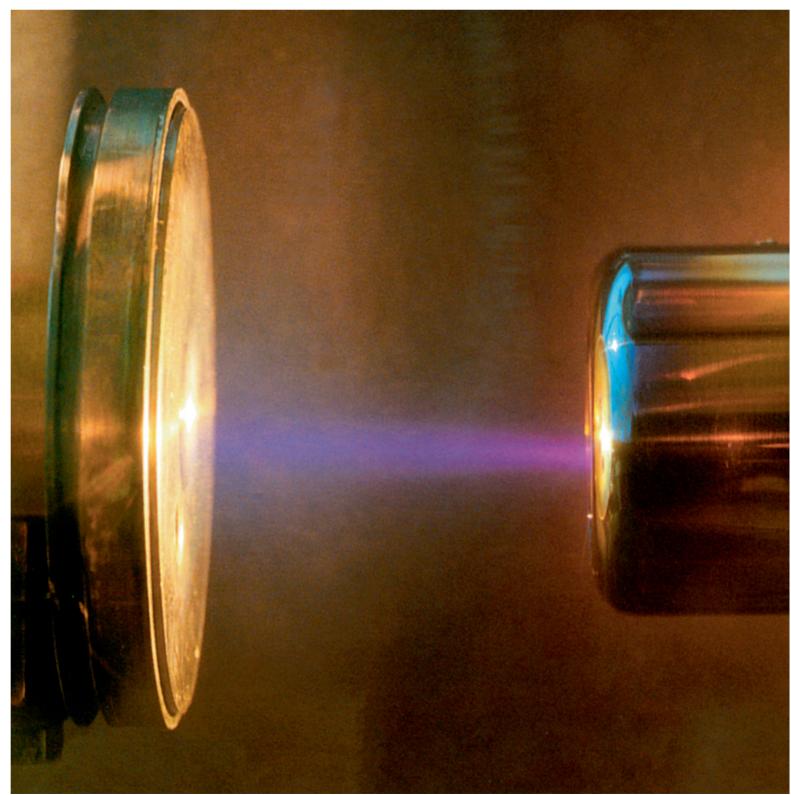


X-RAY TUBES

Technical Information



rtw RÖNTGEN-TECHNIK DR. WARRIKHOFF GmbH & Co. KG

Our Company

RÖNTGEN-TECHNIK DR. WARRIKHOFF KG was founded as an American-Danish-German partnership (KG) in 1973. It started its activity by opening the technology department in January 1974. In 1988 the company got restructured under the name: „rtw RÖNTGEN-TECHNIK DR. WARRIKHOFF KG“ and since then is completely owned by the family Warrikhoff. After 18 years of development and production in Berlin (West), the company's premises were moved to Neuenhagen bei Berlin, a village situated only 25 km from the city of Berlin.

The company has been established by Dr. Harald F. H. Warrikhoff, born at Berlin, who studied physics and had been working with the Max-Planck-Society and AEG Telefunken in the X-ray field. Since the beginning of 2005 his son Alexander Warrikhoff is CEO and owner of „rtw RÖNTGEN-TECHNIK DR. WARRIKHOFF GmbH & Co. KG“.

X-ray tubes in metal-ceramic technology, mainly for OEMs, but also for scientific applications, are being developed and produced. The product range comprises developing and manufacturing metal-ceramic X-ray tubes for tire inspection, security, analytical and radiometric applications. The product range is from 20 kV to 240 kV with focal spot sizes down to 50 microns.

rtw produces X-ray tubes which can be equipped with different target materials and are suitable to work together with X-ray optics.

Low powered and small sized X-ray tubes are available: cathode grounded, anode grounded or bipolar.

rtw

- is specialized in custom designed and OEM products
- is training young people according to the German educational "dual system" (practising and studying)
- takes high responsibility for the occupational health and safety and for our environment
- is member of DGZfP, ASNT and OptecBB
- is certified according to DIN EN ISO 9001:2008 since 2003

For further information, data sheets and technical assistance, please contact us.

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Our Expertise

NDT

Very slim X-ray tubes are used e. g. in nuclear plants to inspect weldings in narrow pipe to pipe space. Mobile X-ray systems up to 240 kV with high resolution guarantee high contrast images on film or digital imaging devices. Tubes for stationary cabinets or for online processes are optimized to inspect e. g. aluminium castings for cracks, voids and inhomogeneity.

Tire Inspection

The very first panoramic tire X-ray tube was introduced by rtw in 1974. The anode is 90° declined to the tube axis. Since then the tube could be inserted into the tire and examined the tire from bead to bead in one turn. A line scan camera is used to detect the steel and plastic cords. Today special designed tubes are produced to inspect the tires of motorbikes, cars, trucks and heavy earth movers. Flat target angles from 0° to 20° and conical targets with one or two or even three focal spots are available.

X-ray Analysis

If material is radiated with X-rays fluorescence and reflection will appear. Modern systems are able to determine the constituents and their quantity down to the per mill range. The X-ray diffraction patterns allow to investigate the structure of their molecules. Very precise and stable focal spots on different target materials are indispensable. Together with X-ray mirrors, monocapillary, polycapillary or multi-layer optics a 30 W rtw X-ray tube is comparable to a 3000 W one without optic.

Thickness Gauging

X-rays are used in rough industrial online processes to measure the thickness of sheets and foils of different sizes and materials. The transmission through the material is precisely measured in the cold and hot milling process. The material gets rolled with 30 km/h and permanently controlled. The X-ray tubes are designed for ultra stable emission output with high reliability.

High Resolution

Digital imaging, X-ray measurements, radiosscopic applications or CT systems require small and brilliant focal spots and long lifetime. High emission filament design and electrostatic focalisation with focal spots down to 50 µm are available. The rtw tube design reduces the dislocation of the focal spot on the target in long and short term conditions to a minimum.

Food Inspection

Various food articles e. g. chocolate, jars with jam and baby food are controlled with fan beam X-ray tubes in digital inspection systems. High X-ray output and small focal spots ensure that metal parts, o-rings or broken glass are sorted out before shipment.

XUV (EUV)

The inspection and measurement of small details is benefiting from the extreme ultraviolet light X-ray tubes. The wavelength of UV light is approximately 60 nm, as the wavelength from XUV tubes at 12 kV is 0,1 nm only. Low energy analytical applications with L and even M characteristic lines are made possible.

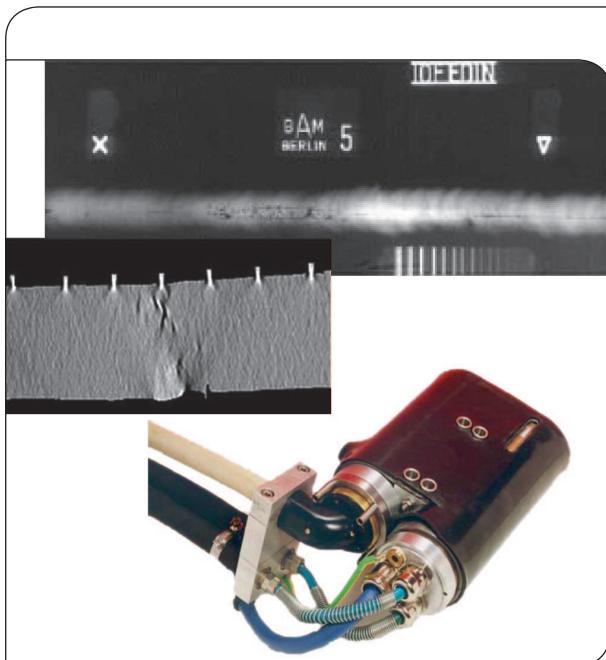
Electron beam

The electron beam is brought out through a thin, e. g. Ti, foil to irradiate surfaces of different shapes for sterilisation or polymerisation. Low energy sealed off tubes around 100 kV with different electron window designs are available.

Special Application

For universities, institutes or for other activities trying a new approach in the X-ray field rtw is ready to develop new tube designs. Unique shapes and the adaptation of the tube parameters allow the OEM engineer to fulfill the market requirements.

OEM Designs and Application Examples

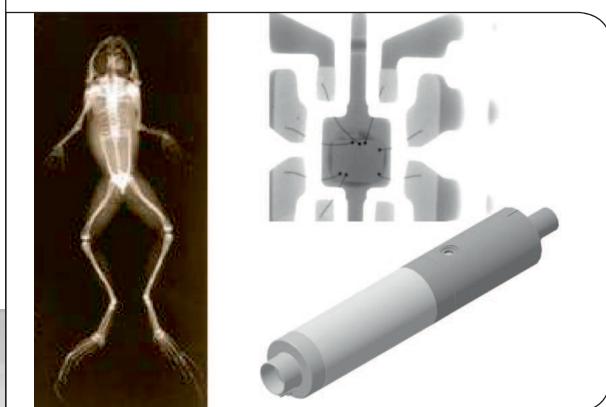


A special design with optimised X-ray tube parameters for **planar tomography** in narrow spaces
e. g. inspecting of pipes in power plants

Tube parameters:

- 240 kV bipolar
- 90° fan beam
- Focal spot: $d = 0,6 / 600 \text{ W}$
- Target angle: 6°
- Anode and cathode are separately encapsulated
- Precise electrostatic focalisation
- Stable emission
- Very flexible HT cables (120 kV right angled)
- Light weight and flat design incl. radiation protection and integrated tube holder
- Oil cooling

BAM TomoCAR, U. Ewert, B. Redmer

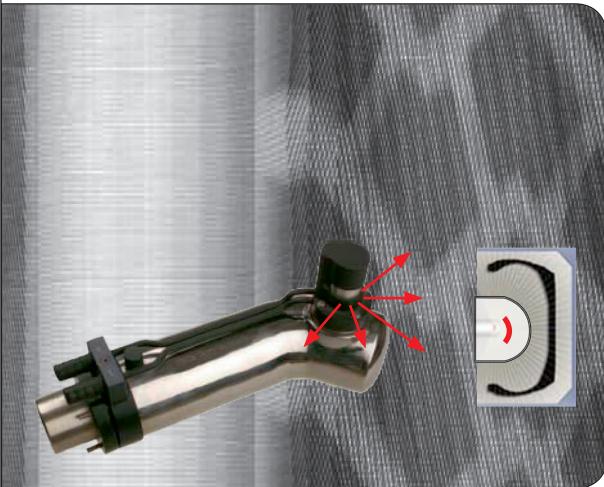


For **high resolution** radiographic and
radioscopic applications and for thickness
gauging

Tube parameters:

- Cathode grounded
- Low power (50 W)
- 65 kV
- Tube housing Ø 40 mm only
- Flexible HT cables
- Air, water or conduction cooling
devices available
- Focal spot size down to $d = 50 \mu\text{m}$
(DIN EN 12543-5)

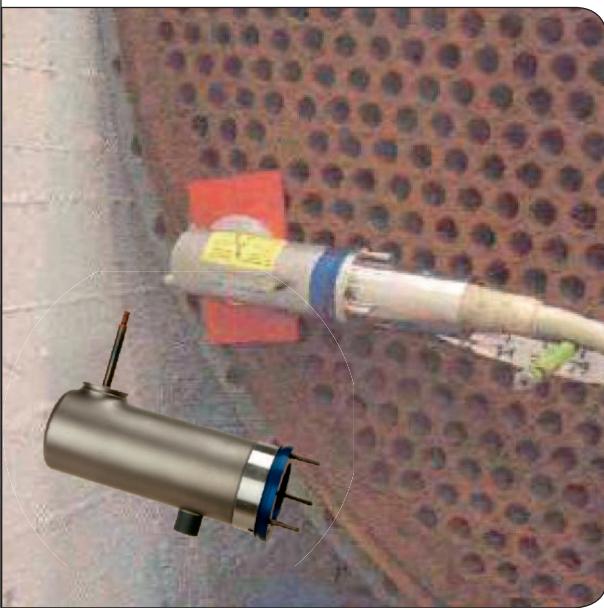
OEM Designs and Application Examples



X-ray tube for **inspection of tires** for earth movers, trucks, cars and motor bikes from bead to bead in one turn

Tube parameters:

- Bended tube housing
- Electron emission right angled to the tube axis
- 280° panoramic X-ray beam
- Various target types possible, e. g. conical and flat target



Special X-ray tube for **mobile inspection** of heat exchangers (world-wide without the limitation for radionuclides)

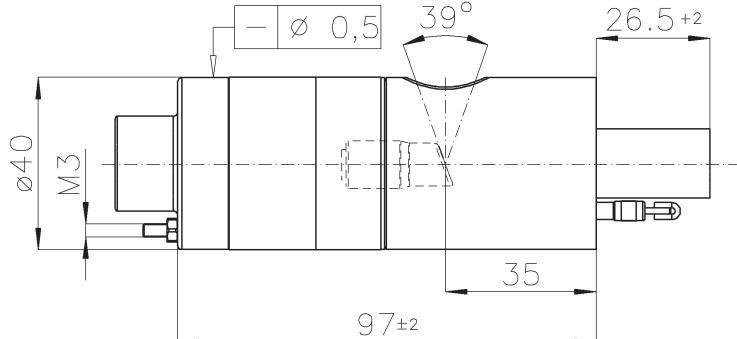
Tube parameters:

- X-ray radiation opposite to electron beam
- Anode load stored in tiny Cu block, to be exchanged together with film
- Film holder is integrated in the tube design
- Rod anode is positioned in the tube with no additional holder
- Up to 130 kV

BASF Ludwigshafen: heat exchanger

MCB 20C-4,5x0,5 x

METAL-CERAMIC X-RAY TUBE



Allgemeine Daten

Targetmaterialien (andere auf Anfrage)

W, Mo, Cu, Rh

Brennfleckgröße vermessnen nach
DIN EN 12543-2

4,5 mm x 0,5 mm

Anodenwinkel

21°

Ausstrahlungswinkel

39°

Lichte Öffnung des Fensters

Ø 10 mm

Eigenfilterung

0,2 mm Be

General Data

Target materials (others on request)

Focal spot size in accordance with
DIN EN 12543-2

Anode angle

Emission angle

Useful diameter of beam window

Inherent filtration

Absolute Grenzwerte

Konstante Gleichspannung

+ 20 kV

Anodenbelastung für Wolframttarget

50 W

Heizfadendaten

3,2 A (2,8 V)

Temperatur (an der Kühlzone)

60 °C

Absolute maximum ratings

Constant DC voltage

Anode load for tungsten target

Filament data

Temperature (at cooling area)

kV	20	15	10	9	8	7	6	5	4	3	2	1
mA	2,5	3,3	5	5,3	5,1	5,0	4,8	4,6	4,4	4,1	3,7	3,0

Masse ca.

0,5 kg

Mass approx.

Kontaktierung

Kathodenanschluss auf Erdpotential

inkl./incl.

Gedämpftes Polyolefin-Hochspannungska-
bel, im Keramikisolator fest verklebt

inkl./incl.

Cathode at ground potential
Polyolefine high voltage cable with inhe-
rent surge resistor potted into ceramic
isolator

Min. Biegeradius

Min. bending radius

Min. Biegeradius, stationär

Min. bending radius at fixed position

Luftisolierte Stecker generatorseitig

100 mm

Air insulated HT plug at HT generator

50 mm

65 kV

Strahlenschutz

Ohne/Without

Radiation shielding

Cooling

Kühlung

Air cooler

Luftkühler

Water cooler

Wasserkühler

Conduction cooling

Konduktionskühlung

Please specify with order

Bei Bestellung bitte angeben

Ident.Nr.: -----

Ident.Nr.: -----

Ident.Nr.: -----

Kabellänge/
Cable length

MCB 50-0,7G x

METAL-CERAMIC X-RAY TUBE

Allgemeine Daten						General Data																													
Targetmaterialien (andere auf Anfrage)			W, Mo, Cu, Rh			Target materials (others on request)																													
Brennfleckgröße vermessen nach DIN EN 12543-2			1,5 mm x 0,1 mm			Focal spot size in accordance with DIN EN 12543-2																													
Anodenwinkel			6°			Anode angle																													
Lichte Weite des Fensters			10 mm			Useful diameter of beam window																													
Eigenfilterung			0,2 mm Be			Inherent filtration																													
Absolute Grenzwerte																																			
Konstante Gleichspannung			+ 50 kV			Constant DC voltage																													
Anodenbelastung für Wolframtarget			40 W			Anode load for tungsten target																													
Heizfadendaten			3,2 A (3,0 V)			Filament data																													
Temperatur (an der Kühlzone)			60 °C			Temperature (at cooling area)																													
<table border="1"> <thead> <tr> <th>kV</th><th>50</th><th>45</th><th>40</th><th>35</th><th>30</th><th>25</th><th>20</th><th>15</th><th>10</th><th>5</th><th></th></tr> <tr> <th>mA</th><td>0,7</td><td>0,8</td><td>1</td><td>1,15</td><td>1,3</td><td>1,5</td><td>1,5</td><td>1,5</td><td>1,0</td><td>0,5</td><td></td></tr> </thead> </table>												kV	50	45	40	35	30	25	20	15	10	5		mA	0,7	0,8	1	1,15	1,3	1,5	1,5	1,5	1,0	0,5	
kV	50	45	40	35	30	25	20	15	10	5																									
mA	0,7	0,8	1	1,15	1,3	1,5	1,5	1,5	1,0	0,5																									
Masse ca.						1 kg																													
Kontaktierung																																			
Kathodenanschluss auf Erdpotential			inkl./incl.			Contacting																													
Gedämpftes Polyolefin-Hochspannungska- bel, im Keramikisolator fest verklebt			inkl./incl.			Cathode at ground potential Polyolefine high voltage cable with inhe- rent surge resistor potted into ceramic isolator																													
Min. Biegeradius			100 mm			Min. bending radius																													
Min. Biegeradius, stationär			50 mm			Min. bending radius at fixed position																													
Luftisolierter Stecker generatorseitig			65 kV			Air insulated HT plug at HT generator																													
Strahlenschutz																																			
Kühlung																																			
Luftkühler			Ident.Nr.: 0606			Radiation shielding																													
Wasserkühler			Ident.Nr.: 1910			Cooling																													
Konduktionskühlung			Ident.Nr.: -----			Air cooler																													
Bei Bestellung bitte angeben			Kabellänge/ Cable length			Water cooler																													
Conduction cooling Please specify with order																																			

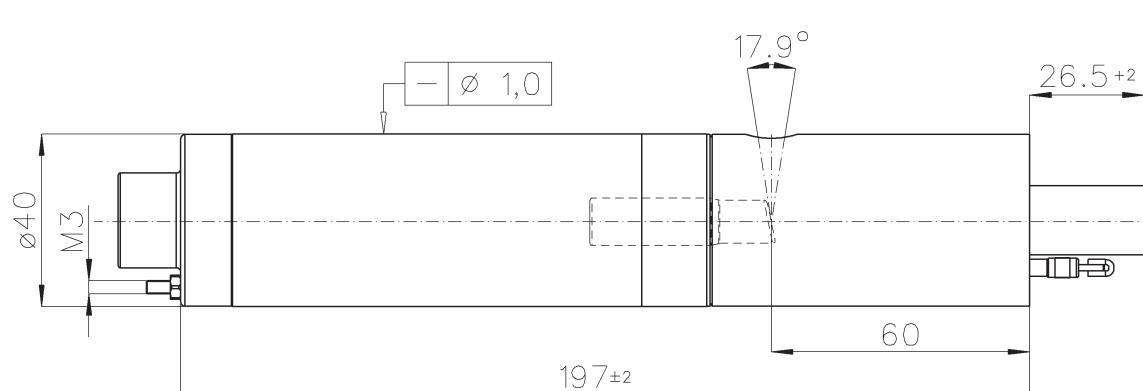
MCB 65C-0,2x40°

METAL-CERAMIC X-RAY TUBE

Allgemeine Daten							General Data																																					
Targetmaterialien (andere auf Anfrage)					W, Mo, Cu, Rh					Target materials (others on request)																																		
Brennfleckgröße vermessen nach DIN EN 12543-2					0,2 mm x 0,2 mm					Focal spot size in accordance with DIN EN 12543-2																																		
Anodenwinkel					21°					Anode angle																																		
Ausstrahlungswinkel					40°					Emission angle																																		
Lichte Öffnung des Fensters					Ø 20 mm					Useful diameter of beam window																																		
Eigenfilterung					0,5 mm Be					Inherent filtration																																		
Absolute Grenzwerte							Absolute maximum ratings																																					
Konstante Gleichspannung					+ 65 kV					Constant DC voltage																																		
Anodenbelastung für Wolframtarget					40 W					Anode load for tungsten target																																		
Heizfadendaten					3,2 A (~ 2,8 V)					Filament data																																		
Temperatur (an der Kühlzone)					60 °C					Temperature (at cooling area)																																		
<table border="1"> <thead> <tr> <th>kV</th><th>65</th><th>60</th><th>55</th><th>50</th><th>45</th><th>40</th><th>35</th><th>30</th><th>25</th><th>20</th><th>15</th><th>10</th><th>5</th><th></th></tr> <tr> <th>mA</th><td>0,6</td><td>0,6</td><td>0,7</td><td>0,8</td><td>0,9</td><td>1,0</td><td>1,1</td><td>1,3</td><td>1,6</td><td>2,2</td><td>2,0</td><td>1,7</td><td>1,0</td><td></td></tr> </thead> </table>															kV	65	60	55	50	45	40	35	30	25	20	15	10	5		mA	0,6	0,6	0,7	0,8	0,9	1,0	1,1	1,3	1,6	2,2	2,0	1,7	1,0	
kV	65	60	55	50	45	40	35	30	25	20	15	10	5																															
mA	0,6	0,6	0,7	0,8	0,9	1,0	1,1	1,3	1,6	2,2	2,0	1,7	1,0																															
Masse ca.							Mass approx.																																					
Kontaktierung							Contacting																																					
Kathodenanschluss auf Erdpotential					inkl./incl.					Cathode at ground potential																																		
Gedämpftes Polyolefin-Hochspannungska- bel, im Keramikisolator fest verklebt					inkl./incl.					Polyolefine high voltage cable with inhe- rent surge resistor potted into ceramic isolator																																		
Min. Biegeradius					100 mm					Min. bending radius																																		
Min. Biegeradius, stationär					50 mm					Min. bending radius at fixed position																																		
Luftisolierter Stecker generatorseitig					65 kV					Air insulated HT plug at HT generator																																		
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Konduktionskühlung					Ident.Nr.: -----					Conduction cooling																																		
Bei Bestellung bitte angeben							Please specify with order																																					

MCBM 50-0,6B x

METAL-CERAMIC X-RAY TUBE



Allgemeine Daten

Targetmaterialien (andere auf Anfrage)
Brennfleckgröße vermessen nach
DIN EN 12543-5
Anodenwinkel
Ausstrahlungswinkel
Eigenfilterung

W, Mo, Cu, Rh
50 µm x 50 µm
12°
8°
0,1 mm Be

Target materials (others on request)
Focal spot size in accordance with
DIN EN 12543-5
Anode angle
Emission angle
Inherent filtration

Absolute Grenzwerte

Konstante Gleichspannung
Anodenbelastung für Wolframtarget
Heizfadendaten
Temperatur (an der Kühlzone)

+ 50 kV
30 W
3,2 A (~ 3,2 V)
60 °C

Absolute maximum ratings
Constant DC voltage
Anode load for tungsten target
Filament data
Temperature (at cooling area)

kV	50	40	35	30	25	20	15	10	5
mA	0,6	0,7	0,8	0,68	0,55	0,4	0,3	0,2	0,1

Mass ca.

1 kg

Mass approx.

Kontaktierung

Kathodenanschluss auf Erdpotential
Gedämpftes Polyolefin-Hochspannungska-
bel, im Keramikisolator fest verklebt

inkl./incl.
inkl./incl.

Contacting
Cathode at ground potential
Polyolefine high voltage cable with inhe-
rent surge resistor potted into ceramic
isolator

Min. Biegeradius
Min. Biegeradius, stationär
Luftisolierter Stecker generatorseitig

100 mm
50 mm
65 kV

Min. bending radius
Min. bending radius at fixed position
Air insulated HT plug at HT generator

Strahlenschutz

Ohne/Without

Radiation shielding

Cooling

Kühlung
Luftkühler
Wasserkühler
Konduktionskühlung
Bei Bestellung bitte angeben

Ident.Nr.: 0606
Ident.Nr.: 1910
Ident.Nr.: -----
**Kabellänge/
Cable length**

Air cooler

Water cooler

Conduction cooling

Please specify with order

MCBM 65B-50 x

METAL-CERAMIC X-RAY TUBE

Allgemeine Daten							General Data							
Targetmaterialien (andere auf Anfrage)							Target materials (others on request)							
Brennfleckgröße ver messen nach DIN EN 12543-5							Focal spot size in accordance with DIN EN 12543-5							
Anodenwinkel							Anode angle							
Ausstrahlungswinkel							Emission angle							
Lichte Öffnung des Fensters							Useful diameter of beam window							
Eigenfilterung							Inherent filtration							
Absolute Grenzwerte							Absolute maximum ratings							
Konstante Gleichspannung							Constant DC voltage							
Anodenbelastung für Wolframtarget							Anode load for tungsten target							
Heizfadendaten							Filament data							
Temperatur (an der Kühlzone)							Temperature (at cooling area)							
kV	65	60	55	50	45	40	35	30	25	20	15	10	5	
mA	0,46	0,5	0,54	0,6	0,66	0,75	0,8	0,68	0,55	0,4	0,3	0,2	0,1	
Masse ca.							Mass approx.							
Kontaktierung							Contacting							
Kathodenanschluss auf Erdpotential							Cathode at ground potential							
Gedämpftes Polyolefin-Hochspannungska- bel, im Keramikisolator fest verklebt							Polyolefine high voltage cable with inhe- rent surge resistor potted into ceramic isolator							
Min. Biegeradius							Min. bending radius							
Min. Biegeradius, stationär							Min. bending radius at fixed position							
Luftisolierter Stecker generatorseitig							Air insulated HT plug at HT generator							
Strahlenschutz							Radiation shielding							
Kühlung							Cooling							
Luftkühler							Air cooler							
Wasserkühler							Water cooler							
Konduktionskühlung							Conduction cooling							
Bei Bestellung bitte angeben							Please specify with order							

Mammoflex

HIGH VOLTAGE CABLE



Allgemeine Daten

Hersteller
Anzahl der Leiter

Claymount Assemblies B. V.

1

Leiter
Nennspannung

$\varnothing 2 \text{ mm Cu}$

60 kV DC

Aufbau

Isolation

Semi-conducting tape;
Semi-conducting rubber,
HV EP rubber

Abschirmung
Außenmantel

Cu, > 95% coverage

PVC

Farbe

Außendurchmesser

Lichtgrau/light grey

11,1 mm $\pm 0,5$ mm

Elektrische Daten

max. Strom

31 A

Isolationswiderstand

$> 1 \times 10^{12} \text{ Ohm} \cdot \text{m}$

Leiterwiderstand @ 20 °C

8,82 mOhm/m

Schirmwiderstand @ 20 °C

7,22 mOhm/m

Kapazität zwischen Leiter und Schirm

171 pF/m

Prüfspannung

90 kV 10 Stunden/hours

Umgebungsbedingungen

Temperatur

- 10 °C bis/to + 100 °C

Lagertemperatur

- 40 °C bis/to + 70 °C

Biegeradius fest verlegt

22 mm

Biegeradius beweglich verlegt

45 mm

Chem. Beständigkeit

TBD

Masse

180 kg/km

General Data

Manufacturer

Number of conductors

Inner conductor

Rated voltage

Construction

Insulation

Shielding

Outer sheath

Colour

Outer diameter

Electrical data

max. current

Insulation resistor

Conductor resistor @ 20 °C

Shiels resistance @ 20 °C

Capacitance between conductor and shield

Test voltage

Environment

Operating temperature

Storage temperature

Bending radius static installation

Bending radius dynamic installation

Chemical resistance

Mass

Polyolefin 04

HIGH VOLTAGE CABLE



Allgemeine Daten

Anzahl der Leiter	1
Leiter	Polyolefin, leitfähig/ Polyolefin, conductive
Nennspannung	70 kV DC

Aufbau

Isolation	Polyolefin, Ø 5,2 ± 0,2 mm
Abschirmung	Cu Ø 5,9 ± 0,2 mm
Außenmantel	PUR, abriebfest, nicht blockend/ PUR, abrasion resistant

Farbe

Außendurchmesser	violett, matt/ purple, dull finish
	7,6 ± 0,5 mm

Elektrische Daten

max. Strom	2 mA
Isolationswiderstand	> 10 GOhm x km
Leiterwiderstand @ 20 °C	30 - 80 KOhm/m
Prüfspannung	70 kV 72 Stunden/hours, 105 kV 30 min

Umgebungsbedingungen

Temperatur	+ 5 °C bis/to + 40 °C, 3 0 bis/to 80 % r. F.
Biegeradius fest verlegt	> 10 x Kabeldurchmesser/ cable diameter

Biegewechselprüfung

Chem. Beständigkeit	> 2.000.000 Zyklen bei 20 °C bedingt beständig gegenüber Xylol/ limited resistance to solvent
---------------------	---

General Data

Number of conductors

Inner conductor

Rated voltage

Construction

Insulation

Shielding

Outer sheath

Colour

Outer diameter

Electrical data

max. current

Insulation resistor

Conductor resistor @ 20 °C

Test voltage

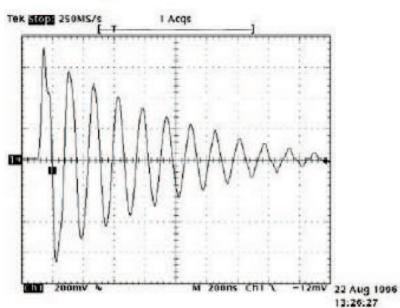
Environment

Operating temperature

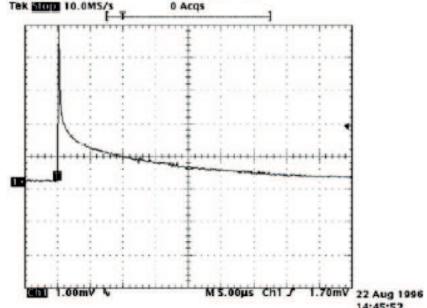
Bending radius static installation

Chemical resistance

Entladungskurve konventionelles Kabel
Discharge curve conventional cable



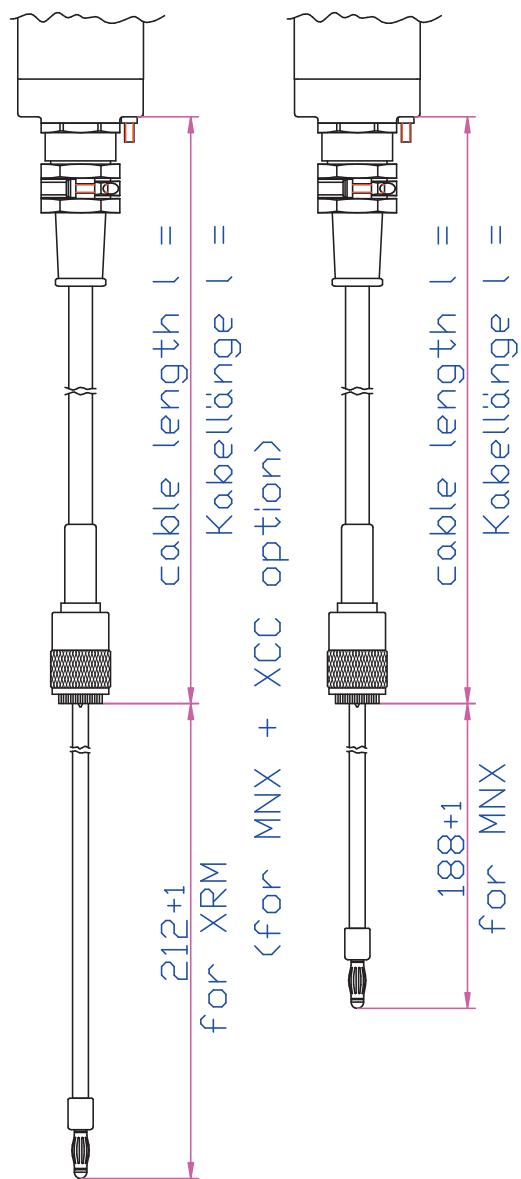
Entladungskurve rtw polyolefin 04 Kabel
Discharge curve rtw polyolefin 04 cable



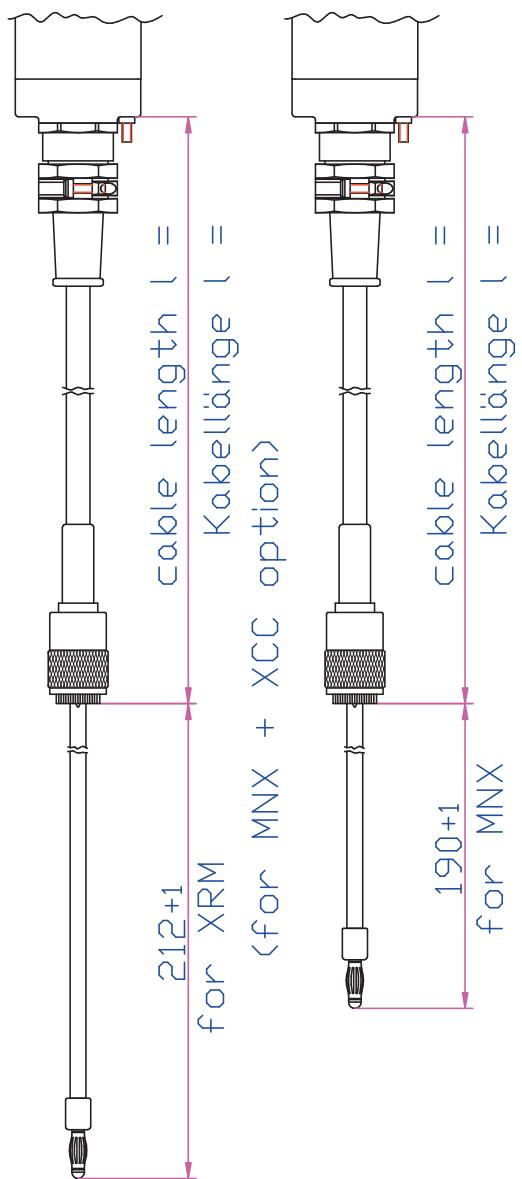
Cable Length + HT Connector

HIGH VOLTAGE CABLE

Mammoflex



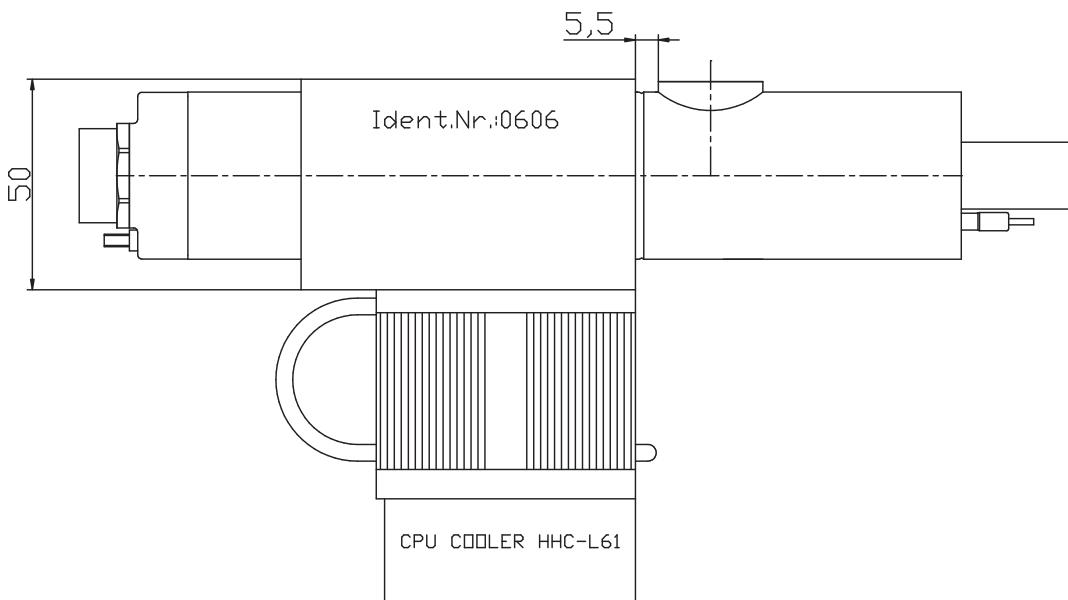
Polyolefin



X-ray tubes of our MCB- and MCBM family are equipped with a glued in HT cable.
The cable length as well as HT connector can be adapted according to the
requirements of our customer and different power supplies.

0606 - Air Cooling Device

ACCESSORIES



Allgemeine Daten

Kühlung	Air	Cooling
Maße Lüfter	60 mm x 60 mm x 25 mm	Fan dimensions
Drehzahl	6800 RPM	Rated speed
Luftstrom	36,11 CFM	Air flow
Extras	Heat pipes	Features
Kühlleistung	50 W	Cooling capacity
Temperaturschalter	Nein/No	Thermal switch
Drehzahlmessung	Ja/Yes	Tacho

General Data

Cooling	Fan dimensions
Fan dimensions	
Rated speed	
Air flow	
Features	
Cooling capacity	
Thermal switch	
Tacho	

Umgebungsbedingungen

Temperatur	- 5 °C bis/to + 30 °C	Operating temperature
Lagertemperatur	- 10 °C bis/to + 70 °C	Storage temperature
Luftfeuchtigkeit	nicht kondensierend/ not condensing	Air humidity
Geräuschpegel	26 dB (A)	Noise level

Environment

Operating temperature	
Storage temperature	
Air humidity	
Noise level	

Elektrische Betriebswerte

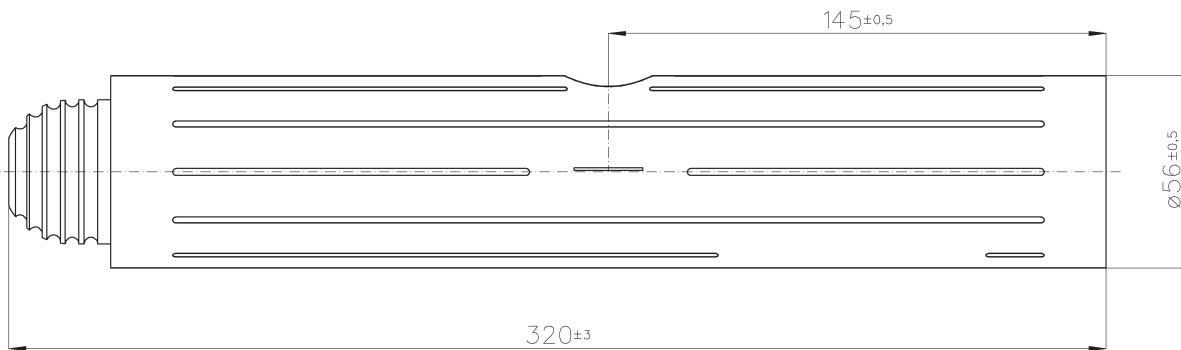
Spannung	12 V DC	Voltage
Leistungsaufnahme	~ 0,96 W	Total load
Steckverbindung	3 Pin Molex Stecker	Interface
Kabellänge	~ 100 mm	Cable length
Masse	~ 0,7 kg	Mass
Strahlenschutz	ohne/without	Leakage radiation protection

Electrical data

Voltage	
Total load	
Interface	
Cable length	
Mass	

2073 - Air Cooling Device with Radiation Shielding

ACCESSORIES



Allgemeine Daten

Kühlung	Air
Maße Lüfter	Ø 56 mm x 290 mm
Drehzahl	11050 RPM
Luftstrom	22,72 CFM
Kühlleistung	50 W
Temperaturschalter	PT 100
Drehzahlmessung	Ja/Yes

General Data

Cooling	Fan dimensions
Rated speed	Air flow
Cooling capacity	Thermal switch
Tachometer	Tacho

Umgebungsbedingungen

Temperatur	- 5 °C bis/to + 30 °C
Lagertemperatur	- 10 °C bis/to + 70 °C
Luftfeuchtigkeit	nicht kondensierend/ not condensing

Environment

Operating temperature	Storage temperature
	Air humidity
	Noise level

Elektrische Betriebswerte

Spannung	24 V DC (9 V DC - 30 V DC)
Leistungsaufnahme	~ 5,3 W
Steckverbindung	TBD
Kabellänge	TBD
Masse	~ 1 kg
Gehäusedurchlassstrahlung bei geschlossenem Strahlenaustrittsfenster in 1 m Abstand	< 1 mSv/h

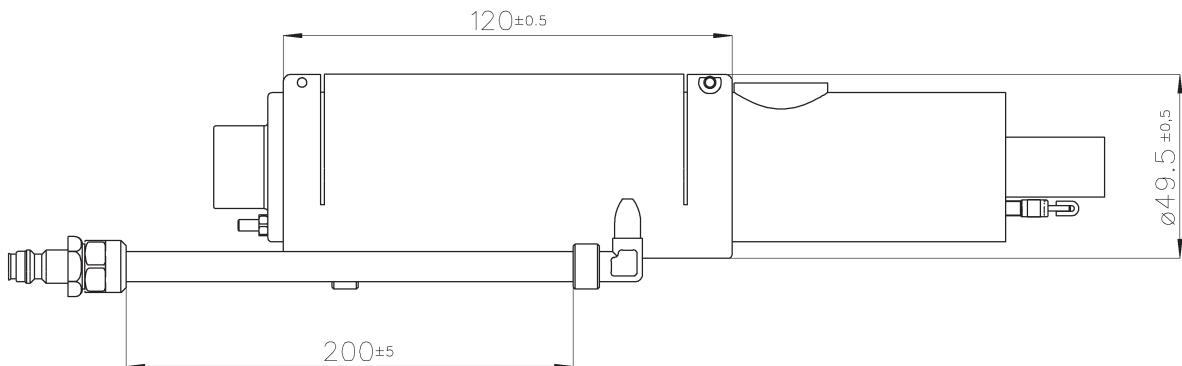
Electrical data

Voltage	Total load
	Interface
	Cable length
	Mass

Leakage radiation with closed X-ray window in 1 m distance

1910 - Water Cooling Device

ACCESSORIES



Allgemeine Daten

Kühlung

Wasserdurchfluss min.

2 l/min @ 3 bar

General Data

Cooling

Water flow rate min.

Wasserdruck max.

6 bar

Water pressure max.

Einlauftemperatur max.

30 °C

Water temperature at inlet max.

Kühlleistung

> 50 W

Cooling capacity

Umgebungsbedingungen

Umgebungstemperatur im Betrieb

- 10 °C bis/to + 70 °C

Environmental temperature when use

Relative Feuchtigkeit im Betrieb

Relative humidity

Lagertemperatur (Wasser abgelassen!)

- 10 °C bis/to + 70 °C

Store temperature (water entirely removed!)

Schutzklasse mit angeschlossenem HS-Kabel

IP54

Safety class with connected HT-cable

Masse

~ 1 kg

Mass

Durchmesser

50 mm ± 0,5

Diameter

Strahlenschutz

ohne/without

Leakage radiation protection

Bei Bestellung bitte angeben

Ident.Nr. 2199

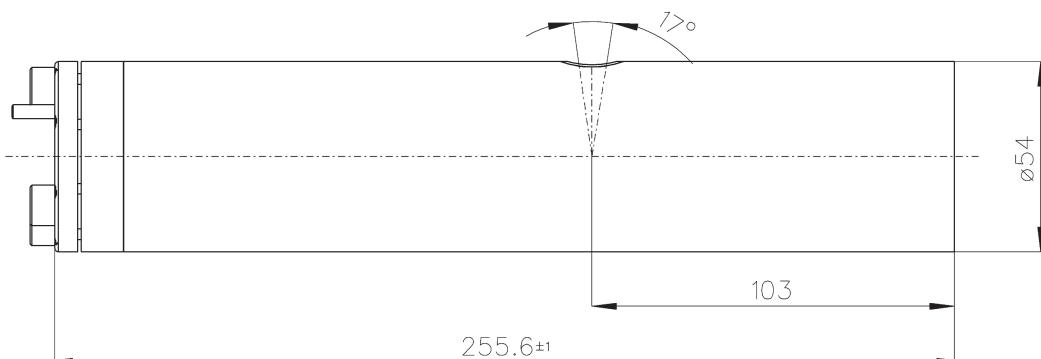
Please specify with order

Schnellverschluss-Dose NW 10

Quick connector NW 10

2554 - Water Cooling Device

ACCESSORIES



Allgemeine Daten

Kühlung

Wasserdurchfluss min.

2 l/min @ 3 bar

General Data

Cooling

Water flow rate min.

Wasserdruck max.

6 bar

Water pressure max.

Einlauftemperatur max.

30 °C

Water temperature at inlet max.

Kühlleistung

100 W

Cooling capacity

Strahlenschutz

Ident.Nr. 2621

optional

Leadkage radiation protection

Ident.Nr. 2573

1 mm Pb

Ident.No. 2621

2 mm W

Ident.No. 2573

Magnetfeld Abschirmung

Ident.Nr. 2574

optional

Magnetic field protection

Ident.No. 2574

0,5 mm

Brennfleckposition

Räumlicher Abstand zwischen Fokusmitte und der auf die Röhrenlängssachse projizierten Mitte des Ausgangsfensters

< 1 mm

Offset of focal spot to the window centre

< 0,5 mm

< 0,01 mm

Focal spot position

Umgebungsbedingungen

Umgebungstemperatur im Betrieb

- 10 °C bis/to + 70 °C

Environmental temperature when use

Relative Feuchtigkeit im Betrieb

Relative humidity

Lagertemperatur (Wasser abgelassen!)

- 10 °C bis/to + 70 °C

Store temperature (water entirely removed!)

Schutzklasse mit angeschlossenem HS-Kabel

IP54

Safety class with connected HT-cable

Masse

~ 1 kg - 3 kg

Mass

Durchmesser

54 ± 0,5 mm

Diameter

Bei Bestellung bitte angeben

Wasseranschluss Nippel NW 10

Ident.Nr. 2298

Please specify with order

Water connection NW 10

Edelstahlwellschlauch L = 300 mm

Ident.Nr. 2217

Stainless steel water hose L = 300 mm

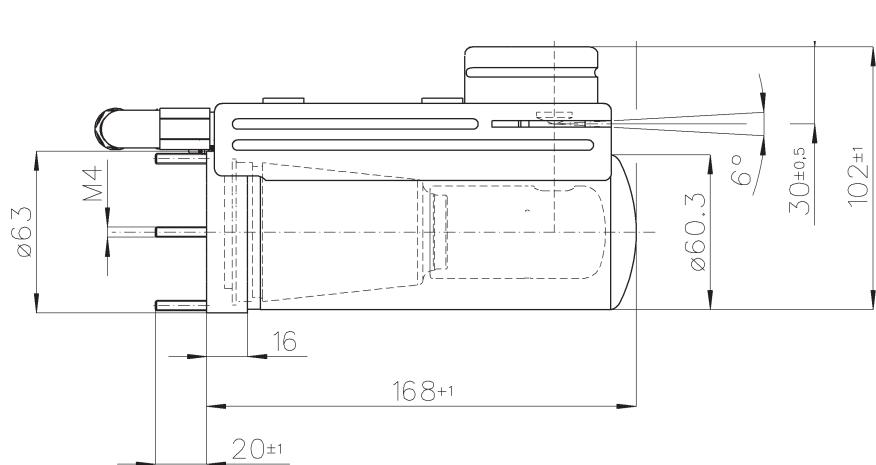
Schnellverschluss-Dose NW 10

Ident.Nr. 2199

Quick connector NW 10

MCT 100F-0,5x1,5

METAL-CERAMIC X-RAY TUBE



Allgemeine Daten

Targetmaterial
Brennfleckgröße vermessen nach DIN EN 12543-2 bei 0°
Brennfleckgröße vermessen nach DIN EN 12543-2 bei + und - 90°
Anodenwinkel
Ausstrahlungswinkel
Eigenfilterung

W
0,5 mm x 1,5 mm
0,3 mm x 0,9 mm
21° conical
6° x 280°
2 mm Be

Target material
Focal spot size in accordance with DIN EN 12543-2 at 0°
Focal spot size in accordance with DIN EN 12543-2 at + and - 90°
Anode angle
Emission angle
Inherent filtration

Absolute Grenzwerte

Konstante Gleichspannung
Anodenbelastung für Wolframtarget
Heizfadendaten
Anodenstrom

100 kV
300 W
4,5 A (4,4 V)
6 mA

Absolute maximum ratings
Constant DC voltage
Anode load for tungsten target
Filament data
Anode current

KV	100	90	80	70	60	50	40	30	20	10
mA	3,0	3,3	3,8	4,3	5,0	6,0	6,0	4,5	3,0	1,5

Hochspannungssteckdose
Kontaktierung

R24 rtw type
Large focal spot

High tension socket
Contacting

Kühlung

Wasserdurchfluss min.
Wasserdruck max.
Einlauftemperatur max.

4 l/min @ 3 bar
6 bar
35 °C

Water flow rate min.
Water pressure max.
Water temperature at inlet max.

Umgebungsbedingungen

Umgebungstemperatur im Betrieb
Relative Feuchtigkeit im Betrieb
Lagertemperatur
(Wasser abgelassen!)
Schutzklasse mit angeschlossenem HS-Kabel
Gehäusedurchlassstrahlung bei geschlossenem Strahlenaustrittsfenster in 1 m Abstand

- 10 °C bis/to + 70 °C
max. 95 %

IP54

kein Strahlenschutz/no radiation protection

Environmental temperature when use
Relative humidity
Store temperature
(water entirely removed!)

Safety class with connected HT-cable

Leakage radiation with closed X-ray window in 1 m distance

Masse

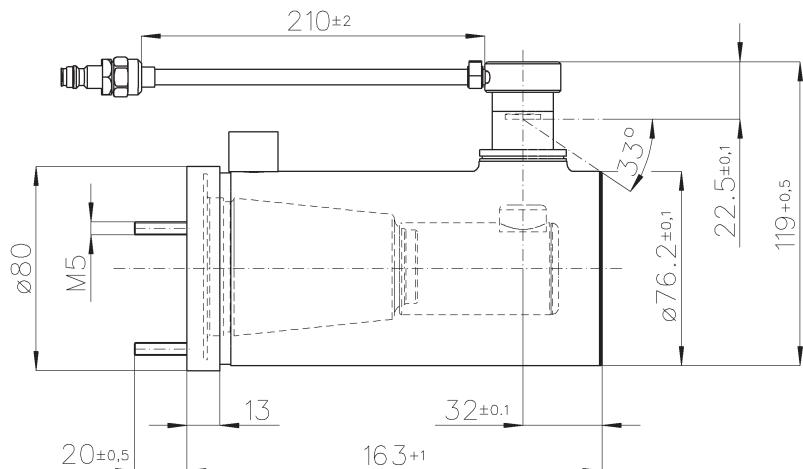
Durchmesser

~ 1,8 kg

Mass
Diameter

MCT 120-4A II

METAL-CERAMIC X-RAY TUBE



Allgemeine Daten

Targetmaterial	W
Brennfleckgröße, thermisch	1,2 mm x 0,4 mm
Anodenwinkel	0°
Ausstrahlungswinkel	33° x 280°
Eigenfilterung	2 mm Be

General Data

Target material	Target material
Focal spot size, thermal	Focal spot size, thermal
Anode angle	Anode angle
Emission angle	Emission angle
Inherent filtration	Inherent filtration

Absolute Grenzwerte

Konstante Gleichspannung	120 kV
Anodenbelastung für Wolframtarget	480 W
Heizfadendaten	4,3 A (4,3 V)
Anodenstrom	8 mA

Absolute maximum ratings

Constant DC voltage	Constant DC voltage
Anode load for tungsten target	Anode load for tungsten target
Filament data	Filament data
Anode current	Anode current

kV	120	110	100	90	80	70	60	50	40	30
mA	4,0	4,4	4,8	5,3	6,0	6,9	8,0	7,6	7,0	6,4

Hochspannungssteckdose

Kontaktierung R24 rtw type Large focal spot

High tension socket

Contacting

Kühlung

Wasserdurchfluss min.	4 l/min @ 3 bar
Wasserdruck max.	6 bar
Einlauftemperatur max.	35 °C

Cooling

Water flow rate min.	Water flow rate min.
Water pressure max.	Water pressure max.
Water temperature at inlet max.	Water temperature at inlet max.

Umgebungsbedingungen

Umgebungstemperatur im Betrieb	- 10 °C bis/to + 70 °C
Relative Feuchtigkeit im Betrieb	max. 95 %

Environmental temperature when use

Lagertemperatur (Wasser abgelassen!)	35 °C
Schutzklasse mit angeschlossenem HS-Kabel	IP54

Relative humidity

Store temperature

(water entirely removed!)

Safety class with connected HT-cable

Gehäusedurchlassstrahlung bei geschlossenem Strahlenaustrittsfenster in 1 m Abstand	kein Strahlenschutz/ no radiation protection
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Leakage radiation with closed X-ray window in 1 m distance

Masse

~ 1,7 kg

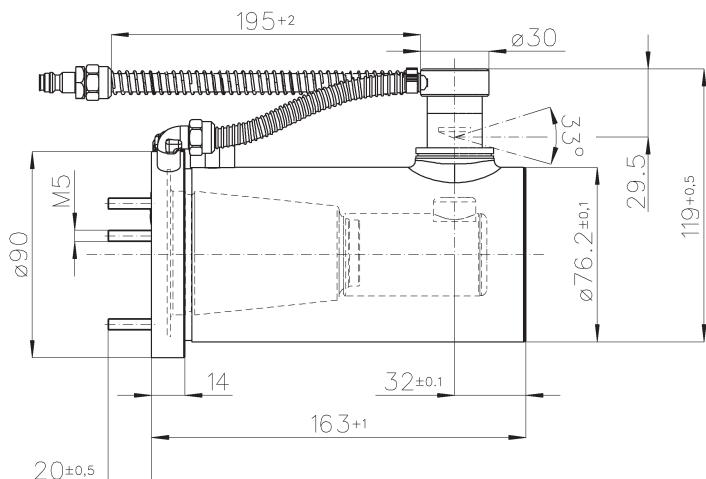
Mass

Durchmesser

Diameter

MCT 120-6F II

METAL-CERAMIC X-RAY TUBE



Allgemeine Daten

Targetmaterial
Brennfleckgröße vermessen nach
DIN EN 12543-2

Anodenwinkel
Ausstrahlungswinkel
Eigenfilterung

W
0,4 mm x 4,5 mm
21° conical
33° x 280°
2 mm Be

Target material
Focal spot size in accordance with
DIN EN 12543-2
Anode angle
Emission angle
Inherent filtration

Absolute Grenzwerte

Konstante Gleichspannung
Anodenbelastung für Wolframtarget
Heizfadendaten
Anodenstrom

120 kV
480 W
4,3 A (4,3 V)
8 mA

Absolute maximum ratings
Constant DC voltage
Anode load for tungsten target
Filament data
Anode current

kV	120	110	100	90	80	70	60	50	40	30
mA	4,0	4,4	4,8	5,3	6,0	6,9	8,0	8,0	8,0	7,0

Hochspannungssteckdose
Kontaktierung

R24 rtw type
Large focal spot

High tension socket
Contacting

Kühlung

Wasserdurchfluss min.
Wasserdruck max.
Einlauftemperatur max.

4 l/min @ 3 bar
6 bar
35 °C

Cooling
Water flow rate min.
Water pressure max.
Water temperature at inlet max.

Umgebungsbedingungen

Umgebungstemperatur im Betrieb
Relative Feuchtigkeit im Betrieb
Lagertemperatur
(Wasser abgelassen!)
Schutzklasse mit angeschlossenem HS-Kabel
Gehäusedurchlassstrahlung bei geschlossenem Strahlenaustrittsfenster in 1 m Abstand

- 10 °C bis/to + 70 °C
max. 95 %

IP54

**kein Strahlenschutz/
no radiation protection**

~ 1,7 kg

Environment
Environmental temperature when use
Relative humidity
Store temperature
(water entirely removed!)

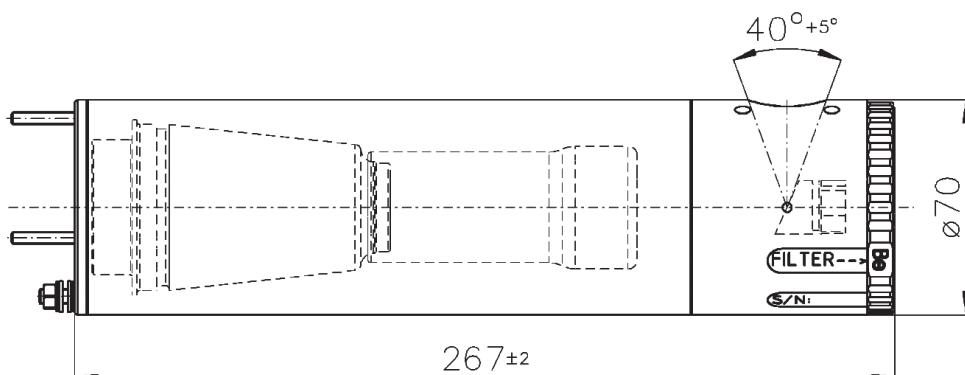
Safety class with connected HT-cable

Leakage radiation with closed X-ray window in 1 m distance

Mass

MCD 100H-1 x

METAL-CERAMIC X-RAY TUBE



Allgemeine Daten

Targetmaterialien (andere auf Anfrage)	W, Mo, Cu, Rh
Brennfleckgröße vermessen nach DIN EN 12543-2	Ø 1 mm
Anodenwinkel	24°
Ausstrahlungswinkel	40° x 40°
Eigenfilterung	1 mm Be
zusätzlich eingebaute Filter	2 mm Al/4 mm Pb

General Data

Target materials (others on request)	Target materials (others on request)
Focal spot size in accordance with DIN EN 12543-2	Focal spot size in accordance with DIN EN 12543-2
Anode angle	Anode angle
Emission angle	Emission angle
Inherent filtration	Inherent filtration
Additional filters	Additional filters

Absolute Grenzwerte

Konstante Gleichspannung	100 kV
Anodenbelastung für Wolframtarget	640 W
Heizfadendaten	4,6 A (2,6 V)
Anodenstrom	16 mA

Absolute maximum ratings

Constant DC voltage	Constant DC voltage
Anode load for tungsten target	Anode load for tungsten target
Filament data	Filament data
Anode current	Anode current

kV	100	90	80	70	60	50	40	30	20	10
mA	6,4	7,1	8,0	9,1	10,6	12,8	16	15	10	4,0

Hochspannungssteckdose
Kontaktierung

EURO 160 kV (R24)
Small focal spot

High tension socket
Contacting

Kühlung

Wasserdurchfluss min.	4 l/min @ 3 bar
Wasserdruck max.	6 bar
Einlauftemperatur max.	35 °C

Cooling

Water flow rate min.
Water pressure max.
Water temperature at inlet max.

Umgebungsbedingungen

Umgebungstemperatur im Betrieb	- 10 °C bis/to + 70 °C
Relative Feuchtigkeit im Betrieb	max. 95 %

Environmental temperature when use

Relative humidity

Lagertemperatur (Wasser abgelassen!)	35 °C
Schutzklasse mit angeschlossenem HS- Kabel	IP54

Store temperature
(water entirely removed!)

Safety class with connected HT-cable

Gehäusedurchlassstrahlung bei geschlossenem Strahlenaustrittsfenster in 1 m Abstand	< 1 mSv/h
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Leakage radiation with closed X-ray window in 1 m distance

Masse	~ 6 kg
Durchmesser	70 ± 1 mm

Mass

Diameter

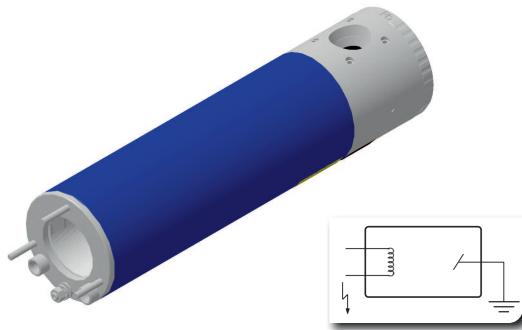
MCD 100H-3 x

METAL-CERAMIC X-RAY TUBE

Allgemeine Daten						General Data																													
Targetmaterialien (andere auf Anfrage)				W, Mo, Cu, Rh				Target materials (others on request)																											
Brennfleckgröße vermessen nach DIN EN 12543-2				Ø 3 mm				Focal spot size in accordance with DIN EN 12543-2																											
Anodenwinkel				24°				Anode angle																											
Ausstrahlungswinkel				40° x 40°				Emission angle																											
Eigenfilterung				1 mm Be				Inherent filtration																											
zusätzlich eingebaute Filter				2 mm Al/4 mm Pb				Additional filters																											
Absolute Grenzwerte						Absolute maximum ratings																													
Konstante Gleichspannung				100 kV				Constant DC voltage																											
Anodenbelastung für Wolframtarget				1500 W				Anode load for tungsten target																											
Heizfadendaten				4,4 A (7,5 V)				Filament data																											
Anodenstrom				45 mA				Anode current																											
<table border="1"> <thead> <tr> <th>kV</th><th>100</th><th>90</th><th>80</th><th>70</th><th>60</th><th>50</th><th>40</th><th>30</th><th>20</th><th>10</th><th></th></tr> <tr> <th>mA</th><td>15</td><td>16,6</td><td>18,7</td><td>21,4</td><td>25</td><td>30</td><td>375</td><td>45</td><td>35</td><td>20</td><td></td></tr> </thead> </table>												kV	100	90	80	70	60	50	40	30	20	10		mA	15	16,6	18,7	21,4	25	30	375	45	35	20	
kV	100	90	80	70	60	50	40	30	20	10																									
mA	15	16,6	18,7	21,4	25	30	375	45	35	20																									
Hochspannungssteckdose				EURO 160 kV (R24)				High tension socket																											
Kontaktierung				Large focal spot				Contacting																											
Kühlung						Cooling																													
Wasserdurchfluss min.				4 l/min @ 3 bar				Water flow rate min.																											
Wasserdruck max.				6 bar				Water pressure max.																											
Einlauftemperatur max.				35 °C				Water temperature at inlet max.																											
Umgebungsbedingungen						Environment																													
Umgebungstemperatur im Betrieb				- 10 °C bis/to + 70 °C				Environmental temperature when use																											
Relative Feuchtigkeit im Betrieb				max. 95 %				Relative humidity																											
Lagertemperatur (Wasser abgelassen!)				IP54				Store temperature (water entirely removed!)																											
Schutzklasse mit angeschlossenem HS-Kabel				< 1 mSv/h				Safety class with connected HT-cable																											
Gehäusedurchlassstrahlung bei geschlossenem Strahlenaustrittsfenster in 1 m Abstand				~ 6 kg				Leakage radiation with closed X-ray window in 1 m distance																											
Masse						Mass																													
Durchmesser						Diameter																													

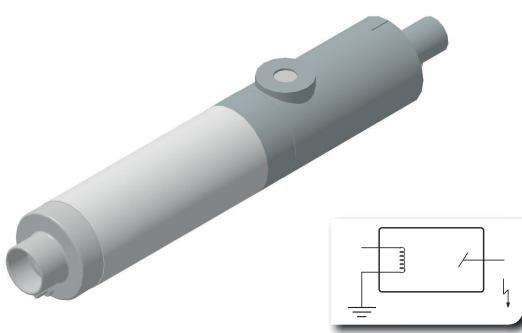
Electrical Connection

Technical X-RAY TUBE Information



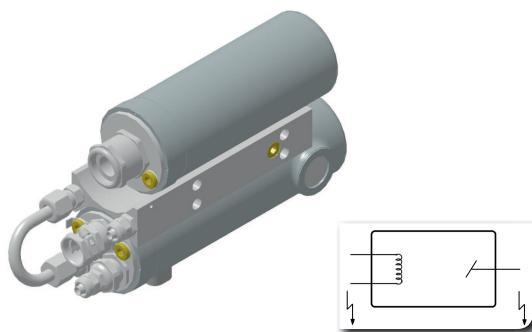
Anode grounded

- Classical technical design for high power
- HT polarity: (-) minus
- Anode at ground potential
- Water cooling
- Filament at high potential
- X-ray window near to focal spot



Cathode grounded

- Low power X-ray tube design
- HT polarity: (+) plus
- Anode at high potential
- Cooling through electrically insulating material (e. g. oil or ceramic)
- Filament at ground potential
- X-ray window positioned outside of the HT field

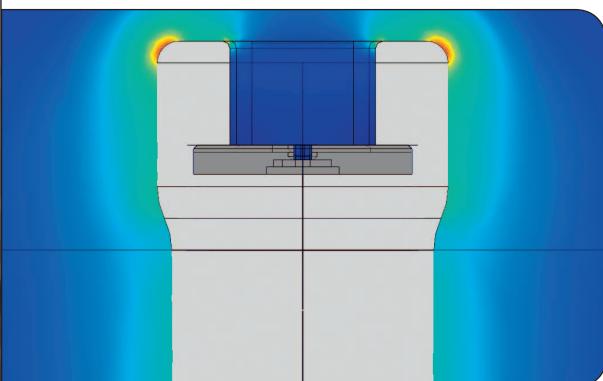
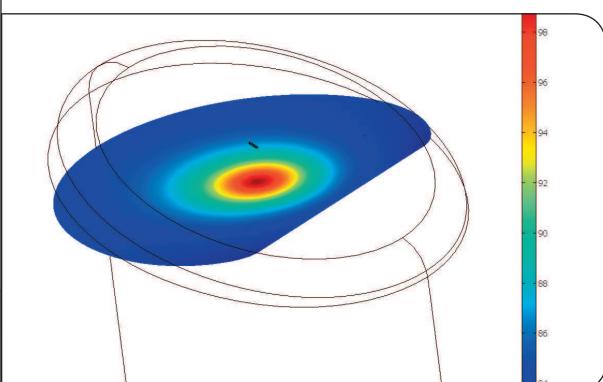
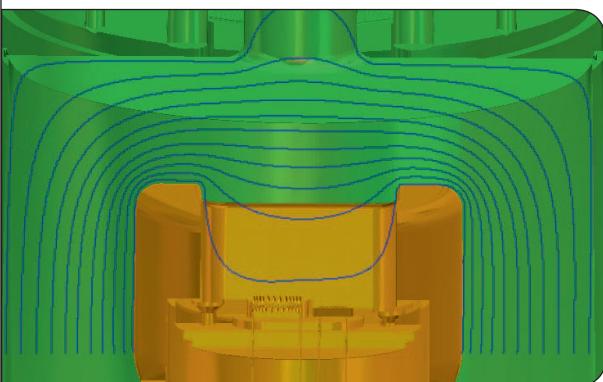
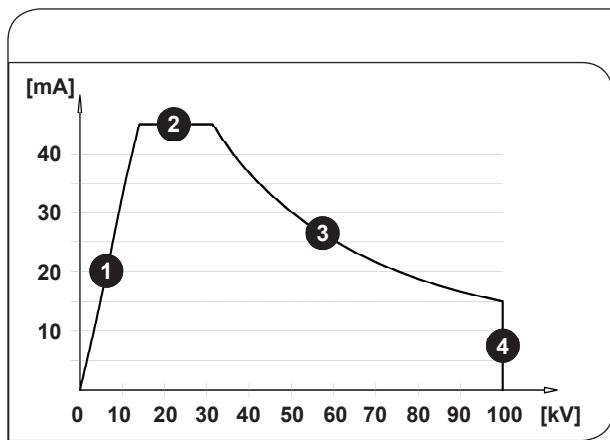


Bipolar

- Preferable designed for higher voltages
- HT polarity: (-) minus and (+) plus
- Anode and cathode at high potential
- Cooling through electrical insulating material (oil or ceramic)
- Filament at high potential
- X-ray window positioned outside of the HT field

X-ray Tube Characteristic

Technical X-RAY TUBE Information



4 different X-ray tube limitations

1. Max. tube power at lower kV
2. Max. mA limited by the power supply only
3. Tube power
4. Max. nominal high tension

Maximum tube power at lower kV

The fieldstrength is not high enough to accelerate the entire electron cloud around the filament. Therefore the filament needs to be heated at higher temperature and is limiting the tube power by its lifetime.

Maximum tube power

The max. tube power is limited by the max. specific load on the focal spot. This varies with the target material.

Maximum high tension

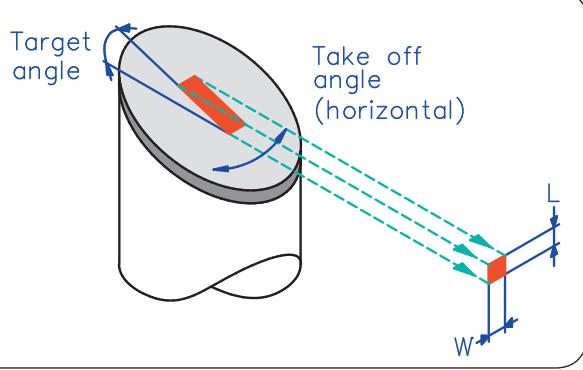
The max. acceleration voltage is based on a risk assessment.

Following will increase with max. HT:

- Duration for conditioning
- Frequency of discharges per period (day, hour, minute)
- Chance of breakdown of the HT cable or its connection

Focal Spot

Technical X-RAY TUBE Information



Optical versus thermal focal spot size

X-ray tubes with reflection target are benefiting from the so called "Goetze-principle". The optical length of the focal spot will be reduced with smaller target angles. In this way higher load can be positioned at the same focal spot. The thermal focal spot can be calculated with the following table:

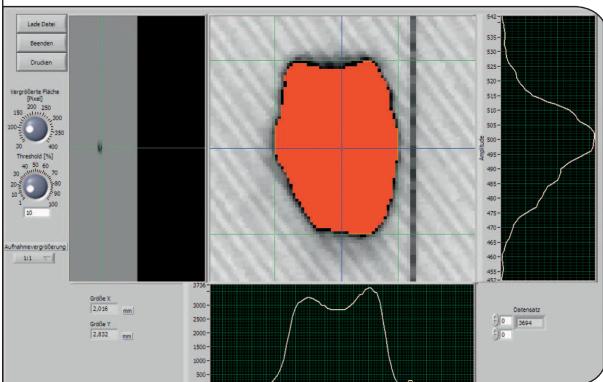
Thermal length		Target angle				
		6°	12°	20°	24°	30°
optical d=	50 µm	480	240	145	125	100
	1 mm	9,6	4,8	2,9	2,5	2
	3 mm	28,80	14,4	8,7	7,5	6

The optical focal spot varies with different directions looking at the target.

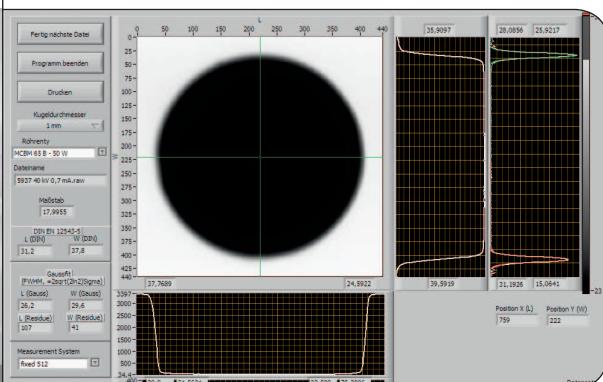
The table below shows the calculated optical focal spot size at different angles.

Optical length		Take off angle (horizontal)				
		0	10	20	30	40
Target angle d=1	24°	1,00	1,37	1,71	2,0	2,2
	12°	1,00	1,80	2,55	3,22	3,79
	6°	1,00	2,64	4,19	5,62	6,88

The measurement according to **DIN EN 12543-2** gives a direct view on the focal spot by means of a pinhole camera. It is taken for focal spots larger than 100 µm.



DIN EN 12543-2

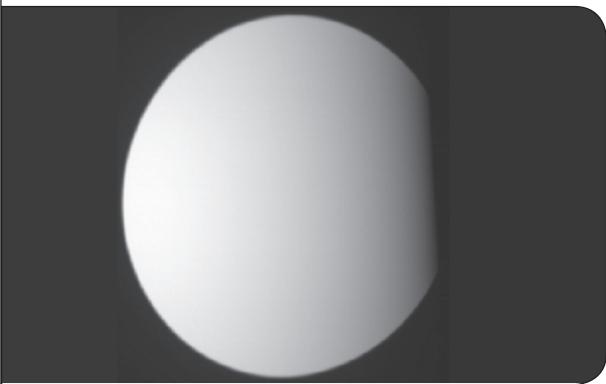


DIN EN 12543-5

The method according to **DIN EN 12543-5** is taken for small focal spots below 100 µm. The focal spot size is calculated from the unsharpness of e. g. a tungsten ball.

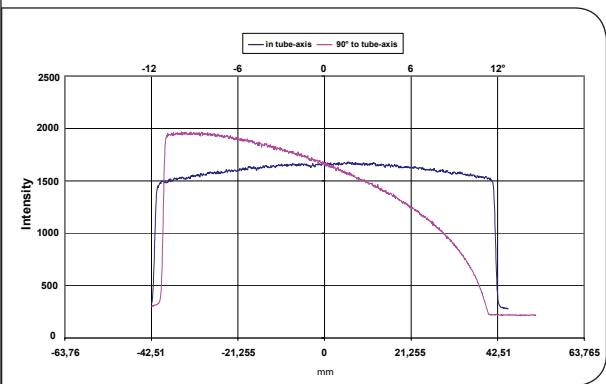
Intensity Distribution

Technical X-RAY TUBE Information



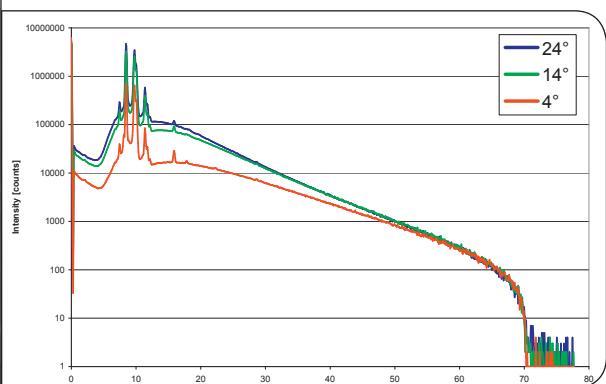
Cone beam

Intensity distribution on a CCD X-ray camera from a 12° target X-ray cone beam.



Intensity distribution

The intensity distribution is horizontally effected by the "distance to square law" and vertically additional by the heel effect.

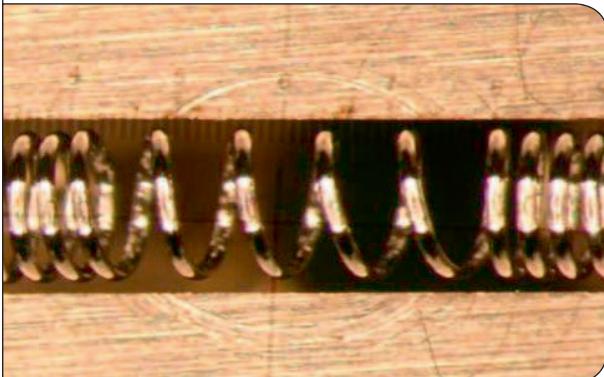


X-ray spectrum from a 24° tungsten target at different take off angles

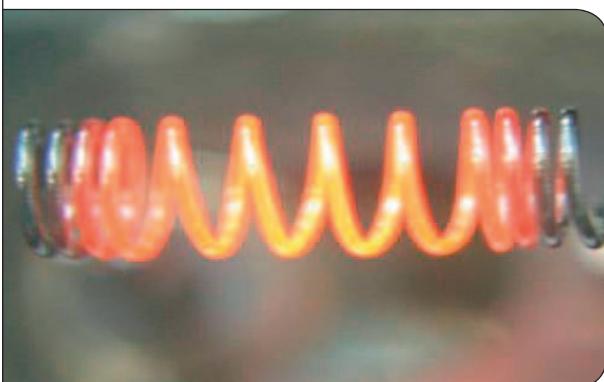
With smaller take off angles more soft X-rays will be absorbed.

Filament

Technical X-RAY TUBE Information



Tungsten filament - cold



Tungsten filament - hot (pre-heated)



Tungsten filament - maximum power

Physics of the filament

The electrical power of the filament in correlation to the diameter of the filament wire determines the electronemission and the lifetime. So the current flow increases the temperature at the filament and hereby the electron emission. This effect is used to control the tube current (mA).

By **reducing the filament current** by 5% only, the lifetime will be extended by 50%.

The **Soret effect and electromigration** is based on a considerable temperature gradient longitudinally along the direction of the wire axis. The mass transport (of tungsten atoms) which occurs, produces a notched surface structure of the filament. This results inevitably in a reduced cross section which can lead to a fracture under the influence of shock or vibration or pulsed working. 50% filament lifetime reduction has to be calculated when working with a DC filament power supply.

Some applications for X-ray tubes involve mechanical **shock and vibration**. The rtw filaments are subject to special annealing procedures during the manufacturing, for high mechanical stability and high resistance to shock and vibration. Shock and vibration has to be avoided anyway.

Switching the filament on and off will cause an alternation of the filament temperature, thus creating a series of phases of internal stress, which in turn reduces the lifetime, too.

rtw recommends to preheat the filament.

During ramping up modes the filament power supply may produce **electrical overshots** (short overvoltages and overcurrent). This shortens the lifetime.

Electrical tube over power or due to insufficient cooling, ions may be released. Their electric charge being opposite to that of electrons, causes them to move opposite to the direction of the accelerated electrons and hit the filament.

Notes



Notes



X-ray Tubes

Analytics



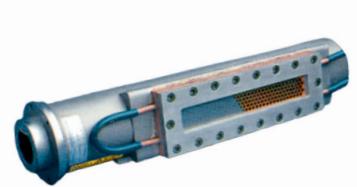
Tire Inspection



High Resolution



Special Application





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