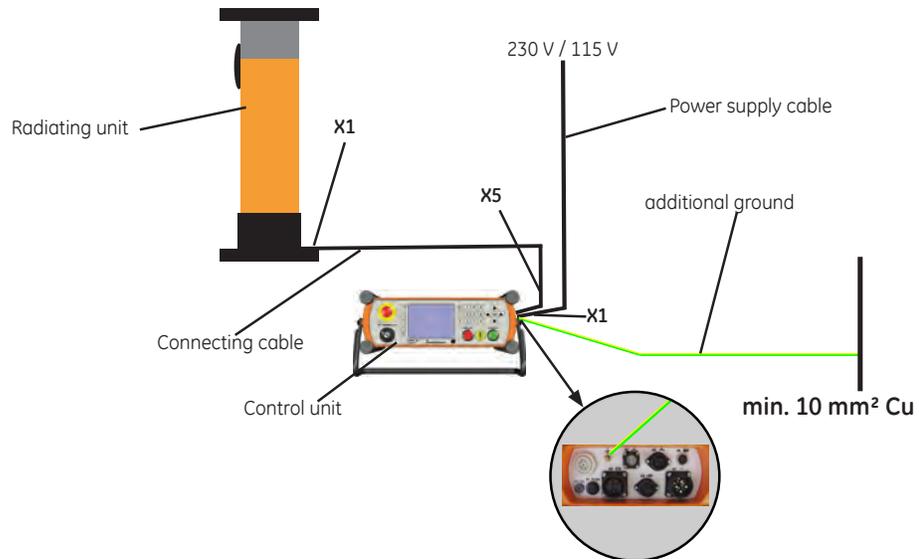
## 1.7 Safety Measures at the Installation Site



Always use the shielding equipment available at site. Structural conditions can quite often be used to enhance safety. You should clearly demarcate and label control areas properly.



**ATTENTION: Increased earth leakage current.**  
 The earth leakage current of this X-ray equipment is higher than 3.5 mA. According to EN 60204-1 an additional (separate) ground cable with the at least same wire gauge (wire cross section) as the wires in the mains cable must be connected from the earthing bolt at the control unit to a ground terminal, that has a minimum wire gauge of 10 mm<sup>2</sup> Cu (AWG7).



## 1.8 Intended Use

The unit is exclusively designed for material testing or material radiation.

The unit should only be used for the described purpose in compliance with the safety notes according to Section 1 to 1.7.

**Any other use of the unit is strictly prohibited.**

Improper use or tampering with the unit may result in personal injuries or damage to the unit.

## 2. Operating Manual

**Preliminary remarks:** The following Operating Manual does not contain instructions on adherence to obligatory radiation protection.

It is the responsibility of the user to equip operating personnel with dosimeters and to monitor them, as well as to carry out any structural radiation protection measures.

With regard to exposure conditions for achieving minimum image quality, we refer to relevant DIN regulations.

### 2.1 Installation of the Unit

The connection diagram in Fig. 1 and the connection plan in Appendix 2 display the necessary connections.

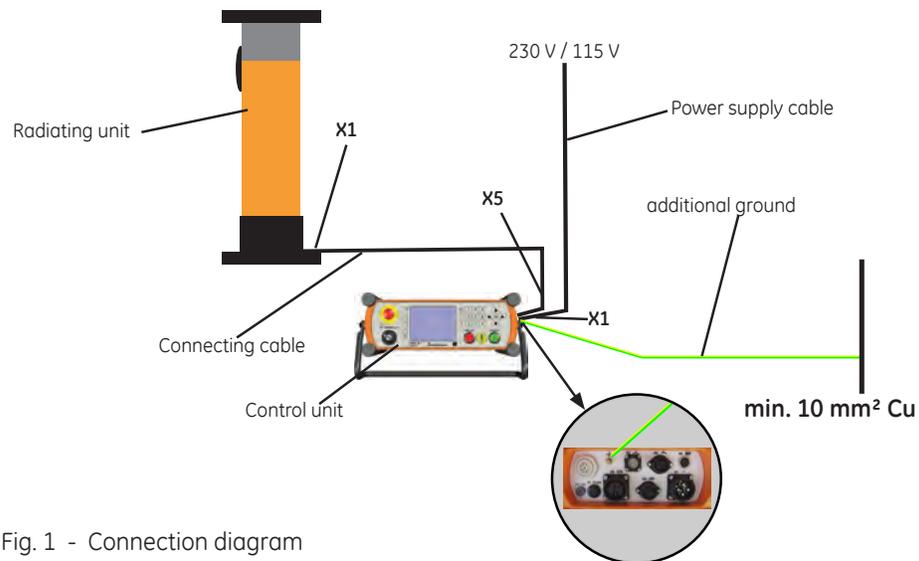


Fig. 1 - Connection diagram

Figures 2 and 5 display the front and side view of the digital control unit **ERESCO MF4 control**.

It is advisable to carry out installation in the following order:

1. If necessary, use a support to position the radiating unit for exposure.
2. Connect the connecting cable to the radiating unit (**X1**).
3. If necessary, connect the water cooling pump or the water turbine flow rate monitor to the control unit (**X4**).
4. Using the whole length of the connecting cable, position the control unit as far away from the radiating unit as possible, facing away from the radiation; connect the connecting cable to socket **X5** and the mains cable to socket **X1**. The plug connections are non-interchangeable.



### CAUTION !

Orange mains cable with "Schuko" plug 230 V AC only !  
Grey mains cable without "Schuko" plug 115 V AC only !



### NOTE:

The digital control unit **ERESCO MF4 control** can operate with restrictions (see section 3.), also as stand-alone equipment (without X-ray unit).



**CAUTION !** Operation with an unsuitable emergency power generator may result in damages to the unit which are not covered by the warranty conditions of GE Sensing & Inspection Technologies GmbH.

When using an emergency power generator, please ensure that a *sinusoidal* voltage is applied as described in section 2.2.1.

If you have any further questions, please contact GE Sensing & Inspection Technologies GmbH.

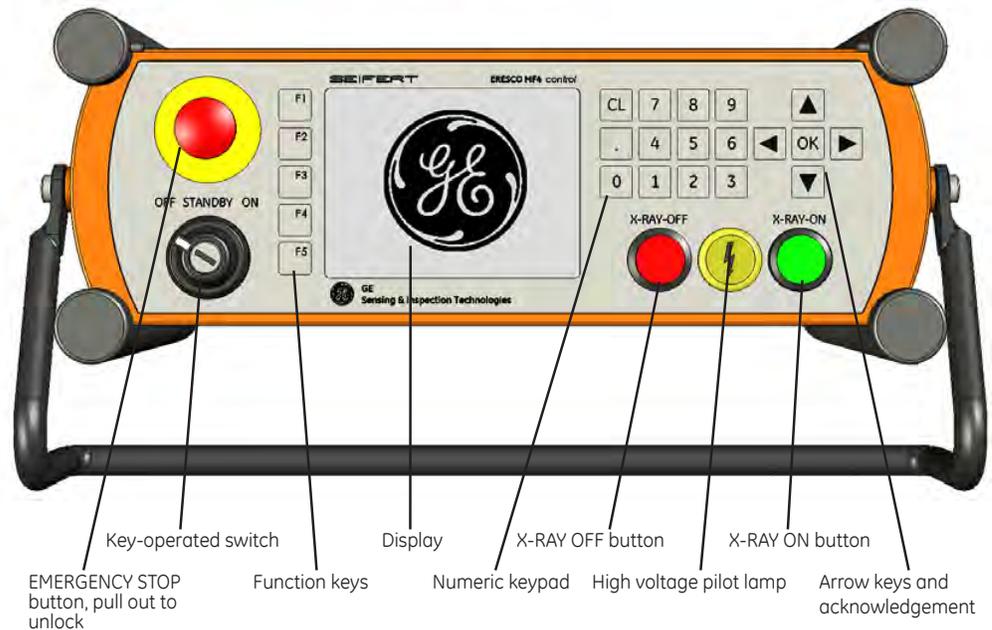


Fig. 2 - Front view of the digital control unit **ERESKO MF4 control** (without covers)

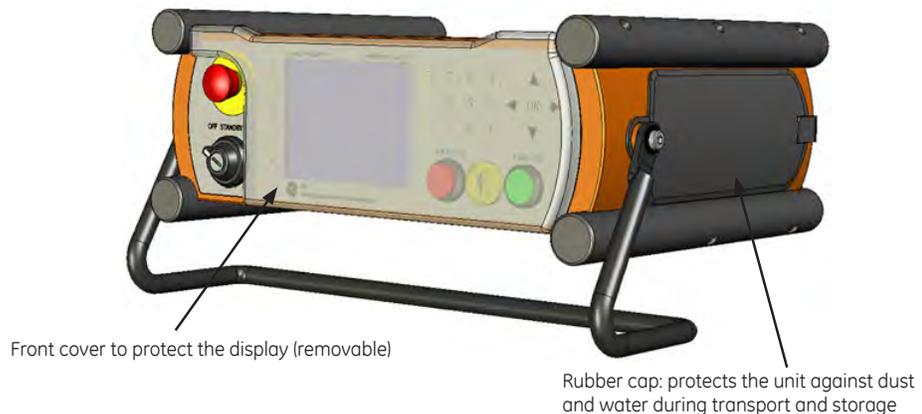


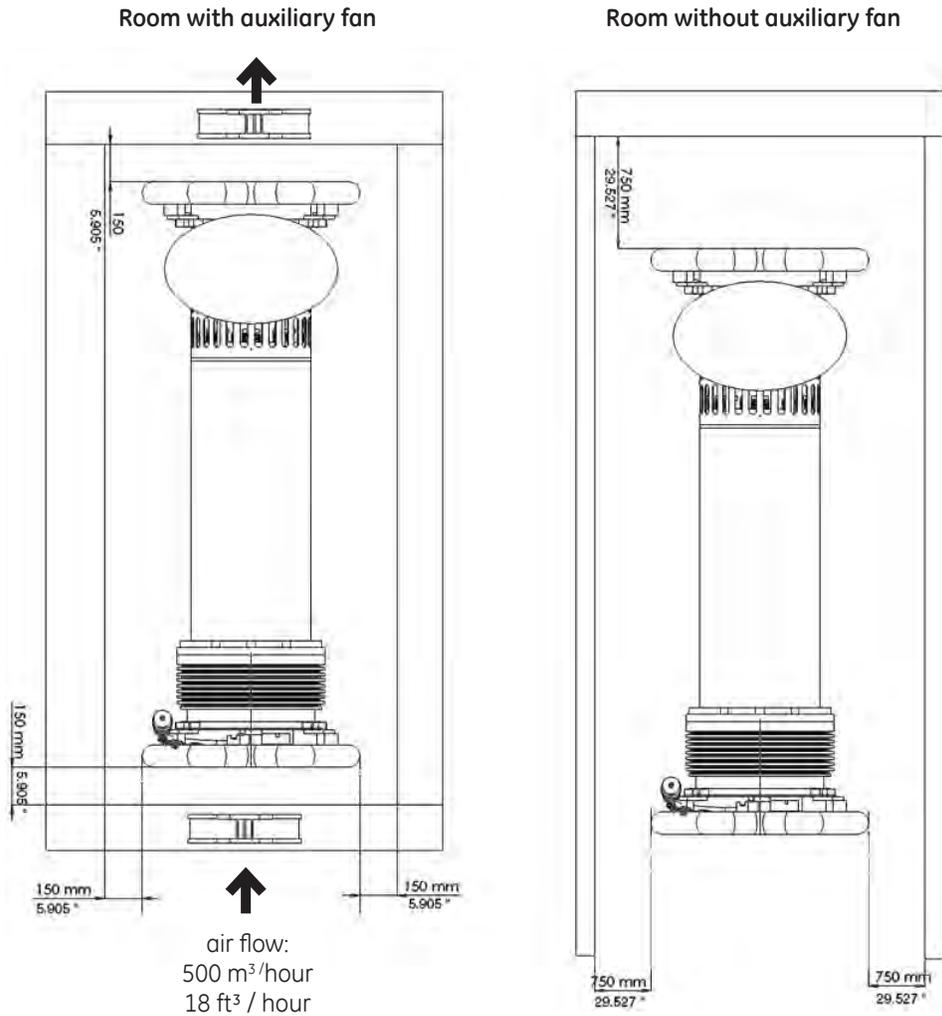
Fig. 3 - Digital control unit **ERESKO MF4 control** (with covers)



**CAUTION !** Protection class IP 65 can only be guaranteed when plugs are connected (seal unused plugs with a cap) or when using the rubber cap!



**CAUTION !:** To prevent the radiating unit from overheating at operation in closed rooms or in radiation protection cabinets, please ensure the following minimum distances to walls and the minimum air flow rate.



Valid for all details  
(minimum values)

Fig. 4 - Radiating unit for operation in closed rooms or radiation protection cabinets

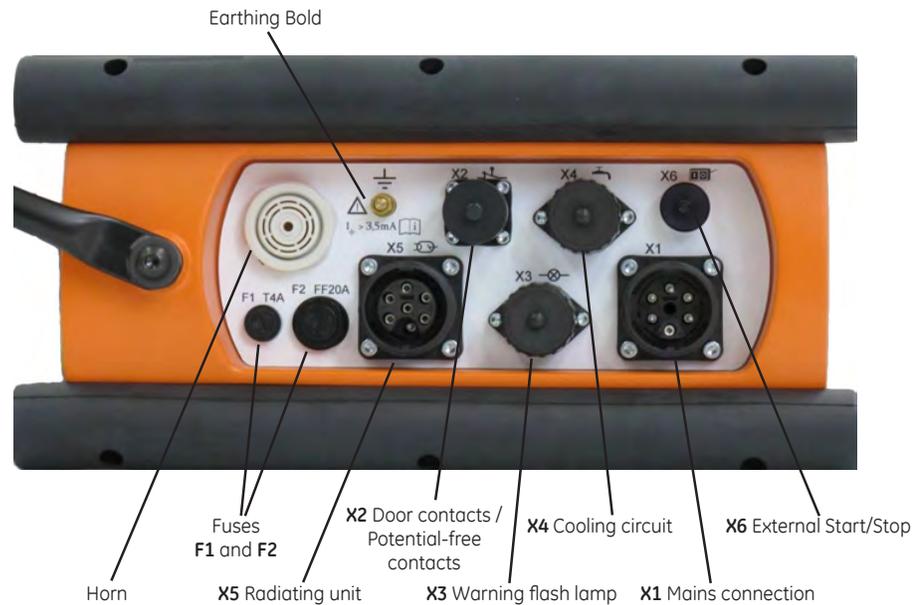


Fig. 5 - Plug hutch of the digital control unit **ERESKO MF4 control** (without cover, without handle)

### 2.1.1 Operation with optional warning flash lamp

Depending on the available power supply 230 V or 115 V, a warning flash lamp can be optionally connected optionally to socket **X3**.  
(Use the supplied eyebolt to remove the short-circuit plug)



**NOTE:** With a connected warning flash lamp, a prewarning time of at least 2 seconds must be set, otherwise the high voltage cannot be switched on.



Short circuit plug

### 2.1.2 Operation with connected door contacts

When the safety door contacts are to be connected, use the supplied eyebolt to remove the short circuit plug for the door contact from socket **X2** at the plug hutch.



**NOTE:** If door contact 1 has been opened, door contact 2 should also be opened. Both door contacts must be closed before the unit is ready for operation again.



Short circuit plug with eyebolt



Eyebolt

## 2.2 Taking into operation

### 2.2.1 Mains connection

Connect the power supply cable to an earthing contact socket.

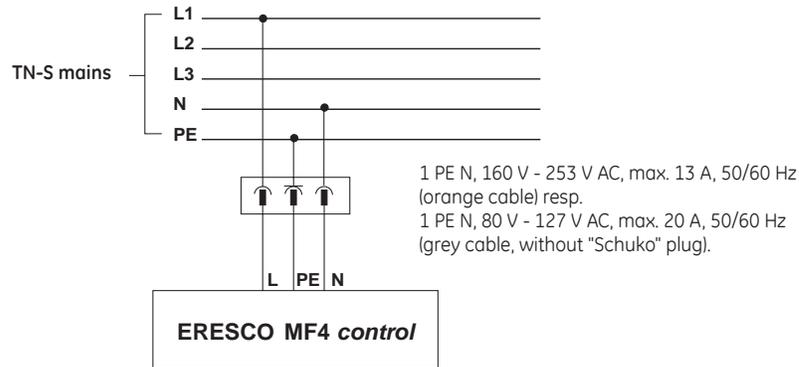


Fig. 6 - Mains connection



**The neutral wire must be grounded.**

The voltage is identified via various mains cables.



**NOTE:** In case of low mains voltage (< 204 V and < 107 V respectively) the setpoint values cannot be reached, depending on the output power. The equipment switches off with the message: *Reduce power*. This means decreasing the preselected tube current [mA] and increasing the preselected exposure time [min and s].

### 2.2.2 Stand-by

After switching on the power supply (turn the key-operated switch from OFF to STAND-BY), the unit is now in **STAND-BY** mode;

The supply to the control unit, computer and a possibly connected coolant pump is switched on. Input via the keypad is not possible.

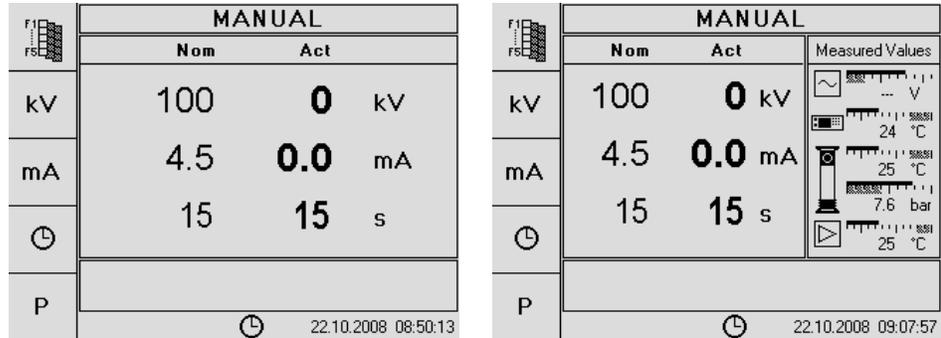
However, a status request via the serial interfaces is possible.

The following mask appears on the display.

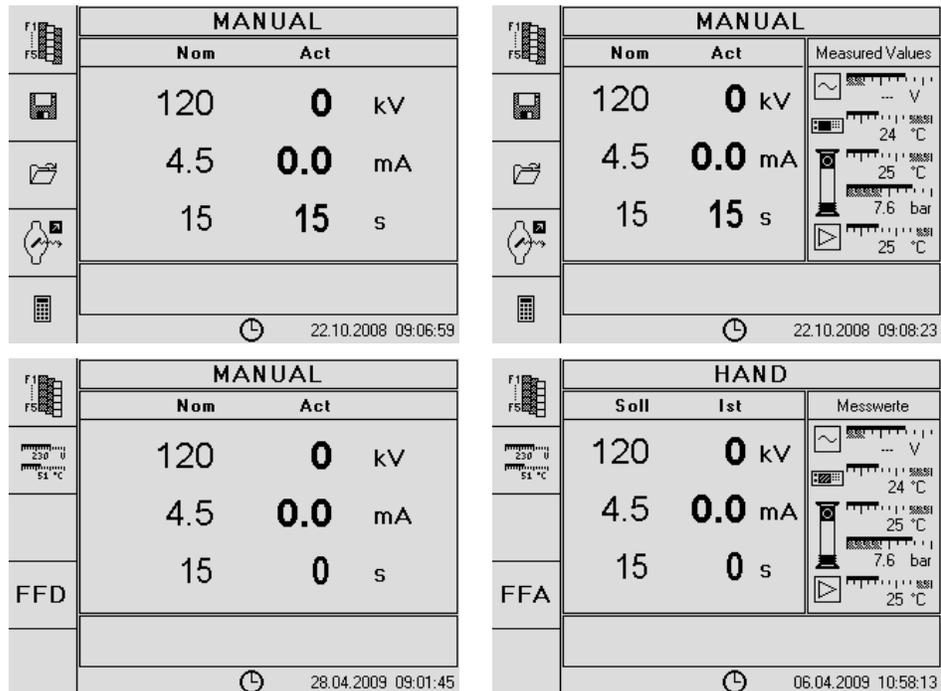


2.2.3 Display modes

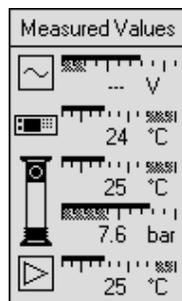
Turn the key-operated switch at **ERESCO MF4 control** from **STAND-BY** to **ON**.  
The unit is now ready for operation and one of the following masks appears on the display:



Use the **F1**  key to change the function key arrangement:



Use key **F2**  to show or hide the **Measured values**.



- The following values are displayed in the **Measured Values** section:
- ➔ Line power **ERESCO MF4 control** (display only when high voltage is switched on)
  - ➔ Rectifier temperature in **ERESCO MF4 control**
  - ➔ Cascade temperature radiating unit
  - ➔ Gas pressure radiating unit
  - ➔ Final stage temperature

Function key arrangement:

	→ Key <b>F1</b> function key arrangement changeover
<b>kV</b>	→ Key <b>F2</b> kV input
<b>mA</b>	→ Key <b>F3</b> mA input
	→ Key <b>F4</b> exposure time input
<b>P</b>	→ Key <b>F5</b> power mode
	→ Key <b>F1</b> function key arrangement changeover
	→ Key <b>F2</b> save programs
	→ Key <b>F3</b> open programs
	→ Key <b>F4</b> call warm-up program
	→ Key <b>F5</b> exposure calculator
	→ Key <b>F1</b> function key arrangement changeover
	→ Key <b>F2</b> show or hide measured values
	→ Key <b>F3</b> not used
<b>FFD</b>	→ Key <b>F4</b> Enter <b>F</b> ilm- <b>F</b> ocal- <b>D</b> istance
	→ Key <b>F5</b> not used

2.2.4 Ready for operation and warm-up



**CAUTION:** Prior to switching on the radiation, insert the optional lead sealing plug into the tube window, and observe the radiation protection measures described in section 1.2 Radiation Protection Information! If a lead sealing plug is not available, the radiation protection information in section 1.2 must be observed.

Turn the key-operated switch at the operation module from **STAND-BY** to **ON**. The unit is now ready for operation. Depending on the last operated tube voltage and the expired operation break, the following masks appear on the display. If the last operated tube voltage is less than half the nominal tube voltage:

MANUAL			
	Nom	Act	
kV	100	0	kV
mA	4.5	0.0	mA
⌚	15	15	s
P	⌚ 22.10.2008 08:50:13		

If the last operated tube voltage is greater than half the nominal tube voltage:

WARM-UP		RTC Auto	
Mode	Nom	Act	
	120	0	kV
Warm-up Voltage	2.0	0.0	mA
<input checked="" type="checkbox"/>	Warm-up Voltage	Time left	
	100 kV		
<input checked="" type="checkbox"/>	⌚ 09.04.2009 10:11:10		

The operator is provided with the last operated tube voltage in the **Warm-up voltage** field.

The operator can accept the provided tube voltage or enter a test voltage up to the maximum level intended for the day of operation.

Press the **F3 / Warm-up voltage** key, enter the desired warm-up voltage in the **Warm-up voltage** field and then press the **OK** key.

WARM-UP		RTC Auto	
	Nom	Act	
	120	0	kV
	4.5	0.0	mA
	Warm-up Voltage	Time left	
	120 kV		
	⌚ 22.10.2008 10:11:06		

Subsequently press the  key or the **OK** key:

The integrated real time clock determines the operation break of the tube, and the time interval for tube warm-up is specified according to the warm-up procedure. The prompt for starting the unit subsequently appears:

WARM-UP		RTC Auto
Nom	Act	
100	0	kV
4.5	0.0	mA
Warm-up Voltage		Time left
120 kV		08'00"
Push X-RAY ON Button		
118		22.10.2008 10:13:40

After the prompt for starting the unit, press the **X-RAY ON** button.



**NOTE:** Operational readiness for switching on the radiation is always displayed via the green illuminated X-RAY ON button.

The remaining warm-up time is displayed in the *Time left* field during the warm-up procedure.

WARM-UP		RTC Auto
Nom	Act	
100	100	kV
4.5	4.5	mA
Warm-up Voltage		Time left
120 kV		07'37"
		22.10.2008 10:16:20

An acoustic signal sounds 2 seconds before the end of the warm-up program. After the warm-up program, the following message appears:

WARM-UP		RTC Auto
Nom	Act	
120	0	kV
4.5	0.0	mA
Warm-up Voltage		Time left
<input checked="" type="checkbox"/>	120 kV	
Warm-up program completed		
119		22.10.2008 11:36:12

Press the  key to confirm the message. The operating mask (e.g. manual mode) which was selected prior to warm-up subsequently appears:

		MANUAL			
		Nom	Act		
kV		120	0	kV	
mA		4.5	0.0	mA	
		15	15	s	
P					
					22.10.2008 08:50:13

If the equipment will be switched off e.g. by uneven operation of the X-ray tube or by a fault during the warm-up program, a corresponding message will appear on the display.

After this type of technical fault (or X-RAY OFF), the user still has two further attempts to warm-up the tube, after which warm-up is terminated and can only be restarted after a renewed mains ON.

**Fault message** example:

		WARM-UP		RTC Auto	
		Nom	Act		
		120	0	kV	
		4.5	0.0	mA	
		Warm-up Voltage		Time left	
		120 kV			
<b>Emergency Stop</b>					
	46				22.10.2008 10:23:54

After eliminating the fault, the message must be confirmed by pressing the CL key. Then, and also after pressing the X-RAY ON button, the following mask appears:

		WARM-UP		RTC Auto	
		Nom	Act		
		120	0	kV	
		4.5	0.0	mA	
		Warm-up Voltage		Time left	
		120 kV			
		<b>Warm-up aborted. Try again</b>			
	117				22.10.2008 10:24:52

If the **F4**  key is pressed, the achieved voltage of approximately 20 kV (but not below  $U_{nominal/2}$ ) is reduced and the following message appears in the comment line on the display:

WARM-UP		RTC Auto
Nom	Act	
100	0	kV
4.5	0.0	mA
Warm-up Voltage		Time left
120 kV		08'00"
Push X-RAY ON Button		
118		22.10.2008 10:13:40

If the F5 key is pressed, the following message appears:

WARM-UP		RTC Auto
Nom	Act	
100	0	kV
4.5	0.0	mA
Warm-up Voltage		Time left
120 kV		
Program aborted		
Consider warm up instructions!		
		121 22.10.2008 10:41:06

After pressing the F5 key, the operating mode used before switching on is shown on the display (e.g. *MANUAL* mode).

If the warm-up program is terminated three times, the following message appears in the comment line on the display:

WARM-UP		RTC Auto
Nom	Act	
100	0	kV
4.5	0.0	mA
Warm-up Voltage		Time left
120 kV		
Warm-up terminated after 3 attempts		
		116 22.10.2008 10:47:51



The unit can only be restarted after a renewed mains ON.  
**In this case, a service technician should be consulted.**

The warm-up program can be called manually as follows:



Press the F1 key until the symbol appears.

Press the F4 key.

The warm-up mask appears (see page 19).

### 2.2.5 Extended Warm-up Mode

In order to establish stable tube performance with new tubes (**green** tubes) or to condition tubes that have been out of operation for longer period (especially in setups with high energies) the extended warm-up mode can be used.

The warm-up mask will be called automatically:

Mode	WARM-UP		RTC Auto
	Nom	Act	
Warm-up Voltage	100	0	kV
	2.0	0.0	mA
<input checked="" type="checkbox"/>	Warm-up Voltage	Time left	
	200 kV		
<input type="checkbox"/>			
14.04.2009 14:53:26			

Use the key **F1 / Mode** to change the function key arrangement:

▲	WARM-UP		RTC Auto
▼	Nom	Act	
	100	0	kV
	2.0	0.0	mA
<input checked="" type="checkbox"/>	Warm-up Voltage	Time left	
	200 kV		
<input type="checkbox"/>			
14.04.2009 14:54:02			

With keys **F1 ▲** and **F2 ▼** or the arrow keys **▲** and **▼** select the warm-up mode:

▲	WARM-UP		RTC Auto
▼	Nom	Act	
	100	0	kV

▲	WARM-UP		EXT
▼	Nom	Act	
	100	0	kV

**RTC Auto:** The X-ray unit can be warmed-up from half of the nominal tube voltage up to the maximum tube voltage as described in chapter 2.2.4.

**EXT:** The X-ray unit will be warmed-up with an special warm-up program always to the maximum tube voltage. It is not possible to enter a warm-up voltage, less than the maximum tube voltage.

WARM-UP		EXT
Nom	Act	
100	0	kV
2.0	0.0	mA
Warm-up Voltage		Time left
200 kV		68'00"
Push X-RAY ON Button		
118		14.04.2009 14:52:43

The warm-up program will be started by pressing the button **X-RAY ON**.

If the equipment will be switched off e.g. by uneven operation of the X-ray tube or by a fault during the warm-up program, a corresponding message will appear on the display. The procedure in case of a shut-down by a fault or an uneven operation of the X-ray tube, is carried out as described in section 2.2.4, page 21 and 22.



After this type of technical fault (or X-RAY OFF) during the extended warm-up mode, the user still has **four** further attempts to warm-up the tube. After this, the warm-up will be stopped and can only be restarted after a renewed mains-ON.

If the warm-up program is terminated five times, the following message appears in the comment line on the display:

WARM-UP		EXT
Nom	Act	
100	0	kV
2.0	0.0	mA
Warm-up Voltage		Time left
200 kV		67'37"
Warm-up terminated after 5 attempts		
116		14.04.2009 14:46:21



The unit can only be restarted after a renewed mains ON. **In this case, a service technician should be consulted.**

### 2.3 Setting the Operating Parameters

Input via the numeric keypad:

The desired value is entered via the numeric keypad. It is displayed on the respective line. If an incorrect value is entered by mistake, the value can be deleted by pressing the **CL** key.

#### 2.3.1 Exposure time

Press the **F4<sub>e</sub>** key. The set-point value display of the minutes/seconds is displayed inversely.

[mm'ss"]	MANUAL		
	Nom	Act	
kV	120	0	kV
mA	4.5	0.0	mA
	0	0	s
P	22.10.2008 11:54:06		

Enter the desired exposure time, confirm the set exposure time via the **OK** key, and the clock symbol  $\text{⌚}$  subsequently appears.

F1 F5	MANUAL		
	Nom	Act	
kV	120	0	kV
mA	4.5	0.0	mA
$\text{⌚}$	15	0	s
P	15.12.2008 14:48:09		

If **0** is entered as the time, the timer is switched off and the high voltage can only be switched on and off via the **X-RAY ON** and **X-RAY OFF** button.

(Special version for Australia: 0 cannot be entered, the input value must be greater than 0.0. The maximum exposure time is 30 min.)

Press the **F1** key [**mm'ss"**] or (**s**) to toggle between the sec. display and the min/sec. display for the exposure time.

mA	4.5	0.0	mA
$\text{⌚}$	15	15	s

mA	4.5	0.0	mA
$\text{⌚}$	01'25"	01'25"	

2.3.2 kV setting

Press the **F2 / kV** key. The set-point value of the high voltage is displayed inversely.

MANUAL			
	Nom	Act	
kV	<b>120</b>	0	kV
mA	4.5	<b>0.0</b>	mA
⌚	15	0	s
P			
⌚ 22.10.2008 13:13:11			

Enter the desired kV value and press the **OK** key to accept the set kV value.

2.3.3 mA setting

Press the **F3 / mA** key. The set-point value of the tube current is displayed inversely.

MANUAL			
	Nom	Act	
kV	120	<b>0</b>	kV
mA	<b>4.5</b>	0.0	mA
⌚	15	0	s
P			
⌚ 22.10.2008 13:13:30			

Enter the desired mA value and press the **OK** key to confirm the set mA value.

## 2.4 Power mode

In power mode, the shortest exposure time that can be achieved with the maximum tube output is calculated.

To switch on the power mode, parameter input must occur as described in section 2.3 according to the exposure diagram (see appendix) in the following order:

Example:

1. kV = 90,
2. mA = 4.5,
3. min = 5.0.

For power optimisation, press the **F5** key **P**:

The unit calculates the shortest exposure time that can be achieved with the maximum tube power.

The shortest exposure time set by the unit is **30 sec.**



**NOTE:** In case of low mains voltage (< 204 V or < 107 V), the nominal values cannot be achieved, depending on the output power.

The unit then switches off with message **124: reduce power**.

**Remedy:** Reduce the power by approx. 20% and increase the exposure time correspondingly.

## 2.5 Exposure calculator

The integrated exposure calculator calculates the appropriate  $mA \times min$  - product based on the pre-selected high voltage and the respective set parameters. The maximum permissible tube current and the appropriate exposure time for the set high voltage are preset with these values.

The exposure calculator is called as follows:

Use the **F1**  key to change the function key arrangement:

MANUAL	
Nom	Act
160	0 kV
4.5	0.0 mA
05'00"	05'00"
23.10.2008 09:04:50	

Press the **F5**  key to call the exposure calculator:

EXPOSURE CALCULATOR		
Nom	Exp. Parameter	
kV 160	kV	Material Fe
mA 4.5	mA	Thickness 42.0 mm
P 05'00"		Density 2.0
		Film D7/C5
		FFD 700 mm
		mA x min 45.0
22.10.2008 14:01:00		

Press the **F2**  key to change the function key arrangement, and the *Material* parameter in the *Exp.Parameter* field is displayed inversely:

EXPOSURE CALCULATOR		
Nom	Exp. Parameter	
160 kV	Material <b>Fe</b>	Thickness 42.0 mm
4.5 mA	Density 2.0	Film D7/C5
05'00"	FFD 700 mm	mA x min 45.0
22.10.2008 14:01:51		

Press the ◀ and ▶ keys to change the parameter.

Press the OK key to accept the new value, the next parameter is displayed inversely and can be changed as described above.

Press the ▲ and ▼ keys to select the next parameters without accepting the changed value.

If all the parameters are entered according to the inspection task, calculation is started by pressing the F4  key.

The function key arrangement is changed.

In accordance with calculation of the mA x min - product, the shortest exposure time for the set kV and mA - values is set:

EXPOSURE CALCULATOR			
	Nom		Exp. Parameter
kV	160	kV	Material Fe
mA	4.5	mA	Thickness 22.2 mm
P	05'18"		Density 2.3
			Film D7/C5
			FFD 800 mm
			mA x min 23.9
<input checked="" type="checkbox"/>			
16.12.2008 08:11:17			

After pressing the F4 / P key, the power mode is switched on and a new calculation of the exposure time is automatically executed so that the calculated mA x min - product remains in place.

Upon changing the kV values the exposure-time will be automatically re-calculated with the same Exp. Parameter setup.

EXPOSURE CALCULATOR			
	Nom		Exp. Parameter
kV	160	kV	Material Fe
mA	5.6	mA	Thickness 22.2 mm
P	04'15"		Density 2.3
			Film D7/C5
			FFD 800 mm
			mA x min 23.9
<input checked="" type="checkbox"/>	Power Mode		
42 16.12.2008 08:13:05			

When all the settings and calculations have been carried out, press the F5  key to exit the exposure calculator:

MANUAL			
	Nom	Act	
kV	160	0	kV
mA	5.6	0.0	mA
⌚	04'15"	04'15"	
Power Mode			
P	42	⌚	16.12.2008 08:14:25

If the calculated values are to be saved as a program, press the **F1**  key, it is then possible via the **F2**  key to save the calculated values as a program as described in section 2.9.

By calling the previously saved program as described in section 2.10, it is possible to carry out exposures with the calculated values in program mode.

P 010:			
	Nom	Act	
⌨	160	0	kV
📁	5.6	0.0	mA
⌚	04'15"	04'15"	
⌚ 16.12.2008 08:15:31			

To carry out exposures with the calculated values in manual mode, the function key arrangement must be changed to *standard mode* by pressing the **F1**  key several times:

MANUAL			
	Nom	Act	
kV	160	0	kV
mA	5.6	0.0	mA
⌚	04'15"	04'15"	
P			
⌚ 16.12.2008 08:16:20			

2.6 FFD-Correction

With the FFD-Correction, the shortest exposure time will be calculated, which is possible with the selected **Film-Focal-Distance** (FFD).

The input parameters must be carried out in accordance with the exposure charts in Annex 1, precisely in the sequence, as described in Section 2.3.



**NOTE:** The values describes in chapter 2.3, refer to the standard Film-Focal-Distance of 700 mm. This value can be changed in the setup menu, item **13 Exposure Calculator** (page 52).

To switch on the FFD Correction the function key arrangement must be changed by pressing key **F1**  twice and the key **F4 / FFD** has to be actuated.

MANUAL			
	Nom	Act	
	120	0	kV
	4.5	0.0	mA
FFD	15	0	s
28.04.2009 09:01:45			

Thereby the **Film-Focal-Distance** will be indicated inversely on the right site of the display.

To get an exposure time for an other **Film-Focal-Distance**, the desired **Film-Focal-Distance** has to be entered via the numeric keypad.

MANUAL			
	Nom	Act	FFD
	120	0	kV
	4.5	0.0	mA
	15	0	s
			<b>700</b> mm
28.04.2009 09:02:27			

The integrated computer calculates the exposure time for the entered **Film-Focal-Distance** and the calculated value is preset.

MANUAL			
	Nom	Act	FFD
	120	0	kV
	4.5	0.0	mA
FFD	7	7	s
			500 mm
28.04.2009 09:03:17			

After pressing key F1  to change to the parameter view, press the button START to start the exposure.

	MANUAL		
	Nom	Act	
kV	120	0	kV
mA	4.5	0.0	mA
	7	7	s
P			
 28.04.2009 09:03:54			



**NOTE:**

In case of low mains voltage (< 204 V or < 107 V), the nominal values cannot be achieved, depending on the output power.

The unit then switches off with message **124: reduce power**.

**Remedy:** Reduce the power by approx. 20% and increase the exposure time correspondingly.

## 2.7 Starting Exposure

Once all the settings have been carried out and all the safety measures for the exposure have been set according to section 1, the exposure can be started by pressing the **X-RAY ON** button.



**NOTE:** **Operational readiness for switching on the radiation is always displayed via the green illuminated X-RAY ON button.**

After the set prewarning time (0,2,3...250s), the control lamp i at the control unit and the indicator lamp at the radiating unit start to flash. If the optional warning flash lamp is connected, it will start to flash after pressing the **X-RAY ON** button.



**CAUTION:** With a connected warning flash lamp, an prewarning time of at least 2 seconds **must** be set, otherwise the high voltage cannot be switched on.

The high voltage is switched on and starting from a minimum value it slowly increases up to the pre-selected nominal values, and the exposure time runs down.

The prewarning time can be switched off in the set-up menu under point 04 (page 43).

6 seconds prior to the end of the exposure time an acoustic signal sounds until the high voltage is switched off.

Once the exposure time has expired, the high voltage will be purposefully reduced to zero and switched off after a short reheat period to discharge the high voltage cascade.

If technical faults occur during operation, the unit will be switched off and the operator will be receive a message explaining the reason for unit shut-down. After eliminating the technical fault, the unit can be restarted.

	MANUAL		
	Nom	Act	
kV	160	0	kV
mA	4.5	0.0	mA
⌚	05'00"	04'52"	
P	Flash lamp faulty		
	87	⌚	23.10.2008 10:33:35

The message disappears and the remaining exposure time runs down.

If the mains supply fails during exposure, the displayed actual-value of the exposure time remains at the current value.

As soon as the power supply returns, exposure can be continued by pressing the **X-RAY ON** button again. An exposure time error cannot occur.

When changing or switching on the high voltage, an automatic check determines whether warm-up is necessary or not.

If necessary, the message **106: Warm-up necessary** is displayed, and the warm-up program is called after pressing the **F4**  key.

WARM-UP		RTC Auto
Nom	Act	
100	0	kV
4.5	0.0	mA
Warm-up Voltage		Time left
120 kV		08'00"
Push X-RAY ON Button		
118	🕒	22.10.2008 10:13:40

Press the **X-RAY ON** button to start the warm-up program.

The X-ray tube is warmed up to the new high voltage value, as described in section 2.2.4.

## 2.8 Exposure Stop

The exposure can be stopped at any time by pressing the **X-RAY OFF** button. The high voltage is reduced to zero before the high voltage supply is switched off.

In this case, the displayed actual-value of the exposure time remains at the current value, and the exposure can be continued at any time by restarting. An exposure time error cannot occur.

If a new exposure is to be carried out after the *manual stop*, the exposure time must be reset as described under point 2.3.1.

If the high voltage is set higher than the warm-up voltage, the message **106: Warm-up necessary!** appears on the display (also see section 2.7).

## 2.9 Generating Programs

In **MANUAL** mode, set the desired parameters as described under section 2.3.

Use the **F1**  key to change the function key arrangement:

MANUAL			
	Nom	Act	
	120	0	kV
	4.5	0.0	mA
	15	15	s
22.10.2008 09:06:59			

Press the **F2**  key. A list with 250 program positions of the data source appears, which is activated in the setup menu item *14 Memory location*:

P 001:			
No	kV	mA	⌚
001	120	4.5	00'15"
002	120	4.5	00'15"
003	0	0.0	00'00"
004	0	0.0	00'00"
005	0	0.0	00'00"
006	0	0.0	00'00"
007	0	0.0	00'00"
008	0	0.0	00'00"
009	0	0.0	00'00"
010	160	5.6	04'15"

Use the arrow keys **▲** and **▼** to select the desired program position and press the **F4**  key to save the program.

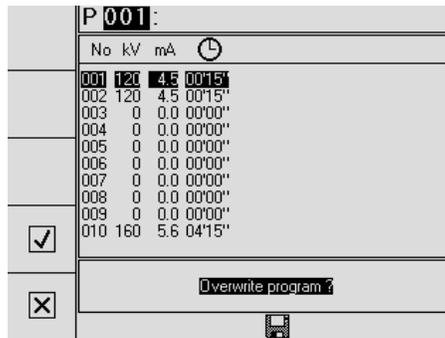


**NOTE:** If you attempt to program a program without an exposure time, the following message appears:

**66: Exposure time = 0**

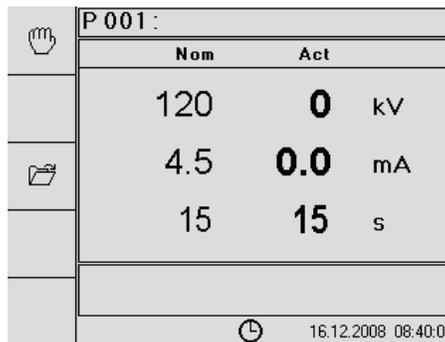
Press the **F5**  key to delete the message, enter the desired exposure time in manual mode, and save the program as described above.

If a program already exists under the desired program number, the following message appears:

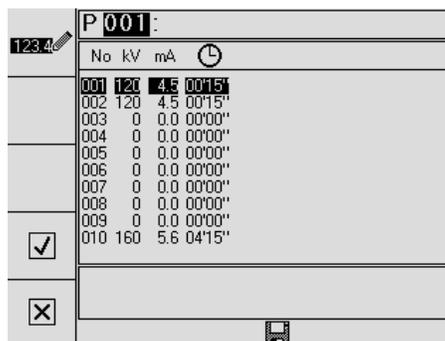


Press the **F5**  key to ensure the existing program is not overwritten. Select another program number.

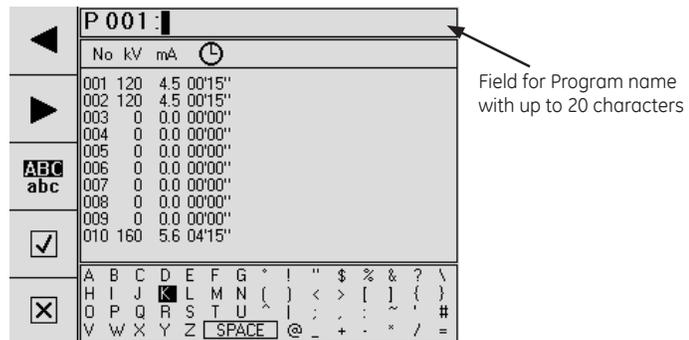
Press the **F4**  key to overwrite the existing program, the program mode appears on the display.



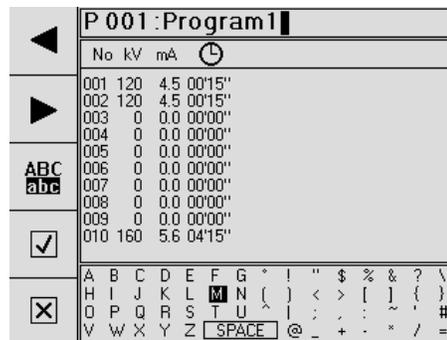
It is possible to give each program a name with up to 20 characters: (The entered program names will not assumed when saving the program into the X-ray unit (see setup menu item 14 Memory location))



To achieve this, press the **F1**  key.



Use the arrow keys ◀ and ▶ as well as ▲ and ▼ to select the desired letters from the lower field and press the **OK** key to enter them in the upper field. Numbers are entered via the numeric keypad without pressing the **OK** key.



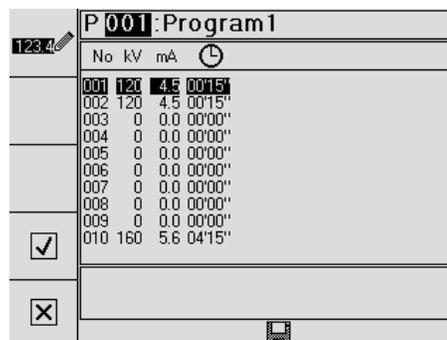
Use the **F1** ◀ and **F2** ▶ keys to move the cursor in the entered name. If another letter is entered while the cursor is positioned in the name, it is entered in front of the highlighted letter.

Press the **F3** **ABC**/**abc** key to toggle between upper and lower case letters.

The **CL** key always deletes the highlighted letter.

Press the **F5** **X** key to exit the mask and to reject the entries.

Press the **F4** **✓** key to accept the name.



Use the arrow keys ▲ and ▼ to select the desired program position and press the F4  key to save the program.

P 002:Program1			
	Nom	Act	
	120	0	kV
	4.5	0.0	mA
	15	15	s
16.12.2008 08:49:08			

If a program already exists under the desired program number, the following message appears:

P 002:			
No	kV	mA	⌚
001	120	4.5	00'15"
002	120	4.5	00'15" Program1
003	0	0.0	00'00"
004	0	0.0	00'00"
005	0	0.0	00'00"
006	0	0.0	00'00"
007	0	0.0	00'00"
008	0	0.0	00'00"
009	0	0.0	00'00"
010	160	5.6	04'15"
Overwrite program ?			

Press the F5  key to ensure the existing program is **not** overwritten. Select another program number.

Press the F4  key to overwrite the existing program, the program mode appears on the display.

P 002:Program1			
	Nom	Act	
	120	0	kV
	4.5	0.0	mA
	15	0	s
16.12.2008 09:12:36			

## 2.10 Calling and Exiting Programs

In **MANUAL** mode, press the **F1**  key to change the function key arrangement:

MANUAL			
	Nom	Act	
	120	0	kV
	4.5	0.0	mA
	15	15	s
22.10.2008 09:06:59			

Press the **F3**  key. A list with 250 program positions of the data source appears, which is active in the setup menu item *14 Memory location*:

P 001:			
No	kV	mA	
001	120	4.5	00'15" Program1
002	120	4.5	00'15" Program1
003	0	0.0	00'00"
004	0	0.0	00'00"
005	0	0.0	00'00"
006	0	0.0	00'00"
007	0	0.0	00'00"
008	0	0.0	00'00"
009	0	0.0	00'00"
010	160	5.6	04'15"

Use the arrow keys to select the desired program number (possible prog. nor. 1 to 250) and then press the **F4**  key to call the selected program.

The display changes to the program mode:

P 002: Program 1			
	Nom	Act	
	120	0	kV
	4.5	0.0	mA
	15	0	s
16.12.2008 09:12:36			

When loading programs from the X-ray unit (see setup item *14 Memory location*) the name of the program will not assumed.

Press the **F3**  key to call a new program at any time, as described above.

It is not possible to change parameters in the program mode. Only the **X-RAY ON** and **X-RAY OFF** button and the **CL** key are active.

If the high voltage is switched off, the **F1**  and **F3**  key are also active in order to call other programs or to switch to the MANUAL mode.

Furthermore, the arrow keys and the **OK** key are active to switch the backlight on and off and to set the contrast (see section 2.11 and 2.12).

Press the **F1**  key to exit the program mode at any time. The manual mode re-appears with the values of the last operated program mode.

		MANUAL			
		Nom	Act		
	kV	100	<b>0</b>	kV	
	mA	4.5	<b>0.0</b>	mA	
		10	<b>10</b>	s	
P					
					24.10.2008 10:06:55

### 2.11 Switching the backlight on and off

In the MANUAL and PROGRAM mode, it is possible to switch the backlight of the display off and on via the **▼** key and **▲** key respectively.

### 2.12 Setting the Display Contrast

In MANUAL and PROGRAM mode, it is possible set the display contrast by pressing either the **◀** or **▶** arrow key.

Press the **OK** key to accept the set value.

		MANUAL			
		Nom	Act		
	kV	100	<b>0</b>	kV	
	mA	4	<b>161</b>	A	
		10	<b>10</b>	s	
P					
					24.10.2008 10:13:50

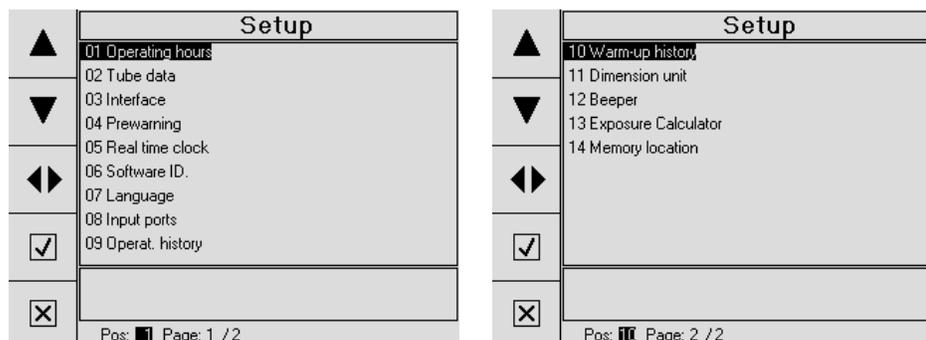


**NOTE:** The backlight and the contrast setting can only be activated when the display mode shows the parameters.

### 3 Setup Menu

Access the setup menu by pressing the **OK** key and simultaneously turning the key-operated switch from **Stand-By** to **ON**.

The setup menu appears after a few seconds.



Use the arrow keys **▲** and **▼** to select the menu items on this page. If the arrow key **▼** is pressed in line 09, the next page will be displayed. With key **F3** **◀▶** you can toggle between the pages.

All the menu items can be selected by entering the respective number and pressing the **OK** key (e.g. **01** and **OK**). The current position is displayed inversely.

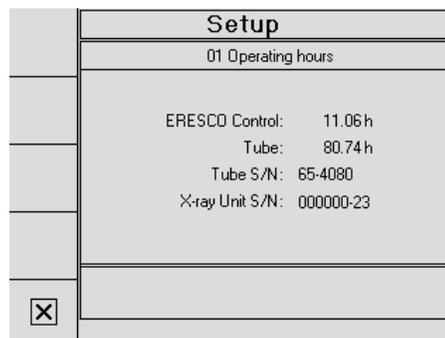
You can leave the menus by actuating key **F5** **✕** at any time.



**NOTE:** If the digital control unit **ERESCO MF4 control** will be used as stand-alone equipment (without X-ray unit) e.g. for setting of the parameters of Interface or Exposure Calculator, following menu items are not available: 01, 02, 04, 05, 08 and 12.. The menu items 09 and 10 can only be selected, if in menu item 14, "control unit **ERESCO MF4 control**" is activated as memory location.

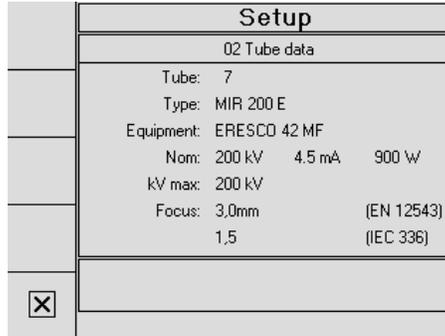
#### 01 Operating hours

The operating hours of the digital control and the radiating unit with integrated insert tube are displayed. Furthermore the serial number of the connected radiating unit and the integrated insert tube are displayed.



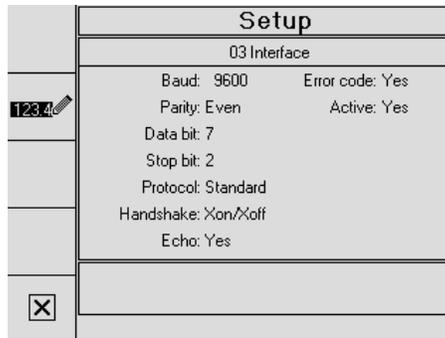
02 Tube data

The operating data of the connected tube, such as tube code, type of radiating unit, nominal voltage, nominal current, nominal output, voltage limitation and focal spot size (according to EN 12543 and IC 336), are displayed.

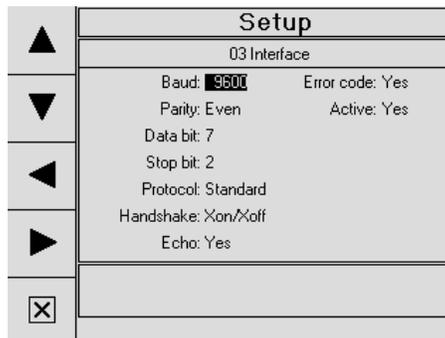


03 Interface

The current interfaces are displayed.



Press the **F2** key to change the function key arrangement. The **Baud** rate is highlighted.

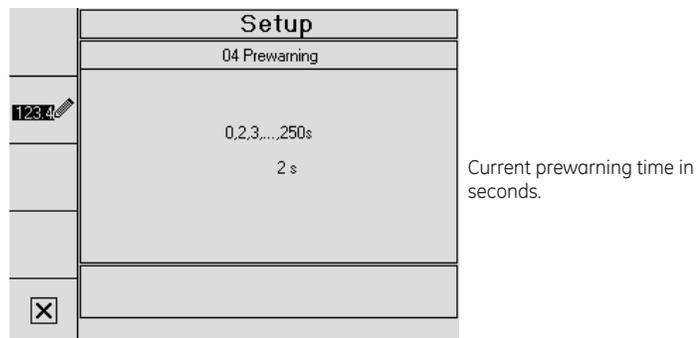


Use the **F3** ▲ and **F4** ▼ keys to select the parameter to be changed and press the **F1** ◀ and **F2** ▶ keys to change the parameter. Press the **OK** key to accept the changed value and to select the next parameter.

After carrying out all the settings and confirming them via the **OK** key, press the **F5** key to return to the setup menu.

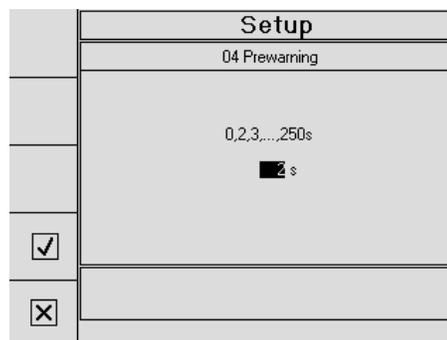
04 Prewarning

The current prewarning time is displayed.



Press the **F5**  key to exit the menu item without changes.

Press the **F2**  key to change the function key arrangement and to display the current prewarning time inversely:



This setting will be changed by entering another value via the numeric keypad or by pressing the **▲** or **▼** keys.

Press the **OK** key to confirm the new setting.

Enter **0** to switch off the prewarning time.

After entering 0 second, the **password 1483** must be entered to confirm the setting. Password input is not required for prewarning time changes above 2 seconds. A prewarning time setting of 1 second is not possible.



**CAUTION:** The prewarning time is designed to protect personnel and should not be set to 0!

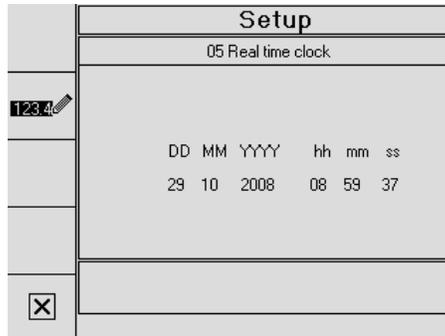


**NOTE:** With a connected warning flash lamp, an prewarning time of at least 2 seconds **must** be set, otherwise the high voltage cannot be switched on.

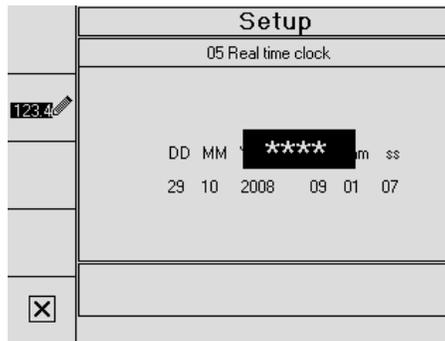
The prewarning time is factory set to 2 seconds.

05 Real time clock

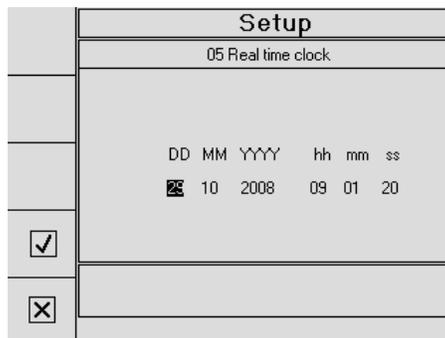
The current time and date are displayed.



Press the **F2**  key to set the real time clock.  
A password prompt appears:



The function keypad changes after entering the **password 1483**:



The parameter **DD** is displayed inversely and can be changed by pressing either the numeric keys or the ◀ and ▶ keys.

Press the **OK** key to accept the new value. The next parameter is displayed inversely and can be changed as described before.

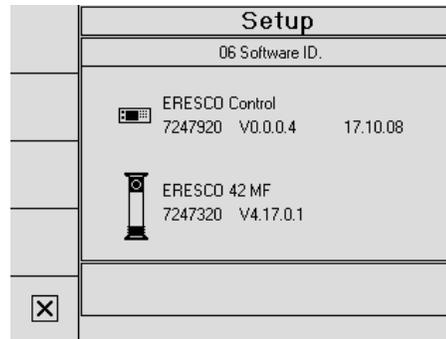
Press the ▲ and ▼ key to select the next parameters **MM**, **YYYY**, **hh**, **mm** and **ss** without accepting the changed value.

Press the **F4**  key to display the mask with the changed values.

Press the **F5**  key to exit the menu item.

06 Software ID.

The software ID number and date of the software in use are displayed.



Press the **F5**  key to exit the display.

07 Language

The current language is displayed inversely. Use the ▼ and ▲ keys to select one of the displayed languages.



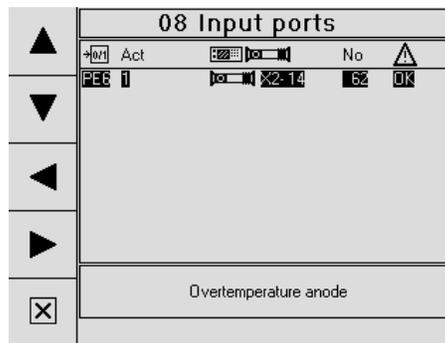
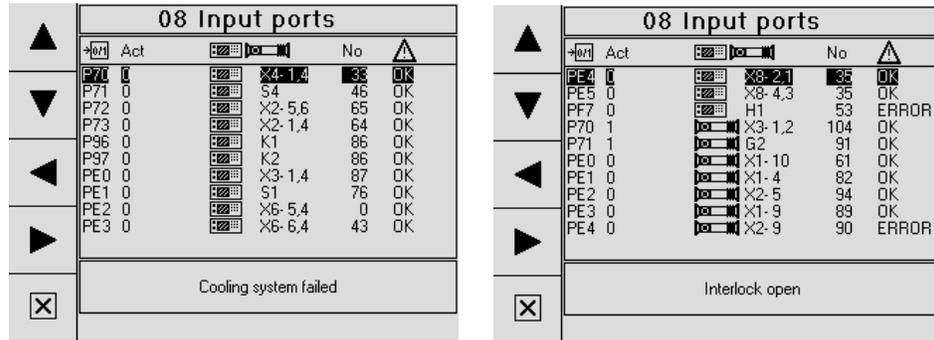
Press key **F4**  or the **OK** key to activate the selected language. The setup menu will be displayed again.

Press the **F5**  key to exit the menu without changes.

08 Input ports

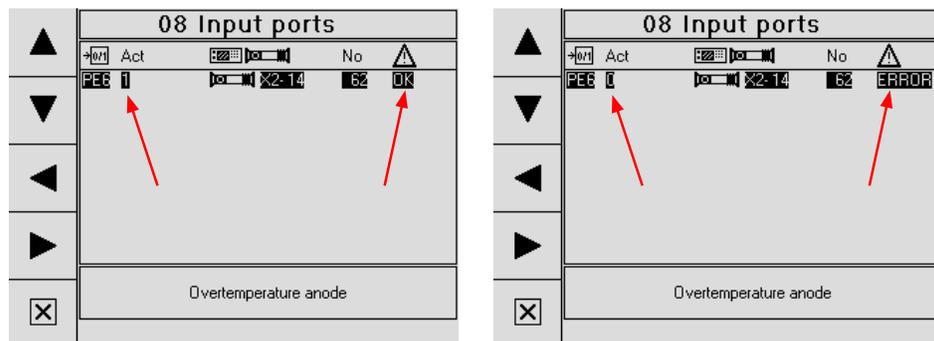
For diagnostic purposes, the digital and analogue input parameters are dynamically displayed for both **ERESCO MF4 control** and radiating unit.

Use keys **F3** ◀ and **F4** ▶ to toggle between the masks.  
 Use keys **F1** ▲ and **F2** ▼ to select individual lines.



Displayed are:

- Row 1: port name
- Row 2: actual state (Bit=0 / Bit=1)
- Row 3: location (Control [Control icon] / X-ray unit [X-ray icon]) and hardware (device e.g. H=lamp, S=switch, X=plug)
- Row 4: no. of the message that appears in the event of an error. The corresponding message is displayed in the lower field, if the cursor is located on the corresponding port.
- Row 5: status indication of the ports (OK / ERROR)



09 Operat. history

Up to 256 data records (0-255) can be requested about the history.

Use the ▲ or ▼ key to select and display the previous or next data record. Press the ◀ or ▶ key to call the next or previous 10 data records.

The data record number (No.), the operating mode (M, W, P), the **kV nominal and actual value**, the **mA nominal and actual value**, the high voltage status f (X-Ray ON (X) or X-Ray OFF) and a possible related message (⚠) are always displayed.

09 Operat. history								000
No	kV	mA	Date	Time	⚡	⚠		
000	W120	120	4.5	4.4	16.12.2008	11:51:29	TT8	
001	W100	0	4.5	0.0	16.12.2008	11:51:29	X 0	
002	W160	160	4.5	4.4	16.12.2008	07:40:54	119	
003	W120	0	4.5	0.0	16.12.2008	07:40:54	X 0	
004	W120	120	4.5	4.4	16.12.2008	07:40:54	119	
005	W100	0	4.5	0.0	16.12.2008	07:40:54	X 0	
006	M 120	0	4.5	0.0	15.12.2008	14:38:10	0	
007	M 120	0	4.5	0.0	15.12.2008	14:38:10	X 0	
008	M 120	0	4.5	0.0	15.12.2008	14:38:10	0	
009	M 120	0	4.5	0.0	15.12.2008	14:38:10	X 0	
Warm-up program completed								

Moreover, this mask displays the **Date** and **Time** of the event.

Press the **F3** key to call a further mask which, in addition to the permanently displayed values (see above), also shows the following measured values:

The mains voltage (V~), the cascade temperature (°C/°F), the gas pressure of the radiating unit (bar) and the temperature of the power stage (°C/°F).

09 Operat. history								000
No	kV	mA	V~	°C	bar	°C	⚡	
000	W120	120	4.5	4.4	228	25	7.6	25
001	W100	0	4.5	0.0	228	25	7.6	25
002	W160	160	4.5	4.4	228	25	7.6	25
003	W120	0	4.5	0.0	228	25	7.6	25
004	W120	120	4.5	4.4	228	25	7.6	25
005	W100	0	4.5	0.0	228	25	7.6	25
006	M 120	0	4.5	0.0	228	25	7.6	25
007	M 120	0	4.5	0.0	228	25	7.6	25
008	M 120	0	4.5	0.0	228	25	7.6	25
009	M 120	0	4.5	0.0	228	25	7.6	25
Warm-up program completed								
16.12.2008 11:51:29								

Press the **F4** key to call a further mask which, in addition to the permanently displayed values (see above), also shows the timer nominal and actual value (⌚) and the program number (📄):

Program number

Timer nominal and actual value

09 Operat. history										000
No	kV	mA	⌚	📁	⚡	⚠				
000	W120	120	4.5	4.4	00'15"	00'00"	000	×	0	119
001	W100	0	4.5	0.0	00'15"	00'00"	000	×	0	
002	W160	160	4.5	4.4	05'00"	05'00"	000	×	0	119
003	W120	0	4.5	0.0	05'00"	05'00"	000	×	0	
004	W120	120	4.5	4.4	00'15"	00'00"	000	×	0	119
005	W100	0	4.5	0.0	00'15"	00'00"	000	×	0	
006	M 120	0	4.5	0.0	00'15"	00'00"	000	×	0	
007	M 120	0	4.5	0.0	00'15"	00'15"	000	×	0	
008	M 120	0	4.5	0.0	00'15"	00'14"	000	×	0	
009	M 120	0	4.5	0.0	00'15"	00'00"	000	×	0	

16.12.2008 11:51:29

Press the **F2**  key to show the first display again with the time and date (see above).

Press the **F5**  key to exit the menu.

### 10 Warm-up history

Up to 256 data records (0-255) about the last used warm-up voltages with date and time can be requested by pressing the **▲** and **▼** keys.

Furthermore, it is also displayed whether the buffer battery is empty (**X**) or not.



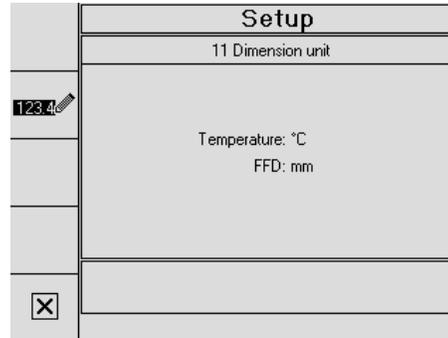
**NOTE:** If a buffer battery is empty, the date and time display is only correct if it has been set correctly after switching on the unit.

Press the **F5**  key to exit the menu.

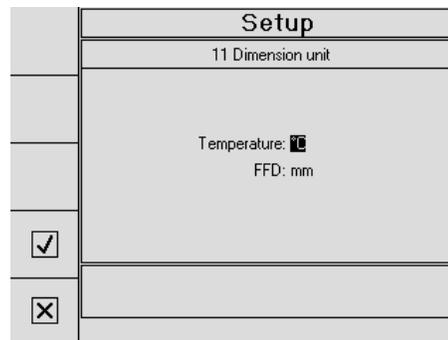
10 Warm-up history					000
No	kV	Date	Time	☐	
000	120	03.11.2008	10:13:00	×	
001	101	24.09.2008	09:59:00		
002	0	01.01.2000	00:00:00		
003	0	01.01.2000	00:00:00		
004	0	01.01.2000	00:00:00		
005	0	01.01.2000	00:00:00		
006	0	01.01.2000	00:00:00		
007	0	01.01.2000	00:00:00		
008	0	01.01.2000	00:00:00		
009	0	01.01.2000	00:00:00		

### 11 Dimension unit

The unit of measurement for the *Temperature* and the *Film Focal Distance* (FFD) are displayed.



Press the **F2**  key to display one of the unit of measurements inversely and to change the function key arrangement:



Use the ▲ and ▼ keys to change the unit of measurements:

(mm <-> inch)  
(°C <-> °F)

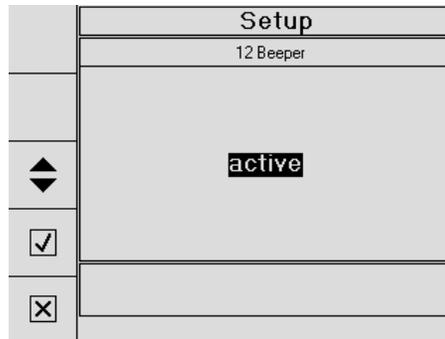
Press the **OK** key to accept the changed unit of measurements and to select the next unit of measurements.

Press the **F4**  key to display the result of the change.

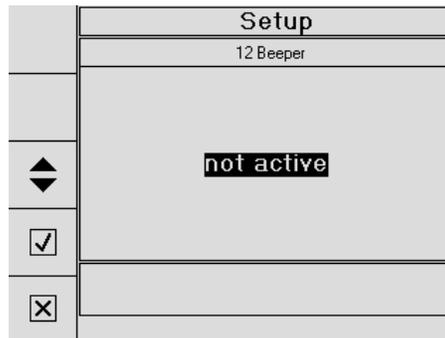
Press the **F5**  key to exit the menu.

12 Beeper

The beeper status is displayed.



Beeper active means: The beeper sounds 10 seconds prior to the end of the exposure time.



Press the **F1**  key to activate or deactivate the beeper.

Press the **F4**  key or the **OK** key to accept the setting.

Press the **F5**  key to exit the menu.

13 Exposure Calculator

Here it is possible to enter or select the exposure factors by which the  $mA \times min - product$  must be multiplied in order to adapt the exposure time, related to a D7 film, or the correction factors in order to convert various materials to the common exposure diagrams for steel and aluminum.

Setup	
13 Exposure Calculator	
Film	Factor
D2	7.00
D3	4.30
D4	2.70
D5	1.50
D7	1.00
D8	0.60
Film 1	0.00
Film 2	0.00
Film 3	0.00

Setup				
13 Exposure Calculator				
Material	50	100	150	220 kV
Fe	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00
Ti	0.00	0.00	0.00	0.00
M1	0.00	0.00	0.00	0.00
M2	0.00	0.00	0.00	0.00
M3	0.00	0.00	0.00	0.00

Press the **F4**  key to toggle between the masks.  
Use the **F2**  key to change the keypad arrangement.

Setup	
13 Exposure Calculator	
Film	Factor
D2	7.00
D3	0.00
D4	0.00
D5	0.00
D7	0.00
D8	0.00
Film 1	0.00
Film 2	0.00
Film 3	0.00

Setup				
13 Exposure Calculator				
Material	50	100	150	220 kV
Fe	0.00	0.00	0.00	0.00
Al	0.00	0.00	0.00	0.00
Ti	0.00	0.00	0.00	0.00
M1	0.00	0.00	0.00	0.00
M2	0.00	0.00	0.00	0.00
M3	0.00	0.00	0.00	0.00



**NOTE:** To compensate differing conditions in the unit or film development set-up, the correction factors for the standard materials Fe, Al and Ti can also be changed

Use the arrow keys  and  or  and  to select the respective parameter. Via the numeric keypad it is possible to enter values for the corresponding *Film* and *Material* parameters.

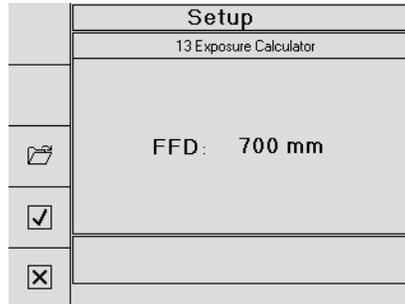
Press the **F4**  key to accept the entry.

Press the **F3**  key to call the default values stored in the unit:

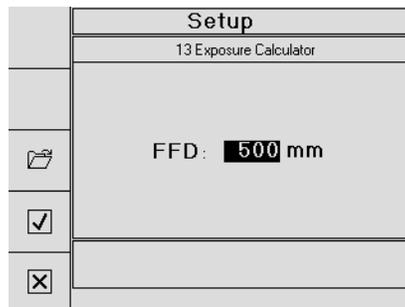
Setup	
13 Exposure Calculator	
Film	Factor
D2	7.00
D3	4.30
D4	2.70
D5	1.50
D7	1.00
D8	0.60
Film 1	0.00
Film 2	0.00
Film 3	0.00

Setup				
13 Exposure Calculator				
Material	50	100	150	220 kV
Fe	0.00	12.00	1.00	1.00
Al	1.00	1.00	0.12	0.18
Ti	0.00	0.00	0.45	0.35
M1	0.00	0.00	0.00	0.00
M2	0.00	0.00	0.00	0.00
M3	0.00	0.00	0.00	0.00

By using key **F4**  a further mask appears in which a new default value of the **Film-Focal-Distance** can be entered.



By using the **F2**  key, the function key arrangement will be changed and the **FFD** value will be displayed inversely:



It is possible to change the default value for the **Film-Focal-Distance** via the numeric keypad.

Press the **F4**  key to accept the entry.

Press the **F3**  key to call up the default values stored in the unit:

After selecting the respective values, press the **F4**  key to accept the values and to display the corresponding basic mask.

Press the **F5**  key to exit each menu without value changes.

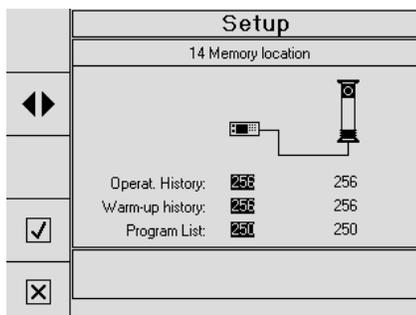
### 14 Memory location

The memory location defines the location (data source) where all relevant system data including operating history, warm-up history, program list and configuration data) is centrally administrated.

The memory location can be changed by pressing the **F2** ◀▶ key.

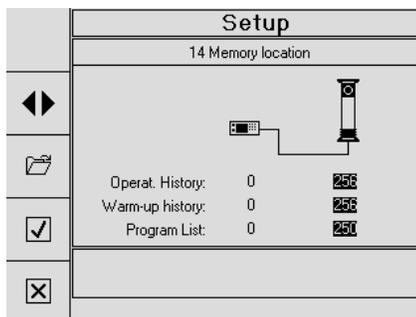
If the active data source is the **ERESCO MF4 control**, all history events will be logged in the control module and radiation unit. However, upon access of this information (download, display) only the data stored in the control will be used.

The program list including the program names will only be managed in the control module.



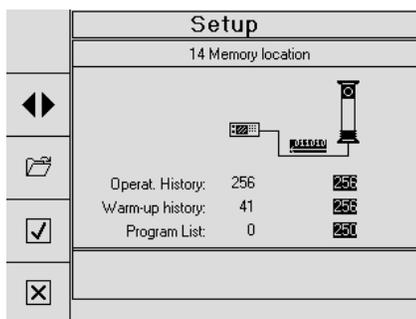
If the active data source is the X-ray unit, the control module does not log or store any data. Upon data access (download, display) the control module accesses the data source on-board of the X-ray unit and temporarily downloads it.

This mode is downwards compatible to MF3 operations.



This mode does not support naming conventions for exposure programs.

By using the key **F3** , the data which is stored in the **ERESCO MF4 control** will be overwritten with the data that is stored in the X-ray unit (e.g. for field service).



**Note:** If the *Administrator Software* program is present, the data can be administrated if necessary with this program.

#### 4 Interlock Mode

Additional safety measures which, e.g., may be caused by the means of transport and the radiation protection elements are often necessary for series exposures on small parts during stationary operation.

The door contact socket (X2) is jumpered with a supplied short circuit plug for portable operation.



**NOTE:** If door contact 1 has been opened, door contact 2 must also be opened since both door contacts are monitored for redundancy (see page 50). Both door contacts must be closed before the unit is ready for operation again.

In order to easily integrate the unit into an safety circuit, the short circuit plug must be removed (see section 2.1.2) and the external safety circuit connected.



Short circuit plug with eyebolt



Eyebolt

For the external safety circuit connection we recommend the ready-made door contact cable (ID No. 7304121).

Pin assignment X2  of the *potential-free contacts* at the digital control unit **ERESKO MF4 control** (see Fig. 7, page 57)

between	pin 2 and 3:	Prewarning, (42 V / 1.0 A)
between	pin 7 and 8:	High voltage ON, (42 V / 1.0 A)
between	pin 13 and 14	Mains voltage ON (110VDC, 125VAC, 1A)

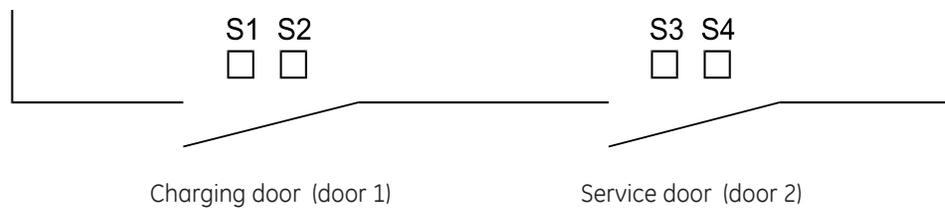
Pin assignment X2  of the *door contacts* at the digital control unit **ERESKO MF4 control** (see Fig. 7, page 57)

between	pin 1 and 4:	Door contact 1
between	pin 5 and 6:	Door contact 2
between	pin 9 and 10:	EMERGENCY STOP
between	pin 11 and 12:	EMERGENCY STOP

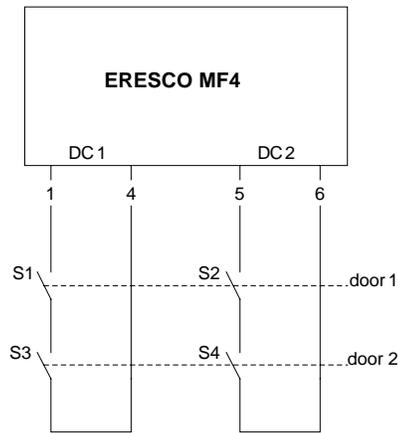


**CAUTION:** In accordance with machinery directive 98/37/EC, the door contact circuits are monitored for redundancy, i.e. if the door contact circuits DC1/DC2 are connected, e.g. when using the unit in systems, they must be connected in a way that ensures that both door contact circuits are opened. Redundancy means that the circuit status of both door contact circuits is monitored for status correspondence. When DC1 is open, DC2 must also be open.

**Example:** X-ray room with a charging door and a service door.

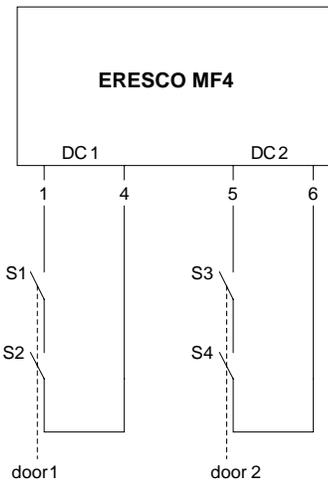


Functions correctly



**Door 1 opens:**  
Both door contact circuits are connected

Does not function correctly



**Door 1 opens:**  
Only 1 door contact circuit is connected

## 5 Protective Devices

1. When the following messages appear

**62: Overtemperatur anode (110°C)**  
**67: Temperature ERESKO control (70°C)**  
**80: Temperature supervision power module (80°C)**  
**105: Overtemperature generator (70°C)**

the high voltage cannot be switched on until the temperature has fallen below the critical level.

The tap symbol on the display flashes until the messages disappear. Press the **CL** key to acknowledge a message.

Basically, heating up the radiating unit depends on the ambient temperature, the pre-selected high voltage and the working position of the radiating unit. Due to the complicated interdependence of these three factors, no general statement can be made about a possible **relationship between the operating time and non-operating time**. With an outside temperature of approx. 30° C and the maximum high voltage, a working rhythm of

**75% exposure time: 25% non-operating time**

is generally possible.

2. Due to sporadic gas eruptions in the the X-ray tube and extremely high mains voltage fluctuations, the tube current can temporarily reach extremely high values which cannot always be regulated via an automatic current control.

In this case, the **overcurrent cut-off** responds and immediately interrupts the high voltage supply to protect the X-ray tube against consequential damages.

**A restart is only possible after the cascade has been discharged (approx. 1 - 2 min).**

3. The yellow high voltage lamp i located on the front of the control unit, the red warning blinker light on the radiating unit and the optionally connectable warning flash light are all fail-safe lamps.

To test the fail-safe operation of the optional warning flash light, press the button on the bottom of lamp. The high voltage should then be switched off and the message *Flash lamp faulty* must appear on the display.

In case of short circuiting or interruption of the lamp circuit, the high voltage cannot be switched on via the **X-RAY ON** button and thus no X-ray radiation can be generated. The following messages appear:

**53: High voltage lamp defective** for the yellow high voltage light i

**104: Warning lamp failed** for the red warning light on the radiating unit

**87: Flash lamp faulty** for the optional warning flash light.

After eliminating the faults, press the **CL** key to confirm the messages.

(If one of the warning lights fails during operation, the high voltage is immediately switched off and the messages described above appear)

6 Fuses and pin assignment at ERESKO MF4 control



Fig. 7 - Plug hutch of the digital control unit **ERESKO MF4 control**

Fuses at the digital control unit **ERESKO MF4 control**

F1	Water cooling pump	Microfuse 4 A/T Ø 5.0 x 20
F2	Power unit 230 V	Microfuse 20 A/FF Ø 6.3 x 32

Plug connections (see Fig. 7):

Pin assignment **X1** ~ mains connection

L	(1)
N	(2)
PE	

Jumper between 3+4 for connecting cable (orange) 230VAC version

Jumper between 3+5 for connecting cable (grey) 115VAC version

Pin assignment **X2** of the *potential-free contacts*

between	pin 2 and 3:	Prewarning, (42 V / 1.0 A)
between	pin 7 and 8:	High voltage ON, (42 V / 1.0 A)
between	pin 13 and 14	Mains voltage ON, (110VDC, 125VAC, 1A)

Pin assignment **X2** of the *door contacts*

between	pin 1 and 4:	Door contact 1
between	pin 5 and 6:	Door contact 2
between	pin 9 and 10:	EMERGENCY STOP
between	pin 11 and 12:	EMERGENCY STOP

Pin assignment X3  for *flash light*

between	pin 1 and 4:	Jumper for operation without warning flash light
between	pin 2 and 5:	230 V AC; max. 0.5 A for prewarning time ON
between	pin 3 and 5:	230 V AC; max. 0.5 A for high voltage ON
between	pin 6 and 5:	230 V AC; max. 0.5 A; constant
	or	
between	pin 1 and 4:	Jumper for operation without warning flash light
between	pin 2 and 5:	115 V AC; max. 0.5 A for prewarning time ON
between	pin 3 and 5:	115 V AC; max. 0.5 A for high voltage ON
between	pin 6 and 5:	115 V AC; max. 0.5 A; constant depending on the applied mains.

Pin assignment X4  for the *cooling circuit*

between	pin 1 and 4:	Signalling contact for the water flow rate monitor
between	pin 2 and 5:	Supply voltage for the water cooling pump 230V AC, 4A constant or 115V AC, 4A constant depending on the applied mains.

Pin assignment X5  for the *connecting cable*

Description

Pin 1:	+27V
Pin 2:	RS485B
Pin 3:	RS484A
Pin 4:	+325V
Pin 5:	-325V
Pin 6:	GND
PE	Protective earth

Pin assignment X6  for *EXTERNAL START/STOP*

between	pin 4 and 5:	External START
between	pin 4 and 6:	External STOP

Normally closed contacts should be used. The function is executed when opening the contact, provided the other one is closed.

If only one connection (pins 4/5 or pins 4/6) is used, the other contact must be jumpered.

Pin assignment X6  for *interface V24*

Pin 1:	GND
Pin 2:	TXD
Pin 3:	RXD

## 7 List of Messages

Code	Message	Possible Cause	Place of Origin
33	Cooling system failed	The coolant flow rate of the pump has dropped below the minimum value, coolant temperature too high	Coolant pump, hoses, flow rate monitor, temperature controller
39	Absolute undercurrent monitoring	Faulty tube filament/ open filament transformer secondary Filament limiting current has not been set or has been set incorrectly Short circuit in the filament Faulty inverter for the filament	There is a tube current of < 300 $\mu$ A
46	EMERGENCY STOP	EMERGENCY STOP circuit open	EMERGENCY STOP button
50	Tube overpower	kV and mA within the permissible range, but the product of kV and mA is too high	Operating error
51	Preselection out of range	The pre-selection is above the nominal voltage of the pre-selected X-ray tube.	Operating error
52	Presel.exceeding rated gener.current		Operating error
53	High voltage lamp defective	The high voltage lamp in ERESKO MF4 is defective	ERESKO MF4
55	Relative overcurrent monitoring	Fault in the control circuit Tube has drawn in gas	The actual tube current value exceeds the pre-selected set-point value.
58	Not programmed	Programs have been called for which a program has not yet been generated	Operating error
60	Relative undercurrent monitoring	Filament current set incorrectly (the value changes if a higher kV value has been selected) Fault in the control circuit Check the filament current setting again	The actual tube current value is less than the pre-selected set-point value.
61	Chopper overcurrent	Defective chopper Defective inverter Supply voltage +15 V <sub>ch</sub> missing	The current in the Chopper IGBT is too high
62	Overtemperatur anode	Defective fan at the radiating unit, or no power supply to the fan Insufficient supply of air to the radiating unit Excessive ambient temperature Thermal controller in the radiating unit defective	The temperature at the X-ray tube has exceeded 110°C
63	Door contact 1 and 2	Door contacts 1 and 2 are open	Door contacts
64	Door contact 1 open	Door contact 1 is open	Door contact
65	Door contact 2 open	Door contact 2 is open	Door contact

Code	Message	Possible Cause	Place of Origin
66	Exposure time = 0	Tried to save a program without a pre-selected exposure time	Operating error
67	Temperature "ERESCO control"	The temperature inside the control unit ERESKO MF4 is too high	ERESCO MF4
72	Preselection out of range, to low	Entered kV or mA value below the permissible value	Operating error
76	--- Stand-by ---		
77	Presetting too large		Operating error
78	Program bridged? (not active)		
79	Low gas pressure	Pressure in the radiating unit too low	Radiating unit
80	Temperature supervision power module	High ambient temperature/Solar radiation Radiating unit has been operating too long (> approx. 2 hours)	The output stage temperature has exceeded 80°C.
82	HV prim. overcurrent	Current too high at the primary side of the high voltage transformer	Radiating unit
86	HV contactor faulty	Appears when - with high voltage OFF - the high voltage contactor is not released	High voltage contactor
87	Flash lamp faulty	Flash lamp defective; no flash lamp connected No prewarning time set (see set-up menu point 05) Short circuit plug is not inserted in X3	Ext. warning flash lamp, cable, plug panel power module, high voltage warning flash lamp in systems
89	Filament primary overcurrent	Defective filament transformer Defective inverter for generating filament voltage	Inverter for generating filament voltage
91	Buffer battery empty	The buffer battery is flat	Radiating unit
94	Power stage, high voltage failed	Flashover in the X-ray tube, or flashover in the high voltage circuit: Defective high voltage circuit Defective inverter for generating high voltage Response threshold for the monitoring circuit is set too low	Radiating unit

Code	Message	Possible Cause	Place of Origin
104	Warning lamp failed	Monitoring of the warning lamp at the radiating unit has responded	Warning lamp, incorrect software setting
105	Overtemperature generator	To long operation or to high ambient temperature.	
106	Warm-up necessary	A high voltage value is selected for which the X-ray tube has not been warmed up	Operating error
107	Keypad error	Keypad error at the control unit; a key is stuck A key at the control unit keypad has been pressed for too long.	ERESCO MF4
108	Power failure (low voltage)	The mains voltage has fallen below the permissible minimum value (nominal voltage -10%); Fuse F2, F6 or F7 defective	Mains; ERESO MF4
109	Warm-up! 0=No		
111	Chopper output voltage failed	The output capacitor has not been discharged The electronic power switches are defective Voltage monitoring error	Control module, IGBT chopper
113	Absolute overcurrent monitoring	The actual current value has exceeded the generator limit current. 10.5 mA for ERESO 42 MF4; 6.5 mA for ERESO 65 MF4 Control circuit error; tube has drawn in gas	Radiating unit
116	Warm-up terminated after 3 attempts	The warm-up program has been terminated three times (see page 18)	Operating error
117	Warm-up aborted. Try again	Warm-up was terminated due to a fault or by the operator	ERESCO MF4; radiating unit
118	Push START button	Prompt to press the X-RAY ON button	ERESCO MF4
119	Warm-up program completed Continue with ENTER	Prompt to press the OK key after successful X-ray tube warm-up	ERESCO MF4
121	Program aborted consider warm-up instructions ! Continue with ENTER	Message after pressing the Taste F2 key = No after the message 117: Warm-up aborted. New attempt?	ERESCO MF4
124	Reduce power	Mains voltage too low; mains impedance too low (e.g. weak generator) The pre-selected power cannot be achieved with this mains voltage	Mains (see page 27 and 32)

**Recommended procedure for message 82, 94 and 111**

The messages 82, 94 and 111 can occur when the radiating unit

- is only operated occasionally at the maximum high voltage.
- has not been operated for a longer period or is only operated occasionally.
- is operated for short operating cycles.
- is operated in extremely high or extremely low ambient temperatures.

To ensure normal operation, GE Sensing & Inspection Technologies recommends conditioning the radiating unit in *power mode*. To achieve this, the following operating parameters are required:

ERESCO 160 MF4-R	60 kV	10 mA	10 min
ERESCO 200 MF4-R	60 kV	10 mA	10 min
ERESCO 42 MF4	90 kV	10 mA	10 min
ERESCO 32 MF4-C	60 kV	10 mA	10 min
ERESCO 65 MF4	150 kV	6 mA	10 min
ERESCO 52 MF4-CL	100 kV	6 mA	10 min
ERESCO 280 MF4-R	100 kV	3.4 mA	10 min
ERESCO 300 MF4-R	150 kV	6 mA	10 min



After successful operation in power mode as described above, normal operation can be resumed.

**Note:** If after execution of the said procedure the radiating unit cannot be operated at the desired high voltage, the power mode procedure can be repeated up to three times. If this does not result in correct operation of the radiating unit, please contact the Customer Service Department of GE Sensing & Inspection Technologies.

## 8 Maintenance

**Warranty claims shall only be considered if maintenance instructions are fully observed.**

### 8.1 Ideal operation for X-ray tubes

These recommendations and instructions are based on our extensive operating experience and describe correct conduct for the daily handling of X-ray systems and, in particular, X-ray tubes. The consistent implementation of these instructions will help to ensure gentle X-ray operation.

This section makes no claim to be complete, since the service life of an X-ray unit depends to a certain degree on various operating conditions and, in particular, on the actual application. Due to these various conditions, it is also impossible to specify an average service life for X-ray units.

#### **Installation:**

Only trained personnel should carry out system installation. All relevant and suitable installation measures must be observed.

#### **Initial start-up:**

Due to the transport and storage, the X-ray tube cannot be immediately operated for a longer period. Since the gassing of molecules from the surface into the evacuated space of the X-ray tube head occurs on a permanent basis and cannot be prevented, the vacuum is continuously reduced in the X-ray tube.

As a result, the free molecules in the reduced vacuum are ionised when a voltage is applied, and the tube cannot be operated up to the nominal output. The potential difference can result in sudden flashovers in the ionising channel.

To increase the service life of the X-ray tube, regularly *warm-up* or *condition* the tube.

In a physical sense, *warm-up* or *conditioning* is a Getter process in vacuum during which free molecules are bound to the inner surface of the tube. The result is an improved vacuum quality factor.

Warm-up is practically an operating mode during which the tube voltage is gradually increased. The cycle time is individually calculated for each step, according to the tube type, the desired nominal voltage and the operating life of the tube.

**ERESCO MF4** has three warm-up programs:

- **Automatic warm-up**
- **Manual warm-up** (only for trained service personnel)
- **Extended warm-up** (for brand new tubes (green tubes) and to condition tubes that have been out of operation for longer period)

In the automatic warm-up program, the ideal operating values are automatically calculated. Automatic warm-up specifically considers the operating life of the tube and calculates the ideal warm-up procedure via the pre-selected target voltage.

The manual warm-up program is only available for trained service personnel.

The Extended warm-up contains three programs:  
up to 160 kV, up to 200 kV and up to 300 kV

## 8.2 Water cooling pump WL 1001 (optional)

The following tasks must be carried out every 3 months:

- ⇒ Remove and clean the filter (see Fig. 8) at the pump.
    - If the water is heavily soiled, rinse the cooling circuit.
      - To prevent cooling water leaking, place the pump on the side opposite the filter.
  - ⇒ Check the coolant level in the cooling pump:
    - Remove the filler cap.
    - The cooling water should be approx. 3 cm above the fins.
    - The water cooling pump should only be filled with water of drinking water quality.
    - If the water cooling pump is operated at low temperatures, anti-freeze must be added to the water.
- Only **GlycoShell** from **SHELL** should be used.

Article No.: 9434660



**CAUTION:** Do not mix **GlycoShell** with other coolant additives, since this will cause coolant flocculation and total failure of the circulation pump (if necessary, empty the water cooling circuit and refill it with a new mixture of **GlycoShell** and water).

It is extremely important to observe the colour:

 **The following cooling water colours are permissible: Clear, dark blue-green.**

 **Any other colours are not permissible: e.g. red, brown, black.**

- For temperatures up to -25°C we recommend a ratio of:

**two parts GlycoShell and three parts water.**

(Filling approx. 1.5 l + 0.075 l/m hose = 3.0 l for 20m hose length [10m outlet hose + 10m inlet hose])

- ⇒ Clean the cooler (with compressed air), to ensure the fins are not soiled with oil or moist air, carry out more often if necessary.



- Soiled cooler fins will result in insufficient cooling of the cooling water. If the cooling water temperature limit value is exceeded, a thermal controller switches the X-ray unit off.
- If the set minimum flow rate is not achieved, a flow rate monitor switches the X-ray unit off.

It is advisable to have maintenance carried out by service experts from **GE Sensing & Inspection Technologies** to avoid possible high resulting costs.

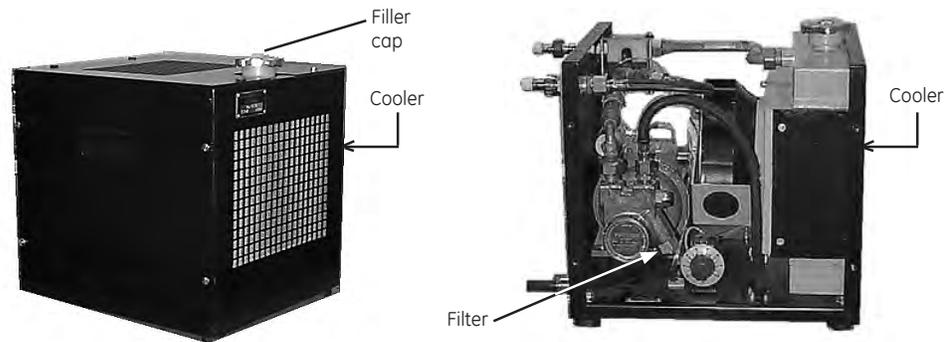
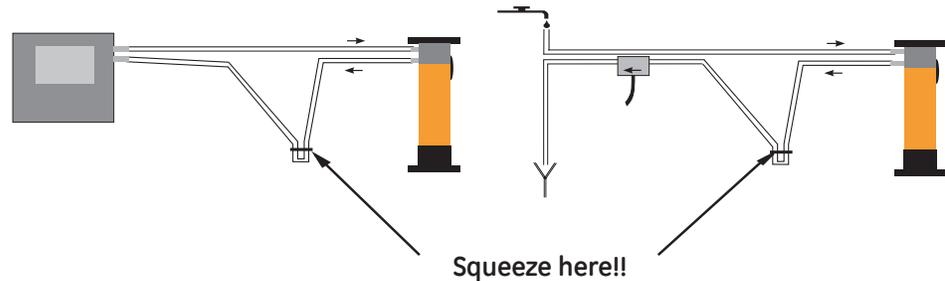


Fig. 8 - Water cooling pump WL 1001

### 8.3 Checking the Automatic Shut-Off of the Flow Rate Monitor (optional)

The return hose to the coolant pump or to the turbine flow rate monitor must be squeezed every 3 months (see diagram).



After approx. 1 second, the following message should appear on the display of the digital control unit **ERESKO MF4 control**

**33: Cooling system failed**

The **tap symbol on the display flashes until the fault has been eliminated** and the high voltage cannot be switched on.

- If these maintenance instructions are not observed, it may result in the X-ray tube head not being cooled, which can cause unit failure and possible **high resulting costs**.

### 8.4 Checking fail-safe operation of the optional warning flash light

To test the fail-safe operation of the optional warning flash light, press the button on the bottom of light.

The high voltage is switched off and the following message

**87: Flash lamp faulty**

appears on the display.

9 Replacing the high voltage lamp at the digital control unit ERESKO MF4 control

High voltage lamp failure at the operation module results in message **53: High voltage lamp defective** and the high voltage is immediately switched off.

Proceed as follows to replace the high voltage lamp:

1. Unscrew the yellow lamp cover



2. Preferably use the lamp extractor (size T1½) to remove the defective lamp with holder:  
Alternatively: Rubber hose, long-nosed pliers, forceps  
Lamp extractor: ID No. 9456540  
Bulb: ID No. 9030420



3. Lamp covers are installed in reverse order.  
When inserting the yellow cap, make sure that the high voltage arrow is pointing downwards.

## 10 Dismantling and disposal

### Operator obligations:

Develop safe technology for the dismantling of the construction under consulting the manufacturer. Naming of persons responsible for occupational safety, supervision and work realisation.

Monitoring of work and control for adherence to the given safety precautions and instructions.

Operator: Inform the manufacturer prior to beginning dismantling of the facility and request his cooperation.

### Manufacturer obligations:

Cooperation with operator requests.

Supply lines (e.g. mains connection and water connection) should be disconnected by specialist personnel and secured against reconnection.

Dismantling is realised on the responsibility of the operator and exclusively by his/her specialist personnel or personnel commissioned for this purpose.

Operational safety measures and instructions of the operator should be designed to reduce any possible risks during work.

It is recommended

- that the X-ray device and associated components be entrusted to the manufacturer for correct disposal.
- control desks and power module and the like be entrusted to a certified disposal company for correct disposal.



The X-ray tube assembly contains **beryllium** and should not be disposed of as standard commercial or domestic waste.

Local disposal regulations should therefore be observed.

The manufacture will assume responsibility for disposal if it is returned carriage-paid.



### DANGER!

Beryllium dust, beryllium vapour and beryllium compounds are toxic, particularly dangerous to the respiratory organs and can be carcinogenic.

Use PPE in accordance with the safety data sheet (e.g. chemical-resistant protective gloves, protective glasses, respiratory protection).



The high voltage generator contains mineral insulating oil and should not be disposed of as standard commercial or domestic waste.

Local disposal regulations should therefore be observed.

Use PPE in accordance with the safety data sheet.

The mineral insulating oil should be entrusted for proper disposal to a certified waste disposal company.

11 Technical Data

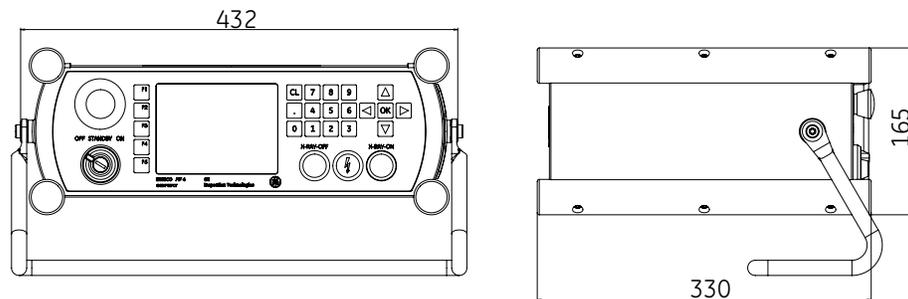
11.1 Digital control unit ERESKO MF4 control

Automatic identification of the connected radiating unit, Microprocessor-controlled diagnosis, Operating parameter memory, The voltage can be set in 1 kV steps	5 - 300 kV (depends on the radiating unit)
The current can be set in 0.1 mA steps	0.5 - 10 mA (depends on the radiating unit)
Exposure time, can be set in steps of 0.1 min or 1 sec	1 to 5994 sec (optional display 99min/99sec) (display optionally in min or sec)
Memory for operating and warm-up history Display	each 256 transreflective backlight, Graphic display 320 x 240 pixels
Available languages	19
Character sets	4, European (ISO), Japanese, Chinese, Cyrillic
Pre-programmable exposure programs	max. 250
Serial interface RS232	1
Safety circuits	2
EMERGENCY STOP button	1
Key-operated switch with 3 positions	OFF, STAND-BY, ON
Mains requirements *)**)	1 PE N, 160 V - 253 V AC, max. 13 A (with grounded neutral) 1 PE N, 80 V - 127 V AC, max. 20 A 50/60 Hz
Connecting cable	20 m / 4 kg (optionally up to max. 60 m)
Mains connecting cable	10 m / 1.2 kg (optionally up to max. 100 m)
Dimensions	see drawing
Weight	8.9 kg
Protection class ***)	IP65

\*) Operation with reduced power is possible for mains voltages below < 204 V or < 107 V.

\*\*) When using emergency power generators, only apply peak value controlled types

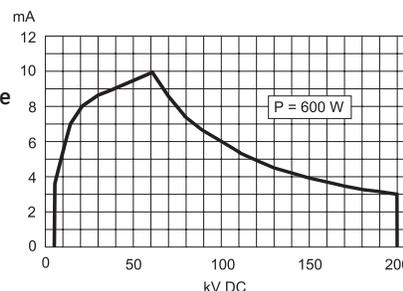
\*\*\*) Protection class IP 65 can only be guaranteed when plugs are connected (seal unused plugs with a cap) or when using the rubber cap!



### 11.2 ERESKO 32 MF4-C

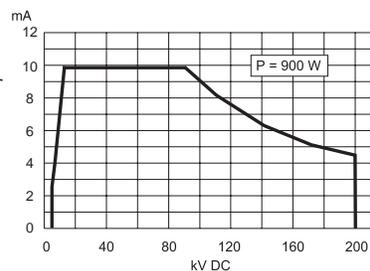
Nominal voltage	5 - 200 kV
Tube current	0.5 - 10 mA (3 mA /200 kV)
Continuous operating power	600 W
Focal spot size	0.4 x 4.00 mm
Anode material	Tungsten (W)
Anode temperature, max.	100° C
Anode tilt angle	22° (mech.)
Beam concentration	40° x 360°
Inherent filtration	0.4 mm Fe/Ni/Co + 2 mm Al
Duty cycle ( $\vartheta_{Amb} = 20^{\circ} C$ )	100 %
Weight	31 kg
Protection class	IP65
Tube head diameter	160 mm
Current and voltage stability	± 1 %
Power consumption, max.	1.0 kVA

If the panoramic radiating unit ERESKO 32MF4-C is operated with a crawler, please observe the separate documentation.



### 11.3 ERESKO 42 MF4 and ERESKO 42 MF4-W

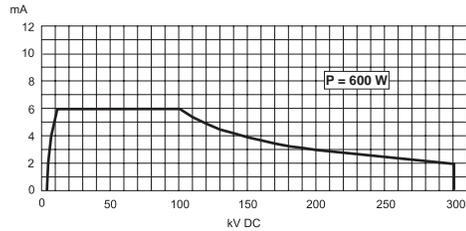
Metal-ceramic X-ray tube	
Nominal voltage	5 - 200 kV
Tube current	0.5 - 10 mA (4.5 mA /200 kV)
Continuous operating power	900 W
Focal spot size (EN 12 543)	3.00 mm (~1.5 IEC 336)
Anode material	Tungsten (W)
Anode temperature, max.	100° C
Anode tilt angle	20° (mech.)
Beam concentration	elliptic 40° x 60°
Inherent filtration	0,8 ± 0.1 mm, Be
Duty cycle ( $\vartheta_{Amb} = 20^{\circ} C$ )	100% (up to 60 min continuous operation for 42 MF4-W)
Weight	26.8 kg (42 MF4); 25.8 kg (42 MF4-W)
Protection class	IP 65
Tube head diameter	160 mm
Current and voltage stability	± 1%
Power consumption, max.	1.6 kVA (without water cooling pump)
<b>only 42MF4-W:</b>	
Min. cooling water flow rate	2.5 l/min
Max. cooling water pressure	10 bar
Cooling water quality	Drinking water
Hose connection	Ø 11 mm



11.4 ERESKO 52 MF4-CL

Metal-ceramic X-ray tube	
Nominal voltage	300 kV
Tube current	0.5 - 6 mA (2 mA /300 kV)
Continuous operating power	600 W
Focal spot size (EN 12 543)	0.5 x 5.5 mm
Anode material	Tungsten (W)
Anode temperature, max.	100° C
Anode tilt angle	22° (mech.)
Beam concentration	38° x 360°
Inherent filtration	0.4 mm Fe/Ni/Co + 3 mm Al
Duty cycle ( $\vartheta_{Amb} = 30^{\circ} C$ )	100 %
Weight	36 kg, 33.5 kg without carrier rings
Protection class	IP 65
Tube head diameter	290 mm, 225 mm without carrier rings
Current and voltage stability	±1 %
Power consumption, max.	1.4 kVA

If the panoramic radiating unit ERESKO 52MF4CL is operated with a crawler, please observe the separate documentation.

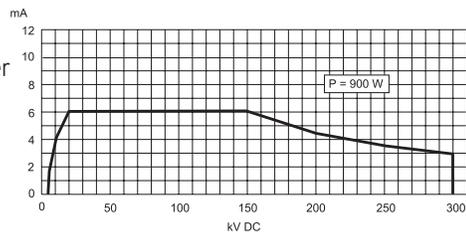


11.5 ERESKO 65 MF4 and ERESKO 65 MF4-W

Metal-ceramic X-ray tube	
Nominal voltage	300 kV
Tube current	0.5 - 6 mA (3.0 mA /300 kV)
Continuous operating power	900 W
Focal spot size (EN 12 543)	3.00 mm (~1.5 IEC 336)
Anode material	Tungsten (W)
Anode temperature, max.	100° C
Anode tilt angle	20° (mech.)
Beam concentration	elliptic 40° x 60°
Inherent filtration	0.8 mm ± 0.1 mm, Be
Duty cycle ( $\vartheta_{Amb} = 30^{\circ} C$ )	100% (up to 60 min continuous operation)
Weight	40 kg / 37.5 kg (without carrier ring)
Protection class	IP 65
Tube head diameter	290 mm / 225 mm (without carrier ring)
Current and voltage stability	± 1%
Power consumption, max.	2.0 kVA (without water cooling pump)

**only 65MF4-W:**

Min. cooling water flow rate	2.5 l/min
Max. cooling water pressure	10 bar
Cooling water quality	Drinking water
Hose connection	Ø 11 mm



**11.6 ERESKO 160 MF4-R and ERESKO 160 MF4-RW**

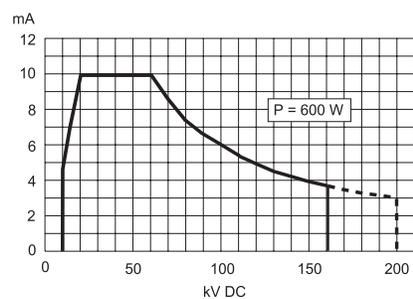
Metal-ceramic X-ray tube	
High voltage	10 -160 kV
Tube current	0.5 - 10 mA (3.7 mA /160 kV)
Continuous operating power	600 W
Focal spot size (EN 12 543)	1.00 mm (~0.5 IEC 336)
Anode material	Tungsten (W)
Anode temperature, max.	100° C
Anode tilt angle	20° (mech.)
Beam concentration	elliptic 40° x 60°
Inherent filtration	0.8 ± 0.1 mm, Be
Weight	26.8 kg
Protection class	IP 65
Tube head diameter	160 mm
Current and voltage stability	± 1%
Power consumption, max.	1.0 kVA

**Optional 200 kV version**

Nominal voltage	10 - 200 kV
Tube current	0.5 - 10 mA (3 mA /200 kV)
Continuous operating power	600 W

**only 160/200MF4-RW**

Min. cooling water flow rate	2.5 l/min
Max. cooling water pressure	10 bar
Cooling water quality	Drinking water
Hose connection	Ø 11 mm (7/16")



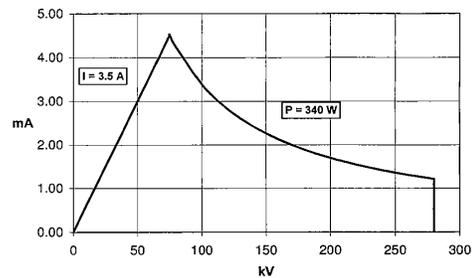
**11.7 ERESKO 280 MF4-R and ERESKO 280 MF4-RW**

Metal-ceramic X-ray tube

High voltage	10 - 280 kV
Tube current	0.5 - 4.5 mA (1.2 mA /280 kV)
Continuous operating power	340 W
Focal spot size (EN 12 543)	0.5 mm
Anode material	Tungsten (W)
Anode temperature, max.	100° C
Anode tilt angle	15° (mech.)
Beam concentration	elliptic 30° x 60°
Inherent filtration	0.8 ± 0.1 mm, Be
Weight	40 kg (88.2 lbs) 37.5 kg (82.7 lbs) without carrier rings
Protection class	IP 65
Tube head diameter	290 mm (11.42"), 200 mm (7.87") without carrier rings
Current and voltage stability	± 1%
Power consumption, max.	1.2 kVA

**only 280MF4-RW**

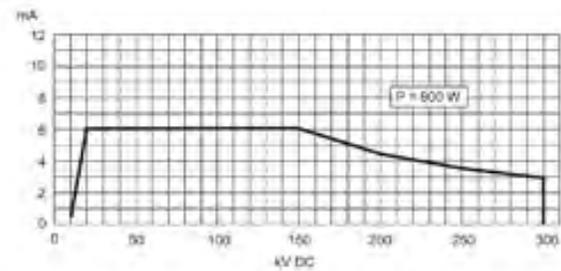
Min. cooling water flow rate	2.5 l/min
Max. cooling water pressure	10 bar
Cooling water quality	Drinking water
Hose connection	Ø 11 mm (7/16")



**11.8 ERESKO 300 MF4-R**

Metal-ceramic X-ray tube

High voltage	10 - 300 kV
Tube current	0.5 – 6.0 mA (3.0 mA /300 kV)
Continuous operating power	900 W
Focal spot size (EN 12 543)	1.0 mm
Anode material	Tungsten (W)
Anode temperature, max.	100° C
Anode tilt angle	15° (mech.)
Beam concentration	elliptic 30° x 60°
Inherent filtration	0.8 ± 0.1 mm, Be
Weight	40 kg (88.2 lbs) 37.5 kg (82.7 lbs) without carrier rings
Protection class	IP 65
Tube head diameter	290 mm (11.42"), 225 mm (8.85") without carrier rings
Current and voltage stability	± 1%
Power consumption, max.	2.0 kVA



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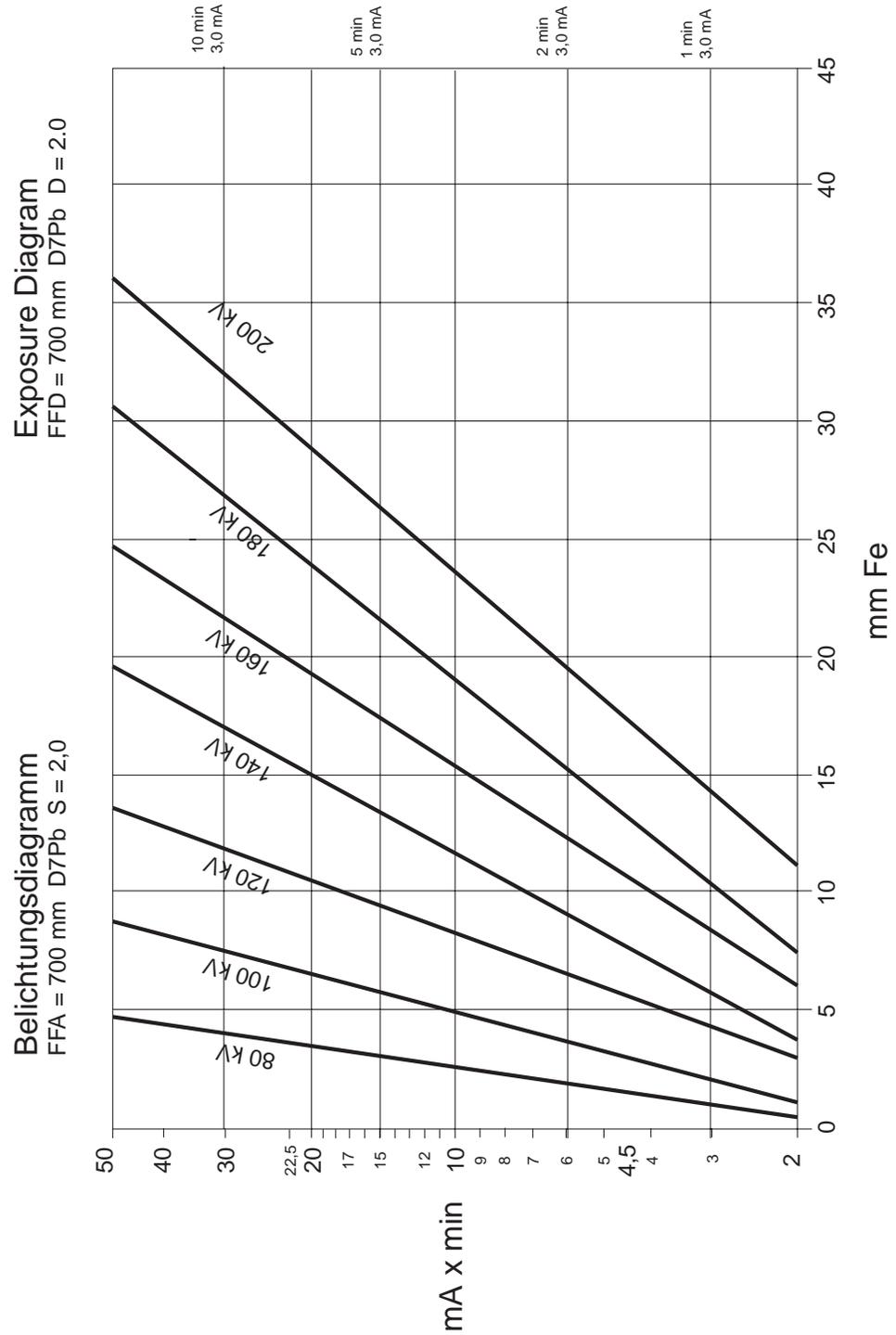
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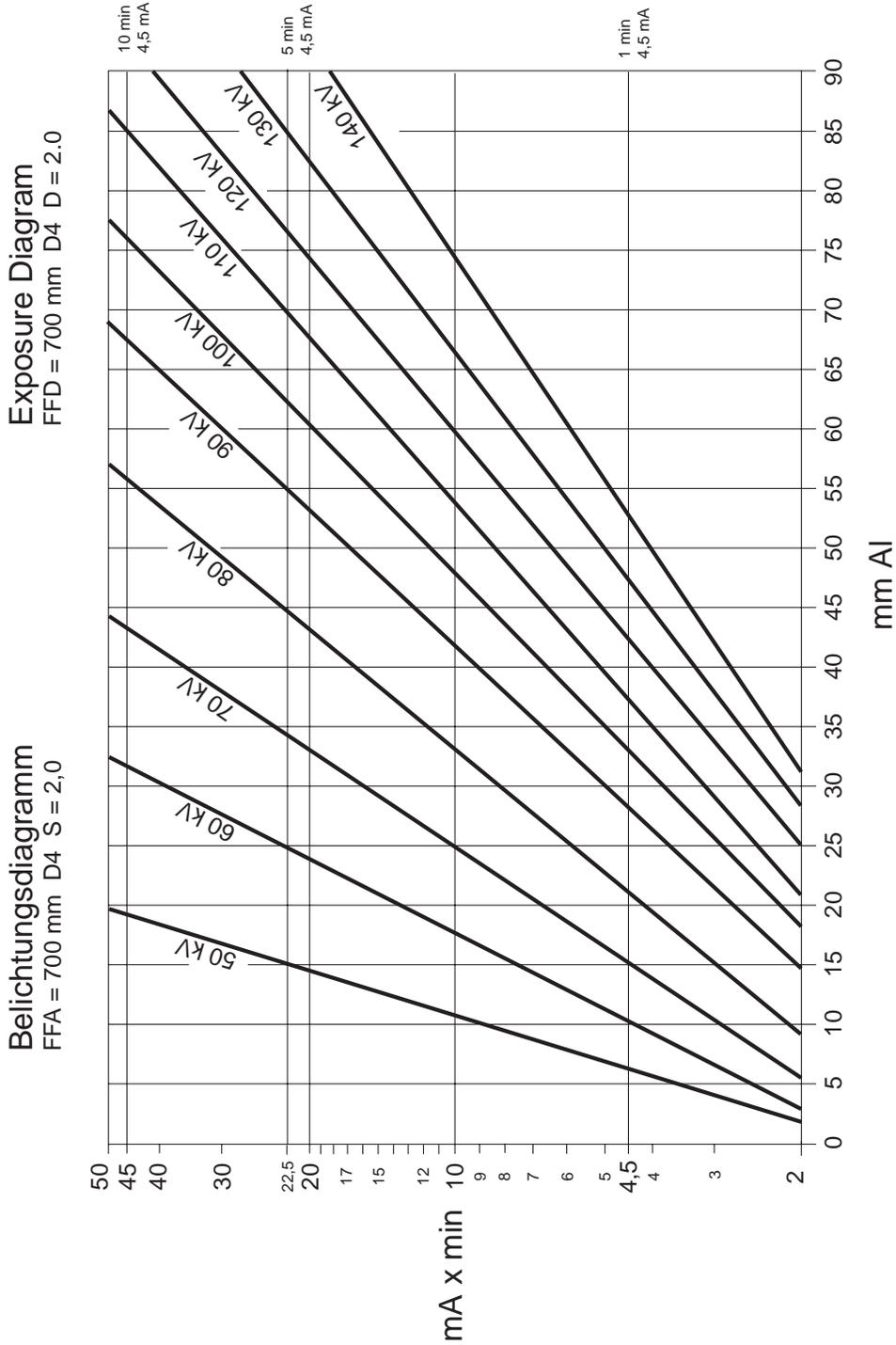
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Appendix 1: Exposure Diagrams

**ERESCO 32 MF4-C**



# ERESCO 42 MF4

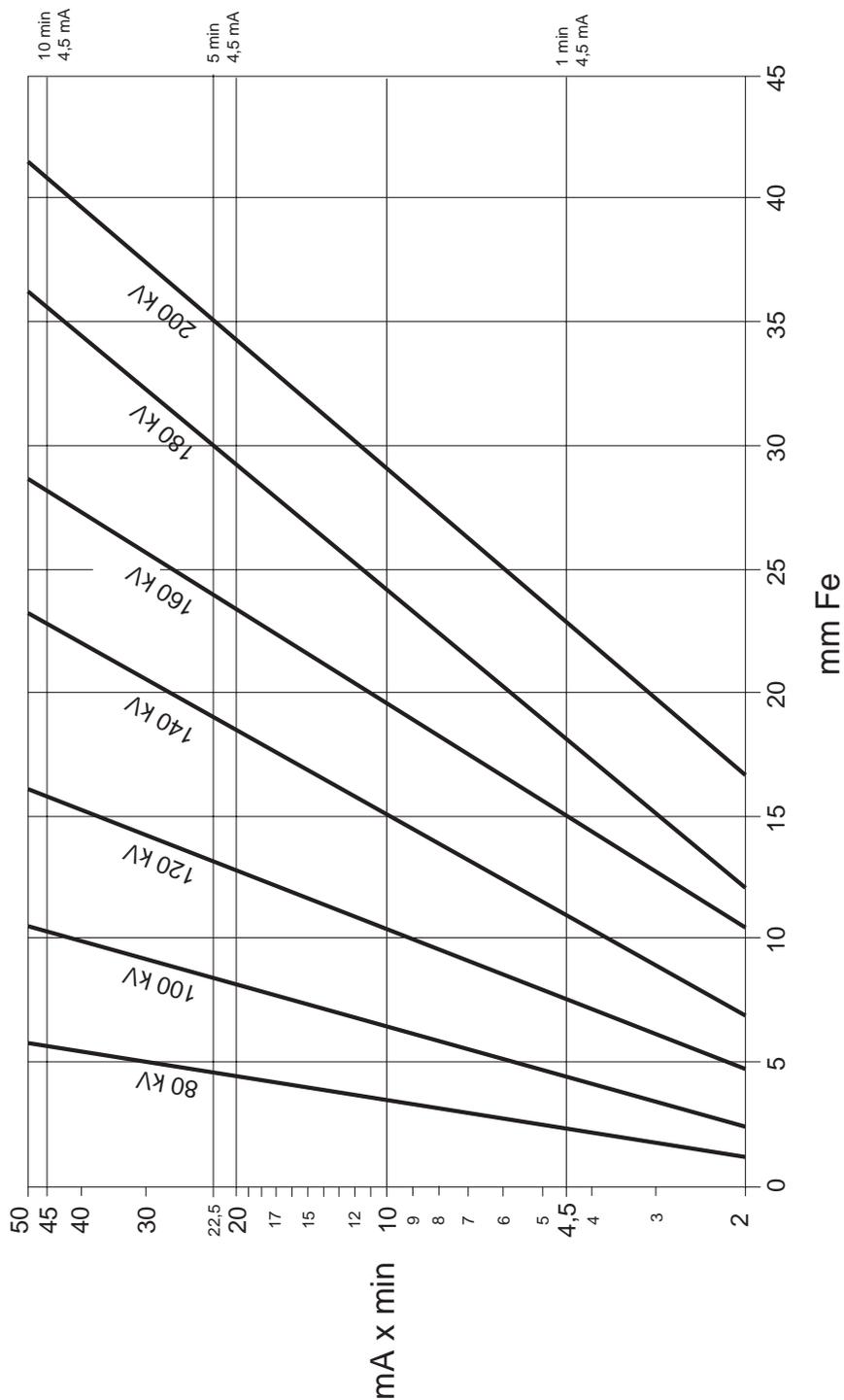


(obige Daten gelten nur mit entfernter Al-Schutzscheibe und entfernter Cu-Vorfilter)  
(the above data are valid with removed Al-protection disk and without Cu-filter only)

# ERESCO 42 MF4

**Beilichtungsdiagramm**  
FFA = 700 mm D7Pb S = 2,0

**Exposure Diagram**  
FFD = 700 mm D7Pb D = 2.0

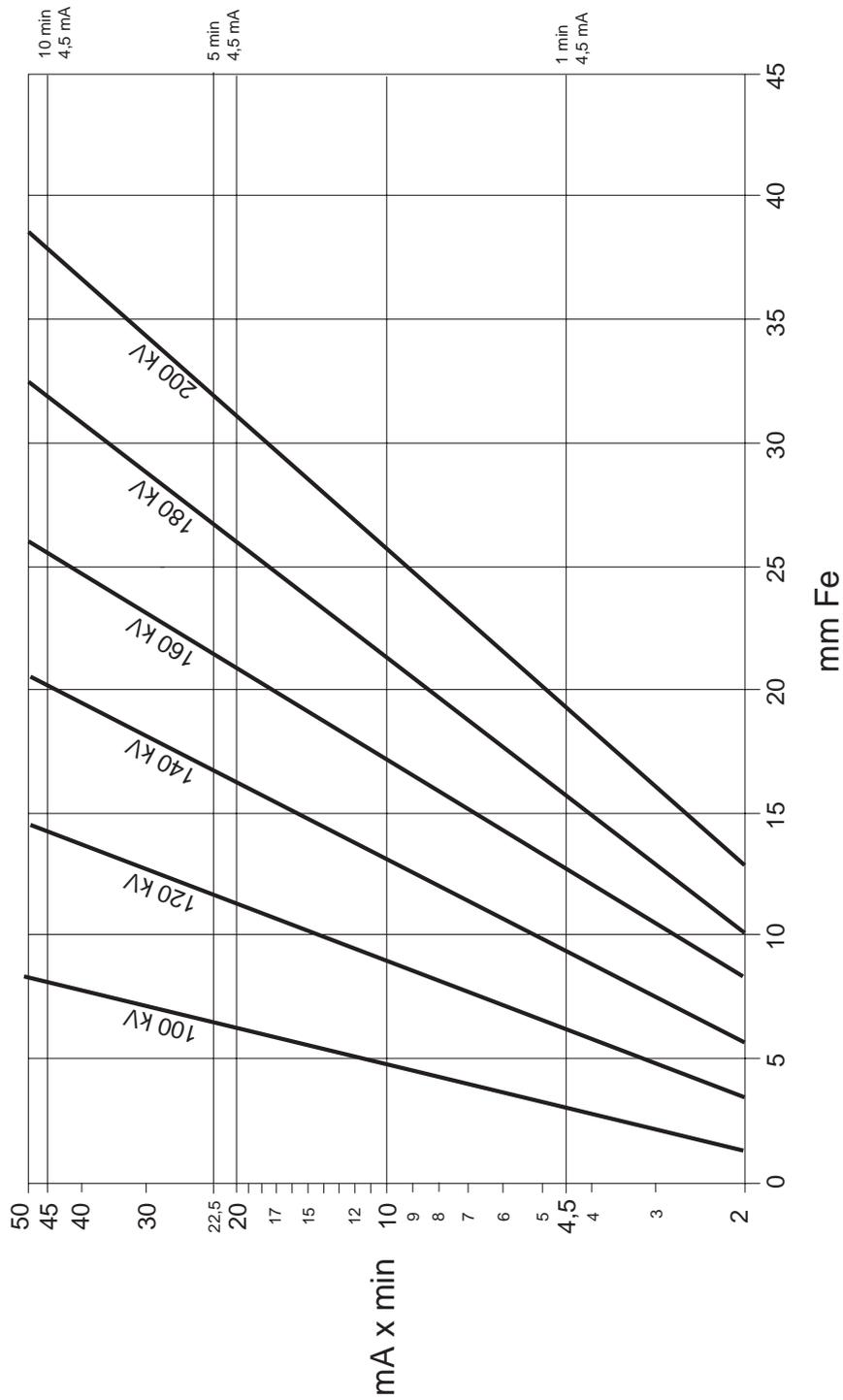


(obige Daten gelten nur mit entfernter Al-Schutzscheibe und entfernter Cu-Vorfilter)  
(the above data are valid with removed Al-protection disk and without Cu-filter only)

# ERESCO 42 MF4

**Belichtungsdiagramm**  
FFA = 700 mm D5Pb S = 2,3

**Exposure Diagram**  
FFD = 700 mm D5Pb D = 2.3

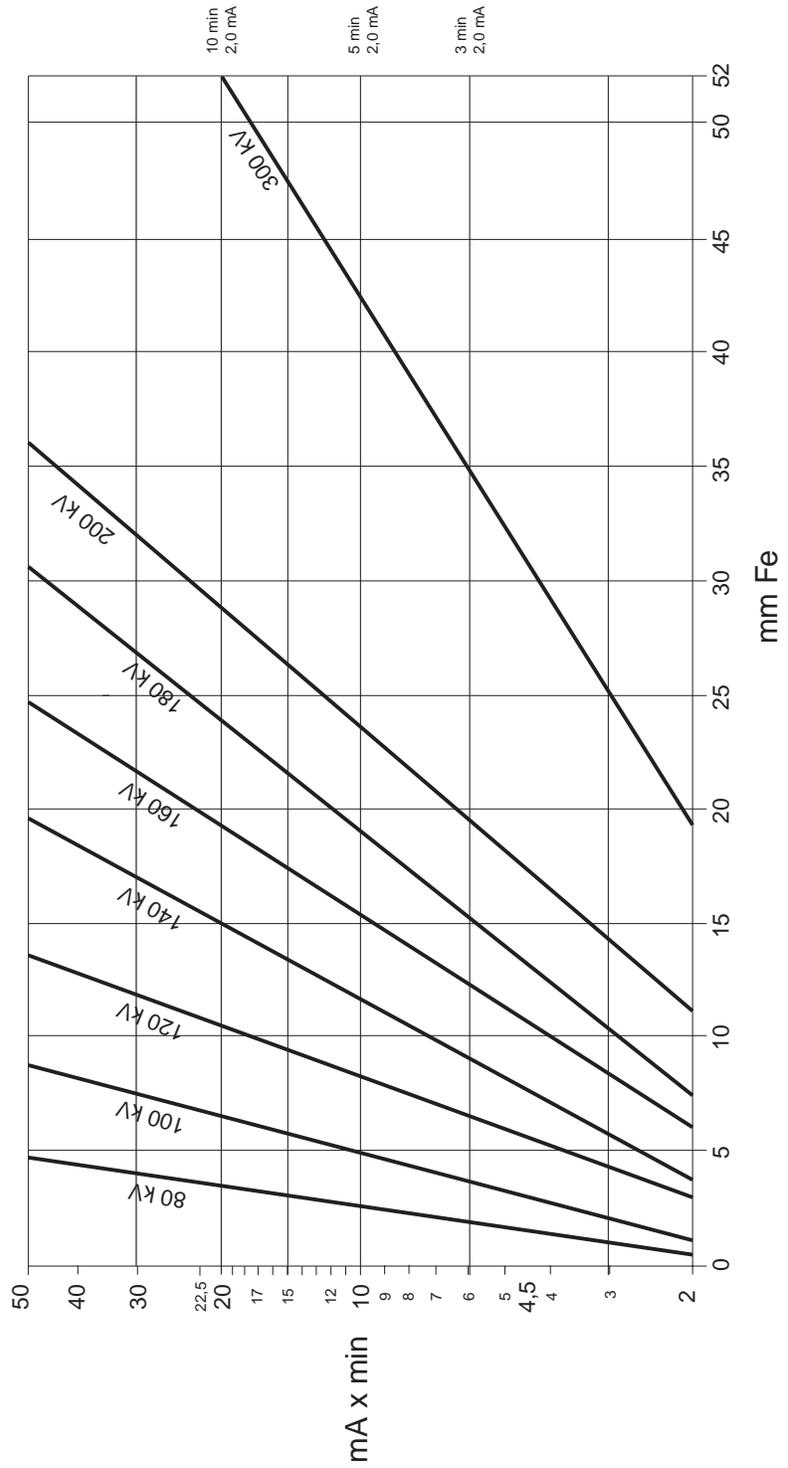


(obige Daten gelten nur mit entfernter Al-Schutzscheibe und entfernter Cu-Vorfilter)  
(the above data are valid with removed Al-protection disk and without Cu-filter only)

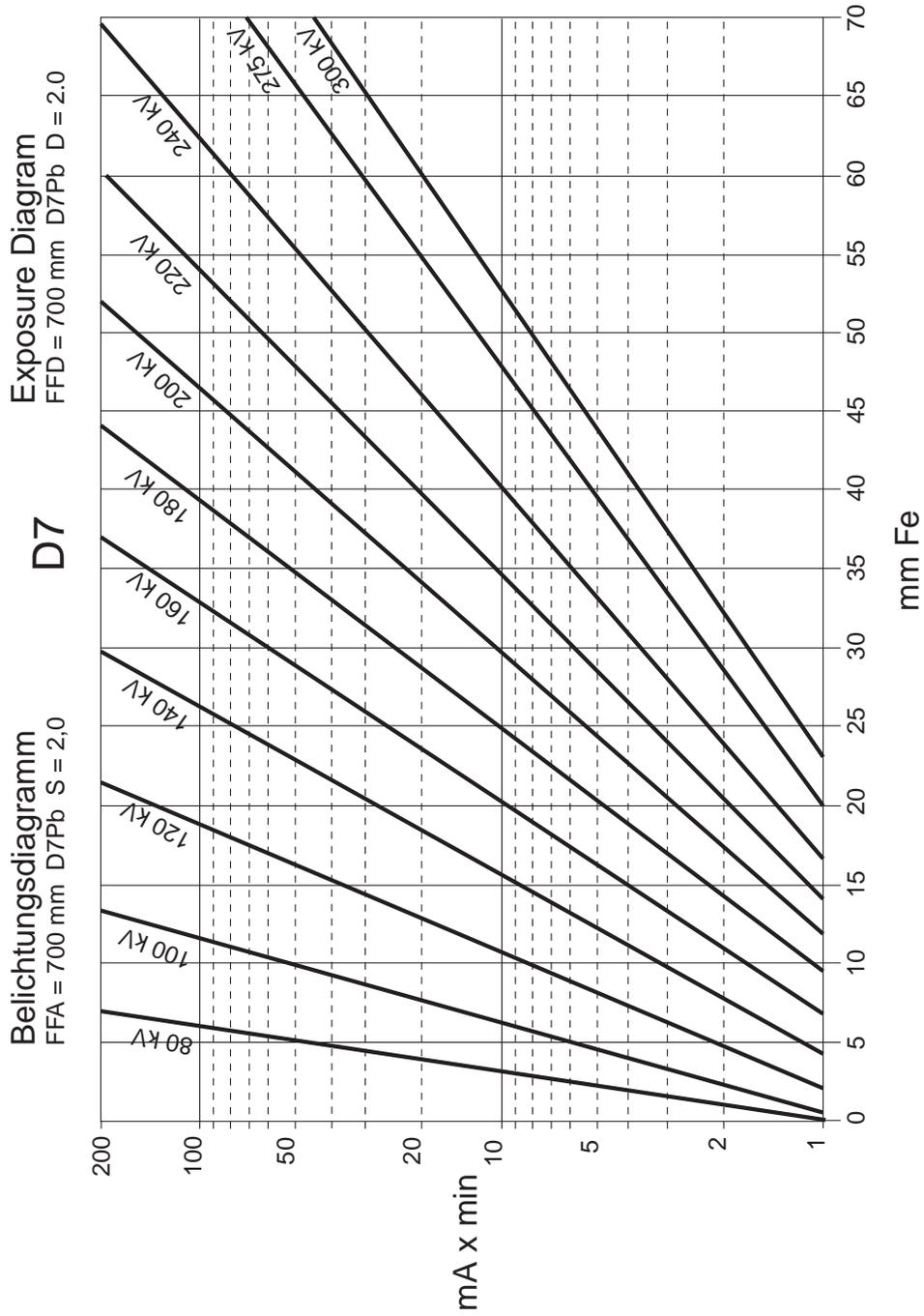
# ERESCO 52 MF4-CL

Belichtungsdiagramm  
FFA = 700 mm D7Pb S = 2,0

Exposure Diagram  
FFD = 700 mm D7Pb D = 2.0

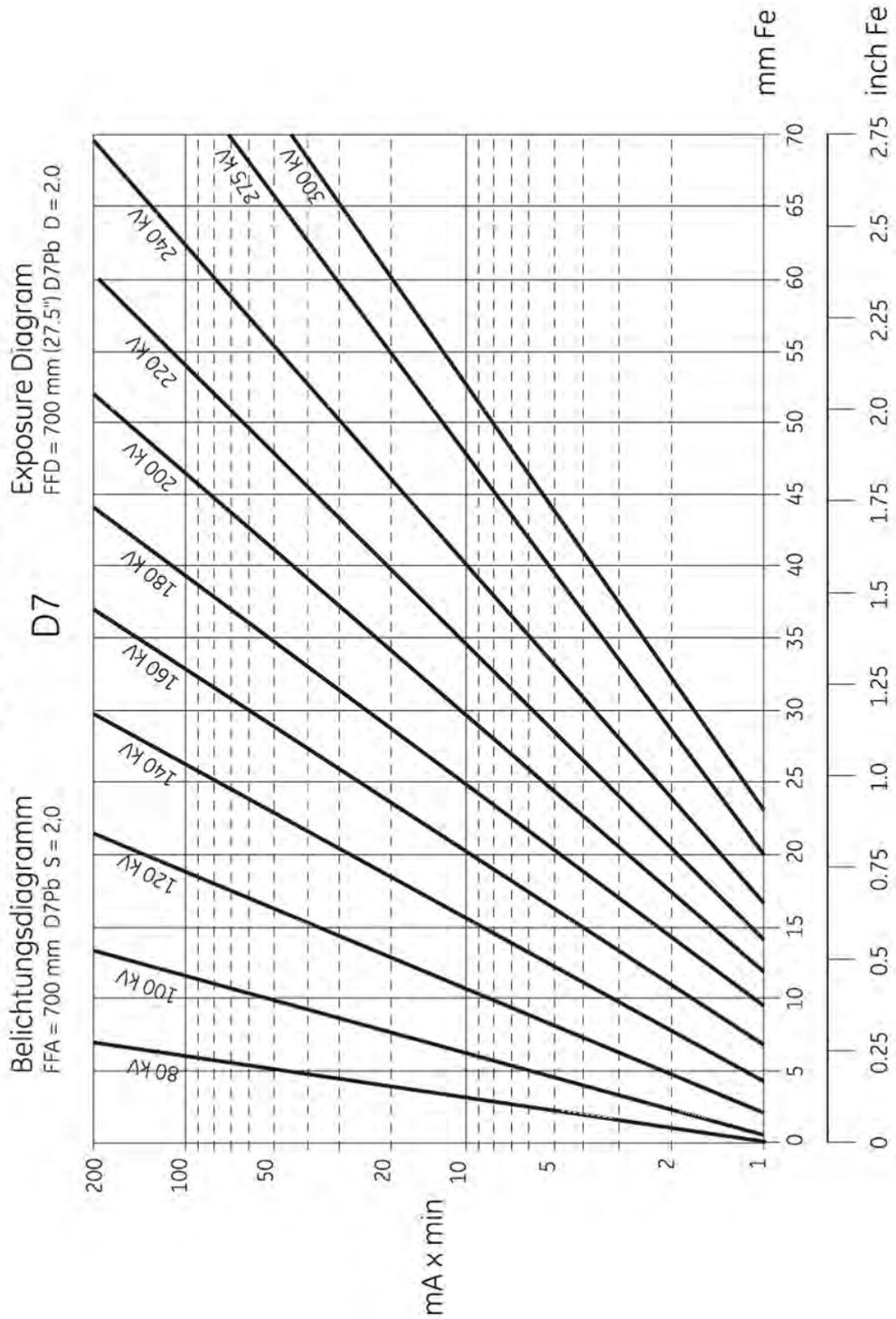


# ERESCO 65 MF4

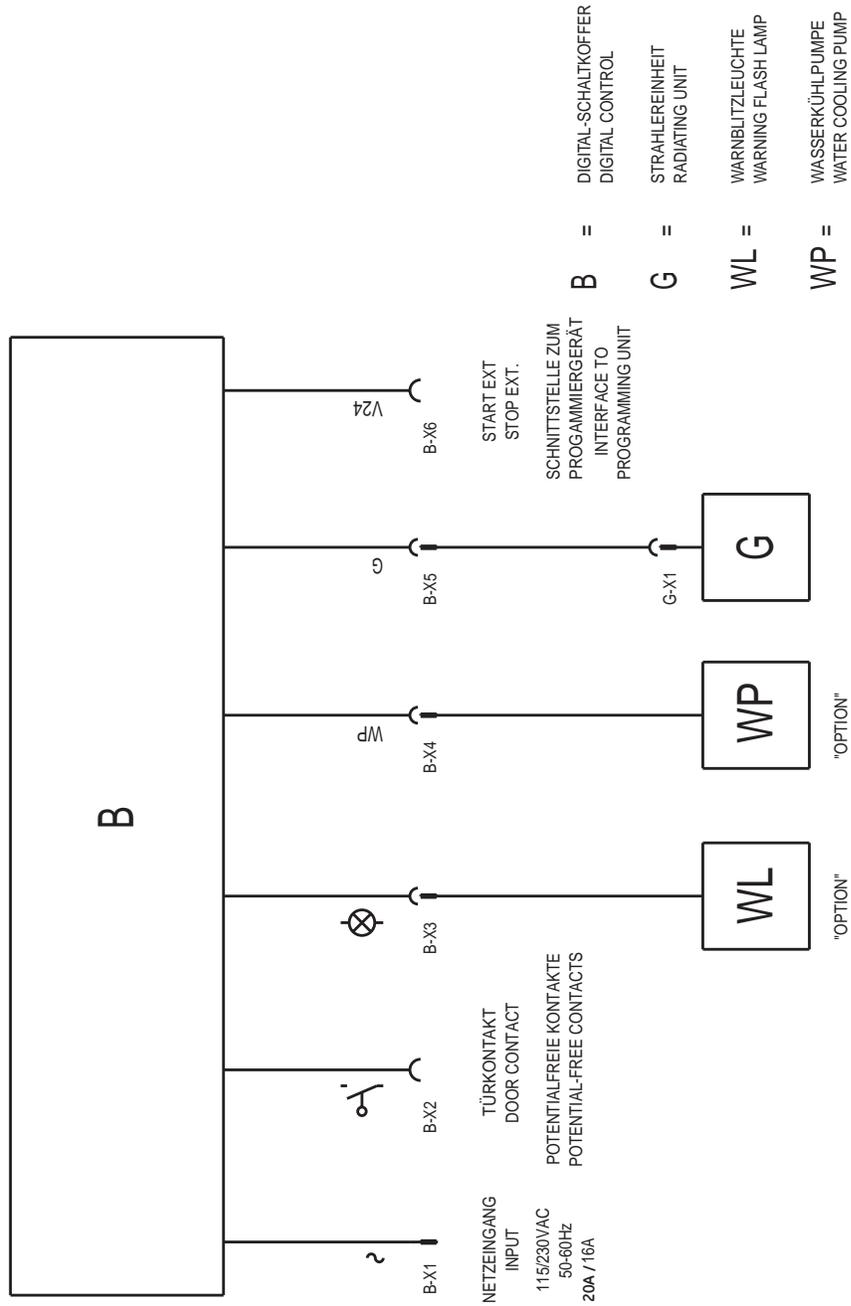


(obige Daten gelten nur mit entfernter Al-Schutzscheibe und entfernter Cu-Vorfilter)  
(the above data are valid with removed Al-protection disk and without Cu-filter only)

# ERESCO 300 MF4-R



Appendix 2: Connection Diagram



Appendix 3: Image Quality of Test Specimen EN 462



GE Sensing & Inspection Technologies

Image Quality Indicators EN 462

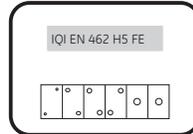


Image Quality Indicators				Wire	
W1	W6	W10	W13	Number	Nominal Diameter mm
x				W 1	3.20
x				W 2	2.50
x				W 3	2.00
x				W 4	1.60
x				W 5	1.25
x	x			W 6	1.00
x	x			W 7	0.80
x	x			W 8	0.63
x	x			W 9	0.50
x	x			W 10	0.40
x	x			W 11	0.32
x	x			W 12	0.25
x	x	x		W 13	0.20
x	x			W 14	0.16
x	x			W 15	0.125
x	x			W 16	0.100
x	x			W 17	0.080
x	x			W 18	0.063
x	x			W 19	0.050

Image Quality Indicators				Hole / Step	
H1	H5	H9	H13	Number	Nominal Diameter Step Thickness mm
x				H 1	0.125
x				H 2	0.160
x				H 3	0.200
x				H 4	0.250
x	x			H 5	0.320
x	x			H 6	0.400
x	x			H 7	0.500
x	x			H 8	0.630
x	x	x		H 9	0.800
x	x			H 10	1.000
x	x			H 11	1.250
x	x			H 12	1.600
x	x			H 13	2.000
x	x			H 14	2.500
x	x			H 15	3.200
x	x			H 16	4.000
x	x			H 17	5.000
x	x			H 18	6.300

Duplex Wire			
Element Number D = duplex	Related Unsharpness mm	Wire Diameter and Distance, d mm	
13 D	0.10	0.05	
12 D	0.13	0.063	
11 D	0.16	0.08	
10 D	0.20	0.10	
9 D	0.25	0.13	
8 D	0.32	0.16	
7 D	0.40	0.20	
6 D	0.50	0.25	
5 D	0.64	0.32	
4 D	0.80	0.40	
3 D	1.00	0.50	
2 D	1.26	0.63	
1 D	1.60	0.80	

Single Wall Radiographic Technique IQI Source Side

Class A			
Wire IQI		Step / Hole IQI	
Wall Thickness t over ... to ... mm	IQI Number	Wall Thickness t over ... to ... mm	IQI Number
1.2 to 2.0	W 18	2.0 to 3.5	H 4
2.0 to 3.5	W 16	3.5 to 6	H 5
3.5 to 5	W 15	6 to 10	H 6
5 to 7	W 14	10 to 15	H 7
7 to 10	W 13	15 to 24	H 8
10 to 15	W 12	24 to 30	H 9
15 to 25	W 11	30 to 40	H 10
25 to 32	W 10	40 to 60	H 11
32 to 40	W 9	60 to 100	H 12
40 to 55	W 8	100 to 150	H 13
55 to 85	W 7	150 to 200	H 14
85 to 150	W 6	200 to 250	H 15
150 to 250	W 5	250 to 320	H 16
250	W 4	320 to 400	H 17
		400	H 18

Double Wall Radiographic Technique Double Image; IQI Source Side

Class A			
Wire IQI		Step / Hole IQI	
Wall Thickness t over ... to ... mm	IQI Number	Wall Thickness t over ... to ... mm	IQI Number
1.2 to 2.0	W 18	1.0 to 2.0	H 3
2.0 to 3.5	W 16	2.0 to 3.5	H 5
3.5 to 5	W 15	3.5 to 5.5	H 6
5 to 7	W 14	5.5 to 10	H 7
7 to 12	W 13	10 to 19	H 8
12 to 18	W 12	19 to 35	H 9
18 to 30	W 11		
30 to 40	W 10		
40 to 50	W 9		
50 to 60	W 8		
60 to 85	W 7		
85 to 120	W 6		
120 to 220	W 5		
220 to 380	W 4		
380	W 3		

Double Wall Radiographic Technique Single or Double Image; IQI Film Side

Class A			
Wire IQI		Step / Hole IQI	
Wall Thickness t over ... to ... mm	IQI Number	Wall Thickness t over ... to ... mm	IQI Number
1.2 to 2.0	W 18	2.0 to 5	H 4
2.0 to 3.5	W 17	5 to 9	H 5
3.5 to 5	W 15	9 to 14	H 6
5 to 10	W 14	14 to 22	H 7
10 to 15	W 13	22 to 36	H 8
15 to 22	W 12	36 to 50	H 9
22 to 38	W 11	50 to 80	H 10
38 to 48	W 10		
48 to 60	W 9		
60 to 85	W 8		
85 to 125	W 7		
125 to 225	W 6		
225 to 375	W 5		
375	W 4		

Class B			
Wire IQI		Step / Hole IQI	
Wall Thickness t over ... to ... mm	IQI Number	Wall Thickness t over ... to ... mm	IQI Number
1.5 to 2.5	W 19	2.5 to 4	H 3
2.5 to 4	W 18	4 to 8	H 4
4 to 6	W 16	8 to 12	H 5
6 to 8	W 15	12 to 20	H 6
8 to 12	W 14	20 to 30	H 7
12 to 20	W 13	30 to 40	H 8
20 to 30	W 12	40 to 60	H 9
30 to 35	W 11	60 to 80	H 10
35 to 45	W 10	80 to 100	H 11
45 to 65	W 9	100 to 150	H 12
65 to 120	W 8	150 to 200	H 13
120 to 200	W 7	200 to 250	H 14
200 to 350	W 6		
350	W 5		

Class B			
Wire IQI		Step / Hole IQI	
Wall Thickness t over ... to ... mm	IQI Number	Wall Thickness t over ... to ... mm	IQI Number
1.5 to 2.5	W 19	1.0 to 2.5	H 2
2.5 to 4	W 18	2.5 to 4	H 4
4 to 6	W 16	4 to 6	H 5
6 to 8	W 15	6 to 11	H 6
8 to 15	W 14	11 to 20	H 7
15 to 25	W 13	20 to 35	H 8
25 to 38	W 12		
38 to 45	W 11		
45 to 55	W 10		
55 to 70	W 9		
70 to 100	W 8		
100 to 170	W 7		
170 to 250	W 6		
250	W 5		

Class B			
Wire IQI		Step / Hole IQI	
Wall Thickness t over ... to ... mm	IQI Number	Wall Thickness t over ... to ... mm	IQI Number
1.5 to 2.5	W 19	2.5 to 5.5	H 3
2.5 to 4	W 18	5.5 to 9.5	H 4
4 to 6	W 16	9.5 to 15	H 5
6 to 12	W 15	15 to 24	H 6
12 to 18	W 14	24 to 40	H 7
18 to 30	W 13	40 to 60	H 8
30 to 45	W 12	60 to 80	H 9
45 to 55	W 11		
55 to 70	W 10		
70 to 100	W 9		
100 to 180	W 8		
180 to 300	W 7		
300	W 6		

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Appendix 4: Operation with Centring Laser



**CAUTION:** Laser radiation, never look directly into the laser beam!!  
Keep the laser out of reach of children.

Press the button (1) to switch on the laser.  
If the laser beam extinguishes, replace the batteries. To achieve this, remove the screw cap (2).  
Use 2 x AAA micro alkaline batteries or equivalent. Ensure correct polarity of the batteries. Insert batteries according to the drawing (3). The laser is reverse polarity protected, i.e. the laser cannot be switched on with incorrectly inserted batteries.



Technical Data	
Power:	$\leq 1$ mW, <b>laser class 2</b>
Battery operation:	2 x 1.5 V AAA micro alkaline or equivalent
Laser type:	Semi-conductor diode laser
Wavelength:	635 - 670 nm red
Dimensions (WxDxH)	175 x 17 x 50 mm



**CAUTION:** To guarantee correct operation, only use original GE Sensing & Inspection Technologies accessories with ERESO MF4



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