ThermoFisher SCIENTIFIC		Cover Sheet
OPERATION MANUAL	5971-3608	**Rev.** D
Model: PXS5-925EA		**Date:** 7/06/98

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Approved By: Date:

Revision Record

Rev	Date	Changes
1	7/6/98	Establised per ER 411
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D	1/3/18	ECO5405 - Added Data and Procedures from 5900-5034, 5900-0034, 5900-0035, 5900-0062, & 5900-0063 to this operation manual under section 8. APPENDIX A, and Updated sheet paging numbers

ThermoFisher
SCIENTIFIC

OPERATION MANUAL
PXS5-925EA

Update Release
Revision D

TABLE OF CONTENTS

NOTES

1. THE X-RAY WINDOW ON THE SOURCE IS FABRICATED FROM BERYLLIUM FOIL. THIS SHOULD BE HANDLED WITH CARE DUE TO ITS FRAGILITY AND DUE TO THE TOXIC NATURE OF BERYLLIUM COMPOUNDS WHEN INTRODUCED INTO THE BODY.

1. INTRODUCTION

Kevex manufactures X-ray sources which are sold to customers as components for incorporation into equipment for sale or for use within their own operations. These instructions are intended to provide the equipment assembler with information needed for the installation, adjustment and testing of the Kevex X-ray source when it is designed into the user's equipment. These instructions also direct attention to some features of these sources which must be considered in order to minimize the chance of accidental X-ray exposure to the equipment operators or to nearby people. In most applications the design and operation of X-ray equipment must comply with the requirements of governmental or other regulatory agencies. It is the assembler's responsibility to ensure that equipment using this X-ray source is in compliance with the appropriate regulations. In the USA information regarding US Government requirements may be obtained from: Division of Radiological Products, Office of Compliance, Center for Devices and Radiological Health, Food and Drug Administration, 8757 Georgia Avenue, Silver Springs, Maryland 20910.

2. GENERAL DESCRIPTION

The x-ray source consists of a miniature microfocus x-ray tube combined with a high voltage power supply in a single, compact, rugged package. The output intensity is adjustable by means of customer supplied controls for beam voltage and current. The high voltage generator has a DC output and is controlled by all solid state components. Complete line regulation of both the beam voltage and current ensures stable x-ray production over the entire input voltage range (9-15 VDC). In addition, long service life is promoted by beam over-current protection (high voltage decreases).

3. SPECIFICATIONS

3.1 X-RAY OUTPUT

3.1.1 X-RAY OUTPUT:

30 $\pm$ 15% R/minute at 1 foot from the tube window when operated at 90kV, 8 watts. Measured with a Keithly 96035B ion chamber and 35050A readout.

3.1.2 FOCAL SPOT:

Less than 9 microns at 8 watts, 45kV-90kV.
Less than 7 microns at 4 watts, 45kV-90kV

3.1.3 X-RAY WINDOW:

Beryllium foil 127 microns thick.

3.1.4 X-RAY SHIELDING:

Integral x-ray shielding reduces the intensity of radiation leakage from the x-ray source to 0.5 mR/hour or less measured 1 inch away from all housing surfaces behind the tube mounting plate. Intensities in front of this plate, especially within the cone of illumination, are much higher and an appropriately shielded enclosure is required.

3.1.5 X-RAY CONE OF ILLUMINATION:

The x-rays emerge from the window in a cone with its apex located at the focal spot. The total included solid angle is approximately 40°. In certain applications, the user must provide an external collimator or beam defining system to limit the area illuminated by x-rays.

3.1.6 X-RAY OUTPUT STABILITY:

+/- 3% from 15 minutes to 24 hr from 45 to 90kV, 4 to 8 watts. The source shall be powered up for at least ½ hour prior to measurement. Measurement is with a Keithly 96035B ion chamber and 35050A readout.

3.2 MECHANICAL

3.2.1 DIMENSIONS:

4.2"W x 10.9"L x 2.9"H (107mm x 277mm x 74mm) approx.

3.2.2 WEIGHT:

8 lbs. (3.7 kilograms) approx.

3.2.3 TEMPERATURE RANGE:

0 TO 32° C Ambient. During operation, the tube mounting plate temperature must not be allowed to exceed 50° C. For long life and stable operation, it is recommended to keep this temperature below 40° C. An external cooling fan is required to ensure this for continuous duty operation.

3.3 ELECTRICAL

3.3.1 INPUT VOLTAGE:

12 ± 3 VDC

3.3.2 INPUT CURRENT:

3.5 amps nominal at 12 VDC input at full power.

3.3.3 BEAM VOLTAGE:

Beam voltage is externally controlled over the range 0 to 90kV DC. The normal range for in-focus operation is 45-90kV.

3.3.4 BEAM CURRENT:

The PXS5-925 includes a constant beam power feature. The beam current is externally set to achieve the desired beam power level. But beam current is internally adjusted by the programmed kV to maintain the programmed beam power, limited to 8 watts. Thus, the beam current varies with kV; for example, at 90 kV, the maximum current is 89 µA, and as kV is lowered, the maximum current will increase to 178 µA at 45 kV. Beam current maximum is 180 µA.

3.3.5 OVERCURRENT PROTECTION:

The beam voltage will drop to a low value if the beam current exceeds 120% of the programmed value.

3.3.6 BEAM VOLTAGE AND CURRENT MONITORS:

Voltages proportional to beam voltage and beam current are available for remote indication of operating levels.

BEAM VOLTAGE MONITOR:

Scale factor is: 1.0 VDC = 20kV.
4.5 Volts ± 0.5% at 90kV.

BEAM CURRENT MONITOR:

Scale factor is: 1.0 VDC = 40uA.
2.5 Volts ± 1.5% at 0.1mA.

SOURCE IMPEDANCE:

1,000 Ohms ± 1%. Calibration is within specified limits when the impedance of the external indicating meters is greater than 1 MOhm. Lower impedance meters may be used if the voltage drop in the source impedance is taken into account in specifying the meter full scale sensitivity.

3.3.7 BEAM VOLTAGE AND CURRENT CONTROL:

The PXS5-926 is intended to be used with external 1,000 ohm potentiometers for control of beam voltage from 0 to 90 kV and beam current to achieve 0 to 8 watts. 89µA ± 1.5% at 90kV (8 watts). Alternatively, beam voltage and current can be controlled by external voltage sources variable over the range 0 to 4.5 VDC to give 0-90kV and 0 to 2.25 VDC to give 0-8 watts. From 45 to 90kV, beam current can be programmed for up to 8 watts. Below 45kV, beam current is limited to a maximum of 180uA.

3.3.8 ON-OFF CONTROL:

X-ray ON-OFF control is by switching the input power. Refer to customer interface schematic, page 7. There are two switches shown, a standby and an operate switch. When standby power is applied, the cathode heater is on and the warm up time to allow normal operation is about 60 seconds. When the operate power is applied, the beam voltage and current will increase to the programmed values.
IF BOTH SWITCHES ARE USED, INSURE THAT THE STANDBY POWER IS NEVER REMOVED BEFORE THE OPERATE POWER IS REMOVED, OR DAMAGE TO THE X-RAY SOURCE WILL RESULT.

4. INSTALLATION AND OPERATION

4.1 UNPACKING AND INSPECTION

Inspect package exterior for evidence of shipping and handling damage. **IF DAMAGE IS DETECTED, A CLAIM WITH THE CARRIER SHOULD BE FILED IMMEDIATELY. DO NOT DESTROY OR REMOVE ANY OF THE PACKING MATERIALS IN A DAMAGED SHIPMENT**. If no exterior damage is detected, proceed to carefully unpack the equipment. Examine the unit for any signs of damage including leaked oil. Always use extreme care when handling the source near the beryllium window.
If any damage is found, immediately contact Thermo Kevex X-Ray.

4.2 INTERCONNECTIONS

Refer to the customer interface schematic, page 7, for connections to the control equipment. This drawing shows a simplified controller schematic which does not include safety interlocks, warning devices, timers, key switches, indicator lights or other features which may be required by applicable regulations or safety codes.

4.3 INSTALLATION

Install the source in its intended location or in a radiation shielded test box. The source requires an external cooling fan to maintain a safe temperature for continuous duty operation (see section 3.2.3). **It is strongly recommended that the temperature of the tube mounting plate be monitored on new installations to ensure safe operation.**

4.4 OPERATION

Connect suitable meters to the voltage and current monitor terminals as shown on the interface schematic, page 7. Set the beam voltage (kV) and beam current (µA) controls to zero and apply the 12 VDC operate power. Raise the voltage control and then the current control to about 20% of maximum. Check for radiation leaks from the shielded enclosure with a survey meter. Progressively raise the beam voltage and current following the run-up procedure (Section 6) checking for radiation leakage at each new level of operation. Add additional shielding if leakage is excessive.

After this initial operation of the source, it is permissible to operate at maximum power. However, it is not recommended to apply operate power with the controls set to their maximum values. **Even after conditioning the source, it is recommended to ramp the beam voltage slowly, over a period of at least 30 seconds, to the desired operating point, especially if the operating point is over 70 kV.**

5. TEST PROCEDURES

If it is suspected that the x-ray source does not perform according to specifications, the following evaluation procedure should be followed:

5.1 Install the unit in a shielded enclosure.

5.2 Apply 12 VDC standby power to the unit. Verify that the voltage control signal varies with potentiometer setting up to 4.5 VDC maximum. Turn on the operate switch and verify the beam current control signal varies with potentiometer setting up to 5 volts maximum. With the controls set to maximum, check that the output at the voltage monitor terminals is 4.5 VDC and the output at the current monitor terminal is 2.25 VDC, measured with a high impedance voltmeter. The total input current from the 12 VCD supplies should be about 3.5 amps. Measure the source output using an ion chamber such as is listed in the specifications.

5.3 If any of the measurements in 5.2 are fluctuating, listen for a ticking sound which could indicate that there is an electrical discharge in the x-ray tube. If ticking noises are audible, repeat the run-up procedure (Section 6).

5.4 If the problem cannot be resolved, contact Thermo Kevex X-Ray for further assistance. The x-ray source is not user repairable and no attempts should be made to dismantle the unit or to adjust the internal pre-set controls.

6. CONDITIONING

An periodic conditioning (or run-up procedure) is required to ensure safe operation, maintain the warranty and help prolong the life of the source. Increasing the target voltage in steps allows the source to become high voltage "conditioned", which prevents arcing and damage to the source. When operating a new source or one that has been idle for more than two days, begin with the target voltage and tube current controls set at their minimum values, and take 10 to 15 minutes to run the source up to full power. At each step in the run-up schedule below, first increase the beam voltage and then the current, waiting at least the minimum time before proceeding to the next step.

IMPORTANT: WHEN RUNNING A SOURCE UP TO FULL POWER, ALWAYS BE ALERT TO ANY ARCING. IF MORE THAN TWO ARCS ARE OBSERVED, DECREASE THE BEAM VOLTAGE TO THE PREVIOUS STEP. THEN WAIT AT LEAST THE MINIMUM TIME, STEP THE VOLTAGE BACK UP AND CONTINUE THE PROCEDURE, **ALWAYS BEING ALERT TO ARCING** (an audible ticking sound will be produced when an arc occurs).

RUN-UP SCHEDULE

STEP	% OF MAX kV	% OF MAX mA	MINIMUM TIME
1	20	0	1 MINUTE
2	40	10	1 MINUTE
3	60	30	2 MINUTES
4	80	50	2 MINUTES
5	90	70	3 MINUTES
6	100	100	3 MINUTES

Once the source has been fully conditioned, turning on x-rays with both the beam voltage and current set to their maximum values is possible. However, the following guidelines are best kept in mind when establishing your own operating routine.

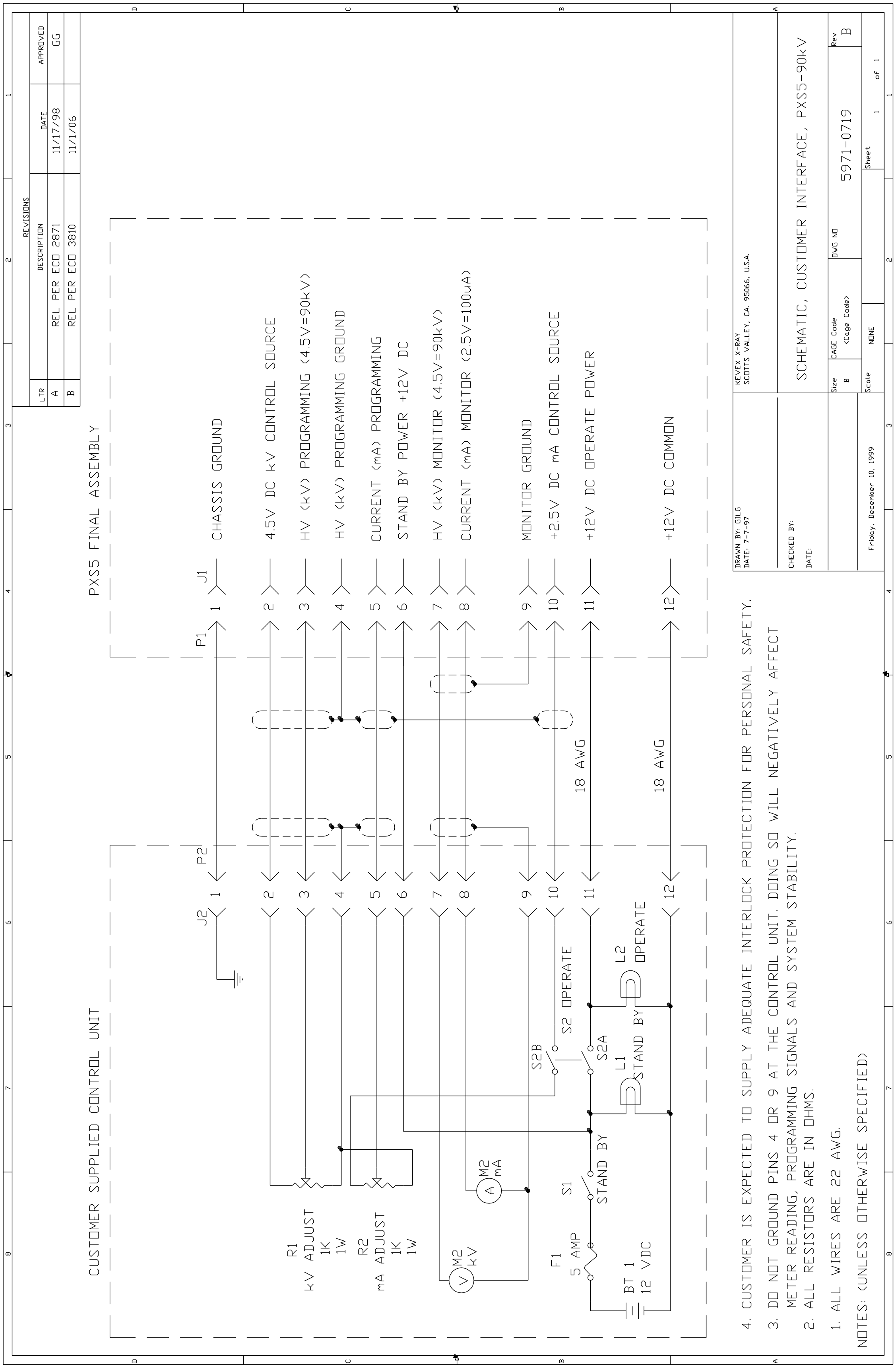
1. If the source is to be used throughout the working day, continuous operation within specified ratings will maintain the source at its normal operating temperature and minimize warm-up drift.

2. Frequent on-off cycling to full power, is stressful to the source. This is especially true if x-rays have been off for several hours or more. In this case, it is recommended to run a short version of the run-up schedule above. For example, if x-rays have been off more than a few hours, but less than 2 days, start the source at 50% of max kV and run it up to full kV and mA over a 1 minute period.

3. Occasional arcs are inherent in x-ray equipment and should not cause alarm. However, frequent arcing which cannot be stopped by repeating this run-up procedure is indicative of a fault in the x-ray source.

4. The source is not focused below 45kV and operation with beam current below 20kV is not recommended.

7. SCHEMATIC, PXS5, CUSTOMER INTERFACE



8. APPENDIX A

8.1 X-RAY SOURCE RUN-UP PROCEDURE

The purpose of the Run-Up Procedure is to safeguard and help prolong the life of the source. This incremental approach to reaching the working voltage allows the source to completely condition itself and prevent premature damage.

When operating a new source or one that has been idle for several days, increase the beam voltage slowly, taking typically 15 minutes (or more, depending on the idle time) to reach the full rated voltage. At the same time, raise the beam current slowly to its maximum value, alternating increases in Voltage and current in a manner similar to the daily run-up.
IT IS UNLIKELY THAT THE SOURCE WILL ARC, BUT IF IT DOES (as indicated by an audible ticking or jump in the kV and mA monitor levels), SHUT OFF THE HIGH VOLTAGE AND WAIT A MINUTE, THEN RESTART THE RUN-UP AT A SLOWER RATE.

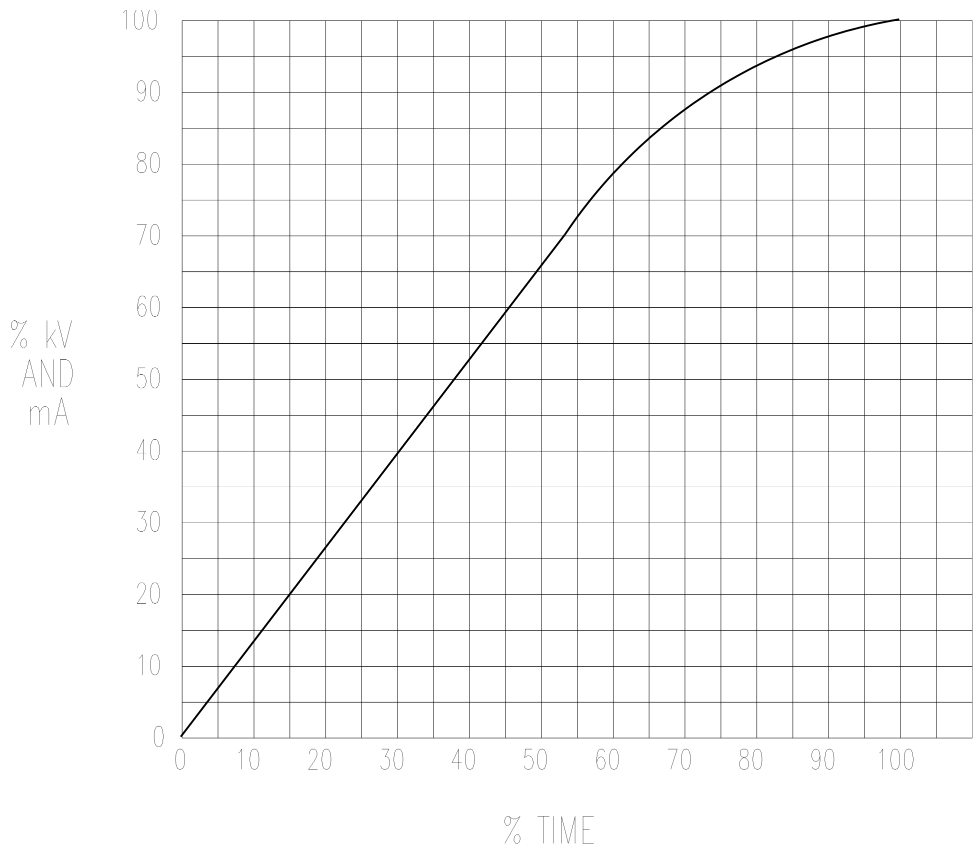
When a source is to be used several times during a working day, turn it on at the start of the day and leave it running. This avoids frequent on-off cycling and has the added benefit of keeping the system at its normal operating temperature, and minimizing warm-up drift. If practical, keep the source running at two-thirds maximum voltage and one-fourth maximum current. If the source must be shut down when a sample is changed, when restarting, raise the voltage and current back up slowly (30 to 60 seconds) to minimize stress to the source.

Even with a source in constant use, **DO NOT TURN ON MAXIMUM VOLTAGE SUDDENLY.** Instead, switch the source on at one-half voltage, then take about 30 seconds to raise the voltage to its maximum value. This can be done at normal source current.

When using a source with a filamentary electron gun, **AVOID PROLONGED OPERATION AT LESS THAN 5kV AND HIGH CURRENTS.** The filament operating temperature under these conditions is higher than normal, thus decreasing filament life expectancy.

Ensure that the source cooling system is performing adequately. This is particularly important since the maximum allowable housing temperature typically is 50 ^{o} C. A good target for normal operating temperature is <40° C.

Suggested daily run-up schedules for sources by kV range are given in the following graph (Page 10).



TIME TO REACH 100% OF MAXIMUM RATED kV AND mA:

Max Rated kV	TIME
50	10 minutes
70	10 minutes
90	10 minutes
110	12 minutes
130	15 minutes
160	20 minutes

For an example, take a source which is rated at 90kV, 0.089mA:

1. Look at chart on left to find that it should take 10 minutes to get full kV and mA.
2. Next, equate the 90kV and .089 mA to 100%.
3. A typical run-up would then follow the graph above. 50% time would equal 5 minutes. From the graph, 50% time equals 65% kV and mA, which would be 58.5 kV and .058 mA.

This is a general daily run-up schedule.
Always be alert to arcing and reduce Kv if any arcs are noticed.

8.2 COLD RUN-UP TIME FOR INACTIVE X-RAY SOURCES

The following run-up times should be used for an x-ray source that has been left inactive for an extended period of time.

Run-Up Time for X-Ray Sources with Maximum Operating Voltage up to:

Off Time	50kV	90kV	130kV
1 day	10 minutes	15 minutes	15 minutes
1 week	20 minutes	25 minutes	30 minutes
1 month	50 minutes	60 minutes	70 minutes
2 months	80 minutes	90 minutes	100 minutes
2-6 months	2 hours	3 hours	3 hours
over 6 months	3 hours	4 hours	4 hours

To bring the x-ray source to full power, follow the Kevex X-Ray "SOURCE RUN-UP PROCEDURE". For long inactive periods (in excess of 2 months) the recommended run-up times should be considered a minimum. Great care should be taken to bring inactive sources up to full voltage.

Recommended Operation During Storage

*An x-ray source held in storage should be operated periodically. We recommend that the source be brought to full power (following the run-up procedure listed above) monthly. The source should then be left operational in an appropriate radiation enclosure for a period of one to two hours.

8.3 WARNING, TUBE TEMP

WARNING

During normal operation of **KEVEX** x-ray tubes, the temperature of the tube housing should not be permitted to rise above 55° C. Operating temperatures in excess of this may lead to instability of the x-ray output or premature tube failure.

Depending upon the ambient temperature within the equipment using the tube and the tube operating duty cycle, this may require the use of a fan or blower with its output directed at the tube housing.

No **KEVEX** x-ray tube should be exposed to harsh chemical environments that could result in window corrosion and premature tube failure.

Any liquid cooled tube or power supply that is returned to the factory for any reason must have all cooling lines purged of glycol or similar coolants, by flushing them with water.

8.4 MATERIAL SAFETY DATA SHEET

October 1, 1996

SECTION I - PRODUCT IDENTIFICATION

This x-ray tube uses a **beryllium** x-ray window.

SECTION II - BERYLLIUM MANUFACTURER

Brush Wellman, Inc., 14710 W. Portage River S. Road, Elmore, OH 43416-9502
24-Hour Emergency Assistance: (800) 862-4118

SECTION III - HAZARDOUS INGREDIENTS

Beryllium Metal: The x-ray window is made of 100% beryllium metal.

SECTION IV - PHYSICAL DATA BERYLLIUM

Appearance:	Varies in color from a grey metallic to a dull greyish red solid
Odor:	None
Atomic Weight:	9.01
Melting Point:	1278 + 5^{O}C
Boiling Point at 1 ATM:	2970^{O}C
Solubility:	N/A
Specific Gravity at 20^{O}:	1.85
Vapor Pressure:	N/A

SECTION V - FIRE AND EXPLOSION HAZARD DATA

Beryllium will ignite at approximately 1200^{O}F. Since the amount of beryllium used is very small, use a fire-fighting agent or media appropriate for the surrounding fire.

Flash Point: NE	**Lower Flammable Limit:** NE
Upper Flammable Limit: NE	**Auto-Ignition Temperature:** 1200^{O}F

NE = NOT ESTABLISHED

SECTION VI - HEALTH HAZARD

Effects of Over Exposure:
Inhalation of beryllium particles may cause berylliosis, a serious chronic lung disease, with cough, chest pain, shortness of breath, weight loss, weakness, and fatigue.

First Aid:
If exposed or if cut by beryllium, remove from area and consult a physician. Handling of solid shapes presents no dermatitis or skin absorption problem.

Potential Carcinogen:
Beryllium is a material which has been listed, principally on animal tests, as a potential carcinogen in the International Agency for Cancer Research Monograph Series and the National Toxicology Program Annual Report on Carcinogens identifying it as a potential cancer hazard.

SECTION VII - REACTIVITY DATA

Oxidation will form on solid shapes when moist. Beryllium with acids may generate hydrogen. Moisture will corrode beryllium and may dissolve through the window in a matter of days.

SECTION VIII - SPILL AND DISPOSAL PROCEDURES

Beryllium metal scrap, and chips are normally recycled. However, in cases where this is not justified, solid material may be landfilled.

If a beryllium window breaks, cover the open part with plastic and tape in place. Wear gloves. Pick up small pieces of beryllium with the sticky side of the tape. These small amounts of beryllium may be disposed of in a landfill as mentioned above.

SECTION IX - SPECIAL PROTECTION INFORMATION

Do not touch the beryllium window, it is extremely fragile and can be toxic. Because of toxicity, it is recommended as a precaution that if the window is accidentally touched you immediately wash your hands with soap and water.

SECTION X - MISCELLANEOUS INFORMATION

The above information is believed to be accurate and represents the best information currently available to us. However, because we do not manufacture the beryllium metal or the beryllium x-ray windows, we make no warranty of merchantability or any other warranty expressed or implied with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes.
See Kevex X-Ray "Radiation Safety Data Sheet" for information regarding radiation hazards.

8.5 RADIATION SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

X-ray tubes and portable x-ray sources.

SECTION II – MANUFACTURER

Thermo Fisher Scientific
320 El Pueblo Road
Scotts Valley, CA 95066
Telephone:(831) 438-5940

SECTION III – HAZARDS

X-Ray radiation is a form of ionization radiation that is potentially very hazardous. The most intense and therefore dangerous part of the instrument is the path of the incident X-ray beam. Thus care should always be exercised to know the expected path of the incident beam. Scattered radiation is typically of such reduced intensity that it poses a much smaller health risk to the researcher.

There are several properties of X-Rays that make this type of radiation particularly dangerous to use in the laboratory. X-Ray radiation cannot be sensed by a human! Some people feel a tingling sensation on their skin when they are around X-Rays from an analytical instrument. They are not feeling the X-ray beams, but rather they are feeling charged air particles produced by the interaction of the ionizing X-Rays with air. If you ever feel a tingling sensation when working around any analytical X-Ray instrument, immediately turn off the instrument and contact the Radiation Safety Officer (RSO). Since only some people feel this tingling sensation, do not assume that if the sensation is not present, that the instrument cannot hurt you. Please note that the two shutters on the instrument are interlocked to the cabinet doors so that if either door is opened, the shutters should close.

Care should be taken when using any analytical X-ray instrument. Never put any part of your body in the expected path of the main beam. Avoid being around the X-Ray tube housing and main beam path as much as possible. Keep the enclosure doors closed whenever possible.

Although X-ray instruments have the potential to be dangerous; when used properly, modern diffraction X-ray instruments pose few risks to careful users. The manufacture and use of analytical X-ray instruments is regulated by both federal and state governments. Current regulations require that a variety of safety devices be built into X-ray instruments that make it very difficult for anyone to even accidentally expose herself or himself to the dangerous incident X-ray beam. The design of the instruments limits even accidental exposures to the hands, arms, and facial areas. Generally, the types of radiation used in diffraction instruments (primarily Mo and Cu $K\alpha$ radiation) are considered soft or low energy radiation. Unlike medical X-Rays, these types of soft radiation generally will not penetrate more than 2-4 cm into the body.

SECTION IV - HEALTH HAZARDS

ALARA, ***As Low As Reasonably Achievable***, goals are also achieved by the user practicing safe techniques when using the X-Ray instrument. As noted above, the user should keep all parts of their body out of the expected main beam path at all times, especially when placing a sample in the instrument or removing a sample from the instrument. When the safety enclosure is opened, the user should keep as far from the X-ray source as practical. Finally, the cabinet doors should be kept closed whenever possible.

Health effects of exposure to X-ray radiation come in two general types, direct or indirect. X-Rays are thought to create radicals in exposed cells of your body that may break or modify chemical bonds within critical biological molecules. As a result (1) cells may be injured or damaged, although many cells repair themselves, resulting in no residual damage, (2) cells may die, which millions of body cells do every day and are replaced in a normal biological process, (3) or cells may incorrectly repair themselves resulting in a biophysical change. Finally, X-Rays may pass through the body with no interaction.

Factors that determine biological effects:

- Dose rate
- Total dose received
- Energy of the radiation
- Area of the body exposed
- Individual sensitivity
- Cell sensitivity
- Most sensitive tissues: Blood-forming organs, reproductive organs, digestive organs
- Least sensitive tissues: Nervous system, muscle and connective tissues

Studies indicate that the risk of cancer in children increases if the mother is exposed to significant X-radiation during pregnancy. The State of California and other Agreement States have established an exposure limit of 5000 millirems per year for occupationally exposed adults. Because the effect of radiation may be greater on an unborn child, the radiation dose limit recommended for them is 500 millirems. Women who are pregnant or expect to become pregnant soon may wish to consider the effect of radiation on their unborn children.

SECTION V - PRECAUTIONS

Each of the following steps must be followed for personnel and equipment safety:

-Insure that portable sources are securely anchored. Tubes should be anchored securely in a radiation proof enclosure with appropriate lead shielding. X-rays can scatter off objects and thus get around corners.

-Operate only when window is in an x-ray shielded chamber.

-Chamber access doors must be interlocked to prevent x-ray tube operation with the doors open.

-The beryllium window is fragile and toxic if scratched, do not subject the window to mechanical pressures.

-User must provide adequate shielding in the window area.

-The vacuum tube is glass and therefore fragile; do not drop mishandle and/or drop.

-Ground the tube mounting surface.

-Check the high voltage cables for frays or damage.

-Never kink or sharply bend the high voltage cable as it is used to supply a ground on the tube which, without proper grounding, is a lethal hazard.

SECTION VI - OCCUPATIONAL DOSE LIMITS

The State of California (see California Radiation Control Regulations, Title 17, California Administrative Code, Section 30265), and other Agreement States, have established maximum dose limits for individuals working in a radiation area. These limits have been established on a calendar quarter basis, but they may be expressed on a yearly, monthly, and hourly basis (assuming 40 hours of exposure per week for 50 weeks per year). The limits are as follows:

Body Part	Rems/CalQuarter	Rems/Year	Millirems/Mo	Millirems/Hr
Whole Body	1.25	5	417	2.5
Hands/Forearms/ Feet/Ankles	18.75	75	6,250	37.5
Skin of Whole Body	7.5	30	2,500	15

Differences in limits for different body parts are a direct consequence of the differences in their sensitivities to radiation. Hands, as an example, are considerably less sensitive to radiation than the body as a whole.

Your safety governing body may have different occupational dose limits. Please see your Radiation Safety Officer, RSO, for more information.

SECTION VII - BIOLOGICAL EFFECTS OF RADIATION

A complete description of the various effects of radiation is outside the scope of this document. Among the documented biological effects of radiation are various types of cancers, blood diseases, weakened bones, sterility, hearing problems, teeth loss, hair loss, digestive troubles, and skin burns. Radiation nonspecifically damages cells and tissues and can have both cancerous and non-cancerous effects.

SECTION VIII - EMERGENCY PROCEDURES

In case of a disaster such as fire, explosion, flooding, or earthquake, the X-Ray equipment must be de-energized immediately. Once de-energized, the x-ray equipment poses no radiation danger. After a disaster the X-Ray equipment must be surveyed before placing it back in operation. The proper approach for operation of X-Ray equipment is to perform the surveys at each power setting as the X-Ray equipment power is increased in a step by step manner from no power to maximum power.

SECTION IX - MISCELLANEOUS INFORMATION

This document serves as a source of basic radiation safety information for users of Thermo Fisher Scientific X-ray equipment. However, these guidelines are **not** to be used in lieu of any regulations specified by your officially recognized regulatory authorities (i.e., U.S. Dept. of Health and Human Services, Food and Drug Administration).