Product Catalog
Oxford Instruments X-Ray Technology

Power Supplies, Integrated Sources and X-ray Tubes

Glass X-ray Tubes with Window

Radiation Shielded X-ray Tubes

Corrosion Resistant Window Coating

Shielded X-ray Tubes and Power Supplies

Ultrabright Microfocus X-ray Source

Pinnacles 50kV Microfocus Source

3900003 Rev B

OXFORD INSTRUMENTS

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X-RAY

Product Catalog

390000 Rev B

Oxford Instruments X-Ray Technology products are compliant with some or all of the following Certifications, Registrations, and Designations:

- CE
- UL
- TUV
- NFC
- Conflict Free Sourcing Initiative

For details about your specific product of interest, please contact Oxford Instruments X-Ray Technology.

TECHNOLOGY

Product Catalog

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Corrosion Resistant Beryllium Window Coating

Forté Coating Option

Forté window coating option is a patented, protective coating designed to extend the life of beryllium x-ray tube windows in harsh and hazardous environments.

Environments with high humidity and acidity can cause detrimental corrosion to the beryllium windows of X-ray tubes. Corrosion of the beryllium window causes atmosphere to leak into the vacuum space of the tube, leading to premature failure of sources. These early life failures increase the total cost of ownership for end consumers through heightened frequency of unscheduled field service and increased system downtime, while damaging an OEM's quality reputation.

The Forté window coating applies a protective barrier to the beryllium window using a patented application of an inorganic coating. The coating protects the beryllium from water and chemical vapor without impact to the source spectrum and adds minimal flux attenuation making it ideal for analytic and industrial imaging applications.

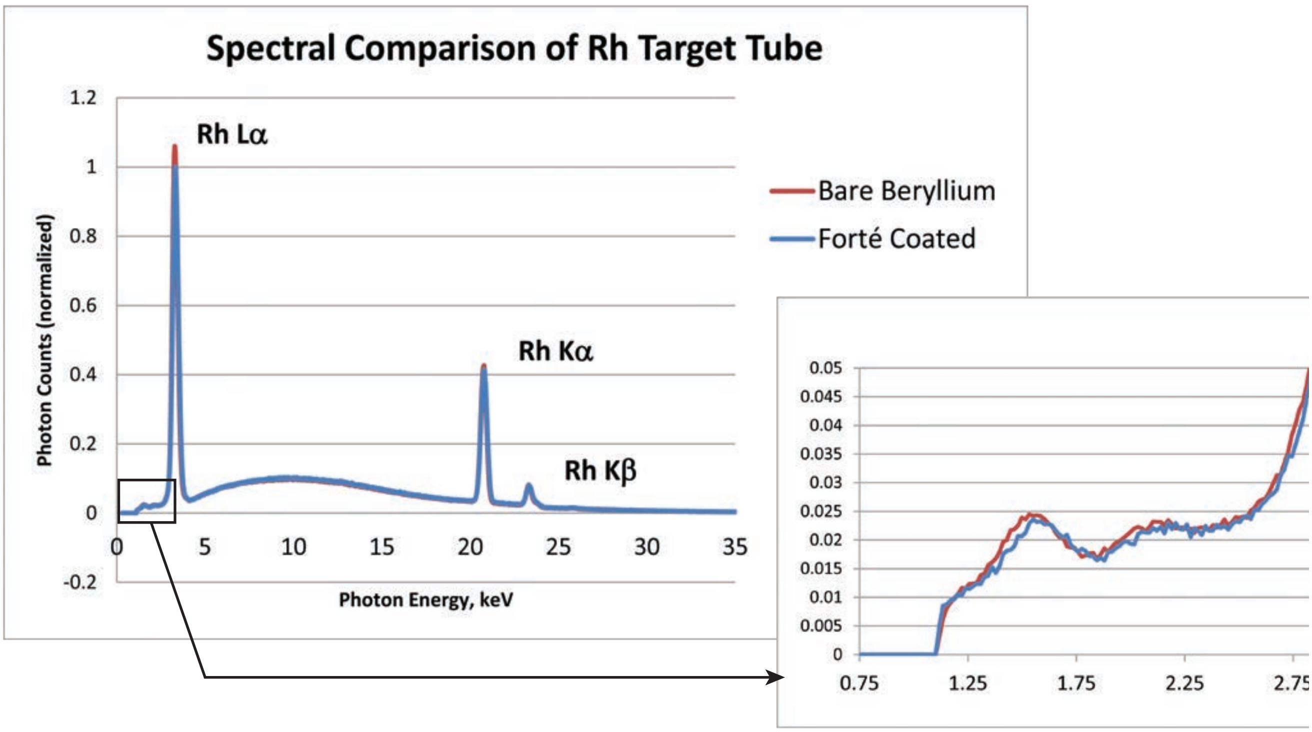
The Forté window coating option is available on all Oxford X-ray tubes.

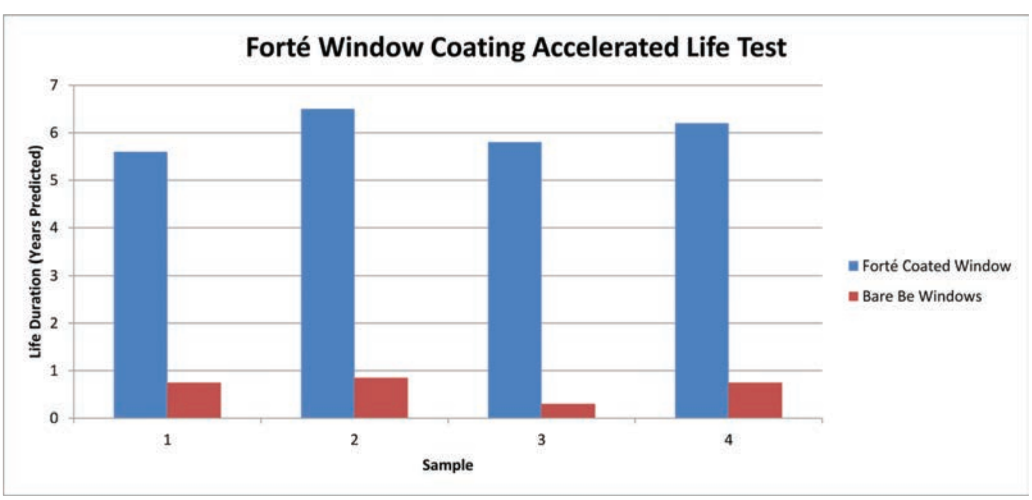
Benefits

- Window life expectancy increase 5X on average when compared to uncoated beryllium window
- Uniform coating provides low attenuation to ensure high transmission of low energy X-rays
- No impact to output spectrum
- 3 year warranty coverage against tube failures due to window corrosion

Specifications	
Material	Patented inorganic coating
Attenuation	< 5% @ > 4keV
Affect to Spectrum	No impact to output spectrum
Ambient Temperature	500°C Maximum
Leak Rate	< 1×10^{-9} atm*cc/sec
Coating Color	Varies (does not impact performance)
Acidic Exposure	≥ 4.2 pH (while covered under 3 year warranty), Higher acidity will reduce window life
Warranty	3 year coverage against failures due to window corrosion
Patent No.	US15/783457, "Window Member for an X-ray Device"

Corrosion Resistant Beryllium Window Coating
Forté Coating Option





90kv Microfocus X-ray Source
UltraBright 96000 Series

The UltraBright Microfocus System 96000 Series is a 90kV, 80W X-ray source designed for applications where high brightness, high magnification and small spot size are important.

Operated by an external high voltage Smart Controller capable of providing variable voltage and power control, the UltraBright Microfocus System delivers exceptional magnification and image quality with full control of "Brightness". Maximum flux output is maintained through automatic matching of a given power setting to a corresponding optimal spot size.

Benefits

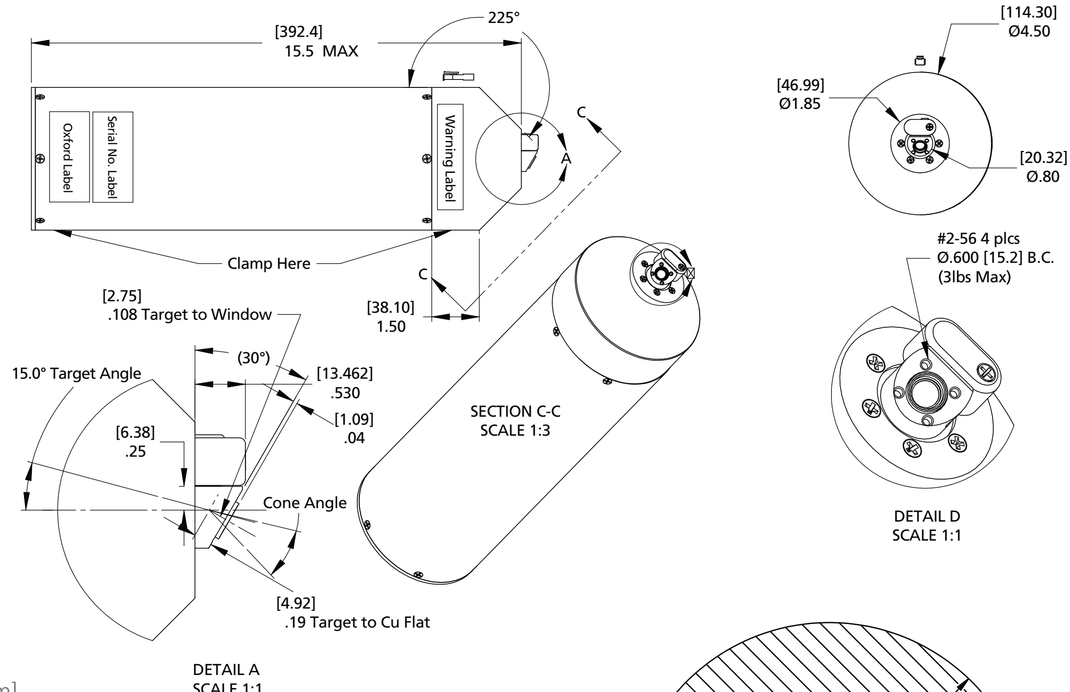
- Exceptional magnification and image quality
- High power operation — ideal for high flux applications and experiments.
- Integrated package eliminates HV cable for improved reliability
- Complete range of user control — ideal for research applications
- Compact, lightweight design — ideal for portable applications
- Includes controller with Smart Brightness control

Applications

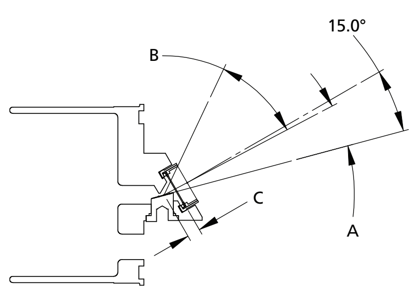
- Microtomography
- Microfluorescence
- CT imaging for life sciences and industrial inspection
- Microdiffraction

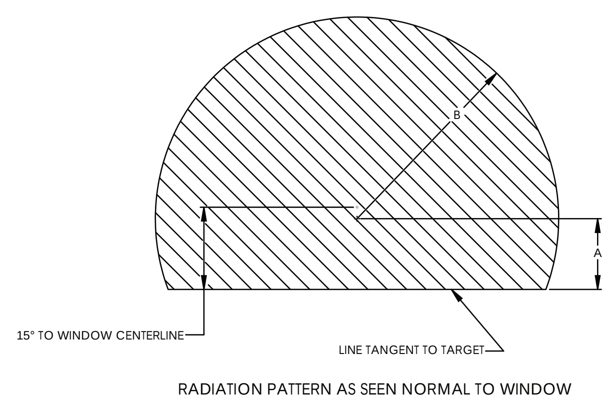
Specifications	
Operating voltage range:	See product ordering table.
Maximum Power:	See product ordering table.
Maximum beam current:	2.0mA
Focal spot size:	14-20µm @ maximum voltage and minimum power
Focus to Object Distance (FOD):	4mm
Cone of illumination:	50° x 74° (nominal) See chart on next page.
Window material and thickness:	Be, 254µm
Window diameter (unobstructed):	9.5mm (0.37")
Window configuration	End window
Target material:	See product ordering table
Ambient operating temperature:	10°C to 40°C
Maximum operating temperature (anode):	70°C
Cooling method:	Forced air (150 CFM @ 4" recommended for continuous operation) See Application Note 3904010 (Thermal Management) on page 58 for details.
Shielding:	Not shielded
Dimensions:	392.4mm L x Ø 114.3mm (15.5" L x Ø 4.5")
Weight:	≤ 4kg (8.81lbs.)
Storage conditions:	-10°C to 55°C Barometric Pressure: 50-106kPa; Humidity: 10-90% (no condensation) Condensation on Be window will cause window corrosion, vacuum loss and X-ray tube failure.

UltraBright 96000 Series 90kV Microfocus X-ray Source



DIMENSIONS: [mm]
Inches





			Emitted Cone and Spot Position		
Dimension	**Description**	**Units**	**Farthest**	**Nominal**	**Nearest**
A	Location of radiation cone center	Degrees	10.6	12.9	16.4
B	Radius of cone	Degrees	32.2	36.8	42
C	Window to spot distance	mm	4.47	3.14	1.82

For a complete understanding of how to use this product, please reference Application Notes: 3904010 Thermal Management on page 56 and AN001 Environmental Conditions on page 48.

The source (left) is connected to the controller (right) with a DB-25 cable (15' length).

The female end of the DB-25 cable connects to the source and the male end of the DB-25 cable connects to the conroller.

RS232 Control Command Set

Protocol:	RS-232-C
Baud Rate:	9600 ASYNC
Flow control:	None
Data bits:	8
Stop bits:	1
Parity:	None
Connector:	Type: 25 pin

Functions

Anode voltage set:	10 to 90kV (example: VCN 50 = set 50kV)
Brightness set:	10 to 80W (example: WCN 40 = set 40W)
Command:	X-ray ON/OFF
Command:	Voltage min-max set
Command:	Brightness min-max set

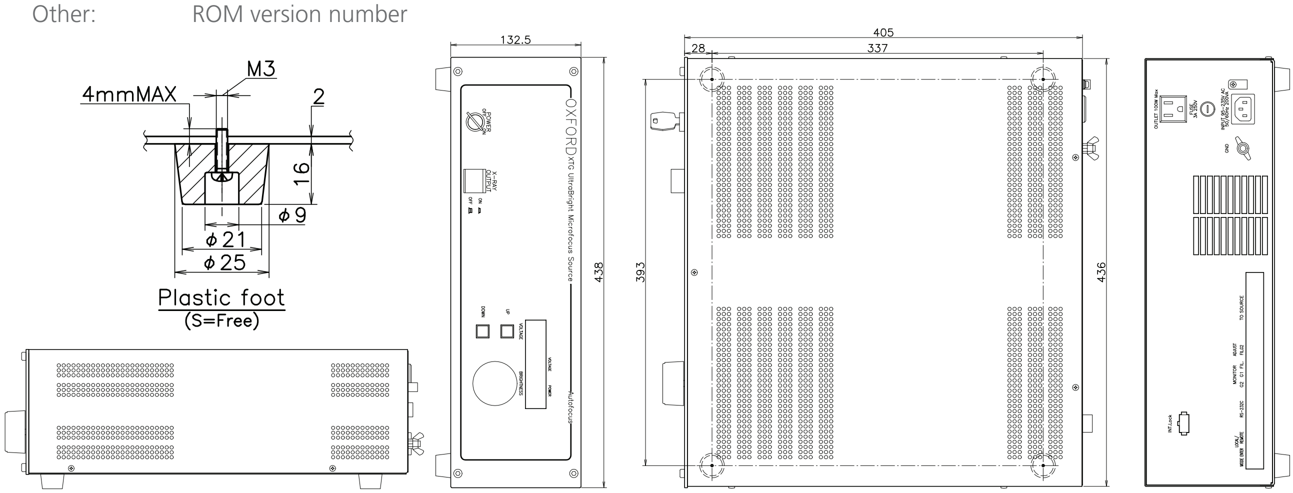
Read Back

Voltage:	(example: VM 30 = 30kV)
Brightness:	(example: WM 20 = 20W)
Status:	Stand-by, warm-up, output, fault modes in ASCII format
Fault:	Display panel information except remote/local mode will be in ASCII format
Other:	ROM version number

Controller Unit Specifications	
Functions:	Key switched power, HV on/off, kV adjust, brightness/autofocus adjust
External control:	Remote control
Power consumption:	100W maximum
Input voltage:	110/240 AC autosensing
Approximate weight:	4kg
HV cable:	Not necessary
LV cable:	Std 25 pin D-type connector (15 feet long)

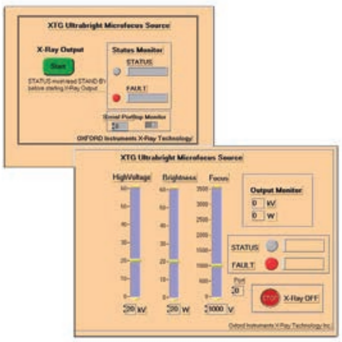
Item	RS232 Control	Manual Operation	Notes
Remote/local switch	No	Yes	Switch is located on rear panel
Power on/off	No	Yes	For remote operation, front panel on/off switch must be "On"
X-ray on/off:	Yes	Yes	For remote operation, front panel on/off switch must be "On"
Voltage up/down	Yes	No	Front panel switch disabled
Brightness control	Yes	No	Front panel switch disabled

Power on can be accomplished remotely by X-ray on/off command. However, if cathode emitter is turned off, power is restored only through front panel on/off switch. Safety interlocks available on real panel.



Controller Unit Reference Drawing / Dimensions in mm

Software Control Option



- Runs under LabVIEW RT & MS-Windows
- Works in conjunction with RS232 control interface
- Complete control of voltage, power, and focus
- Dynamic status display
- Open software architecture allows for modification with available additional development software
- Dynamic fault display
- Ideal for R&D applications

Functions	Software Control	Manual Operation	Notes
Remote/Local switch	No	Yes	Switch is located on rear panel
Power On/Off	No	Yes	For software operation, front panel On/Off switch must be "On"
X-ray On/Off	Yes	Yes	For software operation, front panel On/Off switch must be "On"
Voltage up/down	Yes	No	Front panel switch disabled
Power adjust	Yes	No	Front panel Brightness dial disabled

Microfocus Source with the following Class-Leading Performance Characteristics:

- The UltraBright 96000 Series is a fully integrated 90kV X-ray source. Its high voltage power supply and controller provide variable control of high voltage from 10-90kV and beam current from .33-2 milliamps with full control of "Brightness". The Smart Controller calculates spot size for a given power setting for maximum flux output.
- Voltage and current rating (90kV, 2.0mA) are subject to maximum power dissipation rating of 80W. The X-ray tube assembly is sealed, air-cooled, and rated for continuous operation.
- X-ray microfocus spot size is continuously adjustable from 14µm to 20µm. Power de-rating is provided at small spot sizes but source power is greater than or equal to 20W for a 20µm spot size.
- The anode target material is comprised of Tungsten as standard, however other targets are available (Cu, Mo). The target is inclined at a takeoff angle of 15 degrees with respect to the electron beam, and the exit window is aligned at an angle of 30 degrees with respect to the electron beam, so that a round microfocus X-ray spot is projected through the exit window.
- The stability of the microfocus X-ray spot shall be less than 5µm RMS over a period of 8 hours, as verified by test. A warm- up time of up to two hours is necessary in order to meet this specification.
- The system is supplied with a 254 micron Be exit window, allowing for close coupling (4mm) of object with the anode X-ray spot.
- LabVIEW RT Software Interface: The Smart Controller is outfitted with a software package that provides remote control of the various functions, such as kV, mA, Brightness, power etc. It includes an RS232 Communication package and an RT version of National Instruments LabVIEW. See Software control datasheet for complete description.

Product Ordering Table

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Power Density	Spot Size (µm)**
96002*	8236	Mo	20 - 60	2.0	60	1.5W/µm	20 Max.
96000*	8236	Cu	20 - 60	2.0	60	1.5W/µm	20 Max.
96004*	8236	W	20 - 90	2.0	80	2.5W/µm	20 Max.

Note: Part number specific copies of outline drawings and product specification sheets are available.
*Includes a thermal switch which adds an additional level of protection to the cooling system safeguards.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

90kv Water-Cooled Microfocus X-ray Source
Nova 600 Series

The Nova Microfocus System 600 Series is a 90kV, 80W, water-cooled X-ray source designed for applications where high power, high magnification and small spot size are important.

Operated by an external high voltage Smart Controller capable of providing variable voltage and power control, the Nova Microfocus System delivers exceptional magnification and image quality with full control of "Brightness." Maximum flux output is maintained through automatic matching of a given power setting to a corresponding optimal spot size.

Benefits

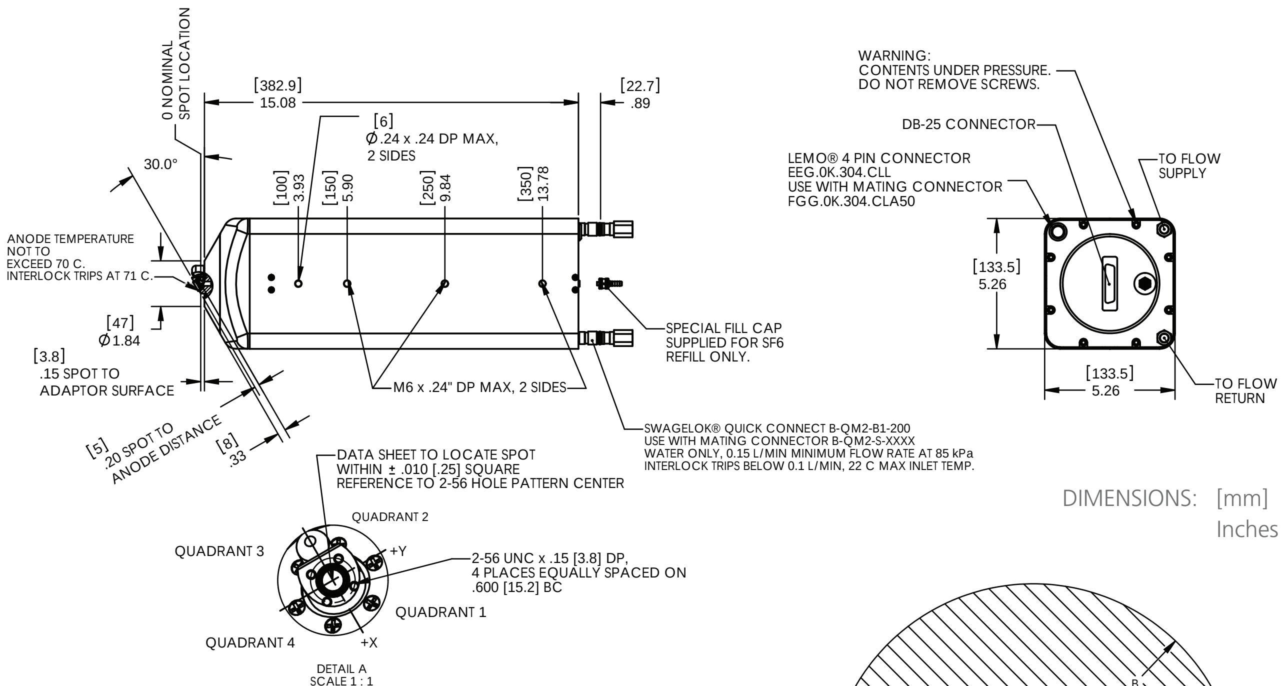
- Exceptional magnification and image quality
- High power operation — ideal for high flux applications and experiments.
- Integrated package eliminates HV cable for improved reliability
- Complete range of user control — ideal for research applications
- Compact, lightweight design — ideal for portable applications
- Includes controller with Smart Brightness control

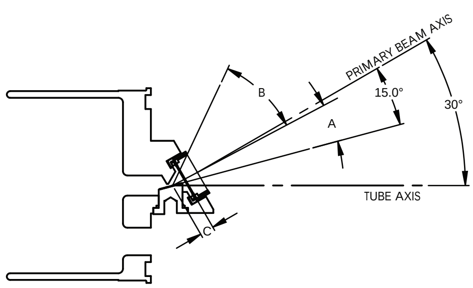
Applications

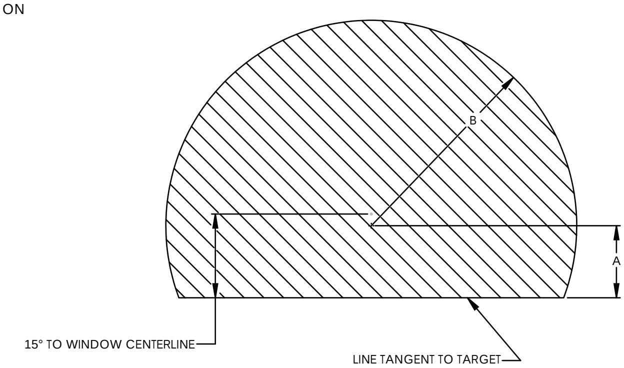
- Microtomography
- Microfluorescence
- CT imaging for life sciences and industrial inspection
- Microdiffraction

Specifications	
Operating voltage range:	See product ordering table
Maximum power:	See product ordering table
Maximum beam current:	2.0mA
Focal spot size:	14-20µm @ maximum voltage and minimum power
Focus to Object Distance (FOD):	4mm
Cone of illumination:	50° x 74° (nominal) See chart on next page
Window material and thickness:	Be, 254µm
Window diameter (unobstructed):	9.5mm (0.37")
Window configuration	End window
Target material:	See product ordering table
Ambient operating temperature:	10°C to 40°C
Maximum operating temperature (anode):	70°C
Cooling method:	H_2O 0.15 l/min @ 15 psi
Shielding:	Not shielded
Dimensions:	392.4mm L x 114.3mm W (15.5" L x 4.5" W)
Weight:	≤ 4kg (8.81 lbs)
Storage conditions:	-10°C to 55°C Barometric Pressure: 50-106kPa; Humidity: 10-90% (no condensation) Condensation on Be window will cause window corrosion, vacuum loss and X-ray tube failure

Nova 600 Series 90kv Water-Cooled Microfocus X-ray Source



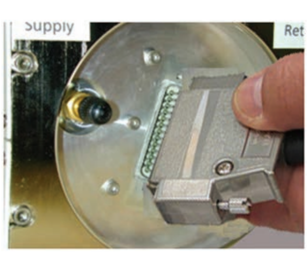




RADIATION PATTERN AS SEEN NORMAL TO WINDOW

			Emitted Cone and Spot Position		
Dimension	**Description**	**Units**	**Farthest**	**Nominal**	**Nearest**
A	Location of radiation cone center	Degrees	10.6	12.9	16.4
B	Radius of cone	Degrees	32.2	36.8	42
C	Window to spot distance	mm	4.47	3.14	1.82

For a complete understanding of how to use this product, please reference Application Notes: 3904010 Thermal Management on page 56 and AN001 Environmental Conditions on page 48.



The source (left) is connected to the controller (right) with a DB-25 cable (15' length).

The female end of the DB-25 cable connects to the source and the male end of the DB-25 cable connects to the controller.

90kv Water-Cooled Microfocus X-ray Source
Nova 600 Series (cont.)

RS232 Control Command Set

Protocol:	RS-232-C
Baud Rate:	9600 ASYNC
Flow control:	None
Data bits:	8
Stop bits:	1
Parity:	None
Connector:	Type: 25 pin

Functions

Anode voltage set:	10 to 90kV (example: VCN 50 = set 50kV)
Brightness set:	10 to 80W (example: WCN 40 = set 40W)
Command:	X-ray ON/OFF
Command:	Voltage min-max set
Command:	Brightness min-max set

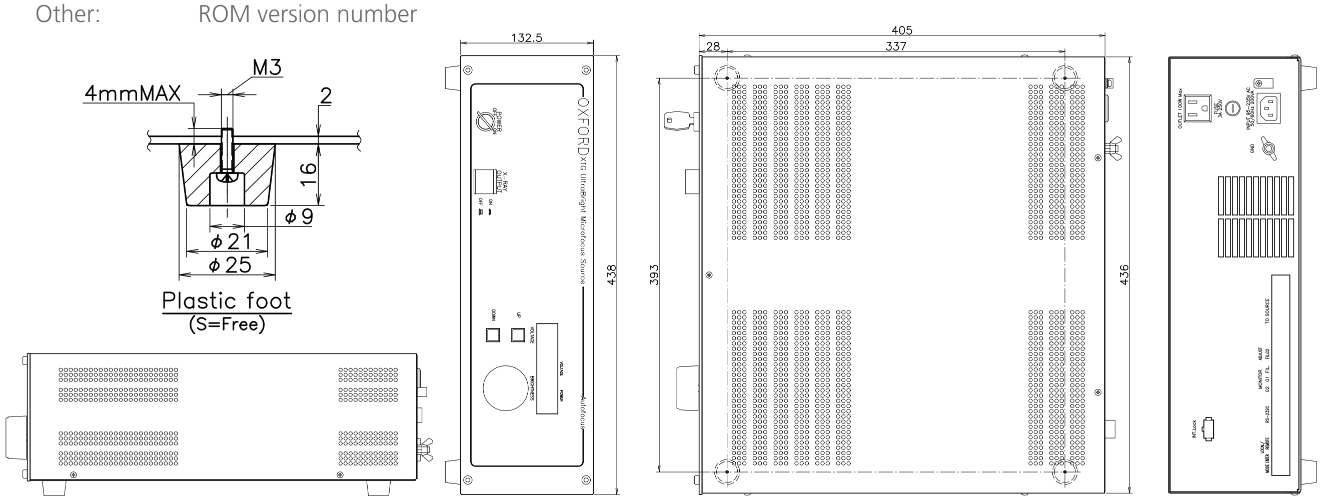
Read Back

Voltage:	(example: VM 30 = 30kV)
Brightness:	(example: WM 20 = 20W)
Status:	Stand-by, warm-up, output, fault modes in ASCII format
Fault:	Display panel information except remote/local mode will be in ASCII format
Other:	ROM version number

Controller Unit Specifications	
Functions:	Key switched power, HV on/off, kV adjust, brightness/autofocus adjust
External control:	Remote control
Power consumption:	100W maximum
Input voltage:	110/240 AC autosensing
Approximate weight:	4kg
HV cable:	Not necessary
LV cable:	Std 25 pin D-type connector (15 feet long)

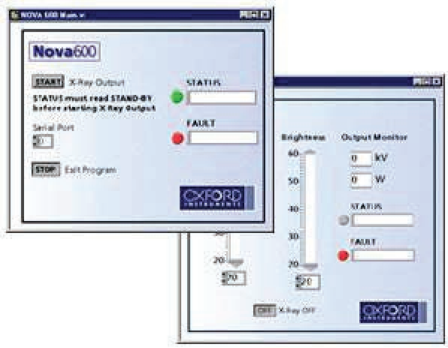
Item	RS232 Control	Manual Operation	Notes
Remote/local switch	No	Yes	Switch is located on rear panel
Power on/off	No	Yes	For remote operation, front panel on/off switch must be "On"
X-ray on/off:	Yes	Yes	For remote operation, front panel on/off switch must be "On"
Voltage up/down	Yes	No	Front panel switch disabled
Brightness control	Yes	No	Front panel switch disabled

Power on can be accomplished remotely by X-ray on/off command. However, if cathode emitter is turned off, power is restored only through front panel on/off switch. Safety interlocks available on real panel.



Controller Unit Reference Drawing / Dimensions in mm

Software Control Option



- Runs under LabVIEW RT & MS-Windows
- Works in conjunction with RS232 control interface
- Complete control of voltage, power, and focus
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- Ideal for R&D applications

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Voltage up/down	Yes	No	Front panel switch disabled
Power adjust	Yes	No	Front panel Brightness dial disabled

Microfocus Source with the following Class-Leading Performance Characteristics:

- The Nova 600 Series is a fully integrated 90kV X-ray source. Its high voltage power supply and controller provide variable control of high voltage from 10-90kV and beam current from .33-2 milliamps with full control of "Brightness". The Smart Controller calculates spot size for a given power setting for maximum flux output.
- Voltage and current rating (90kV, 2.0mA) are subject to maximum power dissipation rating of 80W. The X-ray tube assembly is sealed, air-cooled, and rated for continuous operation.
- X-ray microfocus spot size is continuously adjustable from 14µm to 20µm. Power de-rating is provided at small spot sizes but source power is greater than or equal to 20W for a 20µm spot size.
- The anode target material is comprised of Tungsten as standard, however other targets are available (Cu, Mo). The target is inclined at a takeoff angle of 15 degrees with respect to the electron beam, and the exit window is aligned at an angle of 30 degrees with respect to the electron beam, so that a round microfocus X-ray spot is projected through the exit window.
- The stability of the microfocus X-ray spot shall be less than 5µm RMS over a period of 8 hours, as verified by test. A warm- up time of up to two hours is necessary in order to meet this specification.
- The system is supplied with a 254 micron Be exit window, allowing for close coupling (4mm) of object with the anode X-ray spot.
- LabVIEW RT Software Interface: The Smart Controller is outfitted with a software package that provides remote control of the various functions, such as kV, mA, Brightness, power etc. It includes an RS232 Communication package and an RT version of National Instruments LabVIEW. See Software control datasheet for complete description.

Product Ordering Table

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Power Density	Spot Size (µm)**
96013*	8240	W	20 - 90	2.0	80	2.5W/µm	20 Max.
96016*	8240	Mo	20 - 60	2.0	60	1.5W/µm	20 Max.

Note: Part number specific copies of outline drawings and product specification sheets are available.
*Includes a thermal switch which adds an additional level of protection to the cooling system safeguards.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

50kV Microfocus X-ray Source
Pinnacles 50kV

Developed for applications that require high resolution over a wide-angle field of view, the Pinnacles 50kV Microfocus X-ray source features high flux output.

Its compact design is fully radiation shielded and insulated with an integrated high voltage cable located on the side of the tube for easy connection.

The Shasta µF power supply has been optimized to power the Pinnacles 50kV Microfocus X-ray tube.

Benefits

- Wide operating range enables optimal image contrast
- Wide field of view
- Fully shielded package eliminates X-ray leakage and easily integrates into your system
- Integrated high voltage cable
- Paired power supply for plug and play operation

Applications

- Medical imaging
- Printed circuit board and electronic device inspection
- Nondestructive testing of plastic, metal and mechanical parts

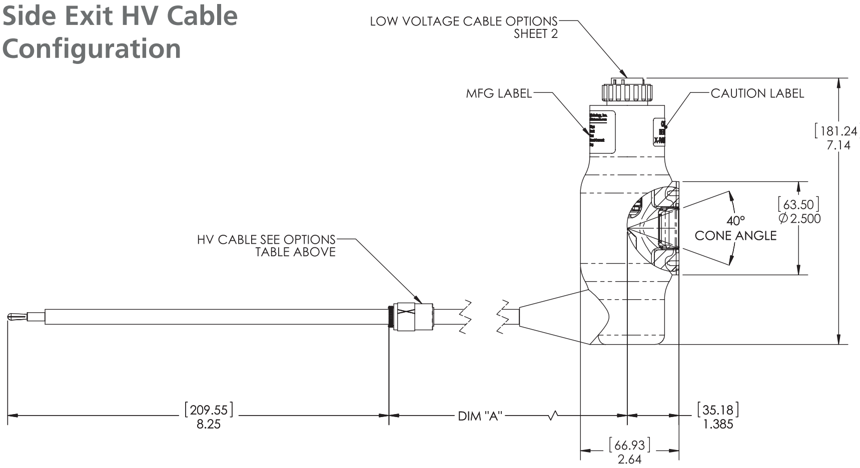
Specifications	
Operating voltage range:	10-50kV
Maximum power:	12W
Maximum beam current:	1.0mA
Focal spot size:	10µm (50kV, 12W) line pair resolution using JIMA RT RC-02[4]
Focus to Object Distance (FOD):	35.18mm (1.385")
Target material:	W
Target angle:	45°
Cone of illumination (unobstructed):	40.5° ± 0.5°
Window material and thickness:	Be, 254µm
Window diameter (unobstructed):	16.88mm (.66")
Maximum operating temperature:	50°C at potting surface
Ambient operating temperature:	0°C to 40°C; 0-95% RH up to 5,000ft
Cooling method:	Forced air @ 150cfm at 100mm (4.0") recommended
Shielding:	Fully shielded. X-ray leakage < 1.0µSv.hr-1 at 10cm
Weight:	≈1.37kg (3 lbs)
Storage conditions:	-10°C to 55°C; Barometric Pressure: 50-106kPa; Humidity: 10-90% (no condensation) Condensation on Be window will cause window corrosion, vacuum loss and X-ray tube failure

Shasta µF Power Supply 9700007

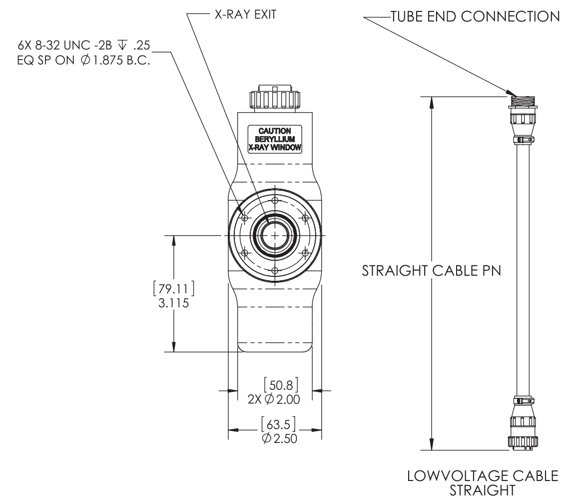
- Industry-standard 24V Input
- High voltage, cathode, and grid controls
- Intuitive analog control interface
- Focusing grid adjustment for optimum spot size
- Designed to meet UL, CE, TUV, and RoHS Directive 2011/65/EU

Pinnacles 50kV Microfocus X-ray Source

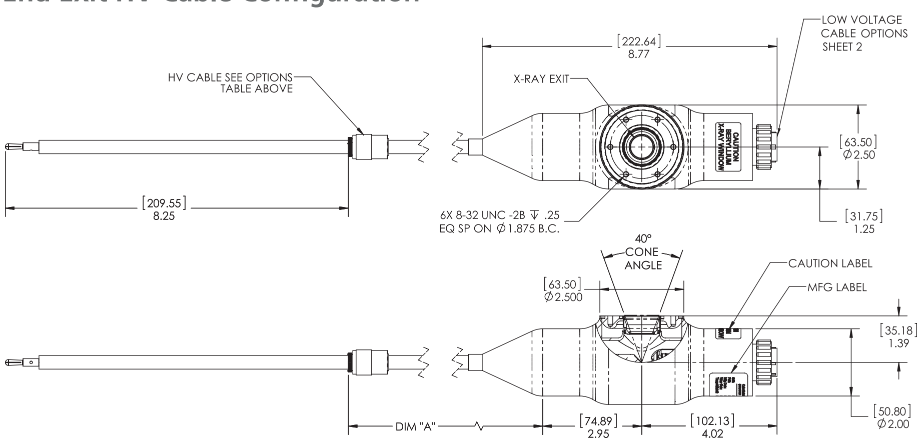
Side Exit HV Cable Configuration



LV Cable Options



End Exit HV Cable Configuration



LOW VOLTAGE STRAIGHT CABLE PN	LV CABLE LENGTH
9290021	32 in
9290022	39in (1m)
9290023	79in (2m)
9290024	118in (3m)

NOTES

1. This tube is fully radiation shielded to 50kV/12W except 40° X-Ray cone.
2. The HV cable is permanently potted to the X-ray tube.
3. Dimensions: Inches [mm]
4. Line pair resolution is defined as achieving a 50% ratio between the line pair intensity modulation and background intensity.

Product Ordering Table

Must be operated with Shasta µF power supply.

Part Number	Outline Drawing	Cable Orientation	HV Cable Length DIM "A"	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Spot Size (µm)**
9400001	8400001	Side Exit	39 in (1m)	W	10 - 50	1.0	12	10 Nom.
9400003	8400002	End Exit	39 in (1m)	W	10 - 50	1.0	12	10 Nom.
9400014	8400002	End Exit	79 in (2m)	W	10 - 50	1.0	12	10 Nom.
9400015	8400002	End Exit	118 in (3m)	W	10 - 50	1.0	12	10 Nom.
9400017	8400001	Side Exit	79 in (2m)	W	10 - 50	1.0	12	10 Nom.
9400018	8400001	Side Exit	118 in (3m)	W	10 - 50	1.0	12	10 Nom.

Note: Part number specific copies of outline drawings and product specification sheets are available.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

Water-Cooled Radiation Shielded X-ray Tube
Neptune 5200 Series

The Neptune 5200 Series is a water-cooled 50kV, 100W packaged X-ray tube designed for applications where high flux density and continuous operation are important.

Utilizing our high stability and high intensity X-ray tube technology, the Neptune 5200 Series is ideal for most industrial inspection and non-destructive testing applications that require high resolution, including plastic, metal and mechanical parts inspection. Flexible and reliable, this unit is also highly suited for use in high power XRF applications.

The 5200 Series has a brass package that utilizes 0.2 liter/min of water flow, which enables the unit to provide maximum X-ray shielding and heat dissipation. The design includes high voltage, filament and water flow connectors, making it ideal for plug and play operation.

The Neptune 5200 Series is available in wide range of targets and price points to meet your needs.

Benefits

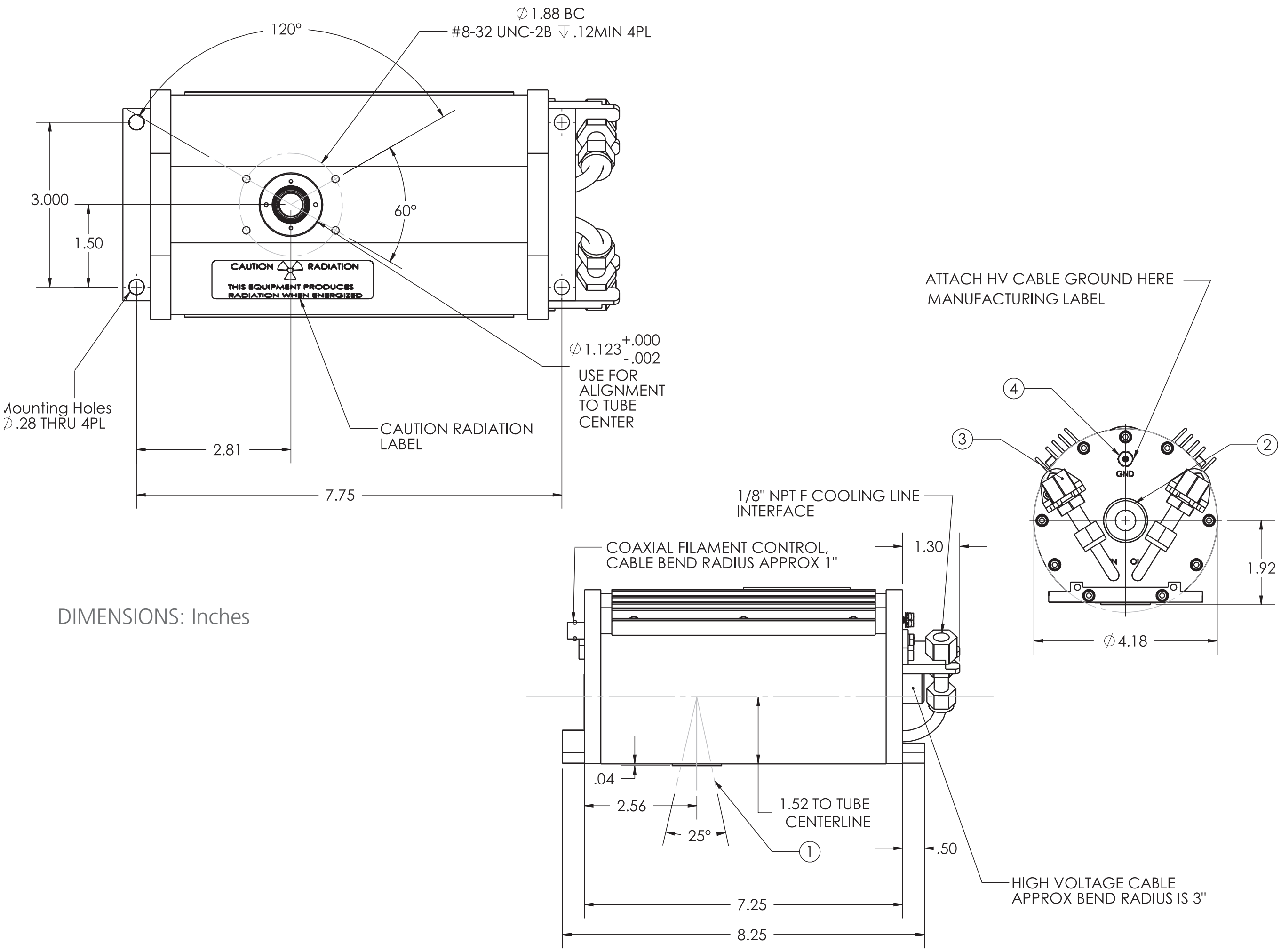
- Wide operating range enables optimal image contrast
- Stable X-ray output delivers high precision measurements
- Low attenuation beryllium window ensures high transmission of low energy X-rays
- Fully-shielded compact package eliminates X-ray leakage and easily integrates into your system

Applications

- Non-destructive testing of plastic, metal and mechanical parts
- Thickness gauging
- Analytical XRF

Specifications	
Operating Voltage Range:	10-50kV
Maximum Power:	100W
Maximum Beam Current:	2.0mA
Maximum Filament Current:	2.40A
Filament Voltage:	3.75V (Nominal)
Target Material:	See Product Ordering Table
Spot Size:	175µm (except 93221) where X+Y/2 and X < 210µm and Y < 210µm
Cone of Illumination:	25°
Spot to Window Spacing (FOD):	48.8 mm ± 1mm (1.92")
Window Material & Thickness:	Be @ 127µm
Flux & Current Stability:	≤ 0.2% over 4-hour period
Duty Cycle:	Continuous
Ambient Temperature Conditions:	Operating: 0 to 40°C Storage: -10°C to 50°C
Humidity:	0-95% RH up to 5,000ft
Cooling:	Water cooling > 0.2 l/min. Forced air cooling directed at the unit at 150 CFM may be required at high power operation. Longest lifetimes are achieved by keeping case temperature as low as possible in operation. Maximum temperature: 55°C. Contact sales@oxinst.com to discuss your specific cooling applications.
Shielding:	0.25mR/hr @ 2" (except HV connection through HV cable)
Dimensions:	210mm L X 106 mm W (8.25" L X 4.18" W)
Weight:	6.17 kg (13.6 lbs)

Neptune 5200 Series Water-Cooled Radiation Shielded X-ray Tube



DIMENSIONS: Inches

Product Ordering Table

See also matched Shasta power supply and/or matching cables part numbers on page 34.

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Max Filament Current (A)	Spot Size (µm)**
93211*	8250	Mo	10 - 50	2.0	100	2.4	175 Max.
93212*	8250	W	10 - 50	2.0	100	2.4	175 Max.
93221*	8250	Rh	10 - 50	2.0	100	2.4	375 Max.

Note: Part number specific copies of outline drawings and product specification sheets are available.
*Includes a thermal switch which adds an additional level of protection to the cooling system safeguards.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

Radiation Shielded X-ray Tube
Jupiter 5000 Series

The Jupiter 5000 Series is a 50kV, 50W packaged X-ray tube designed for applications where high flux density and continuous operation are important.

Utilizing our highly stable and high intensity X-ray tube technology, the Jupiter 5000 Series is ideal for medical imaging applications and most industrial inspection and non-destructive testing applications that require high resolution, including PCB assembly, battery, plastic, metal and mechanical parts inspection.

The 5000 Series features a stainless steel, lead-lined package that is filled with dielectric oil, which enables the unit to provide maximum X-ray shielding and heat dissipation. The design includes high voltage and filament connectors, making it ideal for plug and play operation.

The Jupiter 5000 Series is available in a wide range of spot sizes, targets and price points to meet your needs.

Benefits

- Wide operating range enables optimal image contrast
- Stable X-ray output delivers high precision measurements
- Low attenuation beryllium window ensures high transmission of low energy X-rays
- Fully-shielded compact package eliminates X-ray leakage and easily integrates into your system

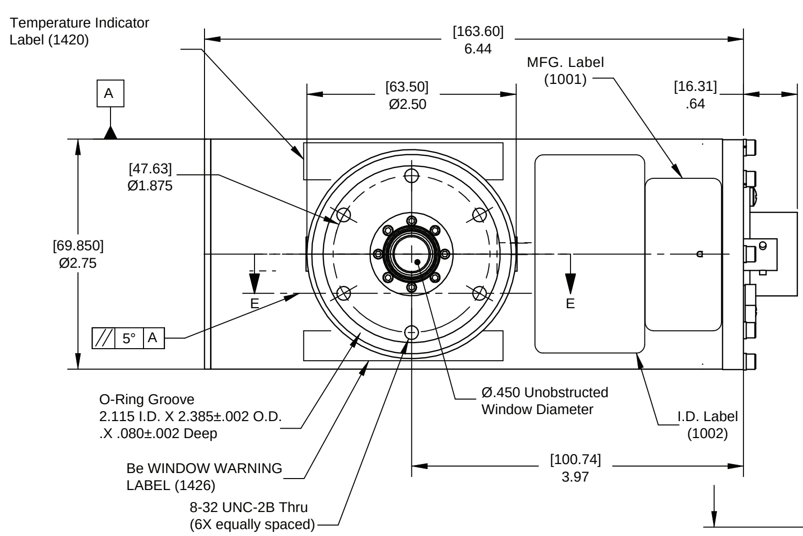
Applications

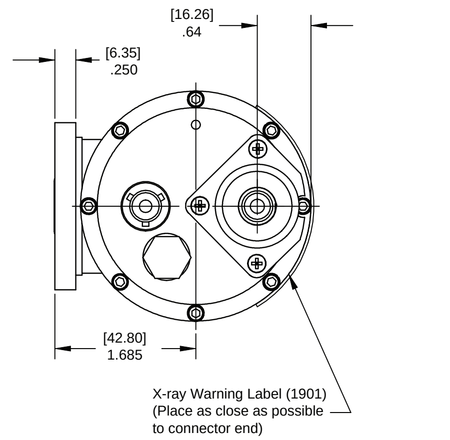
- Medical Imaging
- Printed circuit board and electronic device inspection
- Non-destructive testing of plastic, metal and mechanical parts
- Thickness gauging
- Analytical XRF

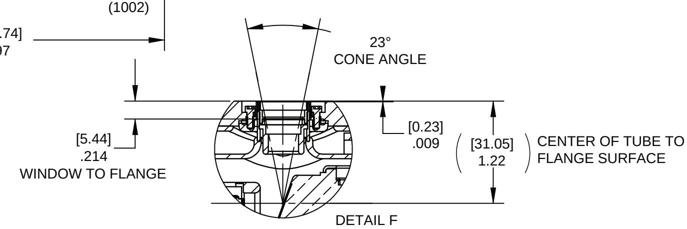
Specifications	
Operating Voltage Range:	50kV max. Lower kV cutoff varies by product. See product ordering table.
Maximum Power:	50W (except 93035)
Maximum Beam Current:	1.0mA (except 93512)
Focal spot size:	See product ordering table.
Maximum Filament Current:	See product ordering table.
Filament Voltage:	2.0V (nominal)
Focus to Object Distance (FOD):	See diagram next page
Window material and thickness:	Be @ 127µm
Cone of illumination (unobstructed):	23°
Window diameter (unobstructed):	11.43mm (.450")
Target material:	See product ordering table next page
Target angle:	12°
Stability:	0.2% 4 hours
Polarity:	Grounded cathode
Ambient operating temperature:	0°C to 40°C
Cooling:	150 CFM forced air recommended. Longest lifetimes are achieved by keeping case temperature as low as possible in operation. Maximum temperature: 55°C. Contact sales@oxinst.com to discuss your specific cooling applications.
Shielding:	0.25mR/hr @ 2" (except at HV connection)
Dimensions:	180mm L x Ø70mm (7.09" L x Ø2.76")
Weight:	2.26kg (5.0 lbs)
Storage Conditions:	-10°C to 55°C Barometric Pressure: 50-106kPa; Humidity: 10-90% (no condensation) Condensation on Be window will cause window corrosion, vacuum loss and X-ray tube failure

Use a Shasta Power Supply for Peak Performance

Jupiter 5000 Series Radiation Shielded X-ray Tube







NOTES
1. Use an AS568A-139 O-RING in mounting plate groove if required.
2. Dimensions are in inches. Dimensions [ ] are in mm.

Product Ordering Table

See also matched Shasta power supply and/or matching cables part numbers on page 34.

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Max Filament Current (A)	Spot Size (μm)**
93000*	8166	W	10 - 50	1.0	50	1.7	165 Max.
93001	8166	Mo	10 - 50	1.0	50	1.7	150 Typ.
93025	8166	Ag	4 - 50	1.0	50	1.3	1000 Typ.
93035	8166	Au	10 - 50	1.0	25	1.3	1000 Typ.
93046	8208	Mo	4 - 50	1.0	50	1.3	1000 Typ.
93048	8166	Cu	10 - 50	1.0	50	1.7	150 Typ.
93057	8166	Rh	10 - 50	1.0	50	1.7	180 Typ.
93059	8203	Rh	10 - 50	1.0	50	1.7	180 Typ.
93069*	8166	W	10 - 50	1.0	50	1.7	70 Max.
93070	8166	Cr	10 - 50	1.0	50	1.7	200 Typ.
93071	8203	W	10 - 50	1.0	50	1.7	150 Typ.
93072	8166	Ti	4 - 50	1.0	50	1.3	1000 Typ.
93073	8166	Pd	10 - 50	1.0	50	1.7	200 Max.
93078*	8203	Cu	10 - 50	1.0	50	1.7	175 Max.
93079*	8203	Mo	10 - 50	1.0	50	1.7	150 Typ.
93089*	8166	W	10 - 50	1.0	50	1.7	50 Max.
93095*	8166	Mo	20 - 50	1.0	50	1.7	55 Max.
93512*	8166	Fe	4 - 50	2.0	50	1.4	1000 Typ.

Note: Part number specific copies of outline drawings and product specification sheets are available.
*Includes a thermal switch which adds an additional level of protection to the cooling system safeguards. // **Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

Radiation Shielded X-ray Tube
Apogee 5500 Series

The Apogee 5500 Series is a 50kV, 50W packaged X-ray tube designed for applications where high flux density and continuous operation are important.

Utilizing our high stability, high intensity X-ray tube technology coupled with grid-controlled variable focus enables our Apogee design to produce very small focal spots; this makes the Apogee 5500 Series ideal for most industrial inspection and non-destructive testing applications that require high resolution, including PCB assembly, battery, plastic, metal and mechanical parts inspection. Flexible and reliable, this unit is also well suited for use with X-ray optics.

The Apogee 5500 Series is configured in a compact stainless steel, lead-lined package filled with dielectric oil, which enables the unit to provide maximum X-ray shielding and heat dissipation. The design includes high voltage and filament connectors, making it ideal for plug and play operation.

Benefits

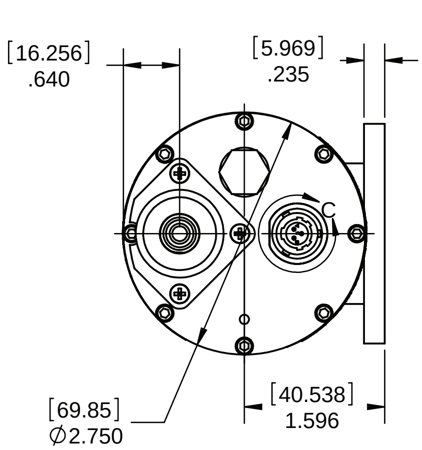
- Wide operating range enables optimal image contrast
- Stable X-ray output delivers high-precision measurements
- Low attenuation beryllium window ensures high transmission of low energy X-rays
- Fully shielded compact package eliminates X-ray leakage and easily integrates into your system

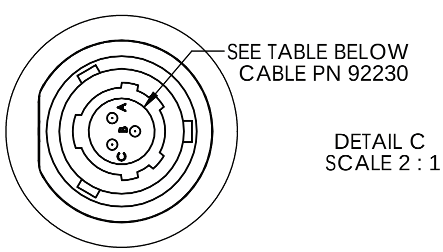
Applications

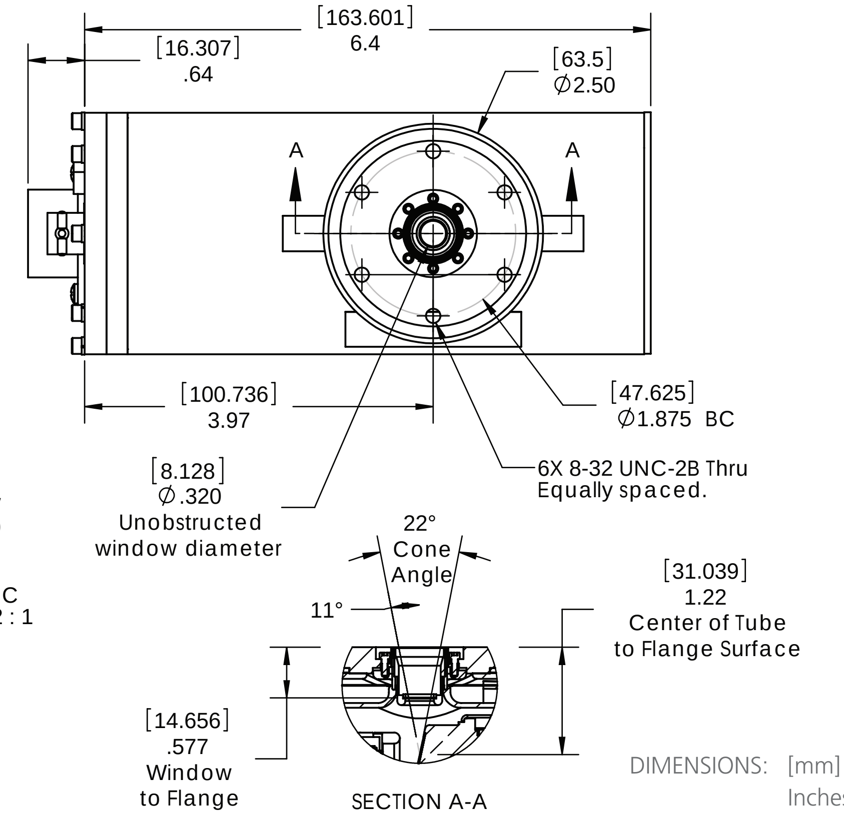
- Medical Imaging
- Inspection of printed circuit boards and electronic devices
- Non-destructive testing of plastic, metal and mechanical parts
- Thickness gauging
- Analytical XRF

Specifications	
Operating Voltage Range:	10-50kV (except 9300005)
Maximum Power:	50W (except 93504)
Maximum Beam Current:	1.0mA
Grid Voltage:	0-100V (Oxford Shasta Power Supply recommended)
Maximum Filament Current:	1.7A
Filament Voltage:	2.0V (Nominal)
Target Material:	See product ordering table on next page.
Focal Spot Size:	35µm *nominal per IEC60336, NEMA XR5-1992 (R1999)
Cone of Illumination:	22°
Spot to Window Spacing (FOD):	31.05mm ±1mm
Target Angle:	12°
Window Material and Thickness:	Be @ 127µm
Flux and Current Stability:	≤0.2% over 4-hour period
Ambient Temperature Conditions:	Operating: 0 to 40°C / Storage: -10°C to 50°C
Humidity:	0-95% RH up to 5,000 feet
Cooling:	150 CFM forced air recommended. Longest lifetimes are achieved by keeping case temperature as low as possible in operation. Maximum temperature: 55°C. Contact sales@oxinst.com to discuss your specific cooling applications.
Shielding:	0.25mR/hr @ 2" (except HV connection through HV cable)
Dimensions:	180mm L X Ø 70mm (7.09" L X Ø2.76")
Weight:	2.26kg (5.0 lbs)

Apogee 5500 Series Radiation Shielded X-ray Tube







Pin	Oxford Cable Wire	Description
A	Red	Filament
B	Black	Filament Return
C	Clear	Grid Bias
Backshell	Eyelet	Ground

Product Ordering Table

See also matched Shasta power supply and/or matching cables part numbers on page 34.

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Max Filament Current (A)	Spot Size (µm)**
93500*	8243	Cu	10 - 50	1.0	50	1.7	35 Nom.
93501*	8243	W	10 - 50	1.0	50	1.7	35 Nom.
93502*	8243	Mo	10 - 50	1.0	50	1.7	35 Nom.
93504*	8243	Rh	10 - 50	1.0	20	1.7	35 Nom.
93508*	8243	Cu	10 - 50	1.0	50	1.7	35 Nom.
93510*	8243	Cu	10 - 50	1.0	50	1.7	35 Nom.
93511*	8243	Mo	10 - 50	1.0	50	1.7	35 Nom.
9300005	8243	Mo	10 - 55	1.0	50	1.7	35 Nom.

Note: Part number specific copies of outline drawings and product specification sheets are available.
*Includes a thermal switch which adds an additional level of protection to the cooling system safeguards.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

30kV X-ray Tube
3000 Series

The Oxford Instruments 3000 Series X-ray tube has been developed for high flux stability and long life, making it ideal for continuous operation.

A low cost answer for high spectral purity radiation, the 3000 Series is encapsulated in silicone rubber and features a grounded cathode and low attenuation Beryllium window.

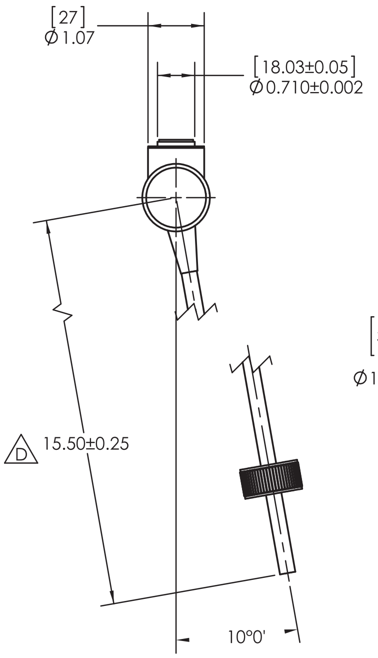
Features	Benefits
Continuous operation	High sensitivity and high precision measurement
Beryllium window	Higher flux of low-energy X-rays, especially from target L series lines
Compact, insulated light-weight package	Configuration allows flexible installation

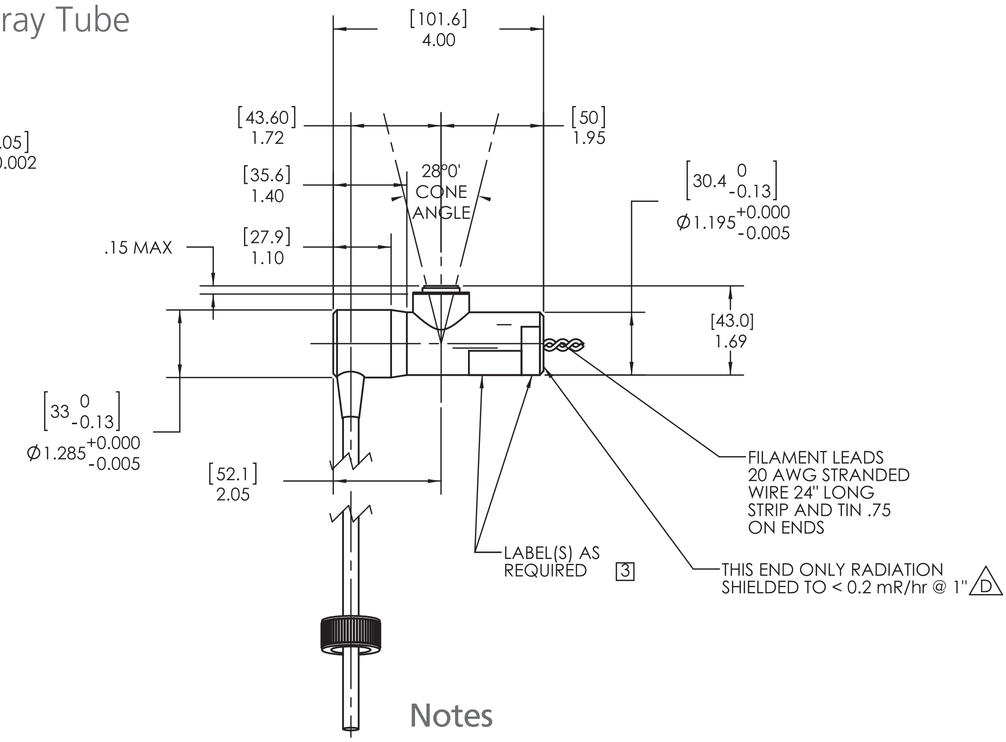
Applications

- Analytical (XRF)
- Particle Analysis
- Thickness Gauging
- Soft X-ray Radiography
- Spectroscopy
- Stress Analysis

Specifications	
Operating Voltage Range:	4-40kV depending on product.
Maximum power:	See product ordering table.
Maximum beam current:	See product ordering table.
Maximum filament current:	1.3 - 2.0A depending on product.
Filament voltage:	1.75V (nominal)
Focal spot size:	1.0mm (nominal)
Focus to Object Distance (FOD):	28.2mm (1.1")
Target material:	See product ordering table.
Window material and thickness:	Be @ 127µm
Unobstructed cone of illumination:	28°
Unobstructed window diameter:	10.4mm (.41")
Shielding:	Unshielded
Weight:	260g typical
Cooling method:	Forced air: 150CFM @ 100mm (4.0") and appropriate heat sink recommended for full power
Maximum operating temp:	50°C at potting surface
Ambient operating temp:	0°C to 40°C
Storage conditions:	-40°C to 70°C* *Note: Barometric Pressure: 50-106kPa Humidity: 10-90% (no condensation) Condensation on Be window will cause window corrosion, vacuum loss, and X-ray tube failure

3000 Series 30kV X-ray Tube





Notes

1. WARNING: THIS TUBE IS NOT RADIATION SHIELDED.
2. DIMENSIONS ARE IN INCHES. DIMENSIONS [] ARE IN MM.

Product Ordering Table

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Max Filament Current (A)	Spot Size (µm)**
90004	8145	W	4 - 30	0.5	15	1.3	1000 Typ.
90020	8052	Ti	4 - 30	0.5	15	1.3	1000 Typ.
90036	8053	W	4 - 30	0.3	9	1.3	1000 Typ.
90042	8195	Mo	4 - 30	0.5	15	1.3	1000 Typ.
90053	8204	Mo	4 - 15	1.0	15	1.3	1000 Typ.
90057	8156	Au	4 - 30	0.5	15	1.3	1000 Typ.
90116	8053	W	4 - 30	0.2	6	1.3	1000 Typ.
90118	8052	Fe	4 - 10	1.5	15	1.3	1000 Typ.
90145	8054	Pd	4 - 40	0.3	9	2.0	1000 Typ.
90146	8057	W	5 - 13.6	2.0	27.2	2.0	1000 Typ.
90151	8063	Rh	4 - 30	0.3	9	2.0	1000 Typ.
90152	8063	Ag	4 - 30	0.3	9	2.0	1000 Typ.
90153	8063	Mo	4 - 30	0.3	9	2.0	1000 Typ.

Note: Part number specific copies of outline drawings and product specification sheets are available.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

Glass X-ray Tube
1000 Series

Oxford Instruments glass X-ray tubes are recognized for their performance and long life.

High flux and spot size stability make our X-ray tubes an ideal solution for demanding applications, such as those requiring continuous operation. The 90507 and other 1000 series tubes are uniquely designed with a very small isostatically focused spot for high resolution applications, such as mini C-Arm fluoroscopy. The robust electron gun assembly has been constructed for optimal use in integrated X-ray sources, where heat dissipation is an issue. Long tube life is achieved by ultra-high vacuum maintained with the Oxford Instruments unique Pin Flash getter. This tube operates in bi-polar mode.

Benefits

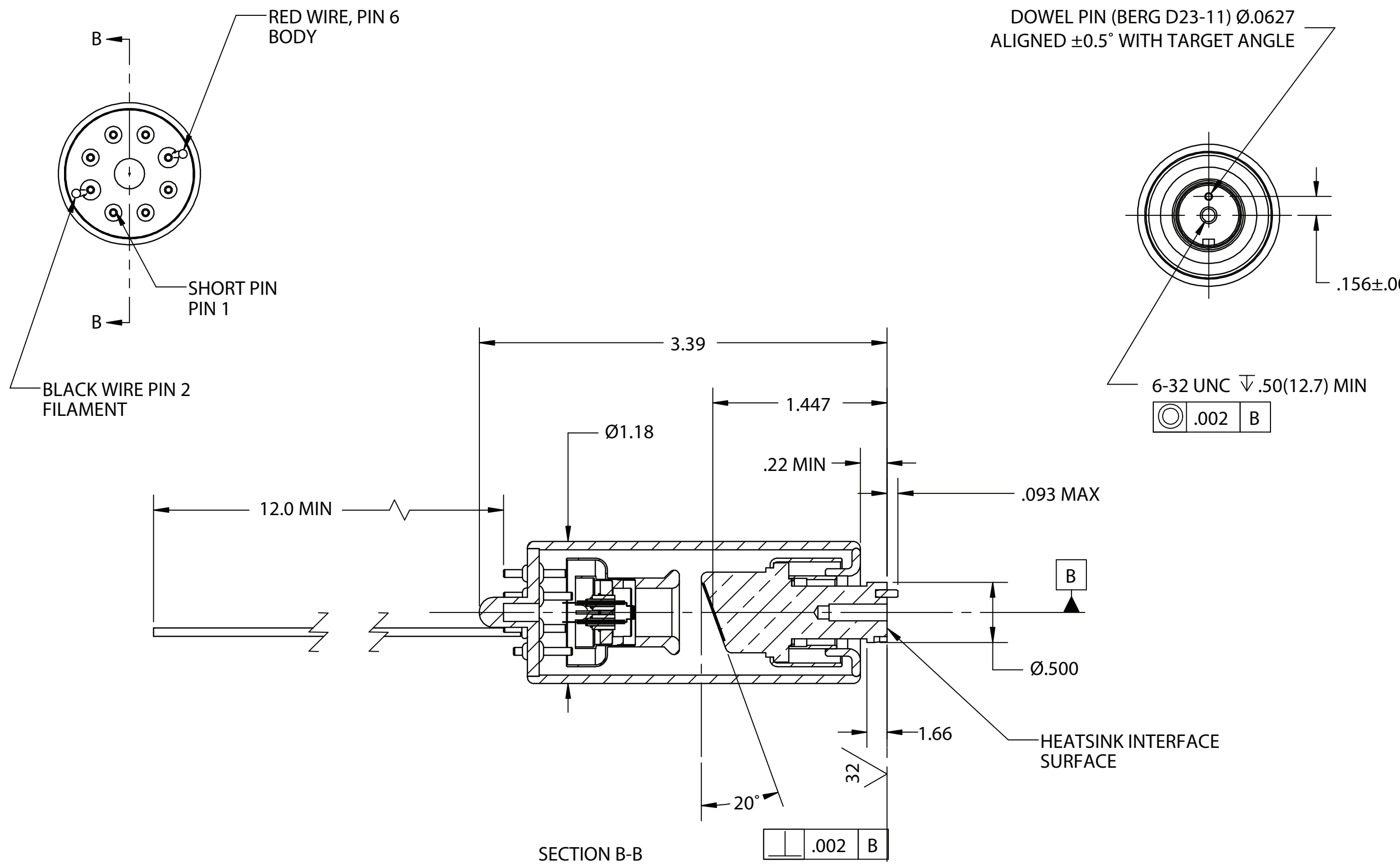
- Exceptional image quality
- Stable X-ray output delivers high precision measurements
- Small, stable spot delivers distortion-free measurements
- RoHS compliant design

Applications

- CT imaging for life sciences and industrial inspection
- Densitometry
- Thickness gauging
- Phase contrast imaging
- Medical imaging

Specifications	
Operating voltage range:	90507, 90501: 40-80kV (bi-polar operation: -40kV cathode, +40kV anode) 90502: 40 - 65kV
Maximum Power:	See product ordering table.
Maximum beam current:	See product ordering table.
Maximum filament current:	1.7A
Filament voltage:	2.0V (nominal)
Focus to Object Distance (FOD):	14.2mm (0.56") (nominal)
Window material and thickness:	Glass—1.40mm ± 0.15
Target material:	W
Target angle:	20°
Maximum oil temperature:	80°C
Cooling method:	Oil
Weight:	114g (0.25 lbs)
Storage conditions:	-10°C to 55°C Barometric Pressure: 50-106kPa; Humidity: 10-90% (no condensation)

1000 Series - Glass X-ray Tube



Notes

1. Dimensions are in inches.
2. This X-ray tube is designed to operate in an oil filled high voltage enclosure. Do not allow the oil to exceed 80˚C. Proper operation of the X-ray tube requires cooling oil to circulate freely around the X-ray tube envelope.
3. This X-ray tube produces X-rays in all directions. As such, it must only be operated in a radiation-shielded enclosure.
4. Tubes to be shipped with two teflon-coated copper wire leads, 1 8 AWG X 12.0 MIN, soldered to pins #6 and #2.

Product Ordering Table

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Max Filament Current (A)	Spot Size (μm)**
90501	8218	W	40 - 80	0.7	56	1.7	100 Max.
90502	8218	W	40 - 65	0.5	32.5	1.7	90 Max.
90507	8218	W	40 - 80	0.5	40	1.7	33 Nom.

Note: Part number specific copies of outline drawings and product specification sheets are available.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

Glass X-ray Tube
1500 Series

The 1550 Series X-ray tube is a 50kV, 50W X-ray tube designed for applications where high flux density and continuous operation are important.

Utilizing our highly stable, high intensity X-ray tube technology coupled with grid-controlled variable focus enables our 1550 Series X-ray tube to produce very small focal spots; this makes the 1550 Series ideal for most industrial inspection and non-destructive testing applications that require high resolution, including PCB assembly, battery, plastic, metal and mechanical parts inspection. Flexible and reliable, this unit is also highly suited for use with X-ray optics.

The 1550 Series X-ray tube can also be supplied in a stainless steel, lead-lined package that is filled with dielectric oil that enables the unit to provide maximum X-ray shielding and heat dissipation; this configuration is our popular Apogee 5500 Series packaged tube, which includes high voltage and filament connectors making it ideal for plug and play operation.

Benefits

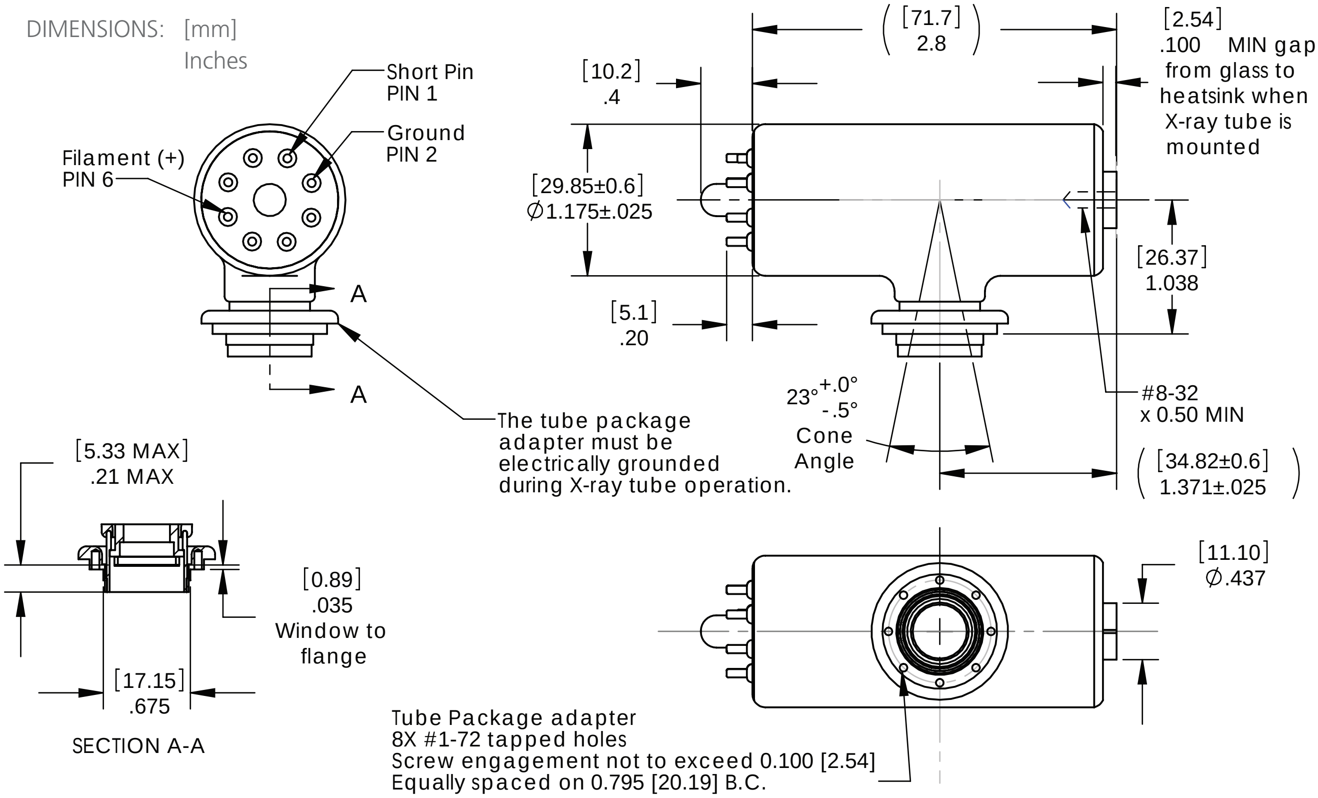
- Wide operating range enables optimal image contrast
- Stable X-ray output delivers high precision measurements
- Low attenuation beryllium window ensures high transmission of low energy X-rays

Applications

- Medical imaging
- Inspection of printed circuit boards and electronic devices
- Nondestructive testing of plastic, metal and mechanical parts
- Thickness gauging
- Analytical XRF

Specifications	
Operating Voltage Range:	10-50kV
Maximum Power:	50W
Maximum Beam Current:	1.0mA
Grid Voltage:	0-100V
Maximum Filament Current:	1.70A
Filament Voltage:	2.0V (Nominal)
Target Material:	Cu, W, Mo, Rh
Spot Size:	<50µm (X and Y)
Cone of Illumination:	22°
Spot to Window Spacing (FOD):	30.8 mm ± 1mm (1.213")
Window Material and Thickness:	Be @ 127µm
Flux & Current Stability:	≤ 0.2% over 4-hour period
Duty Cycle:	Continuous
Ambient Temperature Conditions:	Operating: 0°C to 40°C Storage: -10°C to 50°C
Humidity:	0-95% RH up to 5,000ft
Method of Cooling:	Must not exceed 80°C oil temperature. Customer provides enclosure and cooling.
X-ray Shielding:	Customer must provide enclosure with adequate shielding. Tube emits X-rays in all directions.
Dimensions:	81mm L X 47mm W (3.2" L X 1.8" W)
Weight:	119g

1500 Series Glass X-ray Tube



Product Ordering Table

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Max Filament Current (A)	Spot Size (µm)**
90011	8194	Rh	10 - 50	1.0	50	1.7	150 Max.
90030	8260	Mo	10 - 50	1.0	50	1.7	150 Max.
90034	8188	Cr	10 - 50	1.0	50	1.7	200 Typ.
90046	8162	W	4 - 50	5.0	250	2.4	500 Typ.
90068	8188	Mo	10 - 50	1.0	50	1.7	150 Typ.
90069	8188	Cu	10 - 50	1.0	50	1.7	150 Typ.
90077	8188	Rh	10 - 50	1.0	50	1.7	150 Typ.
90083	8188	W	10 - 50	1.0	50	1.7	150 Typ.
90098	8162	Fe	4 - 50	5.0	200	2.4	500 Typ.
90099	8189	W	10 - 50	1.0	50	1.7	70 Max.

Note: Part number specific copies of outline drawings and product specification sheets are available.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

The 1501 Series X-ray tube is a 50kV, 50-75W X-ray tube designed for applications where high current, high flux density and continuous operation are important.

Utilizing our highly stable and high intensity X-ray tube technology, the 1501 Series X-ray tube is ideal for medical imaging, XRF applications and most industrial inspection and non-destructive testing applications that require high resolution, including PCB assembly, battery, plastic, metal and mechanical parts inspection.

The 1501 Series X-ray tube can also be supplied in a stainless steel, lead-lined package that is filled with dielectric oil that enables the unit to provide maximum X-ray shielding and heat dissipation.

The 1501 Series was designed in response to the need for higher current coupled with lower operating potentials.

The 1501 Series X-ray tube is available in a wide range of spot sizes, targets and price points to meet your needs.

Benefits

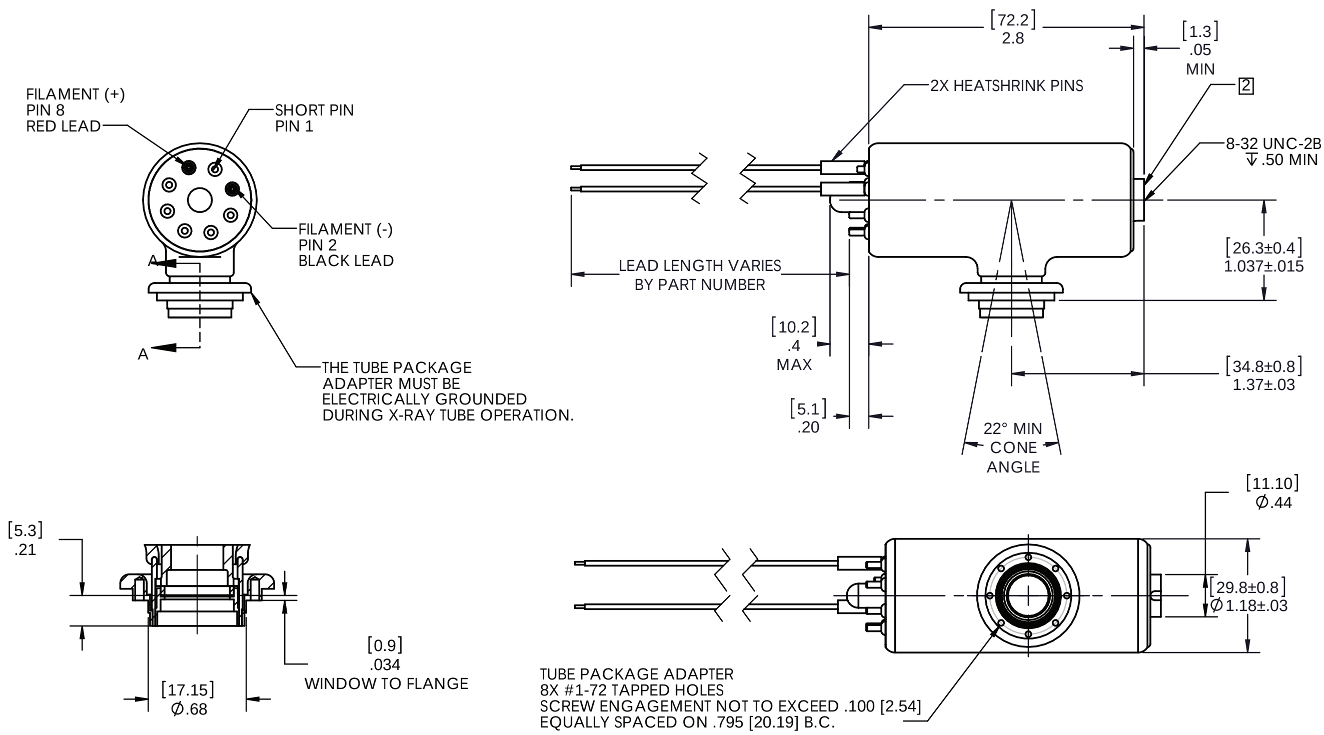
- Wide operating range enables optimal image contrast
- Stable X-ray output delivers high precision measurements
- Low attenuation beryllium window ensures high transmission of low energy X-rays

Applications

- Medical imaging
- Inspection of printed circuit boards and electronic devices
- Nondestructive testing of plastic, metal and mechanical parts
- Thickness gauging
- Analytical XRF

Specifications	
Operating Voltage Range:	4-50kV
Maximum Power:	50-75W
Maximum Beam Current:	2.5mA
Maximum Filament Current:	2.4A
Filament Voltage:	3.75V (Nominal)
Target Material:	Rh, Cr
Spot Size:	125µm (nominal per IEC60336,NEMA XR5-1999)
Cone of Illumination:	22° Minimum
Spot to Window Spacing (FOD):	30.8 mm ± 1mm (1.2")
Window Material and Thickness:	Be @ 127µm
Flux & Current Stability:	≤ 0.2% over 4-hour period
Duty Cycle:	Continuous
Ambient Temperature Conditions:	Operating: 0°C to 40°C Storage: -10°C to 50°C
Humidity:	0-95% RH up to 5,000ft
Method of Cooling:	Must not exceed 80°C oil temperature. Customer provides enclosure and cooling.
X-ray Shielding:	Customer must provide enclosure with adequate shielding. Tube emits X-rays in all directions.
Dimensions:	81mm L X 47mm W (3.2" L X 1.8" W)
Weight:	119g

1501 Series Glass X-ray Tube



DIMENSIONS: [mm]
Inches

Product Ordering Table

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Max Filament Current (A)	Spot Size (µm)**
90015	8194	Rh	4 - 50	2.5	50	2.4	200 Max.
90122	8257	Cr	4 - 50	2.0	75	2.4	175 Max.

Note: Part number specific copies of outline drawings and product specification sheets are available.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

Glass X-ray Tube
1550 Series

The 1550 Series X-ray tube is a 50kV, 50W X-ray tube designed for applications where high flux density and continuous operation are important.

Utilizing our highly stable, high intensity X-ray tube technology coupled with grid-controlled variable focus enables our 1550 Series X-ray tube to produce very small focal spots; this makes the 1550 Series ideal for most industrial inspection and non-destructive testing applications that require high resolution, including PCB assembly, battery, plastic, metal and mechanical parts inspection. Flexible and reliable, this unit is also highly suited for use with X-ray optics.

The 1550 Series X-ray tube can also be supplied in a stainless steel, lead-lined package that is filled with dielectric oil that enables the unit to provide maximum X-ray shielding and heat dissipation; this configuration is our popular Apogee 5500 Series packaged tube, which includes high voltage and filament connectors making it ideal for plug and play operation.

Benefits

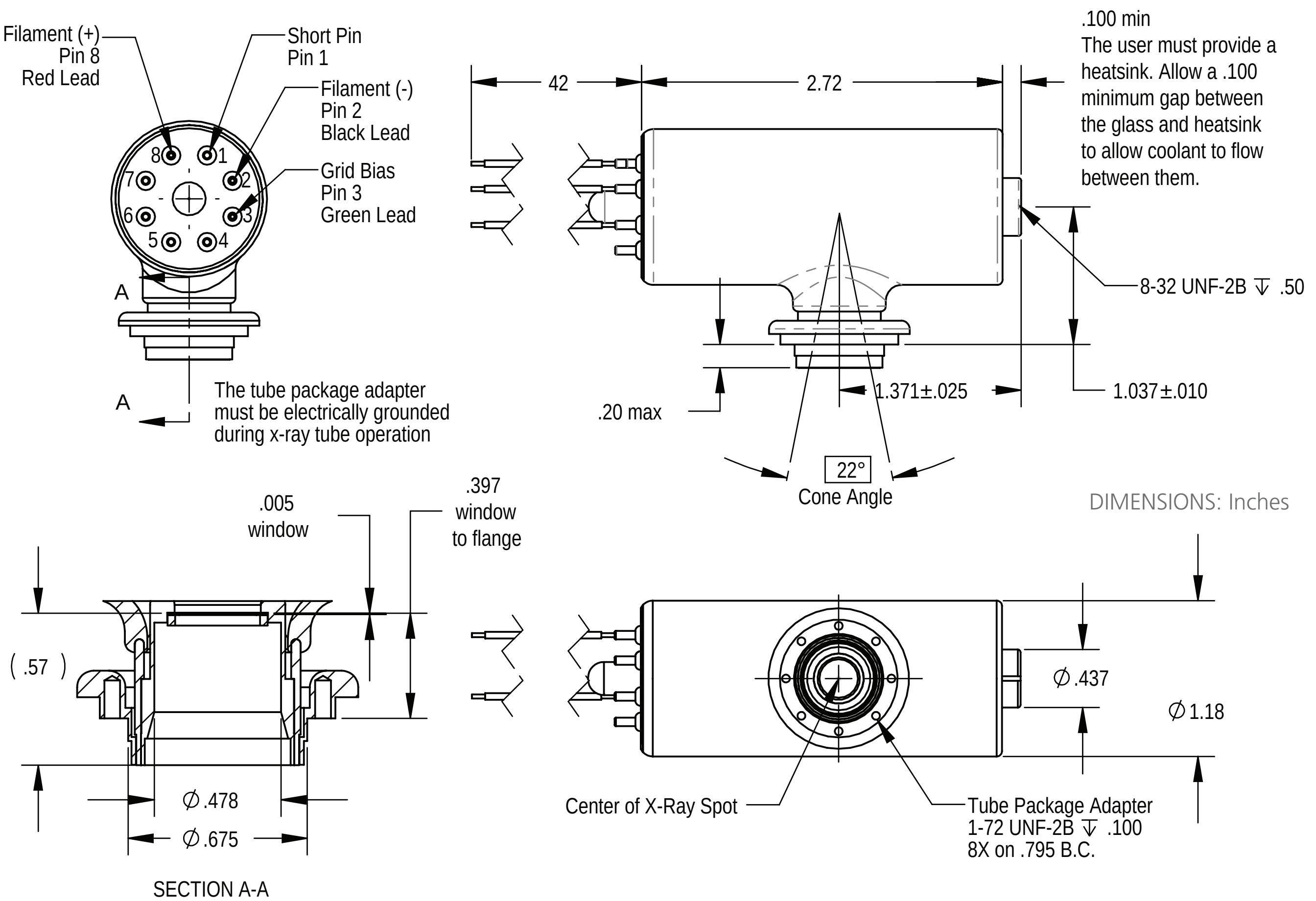
- Wide operating range enables optimal image contrast
- Stable X-ray output delivers high precision measurements
- Low attenuation beryllium window ensures high transmission of low energy X-rays

Applications

- Medical imaging
- Inspection of printed circuit boards and electronic devices
- Nondestructive testing of plastic, metal and mechanical parts
- Thickness gauging
- Analytical XRF

Specifications	
Operating Voltage Range:	10-50kV
Maximum Power:	50W
Maximum Beam Current:	1.0mA
Grid Voltage:	0-100V
Maximum Filament Current:	1.70A
Filament Voltage:	2.0V (Nominal)
Target Material:	Cu, W, Mo, Rh
Spot Size:	<50μm (X and Y)
Cone of Illumination:	22°
Spot to Window Spacing (FOD):	30.8 mm ± 1mm (1.213")
Window Material and Thickness:	Be @ 127μm
Flux & Current Stability:	≤ 0.2% over 4-hour period
Duty Cycle:	Continuous
Ambient Temperature Conditions:	Operating: 0°C to 40°C Storage: -10°C to 50°C
Humidity:	0-95% RH up to 5,000ft
Method of Cooling:	Must not exceed 80°C oil temperature. Customer provides enclosure and cooling.
X-ray Shielding:	Customer must provide enclosure with adequate shielding. Tube emits X-rays in all directions.
Dimensions:	81mm L X 47mm W (3.2" L X 1.8" W)
Weight:	119g

1550 Series Glass X-ray Tube



Product Ordering Table

Part Number	Outline Drawing	Target	Operating Range (kV)	Max Anode Current (mA)	Max Anode Power (W)	Max Filament Current (A)	Spot Size (µm)**
90200	8242	Cu	10 - 50	1.0	50	1.7	50 Max.
90201	8242	W	10 - 50	1.0	50	1.7	50 Max.
90202	8242	Mo	10 - 50	1.0	50	1.7	50 Max.
90204	8242	Rh	10 - 50	1.0	50	1.7	50 Max.

Note: Part number specific copies of outline drawings and product specification sheets are available.
**Max. = Maximum, Typ. = Typical, Nom. = Nominal (per IEC60336,NEMA XR5-1999)

X-ray Tube Power Supply
Shasta Series

Oxford Instruments Shasta series power supply features a robust design that has been optimized to power grounded filament X-ray tubes from Oxford Instruments, yet its versatility enables it to power virtually any grounded filament X-ray tube.

Utilizing closed loop emission control circuitry that delivers low ripple, Shasta provides highly regulated beam current and high stability resulting in superior performance. Local and remote analog control enables convenient operation in setting voltage & emission current.

- Models with grid focus control are designed to provide optimal performance with our Apogee tubes

Benefits

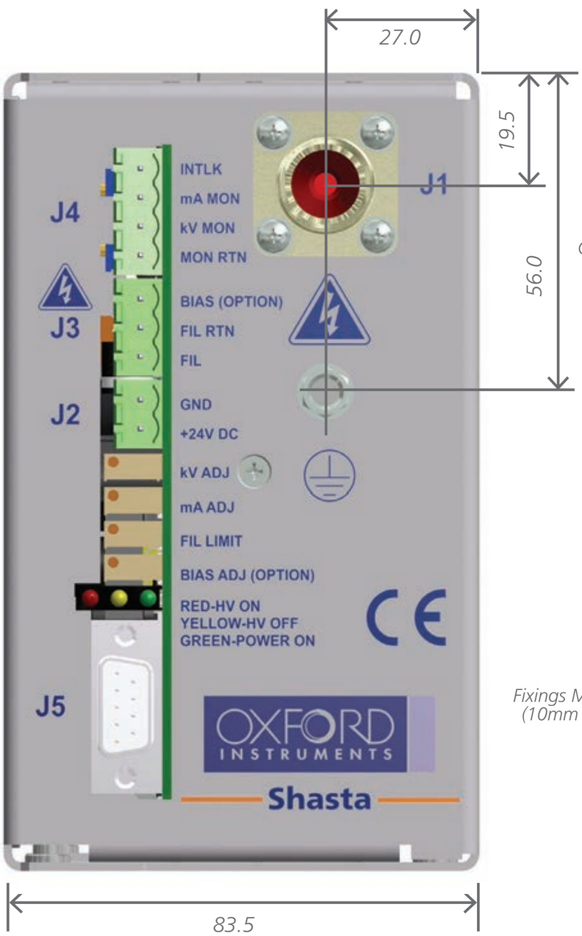
- Compact Design
- Adjustable Emission Current
- Voltage & Current Programming
- Safety Interlock
- Bias Voltage Option Available
- CE & TUV Certified

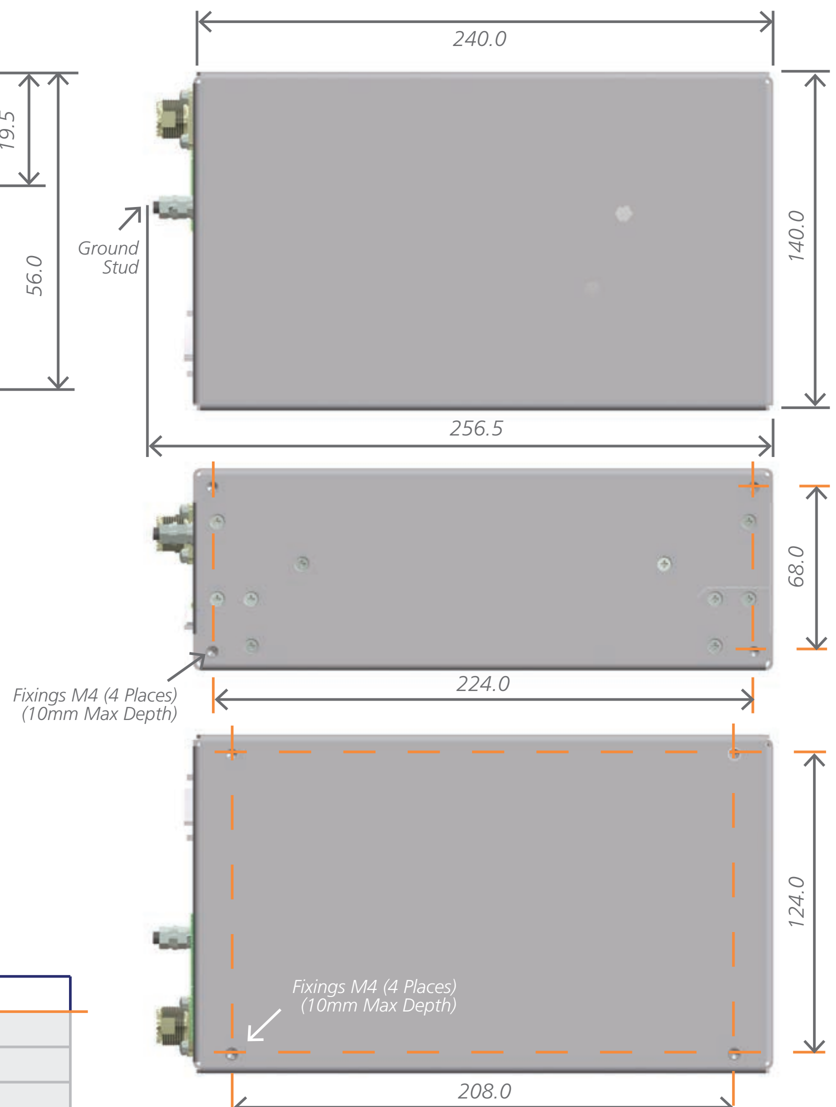
Applications

- XRF, XRD, Medical Imaging, Industrial Inspection & NDT

Specifications	
Operating voltage range:	0-50kV
Maximum Power:	50W
Maximum beam current:	1.0mA
DC Filament Supply:	Current: 0.3 to 3.5A Voltage: 0 to 5.0 VDC
Voltage Regulation:	Load: < 0.01 % for 50% of max load variation Line: < 0.01% for 10% change in input voltage
Current Regulation:	Load: < ± 2µA (Beam Current) Line: < ± 2µA (Beam Current)
Ripple:	< 100V peak to peak
Stability:	± 0.1% over an 8-hour period after 30-minutes warm-up
Input Voltage & Power:	24VDC, ± 10%; 100 Watts
Voltage Control:	Local: via multi-turn potentiometer (kV ADJ) Remote: via external voltage source 0 to 10V (accuracy ± 1%)
Interlock:	Short to GND through a 12V lamp: HV/ON, OPEN:HV/OFF
Protection:	Over voltage, over current protection. Arc, short circuit.
Temperature Conditions:	Operational: 0 to 45˚C Storage: -20 to + 85˚C
Temperature Coefficient:	0.01 % per ˚C, voltage and current
Dimensions:	5.5" H x 3.3" W x 9.45" D (140mm x 83.5mm x 240mm)
Weight:	3.6 kg (7.9 lbs.)
Regulatory & Safety:	Meets the requirements of IEC61010-1:2010, EN61010-1: 2010, UL61010-1: 2012, CA N/CSA C22.2 No. 61010- 1:2012 and 2006/95/EC Low Voltage Directive. Product carries the TUV SUD c/us mark.

Shasta 50kV Power Supplies





Pin Assignments

J1	HV	OUTPUT	**J5**	1	+10VDC
J2	1	+24VDC		2	N.C.
	2	GND		3	kV Prog Input
J3	1	FILAMENT		4	RMT/LCL kV Prog Selector
	2	FILAMENT RETURN (GND)		5	N.C.
	3	BIAS		6	mA Prog Input
J4	1	MONITOR RETURN (GND)		7	RMT/LCL mA Prog Selector
	2	kV MONITOR		8	N.C.
	3	mA MONITOR		9	GND
	4	INTLK			

Product Ordering Table

Part Number	Voltage	Power	Grid Control
9700001	50kV	50W	N/A
9700002	50kV	50W	0 to -300V

Power Supply and Cable Matching Guide

Cable Part Number	Description	Length	Power Supply Part Number
Cables for Stainless Steel Packaged 5000 Series X-ray Tubes All 5000 Series tubes unless noted below			
9200008	Shasta High Voltage Cable	1m	Shasta 9700001
9200009	Shasta High Voltage Cable	2m	Shasta 9700001
9200010	Shasta High Voltage Cable	3m	Shasta 9700001
9200014	Shasta Low Voltage Cable	1m	Shasta 9700001
9200015	Shasta Low Voltage Cable	2m	Shasta 9700001
9200016	Shasta Low Voltage Cable	3m	Shasta 9700001
Cables for Apogee 5500 Series X-ray Tubes All Apogee 5500 Series tubes			
9200008	Shasta High Voltage Cable	1m	Shasta 9700002
9200009	Shasta High Voltage Cable	2m	Shasta 9700002
9200010	Shasta High Voltage Cable	3m	Shasta 9700002
9200011	Shasta Low Voltage Cable	1m	Shasta 9700002
9200012	Shasta Low Voltage Cable	2m	Shasta 9700002
9200013	Shasta Low Voltage Cable	3m	Shasta 9700002
Cables for Stainless Steel Packaged 5000 Series X-ray Tubes Tube part number 93512			
92103	High Voltage Cable	1m	97013
92115	High Voltage Cable	2m	97013
92104	High Voltage Cable	3m	97013
9200014	Shasta Low Voltage Cable	1m	97013
9200015	Shasta Low Voltage Cable	2m	97013
9200016	Shasta Low Voltage Cable	3m	97013
Cables for Neptune 5200 Series X-ray Tubes All Neptune 5200 Series tubes			
92103	LGH High Voltage Cable A1	1m	97013
92104	LGH High Voltage Cable A1	3m	97013
9200014	Shasta Low Voltage Cable	1m	97013
9200015	Shasta Low Voltage Cable	2m	97013
9200016	Shasta Low Voltage Cable	3m	97013

Application

For X-ray tubes that have been in storage or inactive for a period of three months or more.

Description

After a period of not being used, typically three months or more, residual gasses are released from the internal surfaces of the X-ray tube and accumulate into the tube vacuum. If the maximum rated voltage (in kV) is applied after a period of storage without performing a conditioning procedure, permanent damage to the X-ray tube may occur due to the destructive nature of high voltage arcs in the ionized gas. The following conditioning procedure is appropriate for both "new tubes", as there may have been a period of storage, as well as tubes that have been stored for three months or more.

Procedure

To prevent this damage the following special conditioning process should be followed:

- Adjust the kV to the lowest kV that your specific tube is rated for. Set the beam current to 0 mA and if any instability is noted on the mA meter allow it to stabilize to display 0mA. Operate at this condition for a minimum of 15 minutes.
- While maintaining the kV set in the previous step, adjust the beam current to 20% of rated maximum. Maintain this setting for 5 minutes or longer, until no instability is noted on the mA meter.
- Increase high voltage in 5kV steps at 5 minute intervals until 50% of maximum rated kV is reached. Hold 5 minutes at these conditions.
- Increase beam current to maximum rated mA.
- Continue to increase high voltage as before, in 5kV steps every 5 minutes until maximum rated kV or your maximum operating kV is reached. Allow at least 5 minutes at full power to insure that the tube is operating correctly in your system.

Note

If instability (especially loud popping) is observed, lower the kV setting to the previous step. Allow mA to stabilize for at least 5 minutes before increasing settings again.

Typical X-ray Spectra by Anode Material

Application Note
3904006

Summary

Oxford Instruments offers X-ray tubes with different anode materials designed to suit a wide variety of applications. The anode material defines an X-ray tube's characteristic spectrum. This application note shows the typical spectra of several different anode materials. The spectra provided are for reference only; your spectrum may differ from these according to the particular model of detector you are using, the geometry of your measurement setup, and the voltage and current on your X-ray tube.

X-ray Spectrum Theory

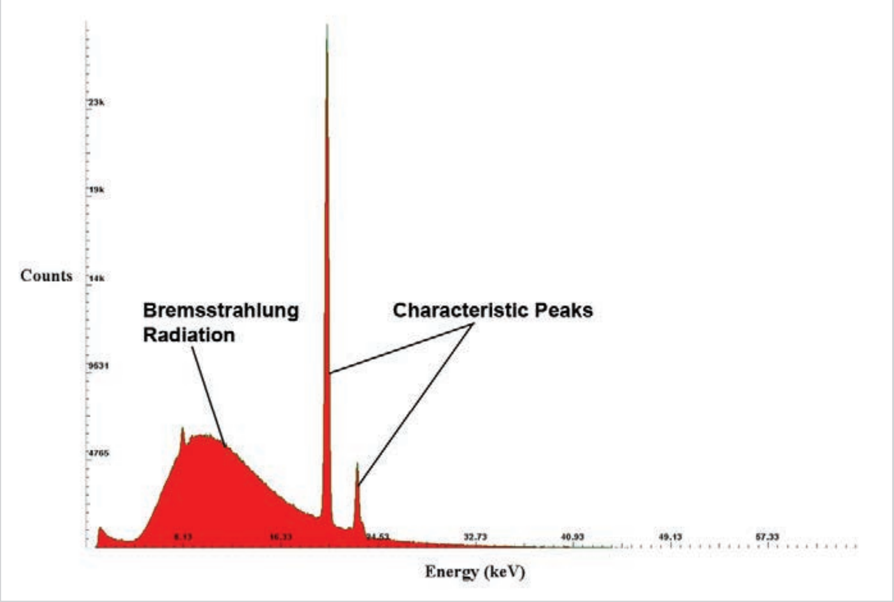
X-ray production involves bombarding a metal target in an X-ray tube with high-speed electrons that have been accelerated by tens to hundreds of kilovolts of electric potential. The electrons can eject other electrons from the inner shells of the atoms of the metal anode. Those vacancies will be filled when electrons drop down from higher energy levels and emit X-rays. These are known as characteristic X-rays and they have sharply defined energies associated with the difference between the atomic energy levels of the anode atoms. The Bohr atomic model predicts the energies of the characteristic X-rays. An X-ray spectrum is partially defined by the "peaks" or "lines" that result from bombarding different anode materials with highly accelerated electrons.

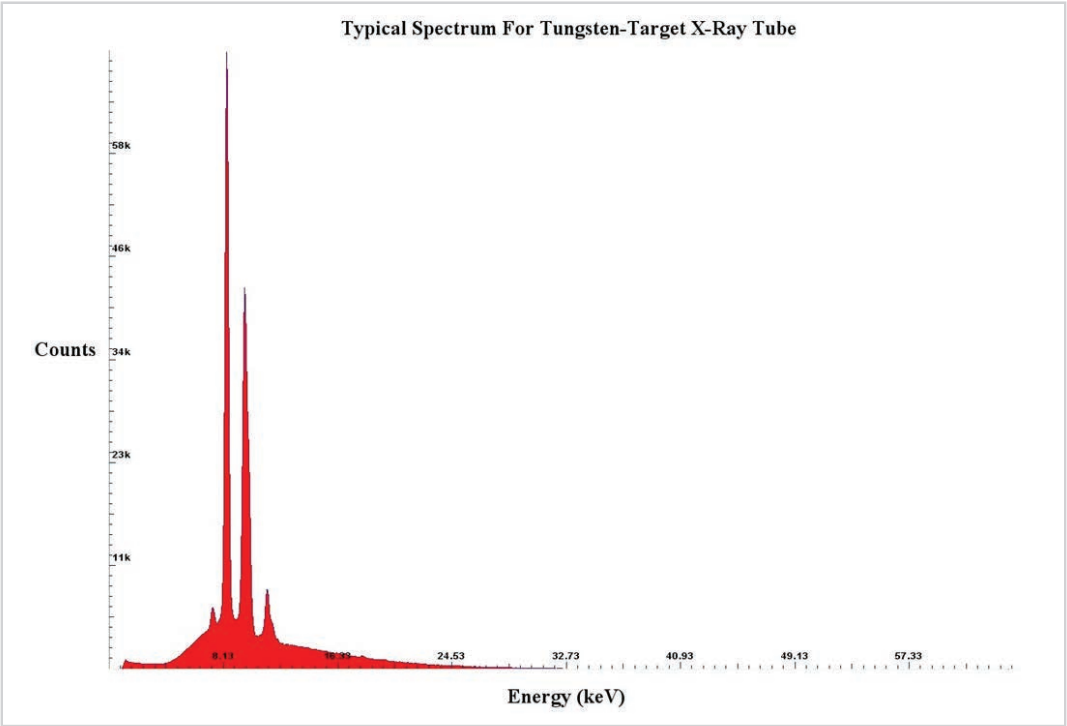
In addition to the characteristic peaks, an X-ray spectrum also has a background radiation pattern called the "Bremsstrahlung." Bremsstrahlung means "braking radiation" and describes the radiation that is emitted when electrons are decelerated through a metal anode. The deceleration leaves behind excess energy, some of which is emitted in the form of radiation. Decelerated charges give off electromagnetic radiation, and when the energy of the electrons is high enough, that radiation is in the X-ray region of the electromagnetic spectrum.

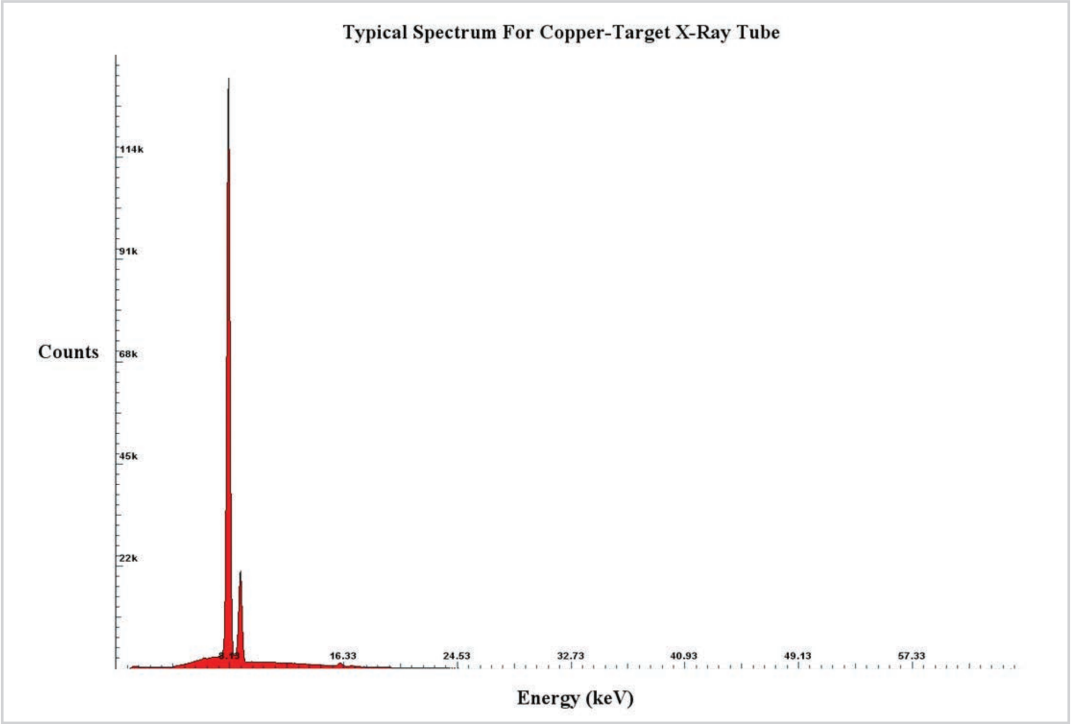
Thus, the X-ray spectrum that is emitted from your X-ray tube is a combination of the characteristic peaks of the specific anode material and the Bremsstrahlung radiation that is present in all X-ray tubes.

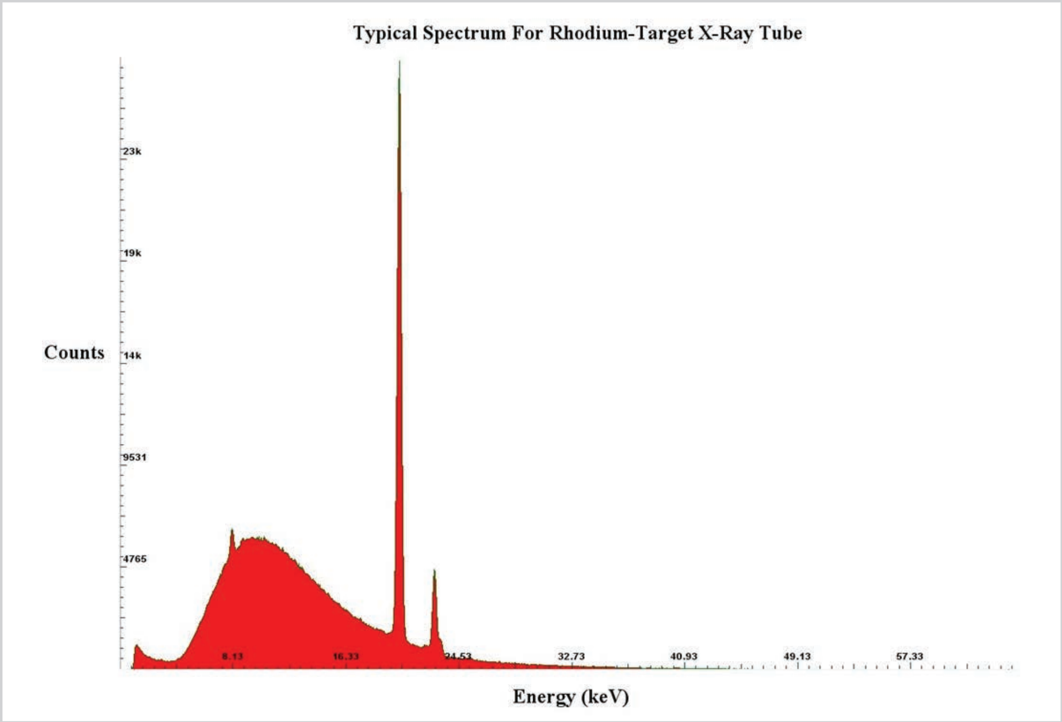
Experimental Setup

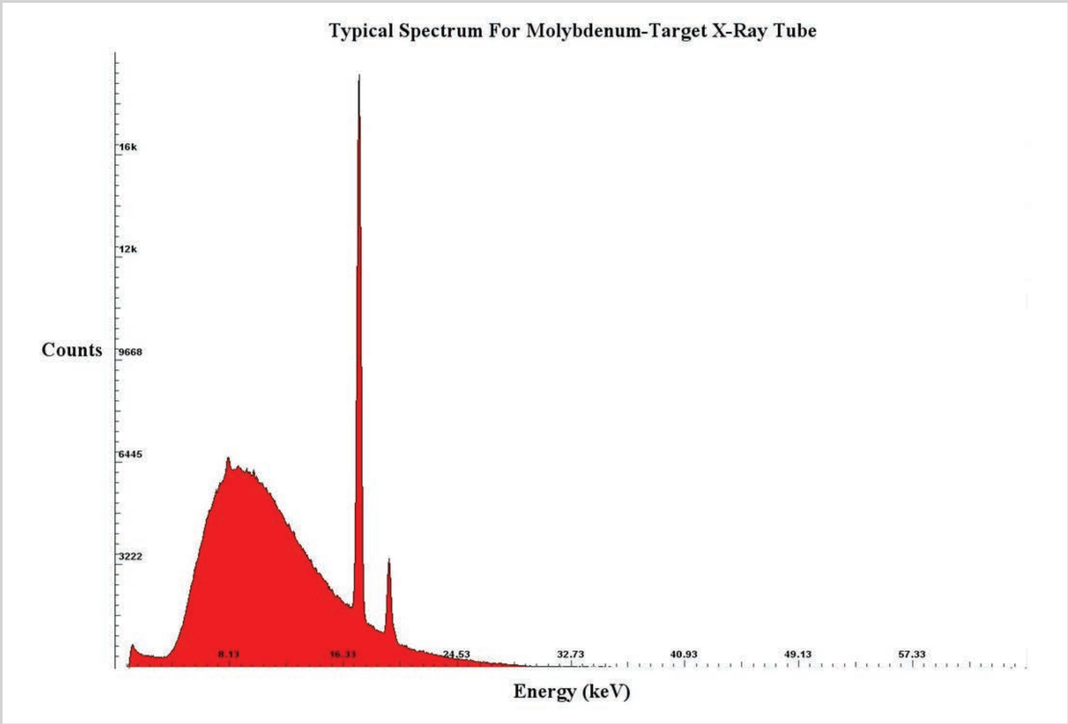
The following spectra were gathered by pointing Oxford Instruments X-Ray Technology's tubes directly at a Si-PIN photodiode detector system. There are a total of approximately one million counts in each spectrum.




Typical Spectrum For Tungsten-Target X-Ray Tube
Counts
58k
46k
34k
23k
11k
8.13
24.53
32.73
40.93
49.13
57.33
Energy (keV)


Typical Spectrum For Copper-Target X-Ray Tube
Counts
114k
91k
68k
45k
22k
16.33
24.53
32.73
40.93
49.13
57.33
Energy (keV)


Typical Spectrum For Rhodium-Target X-Ray Tube
Counts
23k
19k
14k
9531
4765
8.13
16.33
24.53
32.73
40.93
49.13
57.33
Energy (keV)


Typical Spectrum For Molybdenum-Target X-Ray Tube
Counts
16k
12k
9668
6445
3222
8.13
16.33
24.53
32.73
40.93
49.13
57.33
Energy (keV)

Summary

An X-ray tube is constrained in its operating range by four factors – maximum filament current, maximum power delivered to the anode, and maximum and minimum anode voltage. By operating your X-ray tube within these parameters, you may be able to achieve better results for your specific application while ensuring maximum longevity of your X-ray tube. This application note clarifies the constraints above and shows how an operating range is constructed. You can find all the particular values for your X-ray tube described in this application note on the datasheet.

Maximum Filament Current

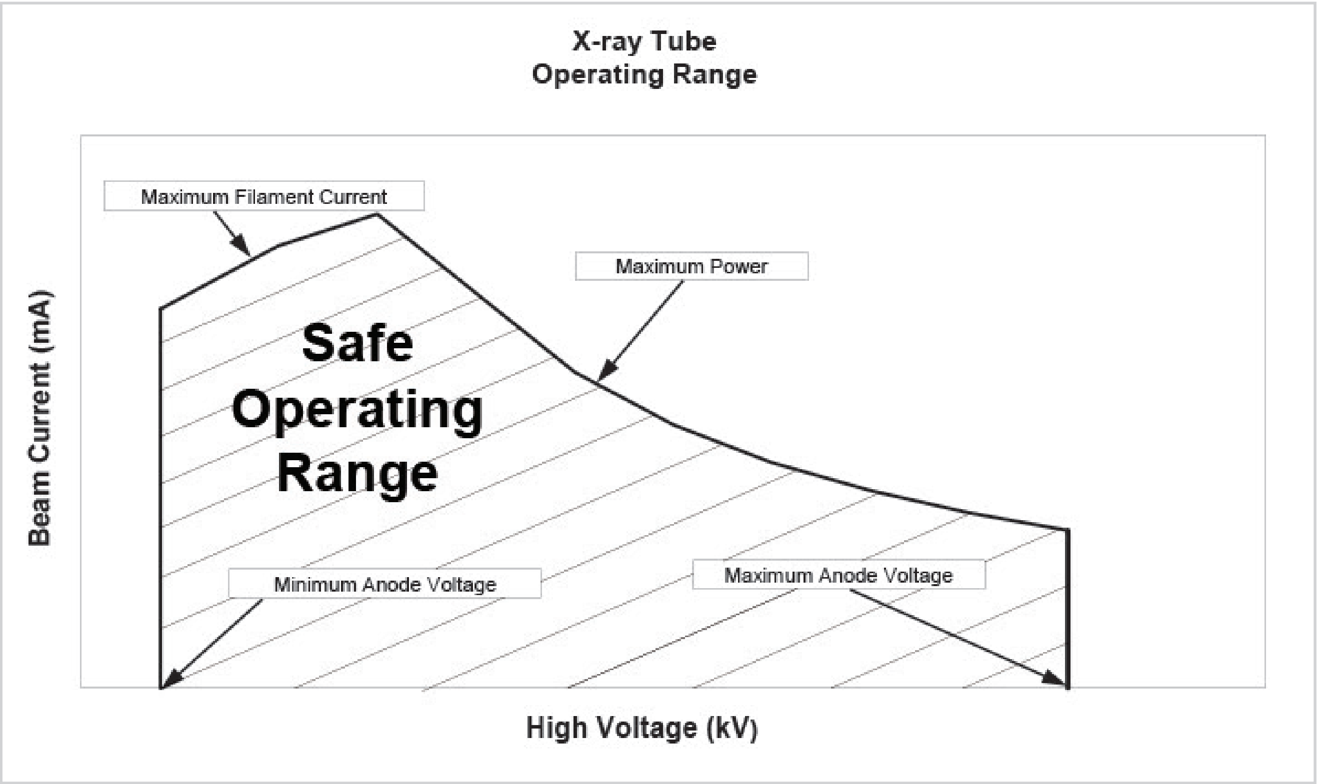
The maximum filament current is a very strict constraint that prevents the filament from burning out, just like the filament in an incandescent light bulb. Like any other wire, a filament will melt because it cannot dissipate the heat generated from excessive current. Oxford Instruments X-Ray Technology has conducted extensive testing to determine the maximum current the filament in your X-ray tube can withstand. A common value is 1.7A, but this value varies by filament type and is given on the datasheet that comes with your X-ray tube. It constrains the first part of the operating range before the maximum power requirement takes over.

Maximum Power

Like the filament current limit, the power limit is a strict constraint that prevents the target from sublimating. An X-ray tube accelerates a very narrow beam of electrons to the target with a total power $P = IV$, where I is the beam current (not to be confused with the filament current – the current delivered to the filament itself) and V is the anode voltage. As you can see, this total power limit does not necessarily prevent using a higher beam current or voltage at a given power. Because beam current and voltage are inversely proportional in this relationship, raising one and lowering the other may still allow you to operate the X-ray tube within the maximum power constraint. Keep in mind that the anode voltage is limited as well, as detailed below. The maximum power constraint takes over after the filament limit is no longer a factor in the operating range.

Minimum and Maximum Anode Voltage

An X-ray tube requires a minimum high voltage applied to the anode in order to draw off electrons from the filament. When this condition is satisfied, the beam of electrons will form and accelerate towards the target. Below the minimum anode voltage, electrons will not be drawn off the filament, and thus the tube will produce no X-rays. At voltages lower than the minimum, some power supplies will overdrive (and potentially melt) the filament in an attempt to produce beam current when there are no electrons available. Our Shasta power supplies are designed to prevent damage to the filament. It is extremely important that you do not attempt to obtain beam current below this minimum anode voltage to avoid damaging the filament. On the other hand, the X-ray tube can only stand off a maximum high voltage applied to the anode. Beyond this voltage, arcing will occur and this can severely damage your X-ray tube. Both the minimum and maximum high voltages are sharp cut-offs that form the left and right edges of the operating range.



Conclusion

Some applications may require different settings than the typical "full power" at which most customers operate their X-ray tubes. By following the guidelines in this document, you may be able to achieve more desirable conditions for your application that still fall within the operating range constraints. In summary, to achieve the best possible conditions for your application, operate your X-ray tube within the constraints of maximum filament current, maximum power, and minimum and maximum anode voltage as described above.

When purchasing an X-ray tube, one of the most important questions which must to be answered is: how will the tube be packaged? System designers often put a lot of thought into the tube specifications, such as target material, spot size, etc, but the physical packaging of the tube can be a critical design choice. Many factors, including heat dissipation, radiation shielding, and design time must be considered.

Bare Tube

Bare tubes are just that – X-ray tubes with nothing else. It is incumbent on the system designer to design the radiation shielding, the insulating material, the high voltage and filament connections, and power supply integration. This can be quite a complex task, and is generally only appropriate for very large volume systems with specific requirements that cannot be met with Oxford's proven tube packaging solutions.

Potted Tube

Potted tubes are encapsulated in a silicone rubber material to provide electrical isolation and, in some cases, radiation shielding. High and low voltage cables may be included in the potting to aid connection to the X-ray power supply. Potted tubes provide an easier integration option than bare X-ray tubes however heat dissipation in a potted tube can be a challenge, and so potted tubes tend to be appropriate in low power or low duty cycle applications.

Packaged Tube

Packaged tubes are enclosed in a metal housing which acts as both a radiation shield and a cooling vessel. The packages are filled with a high dielectric liquid which both prevents high voltage breakdown (arcing) and provides effective heat transfer, requiring only an external fan to provide 50W of continuous power in many applications. Higher power packages with integrated water cooling systems are also available. Oxford's packaged tubes are fitted with connectors for easy plug-and-play operation with our Shasta X-ray power supply, enabling a quick setup procedure.

Integrated Source

Integrated X-ray sources include an X-ray tube, a high voltage and a low voltage power supply, and an analog or digital interface conveniently packaged in one box. This frees the system designer from all high voltage design concerns, and allows the X-ray device to be treated as a true "black box" component. Integrated solutions also speed up time-to-market, as the system designer only needs to integrate with a simple analog or digital interface, and won't be bogged down with often mysterious high voltage integration problems.

Caring for the Beryllium Window of an X-ray Tube

Many Oxford Instruments X-ray tubes come equipped with beryllium X-ray windows for maximum flux transmission. Beryllium is a metal that has low density and low atomic mass, and hence very low absorption of X-rays, making beryllium the preferred choice for X-ray tube windows where low energy transmission is desired.

Oxford Instruments also produces glass window tubes, which are much more robust than their beryllium counterparts, with the trade-off of decreased low energy flux. Glass window tubes are suitable for a wide variety of applications, including imaging and some types of analysis, and should be considered in harsh, humid, or debris filled environments.

If your X-ray tube has a beryllium window, please keep the following considerations in mind:

- The beryllium exit window is comprised of high purity vacuum tight beryllium metal, typically 127 microns thick.
- Beryllium can be toxic if improperly handled. Avoid contact with the beryllium window.
- The beryllium window is fragile and will be damaged by the slightest impact.
- Beryllium is highly soluble in polar solvents. Examples of polar solvents include water (including humidity), alcohol and acids. It is essential that you do not expose the beryllium window to these agents for prolonged periods of time, as they will destroy the beryllium window and compromise the internal high vacuum of the X-ray tube, causing it to fail.
- Unless absolutely necessary, all care should be taken to avoid any contact with the beryllium window, and tube installation should take into consideration keeping the window free of dust and debris. Should your beryllium exit window need to be cleaned, gently use a cotton swab and acetone (a non-polar solvent) and then immediately dry thoroughly with a cotton swab or soft dry air. Please note that damage to the beryllium window due to mishandling is not covered under your warranty.
- Helium is often used in X-ray spectroscopy. Helium is a very small atom and has a high transmission rate through the beryllium window. At a minimum, only beryllium exit windows of at least 127 microns should be considered when operating an X-ray tube in the presence of a Helium environment.
- If you operate an X-ray tube with a beryllium window in a vacuum environment, it is important to remember that the beryllium window is brittle and susceptible to damage caused by cycling between atmospheric pressure and vacuum environments typical for analytical analysis. Utilization of a secondary chamber is recommended to allow the X-ray tube to operate at sub-atmospheric pressures without cycling for each sample introduction.

Summary

A frequent question posed on a manufacturer of x-ray tubes relates to environmental conditions which pose a threat to a long lived x-ray tube. This application note sets out the basic conditions under which an x-ray tube will perform to its maximum life expectancy, as well as identifies known areas of concern.

Modes of Failure

Temperature range The most frequent mode of failure of an x-ray tube is the failure to adequately dissipate the heat generated during normal operation. It is well known that 99%+ of the kinetic energy imparted on the electron beam is lost in the form of heat at the anode target. Thus, a 50W x-ray tube will produce roughly 49.8W of energy in the form of heat just through the conversion process. Add to this the thermal energy produced by the helical tungsten filament and one can readily see that heat dissipation is a major factor.

The failure mechanism, with respect to the x-ray tube itself, due to inadequate cooling can take on two forms; the first is simple sublimation of the anode target material. In converting the anode target material directly from a solid to a gas (sublimation), the resulting vapor rapidly degrades the internal ultrahigh vacuum necessary for proper operation. This loss of ultrahigh vacuum results in a failure of the x-ray tube to withstand the high voltage gap between the cathode electron source (helical tungsten filament) and the target anode. The x-ray tube begins to short circuit, or arc, which in turn liberates more gas, which in turn further degrades the internal vacuum, which finally results in an x-ray tube which no longer functions.

The second failure mode due to improper heat dissipation is the liberation of damaging ions. If the x-ray tube anode is allowed to surpass the vapor pressure point of the target material, than a liberation of ions occur. In turn, these liberated ions are attracted back toward the helical tungsten filament and begin to erode the filament through an ion scrubbing process. This can result in a premature failure of the filament, which manifests itself as a broken filament, or open circuit.

Prevention of both of these failure modes is made possible by ensuring that the x-ray tube is not allowed to overheat. This means careful monitoring of the cooling circuit with fault protection in the event of a cooling system failure. Oxford Instruments now offers integrated thermal protection in its packaged x-ray tubes to prevent this type of failure.

Thus, the acceptable operating temperature range of an x-ray tube relates to the cooling design. Each x-ray tube is slightly different with respect to its tolerance of an allowable temperature range, with some as low at 50 degrees C, while others will tolerate temperatures of 100 degrees C. It is highly recommended that any design integrating an x-ray tube be carefully measured for operating temperature range ensuring the chosen range does not allow the x-ray tube to overheat.

Environmental considerations

Most x-ray tubes possess either a Beryllium exit window or simply allow the x-rays to transmit directly through the glass envelope. The choice of selecting an x-ray tube with or without a Beryllium exit window will depend on the application, with factors such as low energy flux and mounting requirements influencing the decision. That said, if your x-ray tube contains a Beryllium exit window, you must pay special attention to its particular environment requirements. The Beryllium exit window is comprised of high purity Beryllium metal, typically 125 microns thick. In its metal form, Beryllium is highly soluble in polar solvents. Examples of polar solvents include water, alcohol and acids. Therefore, it is essential that you do not expose the Beryllium exit window to these agents for prolonged periods of time, as they will destroy the window, which in turn will compromise the internal high vacuum of the x-ray tube and cause the x-ray tube to fail. Should your Beryllium exit window need to be cleaned, use a cotton swab and acetone (a non-polar solvent).

Finally, as the exit window of the x-ray tube is typically exposed to a sample chamber environment, ensure that the samples to be analyzed do not outgas polar solvents, as this is a frequent failure mechanism of x-ray tubes. As you might suspect, environments containing high water vapor content (high humidity) should also be avoided as condensation of water on the Beryllium exit window will dissolve the Beryllium metal and cause subsequent failure. Should you wish to operate your x-ray tube in these less forgiving environments, contact Oxford Instruments about coating your Beryllium window with a polymer protective material. This material may adversely affect performance, particularly below 10KV, but will protect the fragile Beryllium window against corrosive damage.

As one might suspect, the operation of an x-ray tube with a Beryllium exit window in an environment comprised of hydrocarbons will depend on the polarity of the molecule in question. Typically most aliphatic hydrocarbons, and many aromatic hydrocarbons are safe with respect to the Beryllium exit window. In fact, the x-ray tube spends the better part of the first 5 days of its life submerged in high voltage transformer oil, a low polarity hydrocarbon. Most damage to the Beryllium exit window from hydrocarbons comes from precipitation of the hydrocarbon on the Beryllium window simply degrading the transmission characteristics. In many cases, this material can be cleaned off with acetone (a non-polar solvent) and a cotton swab. Remember, Beryllium is highly toxic and unprotected hands should never touch the window nor should the window be cleaned if it is broken or fragmented.

Another consideration is the operation of an x-ray tube made with a Beryllium exit window in the presence of a Helium environment. Typically found in x-ray spectroscopy, Helium, as a very small atom, has a high transmission rate through the Beryllium window. As such, careful attention to the design must be considered when using an x-ray tube in this environment. At a minimum, only Beryllium exit windows of at least 125 microns should be considered, unless the Beryllium window is coated with a highly transparent diamond-like protective coating.

Should your design require operation of an x-ray tube with a Beryllium window in a vacuum environment, it is important to remember the Beryllium window material is brittle and as such is highly susceptible to damage caused by cycling the Beryllium window between atmospheric pressure and vacuum environments typical for analytical analysis. Utilization of a secondary chamber is highly recommended such that the x-ray tube operates at sub-atmospheric pressures without cycling for each sample introduction. Contact Oxford Instruments for details on an appropriate design should you wish to operate the x-ray tube in a vacuum environment.

Maximizing the Life of the X-ray Tube Filament

The process of producing electrons necessary for the production of X-rays in an X-ray tube begins by heating a tungsten wire. When heated to approximately 2000 degrees Celsius, tungsten is a copious emitter of electrons.

From this point several trade-offs in design become factors, which must be considered. The resulting design of a modern X-ray tube seeks to balance the relationship between performance and filament longevity.

Of importance to those users seeking a small X-ray focal spot, the relationship between a smaller wire filament and a small focal spot is well established. (This applies only to small focal spots when utilizing a tungsten wire filament. In the case of microfocus X-ray tubes, a dispenser cathode is typically employed.)

Since a smaller filament is preferred where possible, a typical filament "driver" circuit must be able to control the current to the filament quite carefully. This is due to the important relationship between filament current and actual temperature of the filament wire itself.

By example, the Jupiter Series 5000 X-ray tube requires more than 1.5 Amps current at 2 Volts to achieve the required filament temperature necessary for electron emission. However above 1.7 amps the filament enters a very high region of evaporation, and by 1.75 amps the filament reaches its melting point. Therefore careful control of the filament circuit is essential to a long lived X-ray tube. Our Shasta X-ray tube power supply has a tightly designed circuit which prevents the filament from exceeding its maximum allowable current. The Shasta power supply is perfectly matched to our X-ray tubes.

The process of heating the helical tungsten filament to produce electrons naturally causes the filament to evaporate. After a certain number of hours of normal operation, the filament will thin to the point of failure. The rate of filament evaporation, and thus the total number of hours required to thin the filament to the point of failure is a function of the chosen operating conditions.

The filament current required to heat and achieve a given X-ray beam current differs depending upon the required applied high voltage, as shown in Figure 1. To determine the anticipated life of a helical tungsten filament, one must estimate the average filament current employed throughout its life. Once estimated, the rate of evaporation can be used to estimate the normal filament life as shown in Figure 2. For example, if the user normally operates the X-ray tube at 40kV and 1.0 mA, this requires a filament current of approximately 1.60 A. Using the chart in Figure 2, this translates to approximately 40,000 hours of expected life.

A stand by condition of ~50% maximum filament current rating places the filament in a very low region of evaporation where the filament life is not measurably affected. You do not need to use a stand by condition to ensure maximum filament life, but you may find it beneficial as your power supply will achieve a steady state sooner.

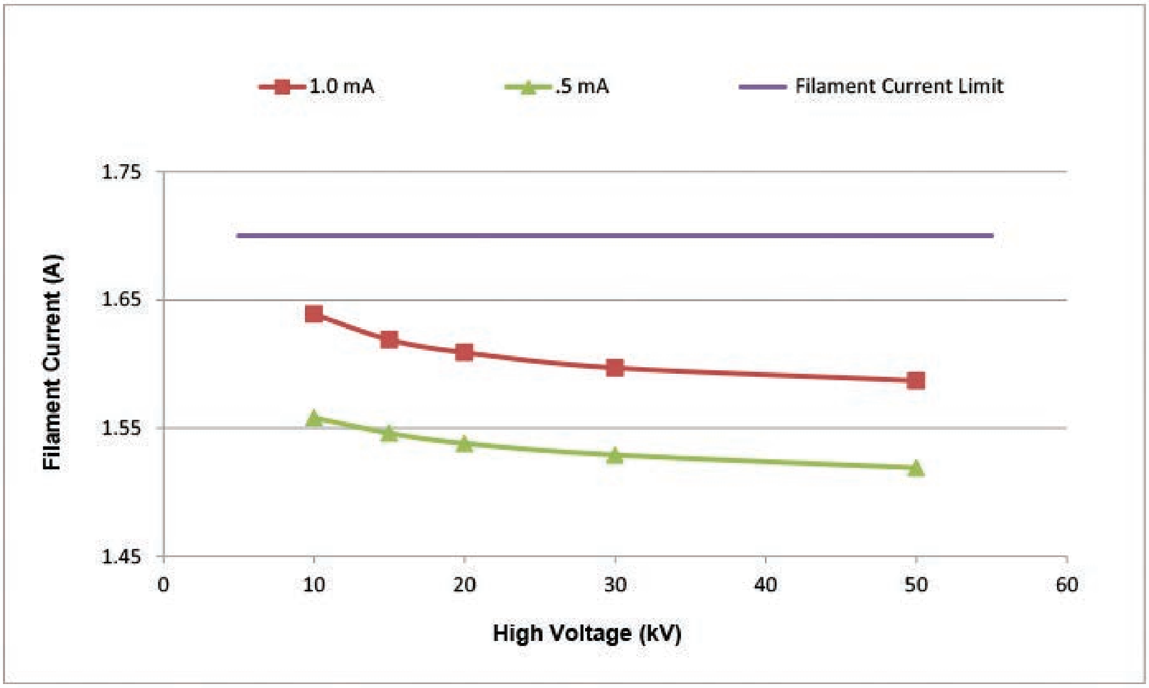


Figure 1: Filament current required for the Jupiter Series 5000 X-ray tube

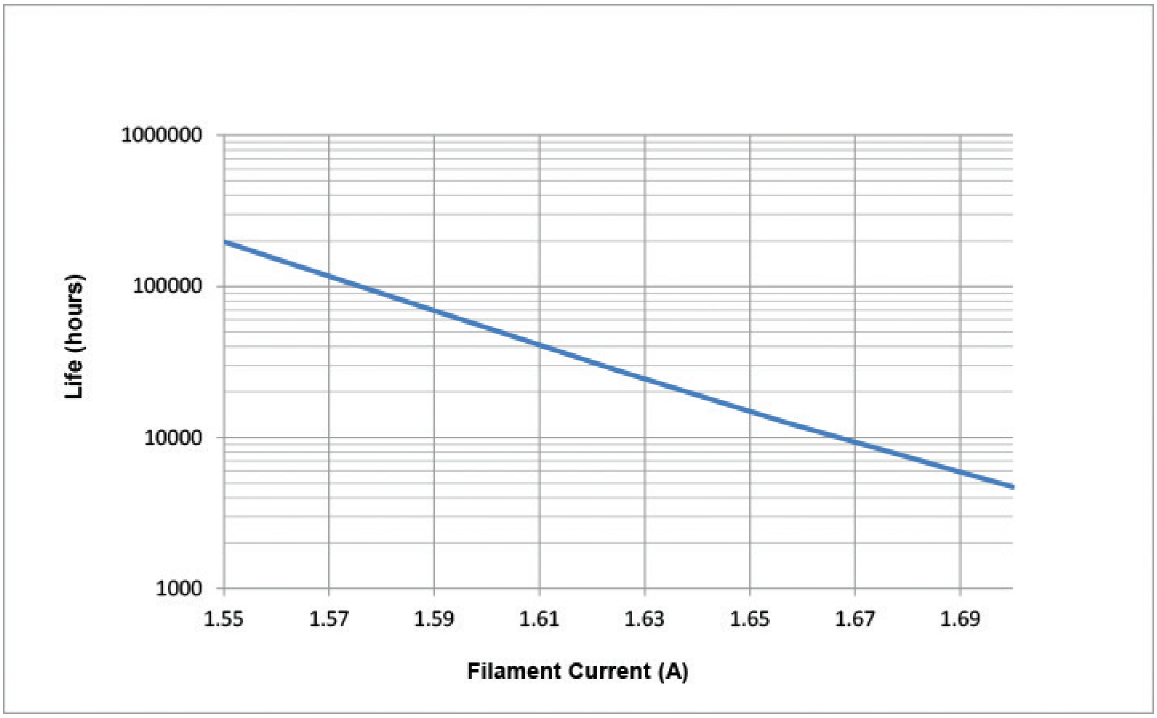


Figure 2: Filament life for the Jupiter Series 5000 X-ray tube

Shielding an X-ray Tube

Summary

One of the most important safety considerations (along with the high voltage) in operating your X-ray tube from Oxford Instruments is how much shielding you should use to contain radiation. Shielding an X-ray tube involves a simple calculation based on mass attenuation coefficients for different materials, described below.

Disclaimer

Oxford Instruments does not make any claim that these calculated values will result in adequate attenuation. Due to material and geometry differences, these values may only be used as a starting point for your application. You must test your setup with a reliable dosimeter to ensure safety.

X-Ray Mass Attenuation Theory

This application note assumes a beam of monochromatic photons with an incident intensity I0 that penetrates a material with mass thickness x and density. This beam will emerge with an intensity I given by the law[1]

$$I/\ I_0 = \exp[-(\mu/)x]$$

Values of μ/ have been empirically obtained using this equation and measured values of I_0, I, and x. These values are compiled in the NIST X-Ray Mass Attenuation Coefficients[2] and are used for all the calculations in this document. Note that mass thickness is defined as the mass per unit area, and is obtained by multiplying the thickness t by the density such that x = t.

For composite materials such as Brass, the mass attenuation coefficients are obtained using a weighted average:

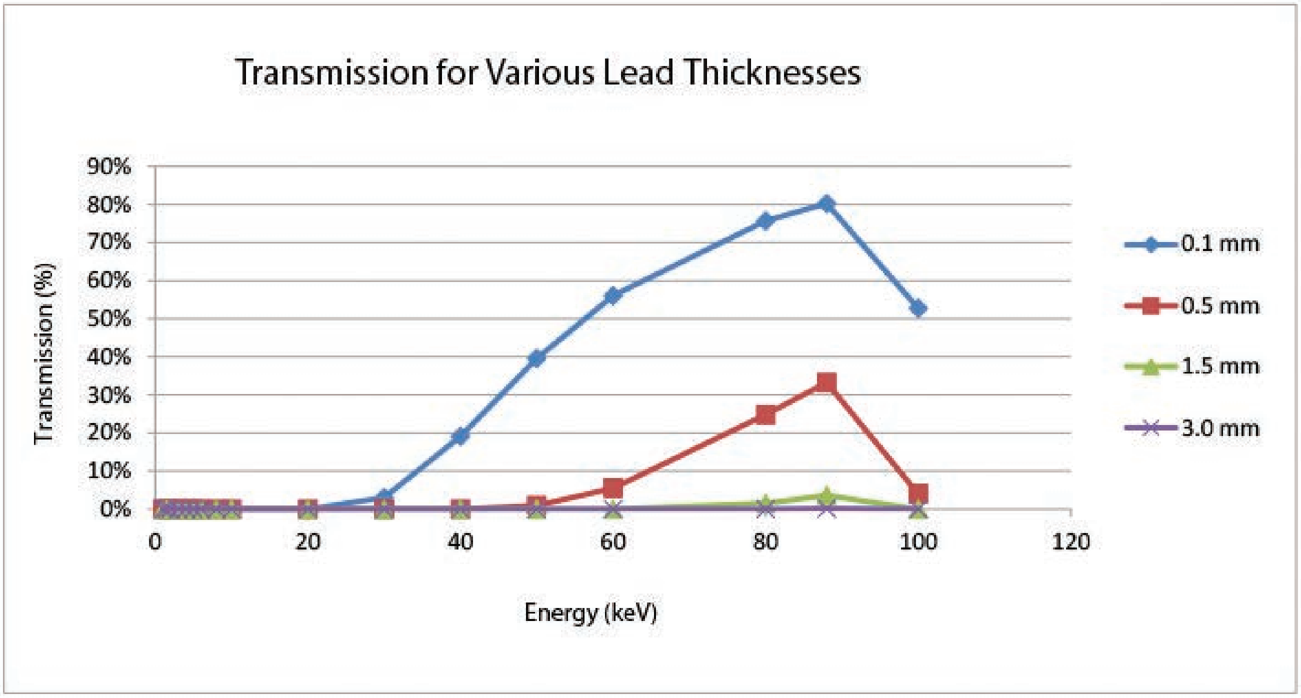
$$\mu/\ =\ w_n(\mu/)_n$$

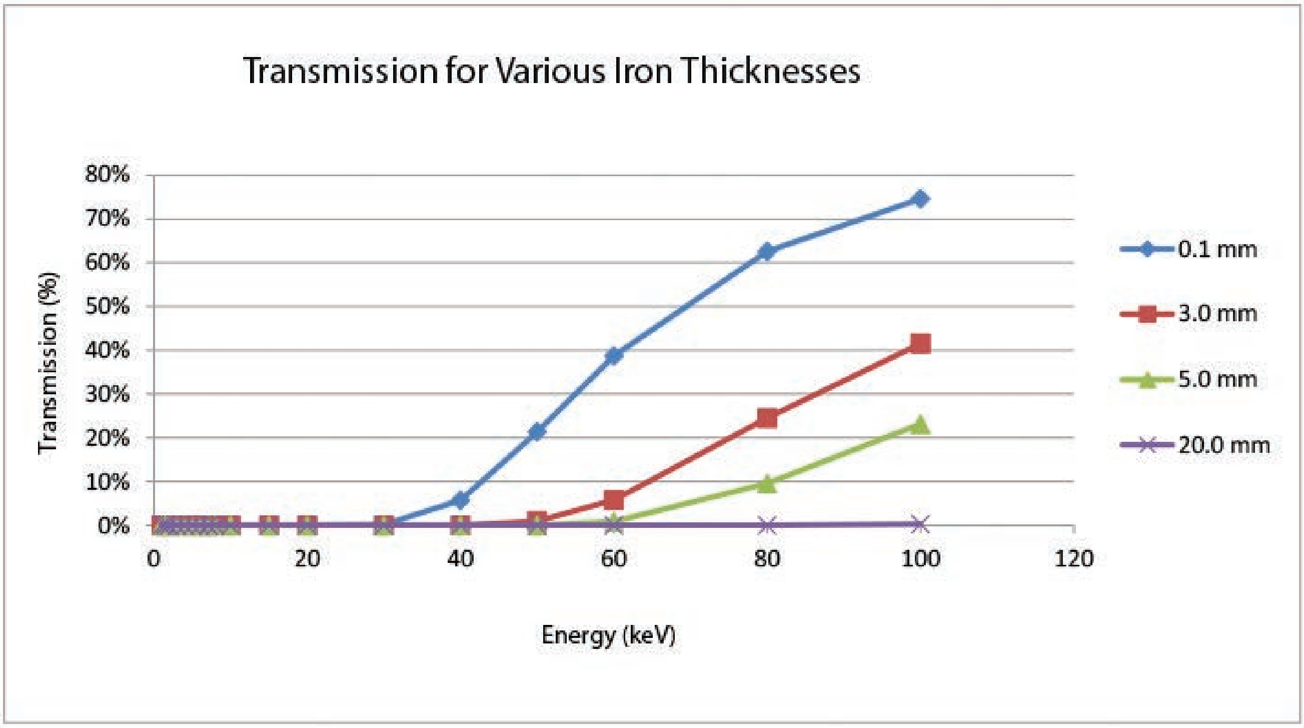
Here w_n is the fraction by weight of the n^{th} element in the material and, similarly, $(\mu/)_n$ is the mass attenuation coefficient of the n^{th} element in the material.

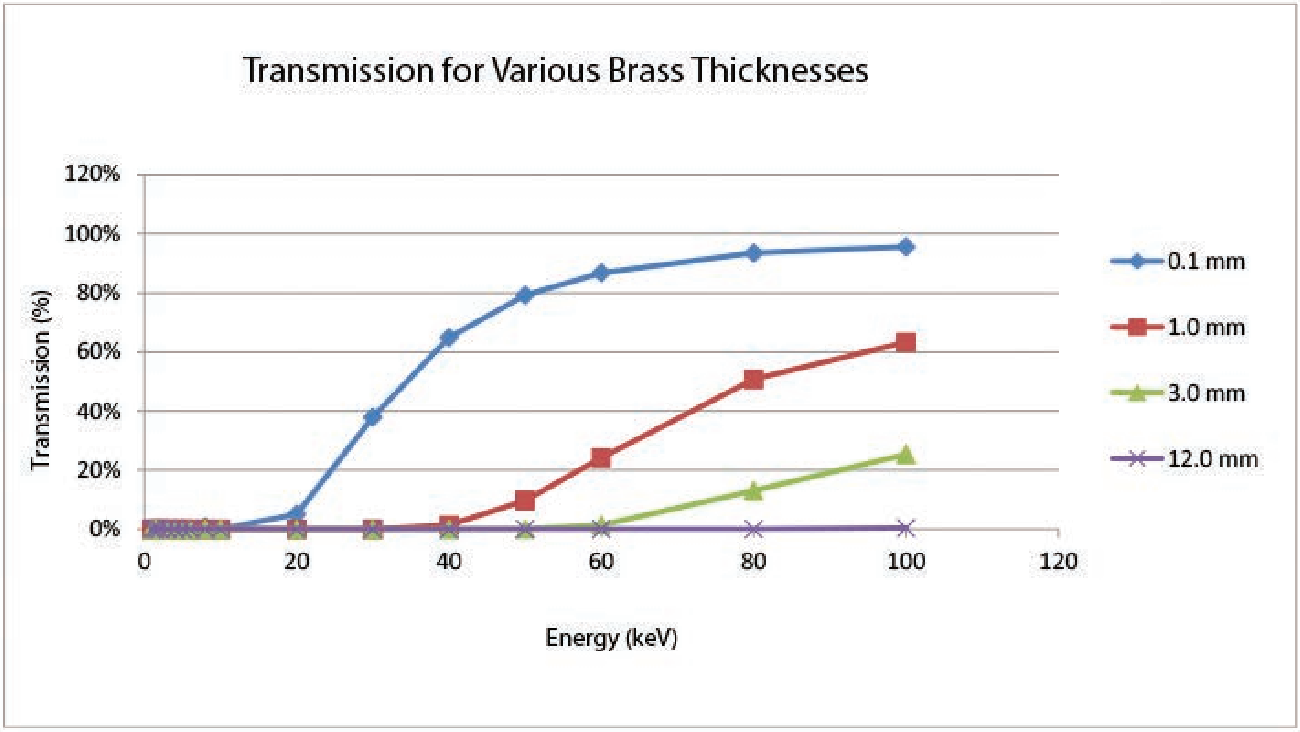
We have completed the shielding calculations with a simple spreadsheet application for various materials using the theory above. The table below shows the shielding values for various materials. (Note that the Brass in this calculation is composed of 65% Copper, 33.5% Zinc, and 1.5% Lead). As a secondary consideration, these values have been crosschecked using existing Oxford Instruments XT experimental equipment.

Material	50 keV	100 keV
Lead	1.5 mm	3.0 mm
Iron	5.0 mm	20.0 mm
Brass	3.0 mm	12.0 mm

The following charts show the transmission characteristics by varying material thickness.


Transmission for Various Lead Thicknesses
Transmission (%)
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
20
40
60
80
100
120
Energy (keV)
0.1 mm
0.5 mm
1.5 mm
3.0 mm


Transmission for Various Iron Thicknesses
Transmission (%)
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
20
40
60
80
100
120
Energy (keV)
0.1 mm
3.0 mm
5.0 mm
20.0 mm



Conclusion

To ensure safety, it is extremely important to adequately shield the outside environment from X-rays that are being emitted from your X-ray tube. In order to do this, we recommend starting with at least the thickness of materials shown above and measuring the output with a dosimeter. Again, while these values have been developed from first principles, it is imperative that you measure any setup thoroughly before putting it into full use.

References

[1] http://www.physics.nist.gov/PhysRefData/XrayMassCoef/chap2.html
[2] http://www.physics.nist.gov/PhysRefData/XrayMassCoef/tab3.html

The most frequent mode of failure of X-ray tubes is the failure to adequately dissipate the heat generated during normal operation.

Greater than 99% of the kinetic energy imparted on the electron beam is lost in the form of heat at the anode target. Thus, a 50W X-ray tube will produce roughly 49.8W of energy in the form of heat just through the conversion process. Add to this the thermal energy produced by the helical tungsten filament and one can readily see that heat dissipation is a major factor.

Inadequate cooling of an X-ray tube can cause it to fail in two ways.

The first is sublimation of the anode target material. In converting the anode target material directly from a solid to a gas (sublimation), the resulting vapor rapidly degrades the internal high vacuum necessary for proper operation on the X-ray tube. The loss of high vacuum results in a failure of the X-ray tube to withstand the high voltage gap between the cathode electron source (helical tungsten filament) and the target anode. The X-ray tube begins to short circuit, or arc, which in turn liberates more gas that further degrades the internal vacuum, resulting in an X-ray tube that no longer functions.

The second failure mode caused by improper heat dissipation is the liberation of damaging ions. If the X-ray tube anode is allowed to surpass the vapor pressure point of the target material, ions will be liberated. These ions are attracted back toward the helical tungsten filament and begin to erode the filament through an ion scrubbing process. This can cause the filament to break, creating an open circuit.

Prevention of both of these failure modes is made possible by ensuring that the X-ray tube is not allowed to overheat. This means careful monitoring of the cooling system with fault protection in the event of a cooling system failure.

Many of our packaged X-ray tubes offer an integrated thermal switch that helps prevent permanent damage to the X-ray tube.

Please confirm that your cooling system can maintain the temperature range that is recommended on our products.

This application note describes the proper way to manage the heat produced by the UltraBright family of products. By following these recommendations you will be able to achieve continuous operation of the X-ray source. It is important to provide proper thermal management for the source. Different applications and system configurations of this device will require different thermal management strategies. In this application note you will find some examples of heat sinks that we use in our factory to thermally manage the unit. The goal is to keep the anode at a temperature of less than 70 °C while the unit is running at full power. For a unit with a Tungsten target, the maximum heat produced at the anode is 80 Watts, while for a unit with a Copper or Molybdenum target, the maximum heat produced at the anode is 60 Watts maximum.

Figure 1

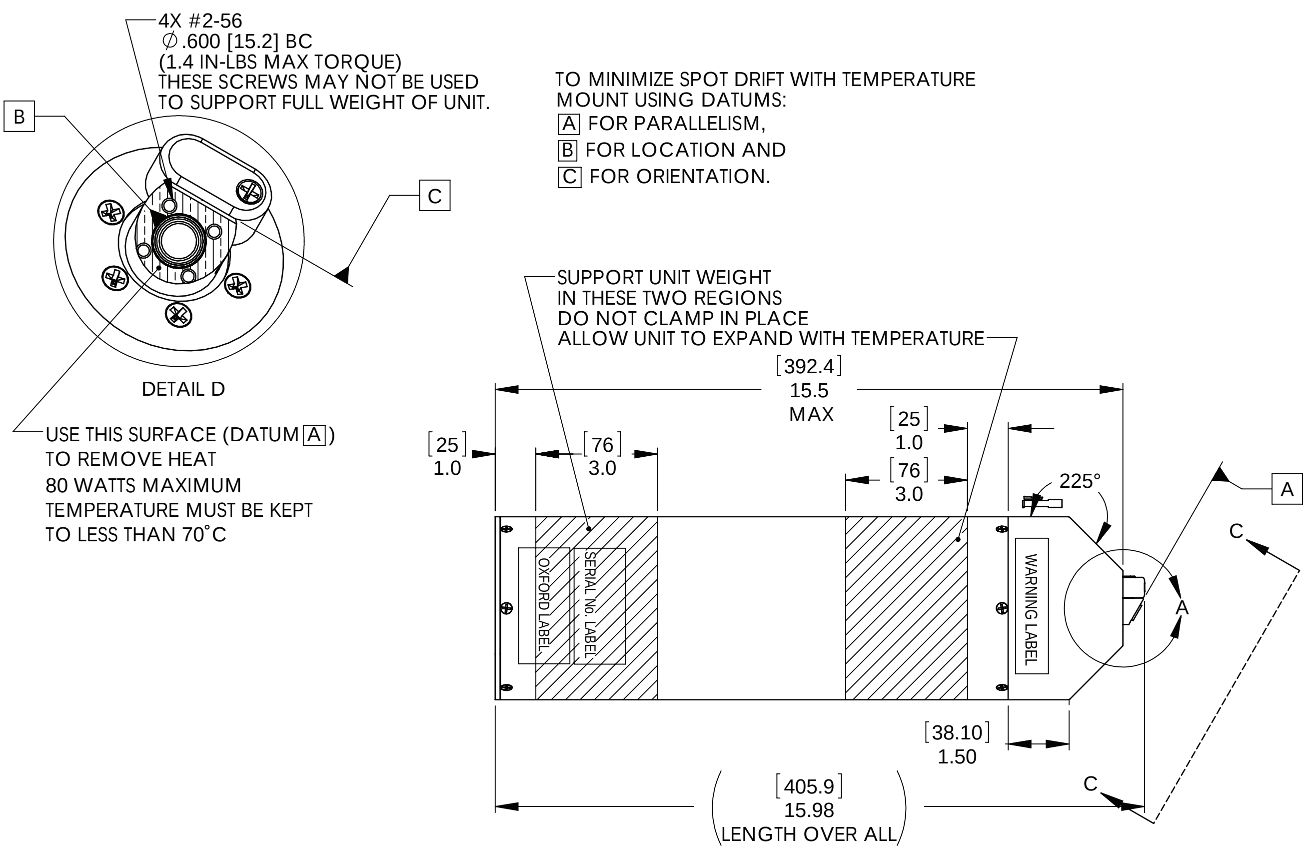
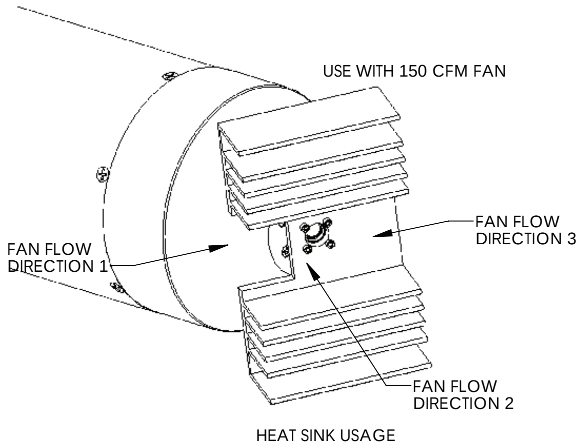


Figure 1 shows a portion of outline Drawing Number 8236. In the lower right corner of the drawing there is a view which indicates the surface that should be used to remove heat from the unit. Some heat also travels up the side of the conical cover but air blowing on this conical surface alone is not sufficient to cool the unit adequately. A heat sink must be attached to the surface indicated. The style of the heat sink is up to the user and will depend upon the location of other devices or mechanisms used in conjunction with this X-ray source.

Figure 2



NOTES:
1) MAKE FROM -
A) SUPPLIER: Digi-Key
B) STOCK-NO: 345-1179-ND
C) TYPE: 396-1AB
D) DESCRTIPTION: LOW PROFILE HEAT SINK
E) SIZE: 5" W x 3" L x 1.38" T
F) MANUFACTURER: Wakefield Engineering
G) MAN. PART NO.: 7331

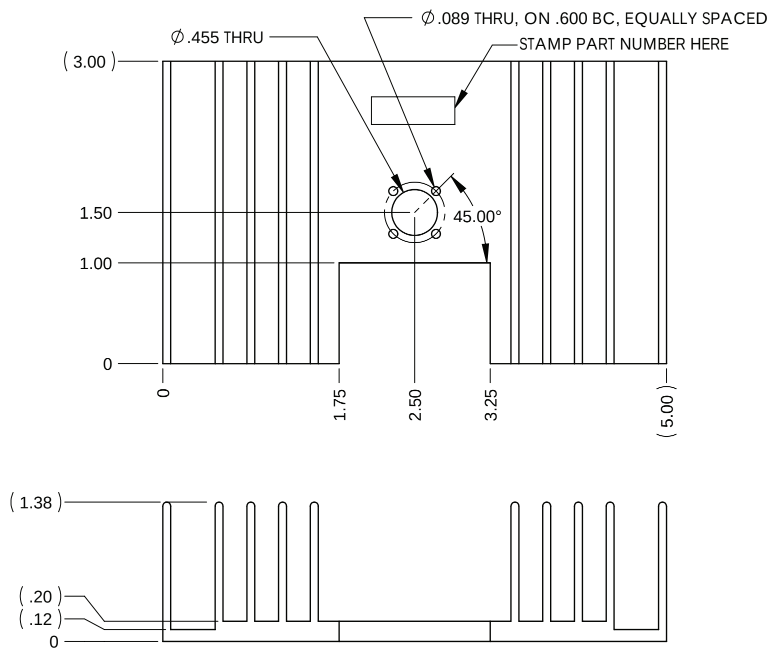


Figure 2 is drawing number 9474 which shows an inexpensive heat sink solution which will work well with a 150 CFM fan if the fan is blowing directly on the finned region. This solution is not ideal for applications which require close access to the exit window. In addition this is not intended to hold the source in relation to other devices to prevent spot drift due to thermal expansion of the unit.

Figure 3 is drawing number 9506 and shows the heat sink we use during spot photo measurements of the X-ray spot size. The bar is hard mounted to a base which is fastened to an optical table. This bar then provides a fixed datum plane for subsequent measurements. A 150 CFM fan blows continuously on this bar and the front of the unit. To allow for thermal expansion of the unit, the rest of the source rests on two plastic cradles which are NOT clamped to the unit but still support a majority of the weight of the unit.

Figure 3

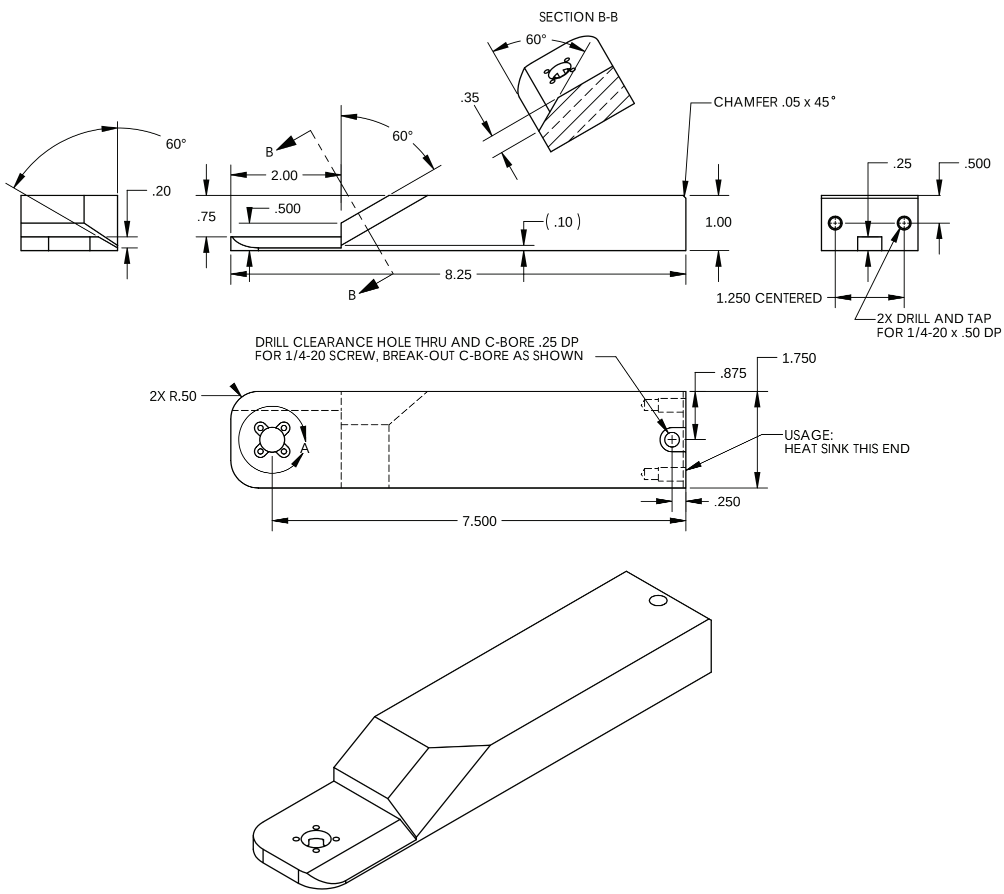
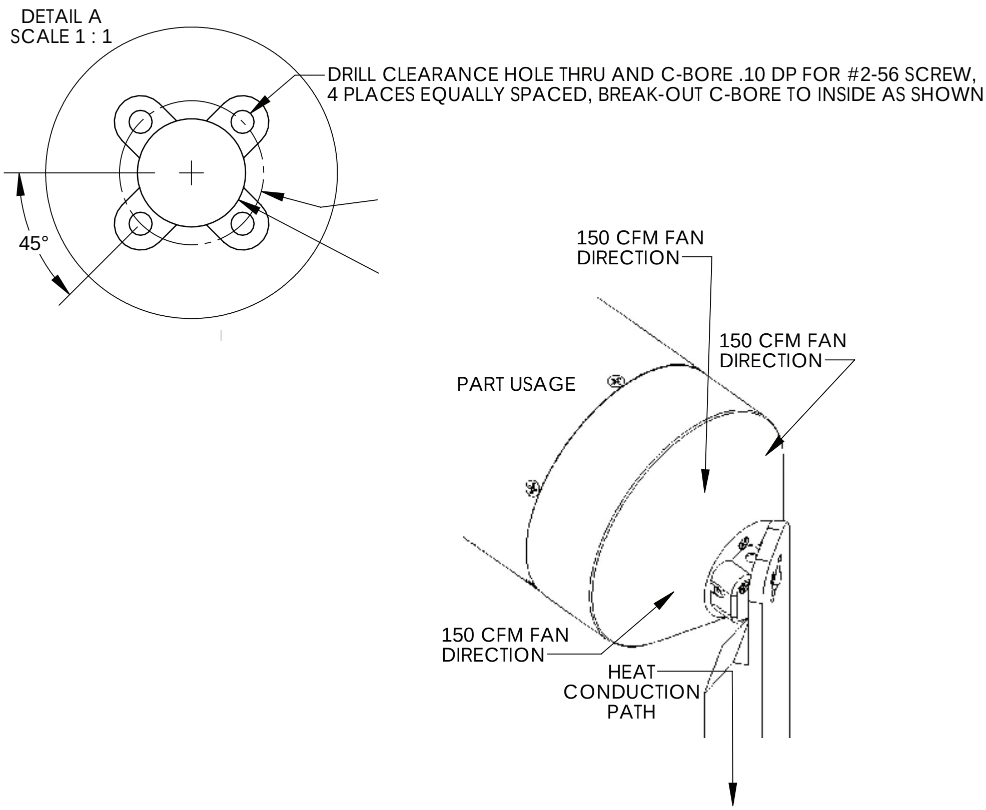


Figure 3 is drawing number 9506 and shows the heat sink we use during spot photo measurements of the X-ray spot size. The bar is hard mounted to a base which is fastened to an optical table. This bar then provides a fixed datum plane for subsequent measurements. A 150 CFM fan blows continuously on this bar and the front of the unit. To allow for thermal expansion of the unit, the rest of the source rests on two plastic cradles which are NOT clamped to the unit but still support a majority of the weight of the unit.

Figure 3 (cont.)



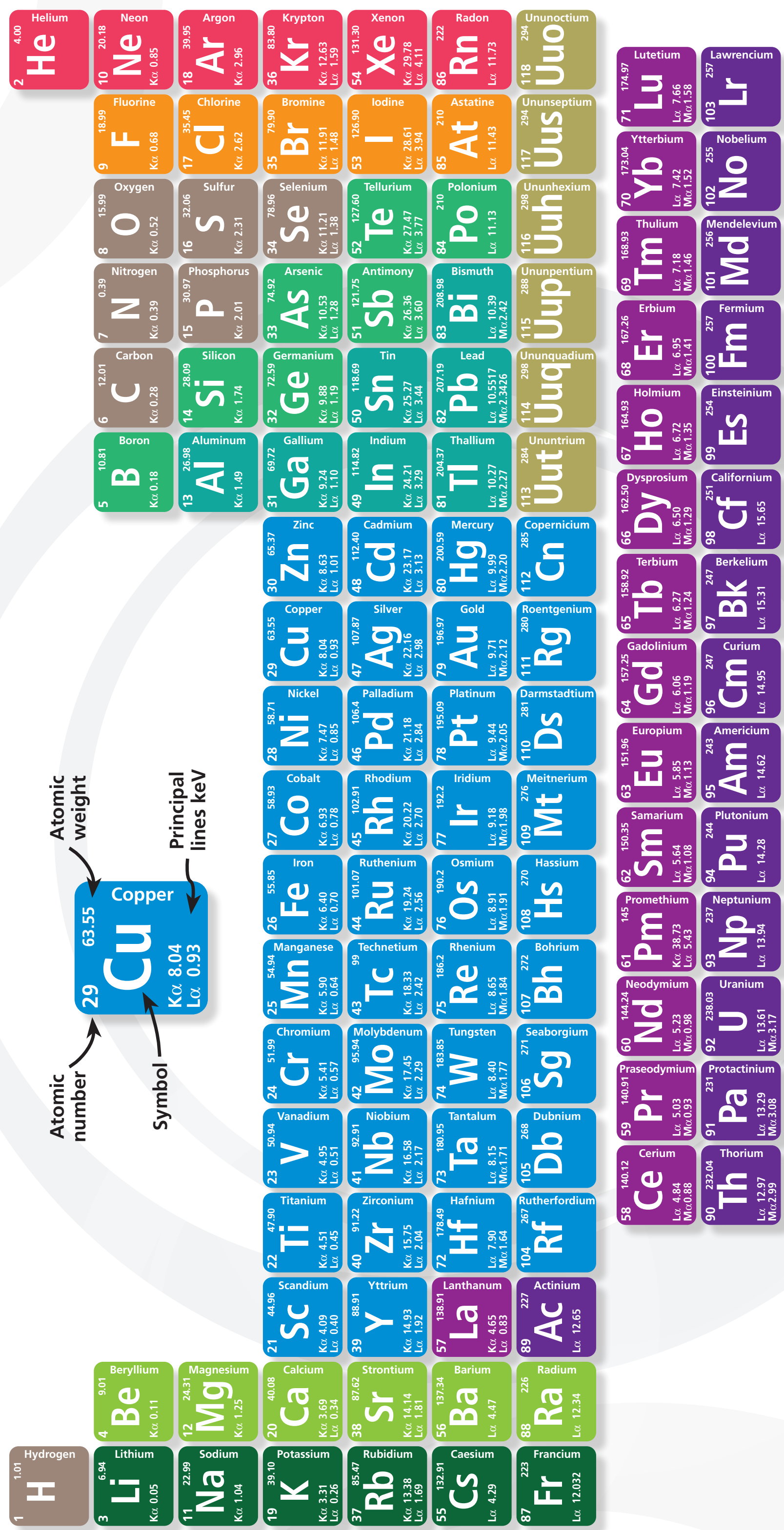
UltraBright has a thermal switch that is connected to an interlock. The maximum operating temperature of the anode is 70°C. The thermal switch will automatically shut down the source if the temperature of the anode exceeds 70°C and FAULT TUBE OT will be displayed on the LCD of the controller. It is important for you know when the unit is over temperature so that you can take actions to properly cool the unit. The thermal switch adds an additional level of protection to the cooling system safeguards.

Oxford Instrument X-ray Technology Technical Support would be pleased to review any mounting configuration and thermal management system the user has designed and make recommendations.

Image credits

1. Image courtesy of Molecubes *(see catalog back cover)*

X-ray Fluorescence Periodic Table



X-RAY

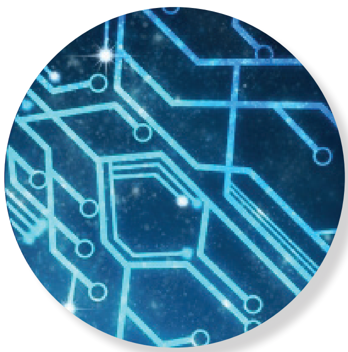
Oxford Instruments X-Ray Technology

X-ray Fluorescence

Metal Analysis
and Identification

Energy and Mining

Industrial Inspection

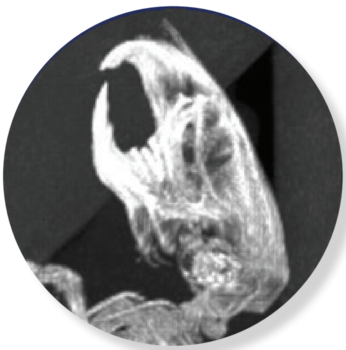


Printed Circuit Board
Drilling and Inspection

Food and Packaging
Safety

Medical Imaging

Bone and Tissue
Imaging



Small Animal
and Drug Studies[1]

Visit **https://xray.oxinst.com/** or **xray-sales@oxinst.com** for more information

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