

Mini-X X-Ray Tube USB Controlled



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The Mini-X is based on the Newton Scientific Inc. miniature X-ray source.

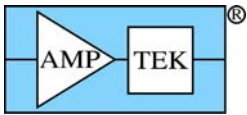
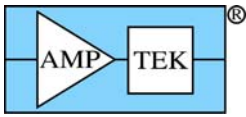


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1 Precautions

CAUTION: The Mini-X is only one component of an X-ray instrument. It is the responsibility of the user, the OEM customer, or experimenter to provide a fail safe metal enclosure to prevent escaping radiation while using this product. The final product (turn-key system) must comply with local government regulations to protect personnel from exposure to radiation. Amptek Inc., bears no responsibility for the incorrect use of this product.

1.1 High Voltage

The Mini-X is designed to generate voltages up to 40 kV. The high voltage system is fully shielded inside the Mini-X enclosure.

DO NOT ATTEMPT TO ACCESS OR MODIFY THE HIGH VOLTAGE SYSTEM.

**DO NOT UNSCREW ANY OF THE SCREWS AT THE NECK OF THE TUBE.
TAMPERING WITH THESE SCREWS WILL VOID WARRANTY.**



Caution

This device produces **HIGH VOLTAGE** when energized.
To be operated only by qualified personnel.



The Mini-X contains a high voltage power supply. High voltage is not exposed, but the Mini-X should still be grounded as a precaution. It should be mounted to a metal fixture via the provided brackets.

The high voltage power supply has been thoroughly tested and should not ever arc to its own case. However, if at any time any high voltage arcing or popping is heard, immediately discontinue use. High voltage arcing has a distinctive sharp cracking sound. Contact sales (sales@amptek.com) if you suspect that the power supply is arcing.

1.2 Radiation

The Mini-X product is intended to generate X-ray radiation during normal operation. The Mini-X has been designed to focus radiation in the designated output direction, however radiation in other directions is possible and should be addressed with shielding and/or monitoring in the final application.

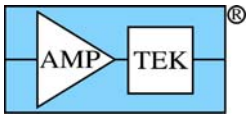


Caution

This device produces **X-RAYS** when energized.
To be operated only by qualified personnel.



Radiation levels external to the X-ray tube housing with the brass safety plug ON do not exceed 2.5 mrem/h measured 5 cm from the surface of the housing in accordance with Requirements 5.2.2.1.1 and 5.2.2.2.2 of the NBS Handbook for Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment. For more information please see <http://www.fda.gov/cdrh/radhlth/pdf/xdfigehb.pdf>.



1.3 Beryllium Window

When unpacking the Mini-X pay careful attention to the Beryllium (Be) window on the front of the unit. This is a fragile window which can be damaged by impact. Beryllium (silver/gray and metallic) and beryllium oxide dust (normally a whitish powder) are harmful if inhaled or ingested.

AVOID ALL CONTACT WITH THIS PART OF THE X-RAY TUBE.

1.4 Heat and Temperature

The ambient temperature surrounding the X-ray tube must not exceed 50 °C. Improper cooling is the single highest cause of X-ray tube failures and is not covered under the Mini-X Warranty. It is the user's responsibility to provide an adequate cooling system for the Mini-X.

2 Overview of the Mini-X X-Ray Tube System for Portable XRF

Important – Read the precautions in Section 1 of this manual before operating this equipment.

Mini-X is the first of its kind; a self-contained, packaged, miniature X-ray tube system, which includes the X-ray tube, the power supply, the control electronics and the USB communication to the computer. It is designed to replace radioisotopes in X-ray fluorescence analysis applications.

Mini-X has been designed to simplify the XRF process by providing a grounded anode, variable current and voltage controlled via USB and ease of operation. It features a 40 kV/100 μ A power supply, a tungsten (W) or silver (Ag) transmission target, and a beryllium end window. A collimator and various filters are also provided. It is designed for continuous operation in industrial environments.

To further simplify the use of Mini-X an AC adaptor is provided to supply the 9 VDC needed to power the system. The only connections needed to operate the tube are a USB cable and AC adaptor. A flashing red LED and a beeper warns the user when x-rays are present.

**CAUTION: DO NOT SET THE VOLTAGE OVER 40 kV.
THIS WILL DAMAGE THE UNIT AND VOID WARRANTY.**

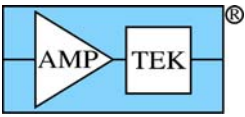


Figure 1. Complete XRF System. The Mini-X together with the XR-100CR X-ray detector and the PX4 Digital Pulse Processor, MCA, and Power Supply.

2.1 Output X-Ray Spectra

Mini-X Output X-Ray Spectrum: Ag Target @ 40 kV

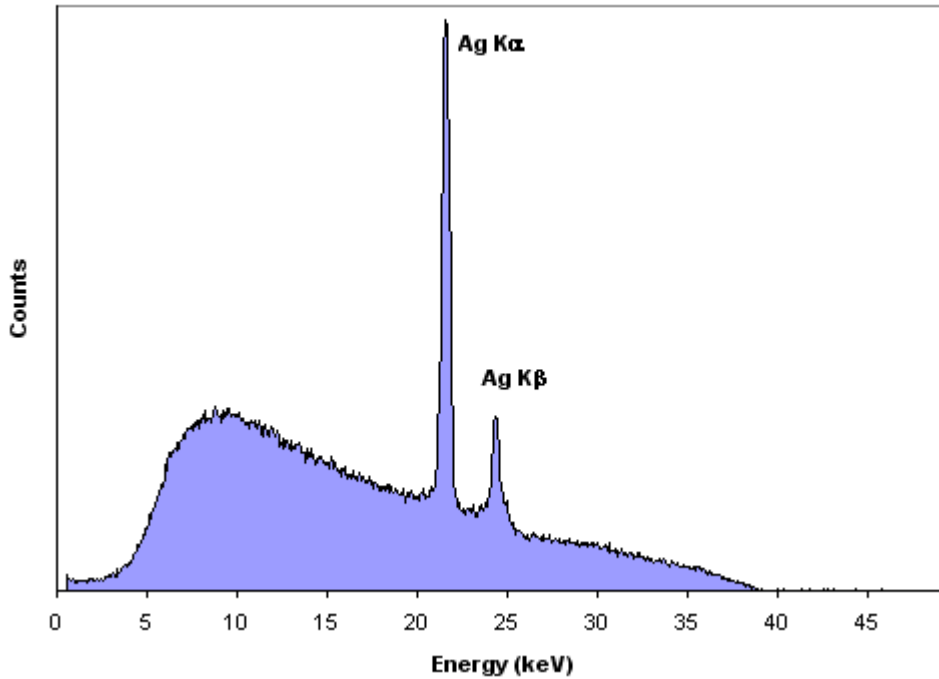


Figure 2. Output Spectrum with Silver (Ag) target.

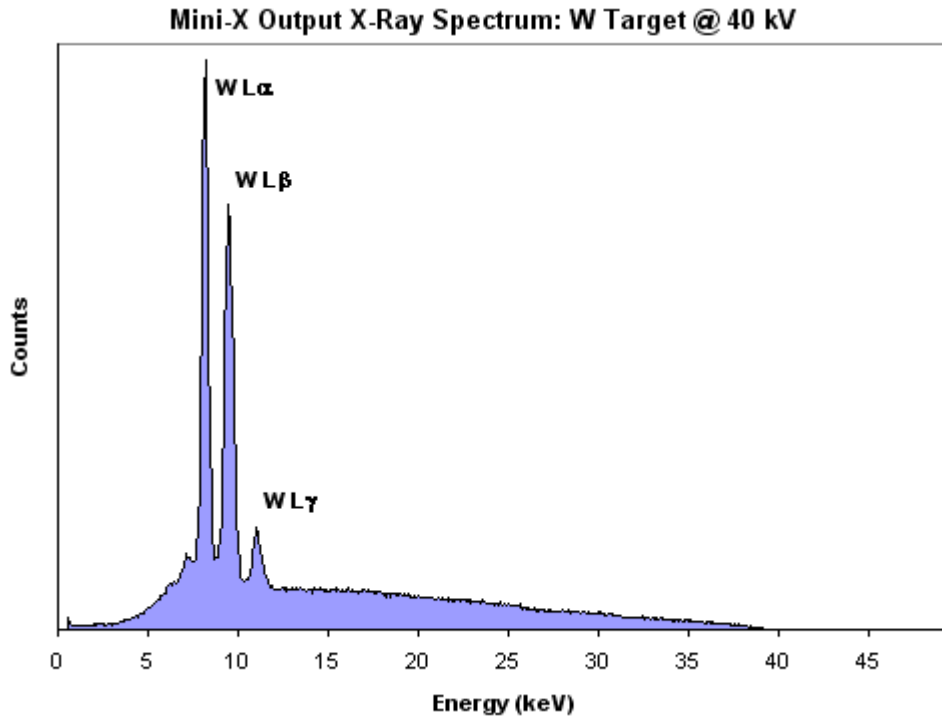


Figure 3. Output Spectrum with Tungsten (W) target.

2.2 Collimator

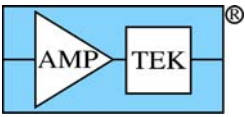
The Mini-X is provided with a collimator to facilitate its use in XRF applications. It consists of a brass collimator with an aluminum (Al) insert and a cover that screws into the Mini-X. Insert the collimator into the cover and then carefully screw the assembly onto the Mini-X. The collimator has a 2 mm diameter hole.



Figure 4. Left photo shows the Mini-X collimator, safety plug, and cover. The middle photo shows the safety plug installed in the cover and attached to the Mini-X. This configuration meets the radiation requirements discussed in Section 1.2. The Mini-X ships from the factory in this configuration. The right photo shows the collimator installed in the cover.

2.3 Brass Safety Plug

When the brass safety plug is installed in the cover (figure 4, middle) and screwed onto the Mini-X it meets the radiation safety requirements of Section 1.2. For personal protection always install the safety



plug into the cover and attach to the Mini-X when not in use. The Mini-X ships from the factory in this configuration.

2.4 Interlock

The Mini-X has a hardware interlock in order to prevent accidental exposure. This interlock must be shorted (enabled) in order for the Mini-X to produce X-rays. The left figure below shows the interlock disabled. The Mini-X will not produce X-rays in this configuration. The right figure shows the interlock enabled. The Mini-X will produce X-rays in this configuration. Always store the Mini-X with the interlock disabled when not in use.



Figure 5. Showing the interlock disabled (left) and enabled (right).

One of the primary purposes of the interlock is so that the user can interface to external safety mechanisms. This is most commonly implemented as a shutter or cover that, when opened, disables the interlock and stops the generation of X-rays. When the tube is producing X-rays and the interlock is disabled, the tube will go into a reset mode. It is therefore necessary to restart the tube through software. Re-enabling the interlock after disabling it will not resume the production of X-rays.

The figure below is a block diagram of the Mini-X power and control interface, illustrating the use of the “Interlock” connector. This connector has two functions: it permits the user to implement a safety interlock, which turns off the X-ray tube when a switch is opened, and it permits the user to implement an external indicator to show when the tube is in use.

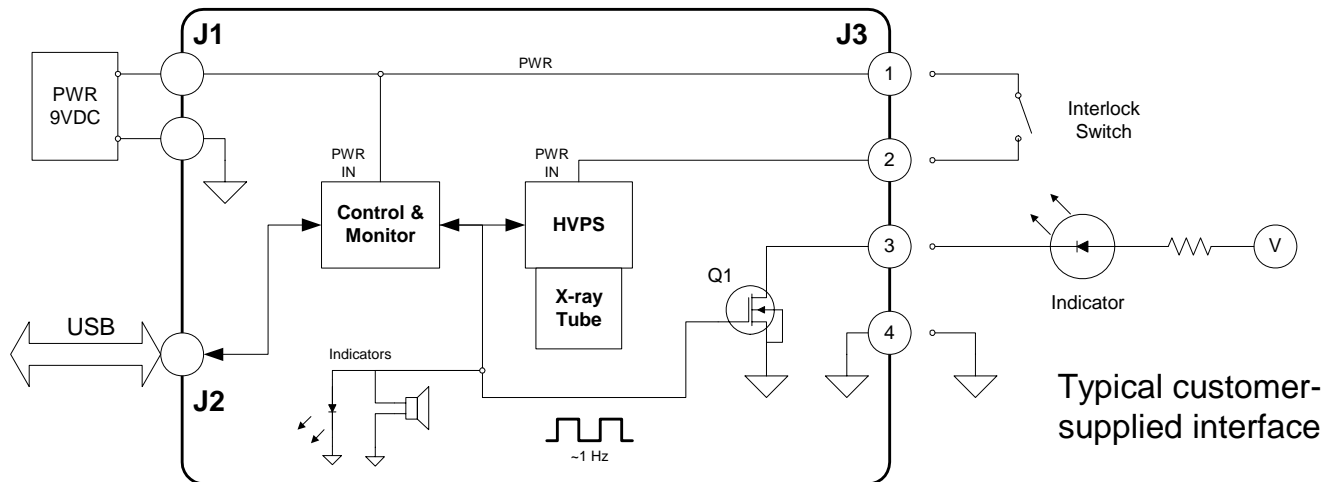
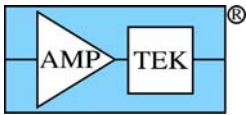


Figure 6. Power and control interface.

As shown in the figure, power is supplied to the high voltage power supply (HVPS) via a connection between pins 1 and 2 of the interlock connector. If the connection between these pins is interrupted, there is no power to the HVPS and so the tube turns off. In addition, this latches a bit in the monitor



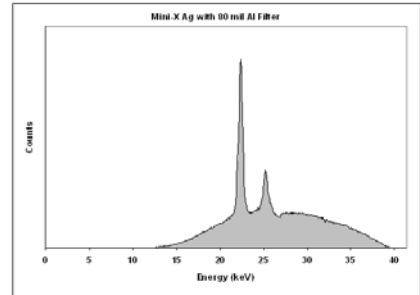
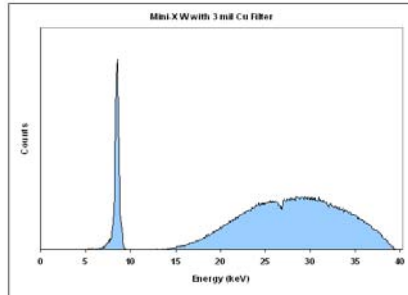
circuit, which must be reset via a USB command. When a connection is restored between pins 1 and 2, although power is restored to the HVPS, the unit is not turned on until this command is received. The voltage at pins 1 and 2 is typically 9VDC. As shown in the figure, a user could connect this to a switch, typically located on the cover of the enclosure housing the X-ray target. If a user accidentally opens the cover without first turning off the tube, this will automatically turn off the power, preventing accidental radiation exposure.

The Mini-X contains a speaker and an LED, both of which indicate that the X-ray tube is turned on. The LED is visible on the back side of the Mini-X package, but in some applications the Mini-X is inside an enclosure. Pins 3 and 4 can be used to drive an external indicator, such as the LED sketched above. The user must provide the circuit interfacing to pins 3 and 4. Q1 is an N-channel enhancement mode MOSFET, part number ZXM61N02FTA. Key ratings are VDSS=20V (absolute max) and ID=1.7A (absolute max, 25oC). The gate of the FET is driven by a square wave at approximately 1 Hz, 10% duty cycle.

2.5 Filters

The Mini-X is shipped with a set of filters to modify the output spectrum of the tube to better suite a particular application. The use of any filter will reduce the flux, so the current may have to be increased to obtain an appropriate flux. Install the filter at the Mini-X screw base. Then screw on the cover with the collimator. Make sure that the cover screws all the way down, otherwise radiation will leak through the gap. All filter thicknesses will fit except for the 40 mil Al. This filter must be installed on the outside output aperture of the collimator and held in place with the black cap provided.

Material	Thickness μm/mils	# Included
Al	1016 / 40	5
Al	254 / 10	5
Cu	25.4 / 1	3
Mo	25.4 / 1	2
Ag	25.4 / 1	1
W	25.4 / 1	1



2.6 Mounting

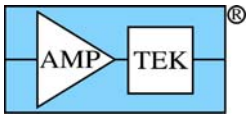
The Mini-X can be fastened to any surface by using the mounting holes and brackets that are provided.

2.7 Cooling

The Mini-X requires proper and adequate cooling for maximum life. As such, it is the user's responsibility to provide a cooling design, such that the ambient temperature around the X-ray tube does not exceed 50 °C. Improper cooling is the single highest cause of X-ray tube failures. Improper cooling is not covered under the warranty.

3 Software and USB Driver Installation

Do not plug in the Mini-X until you have first installed the Application Software. This process will also copy the USB drivers to your computer so that USB driver installation is easier.



3.1 Application Software

Locate the Mini-X folder on the Amptek Installation CD. Run the "Mini-X Setup.exe" file.

1. When the dialog opens click Next.
2. Click Install.
3. Click Finish.
4. Another Wizard will open.
5. Click Next.
6. Click Finish.

3.2 USB Driver

This procedure must be performed for every unique Mini-X (i.e. different serial number) that is connected to the computer. The Mini-X USB interface contains two internal controllers, A and B. This means that two USB drivers must be installed for each Mini-X. Perform the steps below for both Mini-X Controller A and Mini-X Controller B. When a new Mini-X is connected, Windows will prompt for the drivers to be installed.

1. Select "Install from a list or specific location (Advanced)" and then click Next.
2. Select "Don't Search. I will select the driver to install" and then click Next.
3. Select Mini-X Controller A then click Next.
4. Click "Continue Anyway" to install the drivers. Repeat for Controller B.

4 Operation of the Mini-X

X-rays exit the Mini-X in an 120 degree cone.

**SAFETY PRECAUTIONS MUST BE USED FOR
EQUIPMENT THAT PRODUCE X-RAYS.
MINIMIZE HUMAN EXPOSURE TO X-RAYS.
USE A GEIGER COUNTER TO MONITOR RADIATION.
STOP: ONLY QUALIFIED PERSONNEL SHOULD
PROCEED BEYOND THIS POINT.**

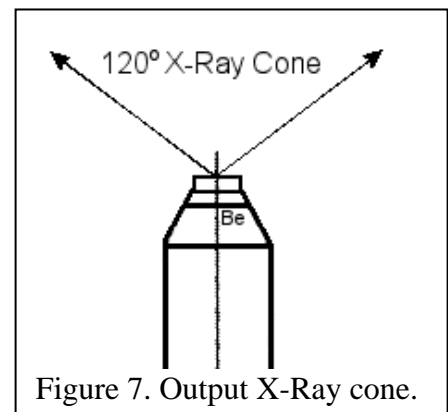
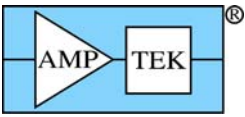


Figure 7. Output X-Ray cone.

4.1 Step by Step Instructions

1. Install the software as described in Section 3.
2. Connect the Mini-X to the PC computer with the USB cable.
3. Connect the AC power adapter to the Mini-X and plug it into an appropriate 110/220 AC power outlet.
4. Remove the safety plug from the cover attached to the Mini-X. Either install the collimator into the cover or leave the cover empty. Re-attach the cover to the Mini-X.
5. Make sure that you have verified the anticipated direction of the X-ray beam as described above.



- 6. The Mini-X has a hardware interlock in order to prevent accidental exposure. This interlock must be shorted (enabled) in order for the Mini-X to produce X-rays. Install the interlock plug to enable the Mini-X to produce X-rays.
- 7. Open the Amptek Mini-X Controller Software. It will appear as below.

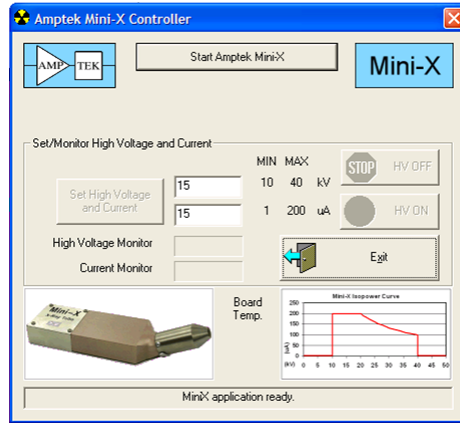


Figure 8.

- 8. Click the Start Amptek Mini-X button. The software will display the serial number of the unit.

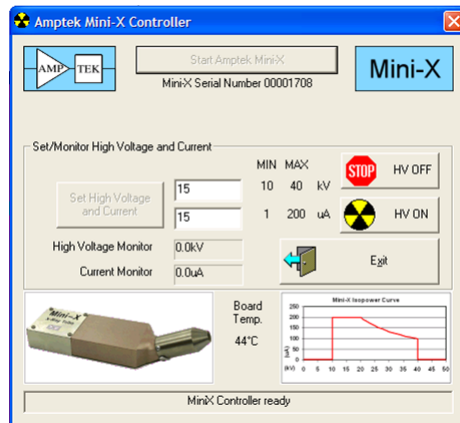


Figure 9.

- 9. The software defaults to a setting of 15 kV and 15 μ A. To change the values click into the appropriate text box and type in the desired number.

IMPORTANT: Do not enter a voltage higher than 40 kV. In addition, the total power of the Mini-X is governed by the Isopower curve. Do not enter a current that exceeds the indicated value for that voltage. If a requested current is too high, the software will automatically adjust it to the maximum allowed value.

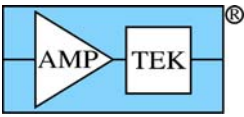
- 10. Click the HV ON button to turn on the tube. The software will ask you to confirm. Click Yes.



THE MINI-X IS NOW PRODUCING X-RAYS



- 11. The Mini-X will start to beep and the red LED on the end panel of the unit will flash. In addition the yellow and black "Radiation Symbol" will blink in the Mini-X Software and the words "X-Ray ON" will appear.



For your safety and for the safety of others, the Beeper should be left ON AT ALL TIMES.

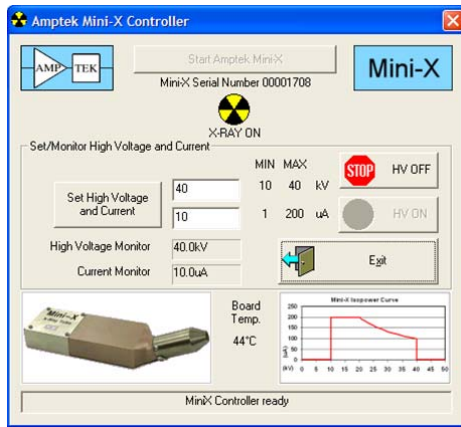


Figure 10.

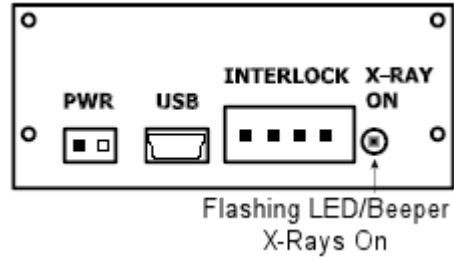
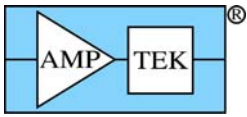


Figure 11.

12. The Voltage and Current monitors now show the actual X-ray tube condition. Although the values for Voltage and Current might be slightly different from the requested values, these are the actual values of the tube.
13. To change the high voltage and current, click into the appropriate text box and enter the number. Then click the Set High Voltage and Current button.
14. To turn off the Mini-X click the HV OFF button, then click the Exit button to exit the software. Always unplug the Mini-X, install the safety plug, and disable the interlock when not in use.



5 Specifications

Target Material	Silver (Ag) or Tungsten (W)
Target Thickness	1.5 μm
Tube voltage	10 to 40 kV
Tube current	5 μA min. / 200 μA max See Isopower curve below
Approximate Dose Rate	800 $\mu\text{Gy/s}$ at 40 kV, 50 μA (W target) at 30 cm
Approximate Flux	10^6 cps at 40 cm through 1 mm diameter collimator (40 keV, 100 μA)
Continuous Output Power	4 W max at 100% duty cycle See Isopower curve
Window Material	Beryllium (Be); window at ground
Window Thickness	500 μm
Focal Spot Size	Approximately 2 mm
Cooling	Air Cooled
High Voltage Stability	<0.03% RSD
Leakage Radiation	<100 nSv/h
Power Consumption	8.5 W at 40 kV and 100 μA , 9 VDC input power
Input Voltage	9 VDC (AC adapter included), connector
Control	USB, mini-USB connector (cable included)
Settling Time	Typical <1 second
Weight	360 grams
Humidity	30 to 90% non-condensing
Operating Temperature Range	-10 $^{\circ}\text{C}$ to 50 $^{\circ}\text{C}$
Storage Temperature Range	-25 $^{\circ}\text{C}$ to 60 $^{\circ}\text{C}$
Safety Controls and Indicators	1) External Hardware Interlock 2) Flashing LED 3) Beeper
Warranty	One year or 2000 hours, whichever comes first

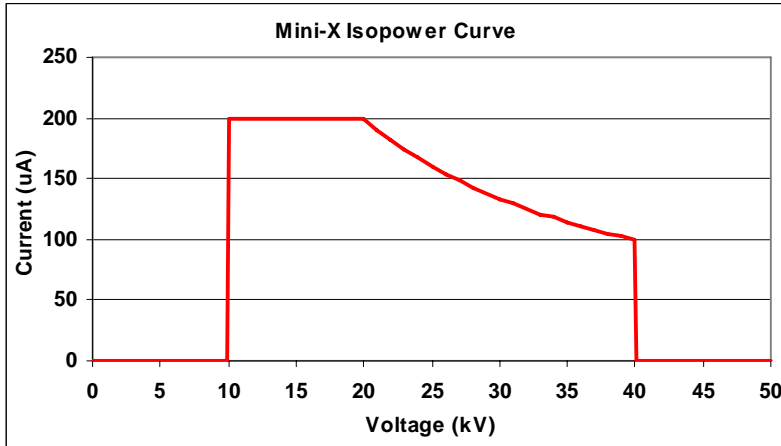
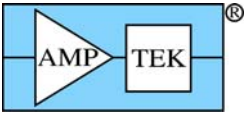


Figure 12. Mini-X Isopower curve. The current and voltage must be set in accordance with this curve or the Mini-X may be severely damaged. Damage of this kind is not covered under warranty.

6 Mechanical Dimensions

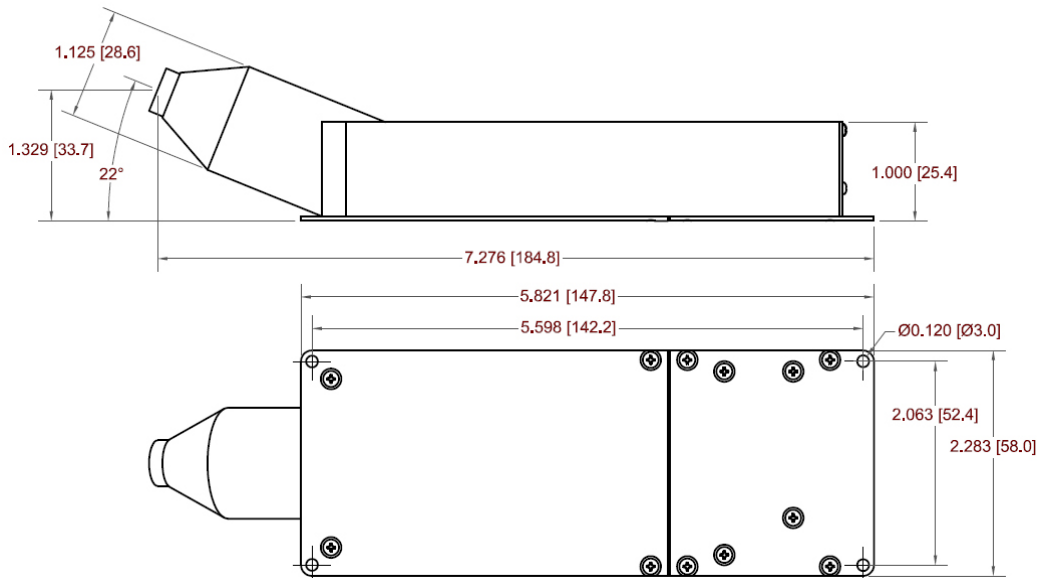


Figure 13. Mini-X mechanical dimensions (mm).

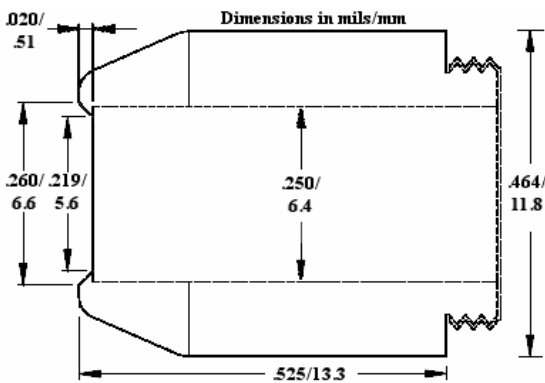


Figure 14. Brass cover dimensions (in mils).