

SBC CAT

Environment, Safety and Health Plan

April 1, 2005

Andrzej Joachimiak, CAT Director

[Signature]

[Date]

SBC

Environment, Safety and Health Plan

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Section 1 SBC Safety Policies

1.0 Purpose

SBC is the national user facility for macromolecular crystallography and is committed to ensuring that all sector activities are conducted in a safe and environmentally sound manner. This plan describes the sector's safety program, which is implemented to fulfill this commitment

1.1 Scope

To ensure that all SBC activities are conducted in a safe and environmentally sound manner, this plan defines:

- 1) the standards to be followed by the SBC staff and users and
- 2) the responsibilities within the SBC organization.

1.2 References

All activities at Argonne National Laboratory (ANL) will conform to the requirements of the documents listed below, except as provided for by variances of Biosciences Division or APS procedures. All of the following are available through the SBC Safety Coordinator.

1. ANL Environment, Safety and Health Manual
2. APS User Policies and Procedures
3. ANL Hoisting and Rigging Manual
4. ANL Transportation Safety Manual
5. ANL Waste Handling Procedures Manual

1.3 General Policies

- 1) Failure to conform to this plan may result in sanctions and/or the loss of access to the APS and SBC facilities.
- 2) Any person has the authority to stop activities that are unsafe or environmentally unsound. In addition, the SBC acknowledges that the APS has the authority to order a halt to SBC activities that the APS, or other entities with oversight responsibilities, deem unsafe or not in compliance with requirements.

- 3) The SBC will comply with current version of the APS Policy and Procedure for configuration control of shielding systems. No safety system under configuration control is to be modified without SBC and APS approval. (Refer to the APS User Policies and Procedures for the complete policy and procedure).
- 4) The SBC will cooperate with the APS to facilitate the oversight responsibilities of the APS, ANL and the DOE.
- 5) The SBC will implement an experiment safety review program. The program will be kept current with the relevant APS policies and procedures, including those set forth in Technical Updates, User Policies and Procedures, and AOD Division Director memoranda covering the subject.
- 6) Experimenters shall identify to the SBC the potential hazards associated with their activities and hazardous materials to be used in experiments at the APS (via the APS Experiment Safety Assessment Form (ESAF), and no experiment shall proceed without a SBC and APS approved ESAF and posted APS Experiment Authorization Form (ESA) and Experiment Hazard Control Plan (EHCP).
- 7) Any new or modified equipment and unreviewed activities must be approved by the SBC Director, or designee, prior to energizing the equipment or the start of work. The SBC will obtain the written approval of the APS Operations Division Director, or designee before any changes are made in the SBC's operations that might reasonably be thought to increase the risk or have an adverse impact on the APS facilities, the environment or any person.
- 8) The SBC will maintain a list of current safety assignments (Appendix A) and will update this plan to keep it consistent with scope of SBC activities. The assignment list will be reviewed at least annually and the plan biannually with updates provided to the APS User Safety Officer.

1.4 SBC Specific Policies

- A. Prior to a user group starting an experiment at the sector the group will submit to SBC a completed SBC Hazard Assessment Form (refer to Appendix C.1)
- B. SBC Sector Orientation
 1. SBC staff will provide its own Sector Orientation (refer to Appendix C.2) to all staff members and users, in accordance with the APS Policy and Procedure for Sector Specific Training.
 2. Included in SBC Sector Orientation is a complete orientation to the Biochemistry Laboratory (refer to Appendix C.3).
 3. Included in SBC Sector Orientation are procedures to be followed for the transport of samples, equipment back to a users home institute (refer to Appendix C.4).

4. Sector Orientation will be given to all staff and users, after their arrival at the sector and before the start of their work, if one of the following is applicable:
 - a. User is a new user of the SBC facility
 - b. It has been two years since the user's last sector orientation.
 - c. If the user is a General User then sector orientation is given at each visit to SBC
 - d. Any significant changes have been made to the SBC facilities, policies, or procedures since the user's last visit to the sector
- C. SBC staff members and users, when working with heavy-atom reagents, will follow the 'SBC Standard Operating Procedure for Derivatization of Macromolecular Crystals with Heavy-atom Reagents' (refer to Appendix C.5).
- D. Use of the SBC Analytical X-ray Generator.
 1. Only those staff that have ANL ES&H training and are trained and authorized by the Analytical X-ray Equipment Custodian are allowed to operate the equipment.
 2. The procedures and checklist to be followed for the maintenance and operation of the Sealed Source Analytical X-ray Generator are given in the instructions document and checklists (refer to Appendix C.6).
- E. Only trained and authorized staff or users are allowed access and use of the sealed source.

Section 2 - SBC Safety Organization & Responsibilities

The SBC **Director** has line responsibility for safety for all SBC activities at ANL and for ensuring that this plan is implemented. The Director is also responsible for evaluating and responding in a graded manner to noncompliance with this plan.

The SBC **Safety Coordinator** reports to the SBC Director and is responsible for implementing and overseeing conformance with this safety plan. The SBC Safety Coordinator is to ensure that the SBC has access to the ANL-E ESH Manual and the other identified standards and to assist SBC members and users in meeting the requirements of these standards.

The SBC **Electrical Safety Coordinator** is appointed by the SBC Director and is responsible for electrical and mechanical safety and ensuring compliance with ANL electrical and mechanical safety standards in all of the SBC's facilities. The Electrical Safety Coordinator is to be aware of ANL ESH Manual defined electrical safety requirements as typically attained through completing ANL electrical safety and LOTO training and should complete ESH375, NFPA70E training

The SBC **Mechanical Safety Coordinator** is appointed by the SBC Director and is responsible mechanical safety and ensuring compliance with ANL mechanical and vacuum safety standards in all of the SBC's facilities.

The SBC **Chemical Safety Coordinator** is appointed by the SBC Director and is responsible for chemical safety, including chemical waste management, and ensuring compliance with ANL and OSHA chemical safety standards in all of the SBC's facilities. The Chemical Safety Coordinator is also responsible for the SBC's proper use of the ANL Chemical Management System. The Chemical Safety Coordinator is to be aware of ANL ESH Manual defined chemical safety requirements.

The SBC **Transportation Safety Coordinator** is appointed by the SBC Director and is responsible for overseeing the safe transportation of materials to and from the SBC and ensuring compliance with ANL transportation safety standards. The shipping coordinator is to be aware of ANL transportation requirements as well as APS specific shipping and receiving requirements. The Transportation Safety Coordinator will remain current in the APS transportation safety course.

The SBC **Hoisting and Rigging Coordinator** is appointed by the SBC Director and is responsible for overseeing the safe use of hoisting and rigging equipment and compliance with ANL hoisting and rigging safety standards. They are also responsible for having the equipment inspected as required by ANL.

The SBC **LOM Shop Coordinator** is appointed by the sector Director and is responsible for ensuring that all sector staff, and users using the LOM Machine Shop in Building 435 follow the APS Policy and Procedure for LOM Shop Usage and will post a list of

authorized shop users. The LOM Shop Coordinator also ensures that all shop equipment is in safe working order, provides training to users qualified to operate shop equipment, and recommends repairs for equipment that is deemed to be unsafe for use, in disrepair, or unusable. The LOM Shop Coordinator will work closely with other LOM Machine Shop coordinators in the building and with the Floor Coordinators.

The SBC **Sealed Source Custodian** is appointed by the SBC Director and is responsible for inspections and appointing authorized users of the sealed source. They are responsible for insuring that SBC activities conform to the applicable ANL regulations and procedures through familiarity with appropriate chapters and sections in the ANL-E ES&H manual.

The SBC **Analytical X-ray Equipment Custodian** is appointed by the SBC Director and is responsible for the analytical x-ray generators within the SBC facility. They are responsible for insuring that SBC activities conform to the applicable SBC approved procedures and ANL regulations and procedures through familiarity with appropriate chapters and sections in the ANL-E ES&H manual.

The SBC **Biochemistry Laboratory Safety Officer** is appointed by the SBC Director and is responsible for overseeing the safe operation of the SBC biochemistry laboratory and compliance with ANL and APS regulations

Appendix A - Safety Assignments & ESAF Approvers

Appendix A.1
SBC Safety Assignments

April 1, 2005

Assignment	Person assigned
SBC Director	Andrzej Joachimiak
SBC User Program Safety Coordinator	Stephan L. Ginell
SBC Electrical Safety Coordinator	Michael Molitsky
SBC Chemical Safety Coordinator	Norma Duke
SBC Transportation Safety Coordinator	Stephan L. Ginell
SBC Mechanical Safety Coordinator	Michael Molitsky
SBC Hoisting and Rigging Coordinator	Randy Alkire
SBC LOM Shop Coordinator	Michael Molitsky
SBC Sealed Source Custodian	Harold E. Gaines
SBC Analytical X-ray Equipment Custodian	Frank Rotella
SBC Biochemistry Laboratory Safety Officer	Norma Duke

Appendix A.2

SBC Personnel with Experiment Safety Approval Authority

As Director of SBC, I authorize the following personnel to conduct hazard evaluations of experimental activities, to specify required control measures, and approve such activities where specified controls have been implemented. Revisions to this list will be forwarded to the APS User Safety Officer:

1. Andrzej Joachimiak
2. Stephan L. Ginell
3. Randy Alkire

Andrzej Joachimiak, Director

[Signature]

[Date]

Appendix B

Standard Procedures Used by SBC

April 01, 2005

SBC has evaluated the hazards that will be encountered in its operations, and, to mitigate these hazards the SBC will follow the unmodified APS Standard Procedures listed below. (Links to these procedures can be found on the APS User Safety web page.)

1. The Management of Hazardous Waste
2. APS Technical Update 23: Transportation of Small Quantities of Hazardous Materials
3. Transportation of Hazardous Materials
4. Hand Tool and Portable Power Tool Usage
5. Guideline for Personal Protective Equipment
6. Work Area Demarcation, Warnings and Controls
7. Electrical Safety Work Practices
8. Management of Chemicals
9. Hoisting and Rigging Operations
10. LOM Shop Usage
11. APS User Safety Guide (ANL/APS/TB-23)
12. APS Experiment Hazard Classes

Appendix C

SBC Specific Procedures

SBC has evaluated the hazards that will be encountered in its operations, and, to mitigate these hazards, the SBC has developed and will follow the procedures listed below. The titles of the procedures should be self-explanatory.

Date: April 1, 2005

1. SBC Hazard Assessment Forms
2. SBC Sector Orientation
3. Biochemistry Lab Orientation
4. SBC User Shipping Preparation Instructions
5. Standard Operating Procedure for Derivatization of Macromolecular Crystals with Heavy-atom Reagents
6. Procedures for use of Analytical X-ray Equipment
 - 6.1 Use of the Kevex 3067 X-ray generator for flood field work sbc/aps sector 19 beamlines
 - 6.2 Procedures for operating the Kevex X-ray generator sbc/aps sector 19 beamlines
 - 6.3 Verification of the safety interlock system for the Kevex X-ray generator SBC/APS sector 19 beamlines
 - 6.4 Kevex X-ray generator assembly checklist SBC/APS sector 19 beamlines
 - 6.5 Safety interlock verification checklist for the Kevex X-ray generator SBC/APS sector 19 beamlines

Appendix C.1

SBC Hazard Assessment Form February 4, 2000
Virus Questionnaire Form (appendix C-2a) April 5, 1999
Virus/Biohazard Information Form (appendix C-2b) April 5, 1999

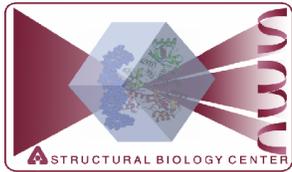
pdf copies of these forms can be found at:

<http://www.sbc.anl.gov/userprogram/visitprep.html>

Appendix C.2

SBC Sector Orientation October 2004

(See next page)



Beamline Orientation

APS User Administration

- o Complete the APS User Orientation and the General Employee Radiation Training (GERT)
- o Obtain APS user badge for access to ANL gate, APS building, and SBC office & laboratory

SBC User Administration

- o Obtain dosimeter (optional; not required by APS)
- o Complete online SBC Sector 19 User Registration

Emergency and Facility Safety

- o Learn Emergency Medical and Security Phone Number: 911
- o Learn how to call APS Floor Coordinator: Pager 2-0101 (*Dial 2-0101, listen to message, enter sector 19 telephone number (2-9823 or 2-9833), press # key, hang up, and wait for coordinator to call.*)
- o Learn Fire Alarm Notification: Continuous ringing means EVACUATE IMMEDIATELY
- o Learn Tornado Alert: Notification via loud speaker tone followed by action message (*Tornado shelters are located in machine shop and restrooms in LOMs.*)
- o Locate nearest Fire Extinguishers
- o Locate nearby Emergency Exits
- o Read Emergency Information on yellow Safety Information board
- o Locate telephones and list of emergency phone numbers for SBC personnel

Beamline Safety and Operations

- o Read "Tour Guide to the SBC Facilities at APS" and/or complete the tour.
- o Complete Experiment End Station Orientation
- o Complete Personnel Safety System (PSS) Training
- o Complete "Biochemistry Laboratory Orientation" (Training Checklist 2)
- o Fill out User Locator (Lyme Green) card
- o Call Floor Coordinator and request posting of "APS Experiment Safety Approval Form"
- o Sign three copies of "APS Experiment Safety Approval Form", ask SBC staff host to sign same, and post signed form on yellow Safety Information board
- o Fill-in & sign this checklist; post this checklist on yellow Safety Information board

I understand the safety and operational procedures outlined above and agree to operate the beamline and conduct my experiment in a safe manner. I understand that my beam time

starts at _____ ***on*** _____ ***and ends at*** _____ ***on*** _____ .

Institutional Affiliation: _____ **SBC Exp. Tracking No.** _____

User's Name	Badge #	Signature	Date

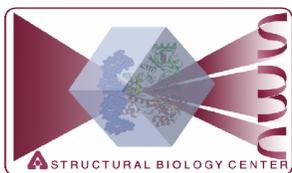
Training valid for this experimental run only. SBC Staff Instructor _____

Appendix C.3

Biochemistry Lab Orientation

October 2004

(See next page)



Emergency and Facility Safety

- o Read the Emergency Information posted on the yellow Safety Information board
- o Locate telephones and list of phone numbers
- o Locate nearest Fire Extinguishers
- o Locate nearest Emergency Exits
- o Locate Emergency Eyewash
- o Locate Emergency Shower
- o Locate safety glasses
- o Locate gloves
- o Locate lab coats (*magenta for use with radioactive materials; blue for all other work*)
- o Have you brought any radioactive materials or hazardous chemical materials?
- o Update, verify, and sign your Hazard Assessment Form and return form to SBC host
- o Locate MSDS (Material Safety Data Sheets) posted outside laboratory door near APS floor.
- o Locate radiation survey meter and learn proper usage
- o Locate hazardous chemicals spill kit and learn proper usage

Introduction to Laboratory

- o Label your equipment and supplies with the user-symbol-coded labels so that we can contact you about items you might have left behind
- o **Fill-in this checklist and post it on the yellow Safety**
- o Store your user-symbol-coded labels in the rack on the yellow Safety Information board
- o Locate laboratory bench work area for your group
- o Locate purified water and learn procedures for dispensing (*demonstrated by volunteer*)
- o Locate microscope and learn operations procedures (*instructions are posted on wall*)
- o Locate chemical storage cabinets and learn proper storage of chemicals
- o Learn proper labeling of chemicals (*label with Name, Date, and Contents*)
- o Learn proper disposal of chemicals *NOTE: For Hazardous Waste Disposal, contact SBC staff.*
- o Locate chemical fume hood and learn operations procedures
- o Learn safe use of cryogenic liquids (*nitrogen, propane*)
- o Locate cryocrystallographic tools and dewars
- o Learn that if you choose to store crystals at the SBC facility, it is at your own risk
- o Learn labeling protocol for crystals to be archived in the SBC liquid nitrogen dewar
- o Learn labeling protocol for crystal trays to remain at the SBC facility

Introduction to Cold Room

- o Locate work area for your group
- o Locate microscope and learn operations procedures

Biochemistry Laboratory Work Station Assignment: _____ Information board

Institutional Affiliation: _____

Principal Investigator: _____ SBC Exp. Tracking No.: _____

Appendix C.4

SBC User Shipping Preparation Instructions

October 2004

(See next page)

SBC User Shipping Preparation Instructions

Instructions: (Additional CAT specific requirements may be in place, consult the CAT Transportation Safety Coordinator)

- A. Write your initials in each blank to signify that you have completed the specified action.
- B. If a statement does not apply indicate with N/A.
- C. If more than one container label as A, B, C, etc.
- D. Sign and date the completed instructions affirming that all responses are accurate.

1		<p>The package is a shipping dewar:</p> <ul style="list-style-type: none"> • Remove free liquid nitrogen from the dry shipper. REQUIRED for SHIPPING • Place the neck-tube insert in the “dry shipper” and secure the insert using a cable tie or lock. If secured with a lock, attach the key or combination in a readily accessible location inside the outer shipping container. • Remove all labels on the outer container. • Complete Fed Ex Airbill
2		<p>The dewar CONTAINS <u>only</u> non-hazardous frozen crystals in nitrogen (NO propane/freon/ethane/etc.):</p> <ul style="list-style-type: none"> • Remove all labels on the outer container except “KEEP UP RIGHT, UPWARD-POINTING ARROW, FRAGILE DO NOT DROP, AND CONTACT IF SHIPPMENT IS DELAYED (OPTIONAL)”. • Complete the “Attachment to Shipping Order” form. • Complete ANL form 126C (HIGHLIGHTED SECTIONS)
4		<p>The dewar CONTAINS propane, freon, ethane or hazardous crystals.</p> <ul style="list-style-type: none"> • Complete the CAT Dry Shipper form. • Complete ANL form 126C (HIGHLIGHTED SECTIONS). • Complete the “Attachment to Shipping Order” form. • Complete the CAT Hazardous Manifest form –CAT version. • Supply an MSDS for each chemical to be shipped. • Attach letter of Competent Authority CA-9807017 (found in TUD-25) [Note: International shipments may require approval by the government of the destination country].
5		<p>The package is not a dry shipper and it CONTAINS NO chemicals or solutions (including lubricants, solvents and commercially available items such as cleaning compounds, detergents and solutions):</p> <ul style="list-style-type: none"> • See SBC Staff for shipping arrangements.
6		<p>The package is not a dry shipper and it CONTAINS chemicals, solutions or hazardous substances (including lubricants, solvents and commercially available items such as cleaning compounds, detergents and solutions). These packages MUST be shipped through ANL Shipping.</p> <ul style="list-style-type: none"> • Inform the CAT Transportation Safety Coordinator that you will be shipping hazardous material. • Supply an MSDS for each chemical to be shipped. • Complete the ANL Hazardous Manifest form – PFS-SS/MAT 001. • Complete ANL form 126C (HIGHLIGHTED SECTIONS). • Verify that all materials/equipment are listed on the ANL 126C. • Contact ANL Shipping for hazmat pickup.
7		<p>Give your completed forms to your host or the CAT administrative assistant NOTE: Users are not to arrange for the direct FedEx pickup of shipments.</p>

Name: (print) _____ Signature: _____

Affiliation: _____ Date: _____

Host Signature: _____

Tracking Number: _____ Shipping Order No: _____

All sections must be complete and Fed Ex account number correct or dewars will not be shipped.

SHIP DEWARS TO:

Attention: _____

Affiliation: _____

Address: (No PO Boxes) _____

City: _____ State: _____ Zip: _____

Country: _____ Phone #: _____

Federal Express Account Number: _____ - _____ - _____

Overnight _____ 2nd Day Air _____ Amount Insured on each \$ _____

Number of Dewars: Hazardous: _____ Non-Hazardous: _____

Does Dewar Contain Propane: No _____ Yes/# _____

Does Dewar Contain Freon: No _____ Yes/# _____

Does Dewar Contain LN2: No _____ Yes/# _____

If yes, be sure to complete the Attachment to Shipping Order (see attached)

Please Note:

- 1) Be sure to dump all LN2 out of dewars before leaving SBC unless dewar will be shipped with LN2
- 2) Be sure to label your dewar, and if you have more than 1 dewar be sure to label them 1,2,3 or A,B,C

List other items that are being shipped:

Complete list of all chemicals or liquids must be included if they are not in the dewar. Provide MSDS and pack properly.

Appendix C.5

Standard Operating Procedure for Derivatization of Macromolecular Crystals with Heavy-atom Reagents
April 4, 2004

(See next page)

Standard Operating Procedure for Derivatization of Macromolecular Crystals with Heavy-atom Reagents

4 April 2005

Purpose

This procedure is to give sector staff and users guidance on the procedures to follow when performing heavy-atom derivatization of macromolecular crystals at SBC facility.

Assumptions

It is assumed that the staff and user personnel who will be conducting heavy atom soaks of macromolecular crystals are experienced in the standard biochemistry laboratory procedures, methodologies, and protocols required for safe and efficient conduct of these experiments. Those individuals that are not familiar with the procedures required to conduct heavy atom soaking experiments should seek training or assistance prior to commencing these experiments.

Safety Remarks

- 1) Most heavy atom compounds are moderately toxic but some are exceedingly toxic.
- 2) The following PPE must be used:
 - a. Safety glasses
 - b. Gloves
 - c. Lab coat
- 3) Material Safety Data Sheets must be on file for all heavy atom compounds to be used and must be read and understood by the experimenter.

Transport

- 1) The transport of heavy atom reagents must be conducted in accordance with ANL transport regulations while on ANL property and in accordance with DOT regulations while off ANL property
- 2) Transport on ANL site is prohibited in private vehicles.

Restrictions

- 1) No radioactive salts, radioactive solutions, or radioactively labeled samples in solution are permitted at the SBC facilities. (Macromolecular samples that have been soaked with radioactive heavy atoms or that have been radioactively labeled are permitted at the SBC facilities provided that they have been crystallized and frozen at the user's home institution and transported frozen.)
- 2) All pathogenic organisms are prohibited from the SBC facilities.
- 3) All heavy atom salts, solutions, pipette tips, wipes, vials, absorbent paper, and gloves are considered hazardous waste.
- 4) No hazardous waste is to be disposed of in the standard waste stream –i.e. sink, garbage pails, etc.

Procedures

- 1) All heavy atom soaks are to be conducted on a absorbent diaper or lab bench cover.
- 2) All heavy atom soaks are to be conducted in the hood. The only exceptions are if the

experiments need to be conducted in the cold room or with the assistance of a microscope. Only small volumes of non-volatile heavy atom solutions are permitted for work in the cold room.

- 3) All hazardous waste must be disposed under the guidance of a SBC staff member who has completed hazardous waste disposal training.

Appendix C.6

Procedures for use of Analytical X-ray Equipment

Appendix C.6.1

Use of the Kevex 3067 X-ray generator for flood field work SBC/APS sector 19 beamlines

(See next page)

USE OF THE KEVEX 3067 X-RAY GENERATOR FOR FLOOD FIELD WORK SBC/APS SECTOR 19 BEAMLINES

1. BACKGROUND:

Argonne National Laboratory's Structural Biology Center (SBC) is involved in the design, testing, and utilization of CCD area detectors, multimodular versions of which are installed at the SBC beamlines of the Advanced Photon Source (APS) at Argonne and are used to measure x-ray fields generated by diffraction from crystals of biological macromolecules. Electronic readout of the multimodular detector is multiplexed through 18 channels, each of which digitizes measured x-ray flux values on a single region of the detector area. Each of these 18 scaling areas is characterized by independent electronic gain and DC offset values. The gain and offset values may drift relative to each other with time. Since the experimental goal is to measure the relative Bragg diffraction intensities accurately, we must maintain accurate correlation among the x-ray response functions of the 18 scaling areas. This state of affairs therefore requires regular calibration of the detector's response to x-ray flux.

Calibration of the detector's nonuniform sensitivity to x rays requires that it be exposed to a uniform x-ray flood field: the correction function is simply the inverse of the recorded measurement of this flood field for each pixel. Generation of the flood field requires the use of an isotropic x-ray source. We have tested a small (200-W) x-ray generator with a sealed-tube copper target as an isotropic x-ray source, and it works well for this purpose. Our intention is to use this x-ray source in the end stations of the SBC/APS Sector 19 beamlines to generate isotropic x-ray fields. This source and its associated safety systems (described below) are designed and operated to comply with the standards set forth in *Radiation Safety for X-ray Diffraction and Fluorescence Analysis Equipment* (ANSI N43.2-1977).

2. DESCRIPTION OF THE INSTRUMENT:

The x-ray generator is a Kevex model 3067. It is capable of operating up to 30-kV accelerating voltage and 6.7-mA beam current: its top power rating is therefore 200 W. We have determined that if we operate this instrument with an accelerating voltage of 20 kV and a beam current of 1.0 mA, it generates sufficient x-ray flux to calibrate the SBC area detectors in 8–20 seconds. The x-ray field generated by this instrument exceeds 100 rad/hr in the forward direction (less than 2 mrad/hr in the backward direction), so that it requires careful management and control in its operation and should be used only inside an enclosed radiation shield.

The x-ray generator needs water cooling for its copper target. The recirculating water pump turns on whenever it is energized. The recirculated fluid is a 20% ethylene glycol in water mixture. The pump is interlocked to the generator via a "Thermal" circuit. If the pump fails or coolant is lost, the generator will stop producing x rays and will be unable to do so until recirculating coolant is made available and the generator is restarted.

The x-ray emitting tube of this generator is a small lead-and-steel cylinder at the end of a 4-foot-long high-voltage cable. A 1-cm-diameter beryllium window on the cylindrical surface permits emission of x rays from the tube. The tube is enclosed in a steel-and-aluminum rectangular housing (the "x-ray wand"), fitted with a steel shutter. The shutter is opened by energizing a solenoid, and is closed by de-energizing the solenoid. With the shutter closed and the generator "on", no discernible x-ray emission from this tube was observed upon radiation survey.

The x-ray generator should be turned on with an accelerating voltage and beam current both set to zero. They should be raised incrementally to their operating values of 20 kV and 1 mA, respectively.

The instrument cannot generate x rays without an energized high-voltage circuit. Turning off the high-voltage circuit stops it instantly from generating x rays. High voltage of the generator is interlocked with two circuits:

- a. A "High Voltage" interlock circuit, which must carry at least 300 mA through a light bulb. An open circuit or too little current causes the high voltage to trip off. This circuit is used to operate a warning light ("CALIBRATION X-RAYS ON") that indicates to the user that the unit is potentially dangerous.
- b. A "Chamber" interlock, which monitors the shutter and end station door. This circuit must be closed for the generator high voltage to remain powered up: a break in this circuit trips off the high voltage.

3. CREATING AN ENCLOSURE WITH THE END STATIONS:

The existing interlock circuitry of the Kevex 3067 generator has been extended so that each beamline end station now is a radiation enclosure for this generator. Features of this extended interlocking system are:

- a. Power to the x-ray generator can be interrupted. The 115-V AC power plug for the generator shall exit the end station and be plugged into a power source outside the end station, permitting the machine to be unplugged without entering the end station, if for any reason one must break power to the instrument.
- b. Implementation of shutter/end station door interlocks. The generator does not come with a ready-made circuit for the "chamber" interlock, but it is designed for beam enclosure monitoring. A microswitch has been installed on the shutter to close a circuit when the shutter is closed and open the circuit when the shutter is opened. We have installed a microswitch on the entrance door to each beamline end station, to close a circuit when the end station door is closed. The two circuits are connected in parallel. When the end station door is open, the generator high voltage can only be activated if the shutter is closed. Likewise, the shutter must be closed before the door is opened or the high voltage will trip off. This satisfies the criterion that the end station acts as an interlocked enclosure for the generator.
- c. "START SEARCH"/"SEARCH COMPLETE" buttons. The shutter and end station door are further interlocked by means of "search" buttons on the inside and outside of the end station. This system is distinct from and does not interact with the Personnel Safety Systems (PSS's) used at the APS Sector 19 end station enclosures, and it is similar to that used to interlock the photon and safety shutters to the experiment enclosure (hutch) doors at the synchrotron beamlines of the National Synchrotron Light Source at Brookhaven National Laboratory. The "START SEARCH" button inside the end station is pressed, then the end station door is closed and the "SEARCH COMPLETE" button outside the end station is pressed to complete the interlock sequence. [NOTE: The start search circuit is activated the first time the "START SEARCH" button is pressed; this circuit remains active until the 12-V DC supply which powers it is turned off.]
- d. Shutter enable switch. A shutter enable switch was installed outside of the end station as part of the interlock system. It also is distinct from and does not interact with the PSS's used at the Sector 19 end station enclosures. In order for the shutter to open, this switch must be in the "ENABLE" position. The "DISABLE" position has a keyless locking detent to prevent accidental movement. This switch was installed to control accidental opening of the shutter (e.g., by the timer; see below).

- e. Indicator and warning lights. A series of indicator and warning lights have been integrated into the interlocking system to provide information about which operations are occurring "at a glance". If the apparatus has been assembled properly at one of the end stations, all of these lights are visible through one of that end station's viewports. The lights, their locations and their functions are outlined below.

Light	Color	Location	When "ON"	When "OFF"
"KEY SWITCH"	Amber	x-ray generator face (backlit)	power switch on generator is turned on	power switch on generator is turned off
"STANDBY"	Green	x-ray generator face (backlit)	generator is incapable of producing x rays	generator is capable of producing x rays
"X-RAY ON "	Red	x-ray generator face (backlit)	"X-RAY ON" button on generator is pressed	generator is incapable of producing x rays
12-V DC Indicator	Red	12-V power supply in end station	power supply "ON"	power supply "OFF"
"SHUTTER CLOSED"	Green	in end station	power supply "ON" and x-ray shutter closed	x-ray shutter open
"CALIBRATION X-RAYS ON"	N/A	in end station	"X-RAY ON" button on generator is pressed	generator is incapable of producing x rays
"START SEARCH"	White	relay control box in end station	"START SEARCH" button pressed	subsequently, any door to end station is opened OR 12-V power supply "OFF"
"SHUTTER OPEN"	Red	relay control box in end station	x-ray shutter open	x-ray shutter closed
"CALIBRATION SHUTTER OPEN"	N/A	in end station	x-ray shutter open	x-ray shutter closed

The effectiveness of a conventional laboratory (D-114) in Building 202 as an enclosure for the generator was determined by an ESH-HP radiation survey of the surrounding labs and corridors while the generator was producing x rays. With the x-ray wand facing the south wall, the shutter open and the generator operating at 20 kV and 2 mA (i.e., *twice* the intended operating current), no detectable increase in the x-ray background was observed from the D-wing corridor (*south wall*), either along the wall or through the window of the door to the laboratory. Additional measurements with the x-ray wand facing the north wall confirmed that no increased radiation above background was observed at the laboratory doors from the Q-wing corridor (*north wall*) and an adjoining room (Q-115). When these results are compared with calculations of the effectiveness of the end stations as radiation enclosures, the end stations provide sufficient shielding from x rays produced by the generator for personnel protection in the experiment hall.

4. TIMING OF X-RAY EXPOSURES BY THE INSTRUMENT:

The shutter's solenoid requires line voltage to operate the shutter. A digital timer has been installed to make/break this circuit subsequent to the shutter enable switch outside the end station. The timer is computer controlled via the data acquisition software used at SBC, *dtcollect*. Typical exposure times set in *dtcollect* are between 0.5 and 20 seconds. When the operator commands *dtcollect* to begin an exposure, the timer is "switched ON", completing the circuit and opening the shutter so that the CCD detector can be exposed to x rays for the desired time. When *dtcollect* completes the exposure, the timer is "switched OFF", breaking the circuit and closing the shutter. The timer has no effect if the shutter switch is in the "DISABLE" position.

5. USE OF CHECKLISTS TO ENSURE PROPER OPERATION:

Two checklists have been developed to aid in ensuring that the x-ray generator and safety interlock/timing systems are assembled and operate properly.

- a. *KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST – SBC/APS SECTOR 19 BEAMLINES*. This checklist shall be used whenever the Kevex 3067 x-ray generator and associated safety and timing systems are assembled or disassembled. In cases when the systems have not been disassembled between CCD detector calibrations, this checklist shall be used to verify that the systems are correctly assembled. Whenever the systems are disassembled, the checklist from the most recent assembly/disassembly verification should be used as the model.
- b. *SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES*. This checklist shall be used whenever the normal operation of the x-ray generator and associated safety and timing systems is verified. It is required that this be performed prior to operating the generator following reassembly after the systems have been disassembled or at least *twice* annually.

There are spaces provided on the checklists to indicate the operator, the time at which the operation was carried out and any remarks that the operator may deem appropriate about the condition of the equipment and/or the functioning of the equipment during the operation. The operator shall complete the *KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST* prior to each operation. The completed checklists from most recent assembly/disassembly and verification operations shall be displayed on the outside of the end station door (19-ID or BM D-hutch). Since the completed checklists are equivalent to "log" entries, *all* shall be retained after display to provide a record of generator and safety interlock systems operations.

6. KEY CONTROL AND OTHER SAFETY ISSUES:

The Kevex 3067 generator requires a key to enable it to produce x rays (the "X-ray Enable Key"). The key (tagged as #13) can be obtained from the lock box in the Administrative Assistant office in the SBC Lab-Office Module (435D LOM). The key shall be returned to the lock box at the conclusion of the operation.

Personal radiation monitors (i.e., TLD badges) must be worn by individuals participating in detector calibration measurements. No one will be allowed in the end station when a CCD detector is being exposed to x rays during calibration measurements (i.e., the x-ray shutter is open and the Kevex 3067 generator is powered).

7. OTHER PERTINENT DOCUMENTATION:

OPERATION MANUAL – HIGH VOLTAGE POWER SUPPLY MODEL P3067D2 (30 kV, 6.7 mA, 200 WATT), Kevex X-ray, Inc., Scotts Valley, CA 95066.

PROCEDURES FOR OPERATING THE KEVEX X-RAY GENERATOR – SBC/APS SECTOR 19 BEAMLINES

VERIFICATION OF THE SAFETY INTERLOCK SYSTEM FOR THE KEVEX X-RAY GENERATOR – SBC/APS SECTOR 19 BEAMLINES

KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST – SBC/APS SECTOR 19 BEAMLINES

SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – APS SECTOR 19 BEAMLINES

RADIATION SAFETY FOR X-RAY DIFFRACTION AND FLUORESCENCE ANALYSIS EQUIPMENT, ANSI V43.2-1977, U.S. Department of Commerce (1978)

Appendix C.6.2

Procedures for operating the Kevex X-ray generator sbc/aps sector 19 beamlines

(See next page)

**PROCEDURES FOR OPERATING THE KEVEX X-RAY GENERATOR
SBC/APS SECTOR 19 BEAMLINES**

The following procedures must be followed when operating the sealed tube copper anode x-ray generator in the end stations of the SBC/APS Sector 19 beamlines. They pertain to the assembly, operation and disassembly of the generator and associated electronic circuitry which is used to calibrate CCD detectors at the beamlines. The equipment used in these procedures has been designed to comply with the standards set forth in *Radiation Safety for X-ray Diffraction and Fluorescence Analysis Equipment* (ANSI N43.2-1977).

*Only SBC technical staff who are current with radiation safety training, which should include X-ray Diffraction Radiation Safety (Course #705), are authorized to carry out this procedure. Finger dosimeters are not required. It is required that at least one of the operators wear a SIEMENS Alarming Electronic Dosimeter when in the end stations during these procedures; the dosimeter reading shall be recorded on the **KEVEX GENERATOR ASSEMBLY CHECKLIST – SBC/APS SECTOR 19 BEAMLINES** at the beginning and end of these procedures.*

I. Positioning of the CCD Detector and Assembly of the Generator

- A. Position the CCD detector as far from the sample position as possible (ca. 950 mm).
- B. Assemble the generator and interlock system as specified in **KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST – SBC/APS SECTOR 19 BEAMLINES**. This checklist is equivalent to an "Operating Log" entry and shall be signed and the date and time entered by the SBC staff member responsible for the safe operation of the KeveX 3067 x-ray generator.
- C. All indicator and warning lights (see **USE OF THE KEVEX 3067 X-RAY GENERATOR FOR FLOOD FIELD WORK – SBC/APS SECTOR 19 BEAMLINES**) should be visible from one of the view ports into the end station. If they are not, they must be repositioned so that they are visible.
- D. A second authorized SBC staff member shall be designated to ensure control over the shutter enable switch box outside the end station at this point and wherever required in the procedures.
- E. Ensure that "dtcollect" and "Goniostat Sync Module" windows appear on the monitor screen of the workstation which will be used to control the experiment outside of the end station. If they do not, use the latest version of the **SBC Data Acquisition Procedures** to login to the workstation and open them.

II. Operation of the Generator

- A. The responsible SBC staff member will:

1. Obtain the x-ray enable key (tagged #13) for the Kevex 3067 generator from the lock box in the SBC Administrative Assistant office in 435D LOM.

2. Before securing the end station:
 - a. Activate the generator by switching the power "ON". The amber "KEY SWITCH" light on the generator face will illuminate. The voltage and current settings should both be zero.

 - b. Enable the generator by placing the x-ray enable key in the "X-RAY ENABLE" keyswitch and turning to the "ON" position. The green "STANDBY" light on the generator face will illuminate.

- c. Inspect the end station to ensure that no other person is inside.
 - d. Activate the "X-RAY ON" button. The red "X-RAY ON" light on the generator face will illuminate.
 - e. Ensure that the "CALIBRATION X-RAYS ON" light inside the end station and the red "KEVEX X-RAY GENERATOR ACTIVATED" light near the door on the outside wall of the end station are illuminated.
 - f. Raise the voltage and current to their operating values of 20 kV and 1 mA, respectively, in 4 increments of 30 seconds each. These settings will generate an x-ray field sufficient to calibrate the CCD detector with an 10–20-second exposure.
3. Secure the end station:
- a. Verify that no one is in the end station.
 - b. Press the "START SEARCH" button on the relay control box inside the end station; the white "START SEARCH " indicator light on the relay control box will illuminate.
 - c. Exit the end station and close the door.
 - d. Verify that no "Configuration Change Work in Progress" sign exists on the end station door.
 - e. Press the "SEARCH COMPLETE" button on the shutter control box outside the end station.
- B. Ensure that the shutter enable switch is switched to the "DISABLE X-RAY SHUTTER" position.
- C. Set the exposure time (*RECOMMENDED: 10 seconds*) in the "dtcollect" window on the workstation monitor, and ensure that "Shutter 2" in the "Goniostat Sync Module" window is enabled.
- D. Switch the shutter enable switch to "ENABLE X-RAY SHUTTER".

- E. Click on the “Expose” button in the “dtcollect” window on the workstation monitor using the left mouse button to begin an x-ray exposure. The CCD detector will be exposed to an isotropic x-ray field for the set time. The actual operating sequence is:
1. Simultaneously:
 - a. The “Expose” button should change to a red “Abort” button in the “dtcollect” window.
 - b. The x-ray shutter will open (*look through an end station view port to verify this*).
 - c. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights will illuminate (*look through an end station view port to verify this*).
 - d. The green "SHUTTER CLOSED" light will turn off (*look through an end station view port to verify this*).

 2. After the set exposure time has elapsed, simultaneously:
 - a. The “Abort” button should change back to an “Expose” button in the “dtcollect” window.
 - b. The x-ray shutter will close (*look through an end station view port to verify this*).
 - c. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights will turn off (*look through an end station view port to verify this*).

- d. The green "SHUTTER CLOSED" light will illuminate (*look through an end station view port to verify this*).

F. Switch the shutter enable switch to "DISABLE X-RAY SHUTTER".

G. Subsequent exposures can be made by repeating Steps C–F in this section.

H. Proceed to Section III (*Entering the End Station to Change the Experiment Setup*) or Section IV (*Turning the Generator Off and Return to Normal Operation*), as appropriate.

III. Entering the End Station to Change the Experiment Setup

A. Ensure that the shutter enable switch is switched to the "DISABLE X-RAY SHUTTER" position. The second SBC staff member shall ensure control over the switch box.

B. The responsible SBC staff member will:

1. Ensure that the end station is safe to enter before opening the door.

- a. Verify that the shutter is closed (*look through an end station view port to verify this*).

- b. Verify that the "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights are off and the green "SHUTTER CLOSED" light is lit (*look through an end station view port to verify this*).

NOTE: *If it cannot be verified that the shutter is closed, AC power to the Kevex 3067 x-ray generator must be disconnected before entering the end station.*

2. Open the door and enter the end station. The white "START SEARCH" light on the relay control box inside the end station will turn off when the door is opened.

3. Press the "X-RAY OFF" button (the green "STANDBY" light on the generator face will illuminate) to put the generator into "STANDBY" mode; the current will drop to zero, but the voltage will remain at its preset value (20 kV). The "CALIBRATION X-RAYS ON" and "KEVEX X-RAY GENERATOR ACTIVATED" (outside wall of end station) lights will turn off.
4. Make desired changes to the experiment setup.
5. Press the "X-RAY ON" button (the red "X-RAY ON" light on the generator face will illuminate) to make the generator operational; the current will rise to the preset value (1 mA) in incremental steps. The "CALIBRATION X-RAYS ON" and "KEVEX X-RAY GENERATOR ACTIVATED" lights will illuminate.
6. Secure the end station:
 - a. Verify that no one is in the end station.
 - b. Press the "START SEARCH" button on the relay control box inside the end station; the white "START SEARCH" light on the relay control box will illuminate.
 - c. Exit the end station and close the door.
 - d. Verify that no "Configuration Change Work in Progress" sign exists on the end station door.

- e. Press the "SEARCH COMPLETE" button on the shutter control box outside the end station.

- C. Proceed to Step B of Section II (*Operation of the Generator*) to carry out further exposures of the CCD detector.

IV. Turning the Generator Off and Return to Normal Operation

- A. Ensure that the shutter enable switch is in the "DISABLE X-RAY SHUTTER" position. The second SBC staff member shall ensure control over the switch box.

- B. The responsible SBC staff member will:

1. Ensure that the end station is safe to enter before opening the door.
 - a. Verify that the shutter is closed (*look through an end station view port to verify this*).
 - b. Verify that the "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights are off and the green "SHUTTER CLOSED" light is lit (*look through an end station view port to verify this*).

NOTE: *If it cannot be verified that the shutter is closed, AC power to the Kevex 3067 x-ray generator must be disconnected before entering the end station.*

2. Open the door and enter the end station.
3. Press the "X-RAY OFF" button (the green "STANDBY" light on the generator face will illuminate), and turn current and voltage settings to zero on the generator.
4. Deactivate the generator by moving the x-ray enable keyswitch and the "POWER" switch to their "OFF" positions.

5. Remove the x-ray enable key from the generator.
 6. Disconnect the Kevex 3067 generator and digital timer circuit from AC power outside the end station.
 7. Return the x-ray enable key to the SBC lock box.
 8. Display the **KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST – SBC/APS SECTOR 19 BEAMLINES** on the outside of the end station door (19-ID or BM D-hutch).
- C. If it is necessary to disassemble the generator and safety interlock/timing systems, proceed to Section V (*Disassembly of the Generator*).

NOTE: *If a problem has been observed in the operation of either the generator, timer or safety systems, the SBC Safety Officer **must** be notified and **must** approve any subsequent operations. Upon approval by the safety officer, the procedures outlined in **VERIFICATION OF THE SAFETY INTERLOCK SYSTEM FOR THE KEVEX X-RAY GENERATOR – SBC/APS SECTOR 19 BEAMLINES** may be used in resolving the problem and **must** be executed to verify the operation of the equipment before its next use.*

V. Disassembly of the Generator

- A. Disassemble the generator, x-ray wand, interlock apparatus and cables by following in reverse order the steps specified in ***KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST – SBC/APS SECTOR 19 BEAMLINES***.
- C. The responsible SBC staff member shall enter the date and time that disassembly was completed on the checklist.

Appendix C.6.3

Verification of the safety interlock system for the Kevex X-ray generator SBC/APS sector 19 beamlines

(see next page)

**VERIFICATION OF THE SAFETY INTERLOCK SYSTEM FOR THE KEVEX X-RAY GENERATOR
SBC/APS SECTOR 19 BEAMLINES**

The following verification procedure has been established to ensure that the components of the safety interlock system, used in the operation of the Kevex 3067 sealed tube copper anode x-ray generator in the end stations of the SBC/APS Sector 19 beamlines, are functioning properly. This system consists of electronic circuitry and devices (e.g., lights, microswitches, relays, etc.). When assembled with the Kevex generator, copper x-ray tube and shutter assembly and digital timer circuit for shutter control, it allows the generator, as it is used to calibrate charge-coupled device (CCD) detectors at the beamlines, to be operated in a safe manner in compliance with *Radiation Safety for X-ray Diffraction and Fluorescence Analysis Equipment* (ANSI N43.2-1977) [see **PROCEDURES FOR OPERATING THE KEVEX X-RAY GENERATOR - SBC/APS SECTOR 19 BEAMLINES**].

*This procedure must be carried out following each reassembly after the system has been disassembled or at least **twice** during each year prior to operation. Only SBC technical staff who are current with radiation safety training, which should include X-ray Diffraction Radiation Safety (Course #705), are authorized to carry out this procedure. An ANL ESH-HP representative shall be present during and will assist in the execution of this procedure. Only those individuals who are necessary to its proper execution are allowed inside the beamline end station during this procedure. It is required that at least one of the operators wear a SIEMENS Alarming Electronic Dosimeter when in the end station during the verification procedure; the dosimeter reading shall be recorded on the **KEVEX GENERATOR ASSEMBLY CHECKLIST – SBC/APS SECTOR 19 BEAMLINES** at the beginning and end of this procedure.*

- I. Preparation for Executing the Verification Procedure
- A. Use the **SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT - SBC/APS SECTOR 19 BEAMLINES** in executing this procedure. This checklist is equivalent to a "Verification Log" entry and should be signed and the date and time entered by the SBC staff member responsible for carrying out the verification procedure. The ESH-HP representative shall also sign and date the checklist.
- B. Before proceeding further:
1. Ensure that all labyrinths in the end station are secure.
 2. Ensure that, for the end station, NO **Configuration Control Work Permit** or **Configuration Change Work in Progress** sign is posted in the locked beamline bulletin board or on the end station door.
 3. You MAY NOT continue with this procedure UNTIL both of the above conditions are true. Work with the APS Floor Coordinator and SBC beamline personnel to make the above conditions true if either or both are not. When both are true, mark check box "1." on the **SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES**, and proceed to Step C.

- C. The responsible SBC staff member will obtain the x-ray enable key for the Kevex 3067 generator from the lockable key box in the SBC administrative office in 435D LOM.

- D. Login using the “sbestaff” account and appropriate password to the Hewlett Packard workstation outside of the end station which will be used to control the experiment, and open the “SBC Control System Panel” on the monitor screen of the workstation. Ensure that “dtcollect” and “Goniostat Sync Module” windows appear on the monitor screen of the workstation. See the *SBC Hypertext Help Browser* on the SBC web page for more details.
1. In the “Goniostat Sync Module” window, ensure that:
 - a. All indicators under “Inputs” are green.
 - b. The “Shutter” indicator under “Outputs” is “Disabled” (red indicator).
 - c. The “Kevex” indicator under “Outputs” is “Enabled” (green indicator).
 - d. All other indicators under “Outputs” are “Enabled” (green indicators).
 2. In the “dtcollect” window, ensure that:
 - a. The value for “Expose” is “Dark Image (shutter closed)”.
 - b. The value for “Seq start” is “1”.
 - c. The value for “Num imgs” is “1”.
 - d. The indicated values are used for the remainder of the parameters.

II. Assembly of the Generator and Safety Interlock System

- A. Assemble the Kevex 3067 generator and interlock system as specified in *KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST - SBC/APS SECTOR 19 BEAMLINES*. This checklist is equivalent to an "Operating Log" entry and shall be signed and the date and time entered by the SBC staff member carrying out the verification procedure. The phrase "**Generator and Safety Interlock Verification**" should be entered under "REMARKS". Also, mark check box “2.” on the *SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES*.
- B. A second authorized SBC staff member shall be designated to ensure control over the x-ray generator power cord and the shutter enable switch box outside the end station at this point and whenever required during verification.

III. Verification of the End Station Door Microswitch Circuitry Without X rays

- A. Disconnect the Kevex 3067 x-ray generator from the AC power source outside the end station. The second SBC staff member shall ensure control over the generator power cord.
- B. Verify the operation of the end station door microswitch circuitry (i.e., opening the end station door will turn-off the white "START SEARCH" light in the end station and open the interlock circuit):
 - 1. Enter the end station.
 - 2. Press the "START SEARCH" button on the relay control box inside the end station; the white "START SEARCH" indicator light on this box should illuminate.
 - 3. Exit the end station and close the door.

4. Press the "SEARCH COMPLETE" button on the shutter control box outside the end station.
 5. Open the end station door. The white "START SEARCH" light on the relay control box in the end station should turn off.
- C. If the end station door microswitch circuitry is operating properly in "x rays off" mode, mark check box "3." on the ***SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES***, and proceed to Section IV (*Verification of Shutter/Timer Operation Without X rays*). If operational problems are observed, proceed to Step VI (*Troubleshooting Operational Problems*).

IV. Verification of Shutter/Timer Operation Without X rays

- A. With the Kevex 3067 x-ray generator still disconnected from AC power, switch the shutter enable switch to "ENABLE X-RAY SHUTTER".
- B. Set a time of 15 seconds in the "dtcollect" window on the workstation monitor.
- C. Click on the "Expose" button in the "dtcollect" window using the left mouse button. The correct operating sequence is:
 1. Simultaneously:
 - a. The "Expose" button should change to a red "Abort" button in the "dtcollect" window.
 - b. The x-ray shutter should open.
 - c. The red "SHUTTER OPEN" light on the relay control box in the end station should illuminate.
 - d. The green "SHUTTER CLOSED" light inside the end station should turn off.

2. After 15 seconds have elapsed, simultaneously:
 - a. The “Abort” button should change back to an “Expose” button in the “dtcollect” window.
 - b. The x-ray shutter should close.
 - c. The red "SHUTTER OPEN" light on the relay control box should turn off.
 - d. The green "SHUTTER CLOSED" light should illuminate.

3. Switch the shutter enable switch to "DISABLE X-RAY SHUTTER".

- D. If the digital timer circuit and shutter are operating properly, mark check box “4a.” on the ***SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES***, and proceed to Step E. If operational problems are observed, proceed to Section VI (*Troubleshooting Operational Problems*).

- E. Verify that the shutter enable switch is in "DISABLE X-RAY SHUTTER" mode.

- F. Set a time of 15 seconds in the “dtcollect” window on the workstation monitor.

- G. Click on the “Expose” button in the “dtcollect” window using the left mouse button.
 1. The “Expose” button should change to a red “Abort” button in the “dtcollect” window.

2. The x-ray shutter should **not** open.
3. The red "SHUTTER OPEN" light on the relay control box in the end station should **not** illuminate.
4. The green "SHUTTER CLOSED" light inside the end station should remain illuminated.
5. After 15 seconds have elapsed, the "Abort" button should change back to an "Expose" button in the "dtcollect" window.

H. If the shutter enable switch, green "SHUTTER CLOSED" and red "SHUTTER OPEN" lights and, thus, the x-ray shutter/timer system are operating properly, mark check boxes "4b.", "4c.", "4d." and "4." on the ***SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES***, and proceed to Section V ("*X rays ON*" *Verification of Safety System*). If operational problems are observed, proceed to Section VI (*Troubleshooting Operational Problems*).

V. "X rays ON" Verification of Safety System

- A. Connect the Kevex 3067 x-ray generator to AC power outside the end station.
- B. Verify that the "X-RAY ENABLE" keyswitch on the generator is operating properly (i.e., if the generator is not enabled using the x-ray enable key, the "X-RAY ON" button will not function):
 1. Verify that the shutter enable switch is in "DISABLE X-RAY SHUTTER" mode. The second SBC staff member shall ensure control over the switch box.
 2. Activate the x-ray generator by switching the power "ON":

- a. The amber "KEY SWITCH" light on the generator face should illuminate.
 - b. The current and voltage meters should both read zero.
 - c. The green "SHUTTER CLOSED" light inside the end station should remain illuminated.
3. Press the "X-RAY ON" button on the generator. The generator should **not** respond.
- C. If the "X-RAY ENABLE" keyswitch is operating properly, mark check box "5a." on the ***SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES***, and proceed to Step D. If operational problems are observed:
1. Deactivate the x-ray generator by switching the power "OFF".
 2. Proceed to Section VI (*Troubleshooting Operational Problems*).
- D. Verify that the informational lights on the generator face are operating properly:
1. Verify that the shutter enable switch is in "DISABLE X-RAY SHUTTER" mode, and ensure control over the switch box.

2. Enable the generator by placing the x-ray enable key in the "X-RAY ENABLE" keyswitch and turning to the "ON" position.
 - a. The green "STANDBY" light on the generator face should illuminate.
 - b. The green "SHUTTER CLOSED" light should remain illuminated.
 - c. The voltage and current settings should remain at zero.
 - d. The amber "KEY SWITCH" light should turn off.

- E. If the amber "KEY SWITCH" and green "STANDBY" lights are operating properly, mark check boxes "5b." and "5c." on the ***SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES***, and proceed to Step F. If operational problems are observed:
 1. Disable the generator by turning the "X-RAY ENABLE" keyswitch to the "OFF" position, and remove the x-ray enable key.
 2. Deactivate the generator by switching the power "OFF".
 3. Proceed to Section VI (*Troubleshooting Operational Problems*).

- F. Verify that the generator operates properly in "verification" mode:
 1. Activate the "X-RAY ON" button.
 - a. The "CALIBRATION X-RAYS ON" light should illuminate.
 - b. The red "KEVEX X-RAY GENERATOR ACTIVATED" light near the door on the outside wall of the end station should illuminate.

- c. The green "SHUTTER CLOSED" light should remain illuminated.
2. Raise the voltage and current to their verification values of 5 kV and 0.25 mA, respectively.
- G. If the "X-RAY ON" button, the "CALIBRATION X-RAYS ON" light, the "KEVEX X-RAY GENERATOR ACTIVATED" light and, thus, the generator are operating properly, mark check boxes "5d.", "5e.", "5f." and "5." on the ***SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES***, and proceed to Step H. If operational problems are observed:
1. Lower the current and voltage to zero and press the "X-RAY OFF" button.
 2. Disable the generator by turning the "X-RAY ENABLE" keyswitch to the "OFF" position, and remove the x-ray enable key.
 3. Deactivate the generator by switching the power "OFF".
 4. Proceed to Section VI (*Troubleshooting Operational Problems*).
- H. Verify that the "START SEARCH"/"SEARCH COMPLETE" safety circuitry operates properly (i.e., attempt to open the x-ray shutter **without** using the "START SEARCH"/"SEARCH COMPLETE" buttons):
1. Inspect the end station to ensure that no other person is inside.

2. The first part of this test skips both the "START SEARCH" and "SEARCH COMPLETE" steps.
 - a. Exit the end station and close the door.
3. Switch the shutter enable switch to "ENABLE X-RAY SHUTTER".
4. Set a time of 15 seconds in the "dtcollect" window on the workstation monitor.
5. Click on the "Expose" button in the "dtcollect" window using the left mouse button. Simultaneously:
 - a. The "Expose" button should change to a red "Abort" button in the "dtcollect" window.
 - b. The red "KEVEX X-RAY GENERATOR ACTIVATED" light near the door on the outside wall of the end station should turn off.
 - c. The generator should switch to "STANDBY" mode and the green "STANDBY" light on the face of the generator should illuminate (*look through an end station view port to verify this*).
 - d. The "CALIBRATION X-RAYS ON" light should turn off (*look through an end station view port to verify this*).
 - e. The x-ray shutter should open (*look through an end station view port to verify this*).
 - f. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should illuminate (*look through an end station view port to verify this*).
 - g. The green "SHUTTER CLOSED" light should turn off (*look through an end station view port to verify this*).
6. After 15 seconds have elapsed, simultaneously:

- a. The “Aabort” button should change back to an “Expose” button in the “dtcollect” window.
 - b. The x-ray shutter should close (*look through an end station view port to verify this*).
 - c. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should turn off (*look through an end station view port to verify this*).
 - d. The green "SHUTTER CLOSED" light should illuminate (*look through an end station view port to verify this*).
7. Switch the shutter enable switch to "DISABLE X-RAY SHUTTER". The second SBC staff member shall ensure control over the switch box.
 8. Ensure that the end station is safe to enter before opening the door; look through an end station view port to:
 - a. Verify that the shutter is closed.
 - b. Verify that the "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights are off and the green "SHUTTER CLOSED" light is illuminated.
 - c. Verify that the green "STANDBY" light on the face of the generator is illuminated.

NOTE: *If it cannot be verified that the shutter is closed, AC power to the Kevex 3067 x-ray generator must be disconnected before entering the end station. Proceed to Section VI (Troubleshooting Operational Problems).*

9. Enter the end station and activate the "X-RAY ON" button.
 - a. The "CALIBRATION X-RAYS ON" light should illuminate.
 - b. The green "SHUTTER CLOSED" light should remain illuminated.
 - c. The voltage and current should register their verification values (5 kV and 0.25 mA, respectively) on the generator.
 - d. The red "KEVEX X-RAY GENERATOR ACTIVATED" light near the door on the outside wall of the end station should illuminate.

10. Inspect the end station to ensure that there is no other person inside.

11. Exit the end station and close the door.

12. The second part of this test skips the "START SEARCH" step:
 - a. Press the "SEARCH COMPLETE" button on the shutter control box outside the end station.
 - b. The white "START SEARCH" indicator light on the relay control box in the end station should **not** illuminate.

13. Switch the shutter enable switch to "ENABLE X-RAY SHUTTER".

14. Set a time of 15 seconds in the "dtcollect" window on the workstation monitor.

15. Click on the "Expose" button in the "dtcollect" window using the left mouse button. Simultaneously:
 - a. The "Expose" button should change to a red "Abort" button in the "dtcollect" window.

- b. The red “KEVEX X-RAY GENERATOR ACTIVATED” light near the door on the outside wall of the end station should turn off.
 - c. The generator should switch to "STANDBY" mode and the green "STANDBY" light on the face of the generator should illuminate (*look through an end station view port to verify this*).
 - d. The "CALIBRATION X-RAYS ON" light should turn off (*look through an end station view port to verify this*).
 - e. The x-ray shutter should open (*look through an end station view port to verify this*).
 - f. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should illuminate (*look through an end station view port to verify this*).
 - g. The green "SHUTTER CLOSED" light should turn off (*look through an end station view port to verify this*).
16. After 15 seconds have elapsed, simultaneously:
- a. The “Abort” button should change back to an “Expose” button in the “dtcollect” window.
 - b. The x-ray shutter should close (*look through an end station view port to verify this*).
 - c. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should turn off (*look through an end station view port to verify this*).
 - d. The green "SHUTTER CLOSED" light should illuminate (*look through an end station view port to verify this*).

17. Switch the shutter enable switch to "DISABLE X-RAY SHUTTER". The second SBC staff member shall ensure control over the switch box.
18. Ensure that the end station is safe to enter before opening the door; look through an end station view port to:
 - a. Verify that the shutter is closed.
 - b. Verify that the "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights are off and the green "SHUTTER CLOSED" light is illuminated.
 - c. Verify that the green "STANDBY" light on the face of the generator is illuminated.

NOTE: *If it cannot be verified that the shutter is closed, AC power to the Kevex 3067 x-ray generator must be disconnected before entering the end station. Proceed to Section VI (Troubleshooting Operational Problems).*

19. Enter the end station and activate the "X-RAY ON" button.
 - a. The "CALIBRATION X-RAYS ON" light should illuminate.
 - b. The green "SHUTTER CLOSED" light should remain illuminated.
 - c. The voltage and current should register their verification values (5 kV and 0.25 mA, respectively) on the generator.
 - d. The red "KEVEX X-RAY GENERATOR ACTIVATED" light near the door on the outside wall of the end station should illuminate.
20. Inspect the end station to ensure that there is no other person inside.
21. The third part of this test skips the "SEARCH COMPLETE" step:
 - a. Press the "START SEARCH" button on the relay control box inside the end station.

- b. The white "START SEARCH" indicator light on the relay control box should illuminate.
 - c. Exit the end station and close the door.
22. Switch the shutter enable switch to "ENABLE X-RAY SHUTTER".
23. Set a time of 15 seconds in the "dtcollect" window on the workstation monitor.
24. Click on the "Expose" button in the "dtcollect" window using the left mouse button. Simultaneously:
- a. The "Expose" button should change to a red "Abort" button in the "dtcollect" window.
 - b. The red "KEVEX X-RAY GENERATOR ACTIVATED" light near the door on the outside wall of the end station should turn off.
 - c. The generator should switch to "STANDBY" mode and the green "STANDBY" light on the face of the generator should illuminate (*look through an end station view port to verify this*).
 - d. The "CALIBRATION X-RAYS ON" light should turn off (*look through an end station view port to verify this*).
 - e. The x-ray shutter should open (*look through an end station view port to verify this*).

- f. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should illuminate (*look through an end station view port to verify this*).
 - g. The green "SHUTTER CLOSED" light should turn off (*look through an end station view port to verify this*).
25. After 15 seconds have elapsed, simultaneously:
- a. The "Abort" button should change back to an "Expose" button in the "dtcollect" window.
 - b. The x-ray shutter should close (*look through an end station view port to verify this*).
 - c. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should turn off (*look through an end station view port to verify this*).
 - d. The green "SHUTTER CLOSED" light should illuminate (*look through an end station view port to verify this*).
26. Switch the shutter enable switch to "DISABLE X-RAY SHUTTER". The second SBC staff member shall ensure control over the switch box.
27. Ensure that the end station is safe to enter before opening the door; look through an end station view port to:
- a. Verify that the shutter is closed.
 - b. Verify that the "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights are off and the green "SHUTTER CLOSED" light is illuminated.
 - c. Verify that the green "STANDBY" light on the face of the generator is illuminated.

NOTE: *If it cannot be verified that the shutter is closed, AC power to the Kevex 3067 x-ray generator must be disconnected before entering the end station. Proceed to Section VI (Troubleshooting Operational Problems).*

28. Open the door and enter the end station.
-
- I. If the “START SEARCH” and “SEARCH COMPLETE” buttons, the white “START SEARCH” light and, thus, the “START SEARCH”/“SEARCH COMPLETE” circuitry are operating properly, mark check boxes “6a.”, “6b.”, “6c.” and “6.” on the ***SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES***, and proceed to Step J. If operational problems are observed:
 1. Lower the current and voltage to zero and press the "X-RAY OFF" button.
 2. Disable the generator by turning the "X-RAY ENABLE" keyswitch to the "OFF" position, and remove the x-ray enable key.
 3. Deactivate the generator by switching the power "OFF".
 4. Proceed to Section VI (*Troubleshooting Operational Problems*).
 - J. Verify that the end station door microswitch circuitry operates properly (i.e., open the end station door to the end station during operation):

1. Activate the "X-RAY ON" button.
 - a. The "CALIBRATION X-RAYS ON" light should illuminate.
 - b. The green "SHUTTER CLOSED" light should stay lit.
 - c. The red "KEVEX X-RAY GENERATOR ACTIVATED" light near the door on the outside wall of the end station should illuminate.
2. Inspect the end station to ensure that no other person is inside.
3. Press the "START SEARCH" button on the relay control box inside the end station; the white "START SEARCH" light on this box should illuminate.
4. Exit the end station and close the door.
5. Press the "SEARCH COMPLETE" button on the shutter control box outside the end station.
6. Switch the shutter enable switch to "ENABLE X-RAY SHUTTER".
7. Set a time of 15 seconds in the "dtcollect" window on the workstation monitor.
8. Click on the "Expose" button in the "dtcollect" window using the left mouse button. Simultaneously:
 - a. The "Expose" button should change to a red "Abort" button in the "dtcollect" window.
 - b. The x-ray shutter should open (*look through an end station view port to verify this*).

- c. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should illuminate (*look through an end station view port to verify this*).
 - d. The green "SHUTTER CLOSED" light should turn off (*look through an end station view port to verify this*).
9. Before the timing cycle finishes, open the end station door. Simultaneously, the red "KEVEX X-RAY GENERATOR ACTIVATED" light near the door on the outside wall of the end station should turn off and (*look through an end station view port to verify the following*):
- a. The generator should switch to "STANDBY" mode and the green "STANDBY" light on the face of the generator should illuminate.
 - b. The "CALIBRATION X-RAYS ON" light should turn off.
 - c. The white "START SEARCH" light on the relay control box should turn off.
10. After 15 seconds have elapsed, simultaneously:
- a. The "Abort" button should change back to an "Expose" button in the "dtcollect" window.
 - b. The x-ray shutter should close (*look through an end station view port to verify this*).
 - c. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should turn off (*look through an end station view port to verify this*).
 - d. The green "SHUTTER CLOSED" light should illuminate (*look through an end station view port to verify this*).

11. Switch the shutter enable switch to "DISABLE X-RAY SHUTTER". The second SBC staff member shall ensure control over the switch box.
12. Ensure that the end station is safe to enter; look through an end station view port to:
 - a. Verify that the shutter is closed.
 - b. Verify that the "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights are off and the green "SHUTTER CLOSED" light is illuminated.
 - c. Verify that the green "STANDBY" light on the face of the generator is illuminated.

NOTE: *If it cannot be verified that the shutter is closed, AC power to the Kevex 3067 x-ray generator must be disconnected before entering the end station. Proceed to Section VI (Troubleshooting Operational Problems).*

13. Enter the end station.
- K. If the end station door microswitch circuitry is operating properly in "x rays on" mode, mark the check box "7." on the ***SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES***, and proceed to Step L. If operational problems are observed:
1. Lower the current and voltage to zero and press the "X-RAY OFF" button.
 2. Disable the generator by turning the "X-RAY ENABLE" keyswitch to the "OFF" position, and remove the x-ray enable key.
 3. Deactivate the generator by switching the power "OFF".

4. Proceed to Section VI (*Troubleshooting Operational Problems*).
- L. Finally, verify that the entire generator and safety interlock system operates properly:
1. Activate the "X-RAY ON" button.
 - a. The "CALIBRATION X-RAYS ON" light should illuminate.
 - b. The green "SHUTTER CLOSED" light should stay lit.
 - c. The red "KEVEX X-RAY GENERATOR ACTIVATED" light near the door on the outside wall of the end station should illuminate.
 2. Inspect the end station to ensure that no other person is inside.
 3. Press the "START SEARCH" button on the relay control box inside the end station; the white "START SEARCH" light on this box should illuminate.
 4. Exit the end station and close the door.
 5. Press the "SEARCH COMPLETE" button on the shutter control box outside the end station.
 6. Switch the shutter enable switch to "ENABLE X-RAY SHUTTER".
 7. Set a time of 15 seconds in the "dtcollect" window on the workstation monitor.

8. Click on the “Expose” button in the “dtcollect” window using the left mouse button. Simultaneously:
 - a. The “Expose” button should change to a red “Aabort” button in the “dtcollect” window.
 - b. The x-ray shutter should open (*look through an end station view port to verify this*).
 - c. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should illuminate (*look through an end station view port to verify this*).
 - d. The green "SHUTTER CLOSED" light should turn off (*look through an end station view port to verify this*).

9. After 15 seconds have elapsed, simultaneously:
 - a. The “Aabort” button should change back to an “Expose” button in the “dtcollect” window.
 - b. The x-ray shutter should close (*look through an end station view port to verify this*).
 - c. The "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights should turn off (*look through an end station view port to verify this*).
 - d. The green "SHUTTER CLOSED" light should illuminate (*look through an end station view port to verify this*).

10. Switch the shutter enable switch to "DISABLE X-RAY SHUTTER". The second SBC staff member shall ensure control over the switch box.

11. Mark check box “8.” on the ***SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX UNIT – SBC/APS SECTOR 19 BEAMLINES*** to indicate that the generator and safety interlock system are operating properly.

- M. If operational problems are observed, proceed to Section VI (*Troubleshooting Operational Problems*). Otherwise:
1. Ensure that the ***SAFETY INTERLOCK VERIFICATION CHECKLIST - FOR THE KEVEX UNIT - SBC/APS SECTOR 19 BEAMLINES*** has been completed.
 2. Enter the phrase "**All Safety Systems Operational.**" under "REMARKS" on the checklist ***KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST - SBC/APS SECTOR 19 BEAMLINES***.
 3. Display both checklists on the "SAFETY INFORMATION" board on the end station.
 4. Proceed to Section VII (*Return to Normal Operation*).

VI. Troubleshooting Operational Problems

- A. Notify the SBC Safety Officer and SBC Director of any operational problems.
1. The safety officer **must** approve any subsequent operations.

- B. Upon approval of the safety officer, identify any operational problems by one of the following:
1. Verify that the Kevex 3067 generator and safety interlock system are assembled correctly.
 - a. Proceed to Section VII (*Return to Normal Operation*).
 - b. Proceed to Section II (*Assembly of the Generator and Safety Interlock System*).
 2. Proceed to Section VII (*Return to Normal Operation*). The SBC Safety Officer will ensure that any problems with the generator and safety interlock system are properly repaired.

VII. Return to Normal Operation

- A. Ensure that the shutter enable switch is in the "DISABLE X-RAY SHUTTER" position. The second SBC staff member shall ensure control over the switch box.
- B. The responsible SBC staff member will:
1. Ensure that the end station is safe to enter before opening the door; look through an end station view port to:
 - a. Verify that the shutter is closed.
 - b. Verify that the "CALIBRATION SHUTTER OPEN" and red "SHUTTER OPEN" (relay control box) lights are off and the green "SHUTTER CLOSED" light is illuminated.

NOTE: *If it cannot be verified that the shutter is closed, AC power to the Kevex 3067 x-ray generator must be disconnected before entering the end station.*

2. Open the door and enter the end station.

3. Press the "X-RAY OFF" button, and turn current and voltage settings to zero on the generator.
 4. Deactivate the x-ray generator by moving the "X-RAY ENABLE" keyswitch and the "POWER" switch to their "OFF" positions.
- C. Remove the x-ray enable key from the generator.
 - D. Disconnect the x-ray generator and digital timer circuit from AC power outside the end station.
 - E. Return the x-ray enable key to the key box in the SBC administrative office in 435D LOM.
 - F. If it is necessary to disassemble the generator and safety interlock/timing systems, proceed to Section VIII (*Disassembly of the Generator*).

VIII. Disassembly of the Generator

- A. Disassemble the generator, x-ray wand, interlock apparatus and cables by following in reverse order the steps specified in ***KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST - SBC/APS SECTOR 19 BEAMLINES***.
- B. The responsible SBC staff member shall enter the date and time that disassembly was completed on the checklist.

Appendix C.6.4

KeveX X-ray generator assembly checklist SBC/APS sector 19 beamlines

(see next page)

**KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST
SBC/APS SECTOR 19 BEAMLINES**

- ρ 1. Verify that all labyrinths in the end station are secure and that no ***Configuration Control Work Permit*** or ***Configuration Change Work in Progress*** sign is posted in the locked beamline bulletin board or on the end station door.

- ρ 2. Mount x-ray wand on tripod an appropriate distance upstream of and facing the CCD detector.

- ρ 3. Verify high-voltage connection is made from x-ray wand to Kevex generator.

- ρ 4. Verify coolant reservoir lines are attached to the wand and coolant is at proper level.

- ρ 5. Supply AC power to coolant reservoir (the pump will begin operating upon plug in.).

- ρ 6. Connect interlock cable assembly to:
 - ρ a. "BEACON" and "CHAMBER" terminal posts on back of Kevex generator.
 - ρ b. relay control box (*plugs "A" and "B"*).
 - ρ c. "CALIBRATION X-RAYS ON/SHUTTER OPEN" lights (*plug "C"*).
 - ρ d. x-ray shutter microswitch (*plug "E"*) and solenoid power (*plug "G"*).
 - ρ e. end station door microswitch (*plug "F"*).
 - ρ f. "KEVEX X-RAY GENERATOR ACTIVATED" light (*plug "H"* near back of generator and *plug "J"* outside end station).
 - ρ g. shutter control box (*plug "D"* outside end station).

- ρ 7. Connect 12-V DC power supply to AC power and turn on (the red indicator light on the power supply and the green "SHUTTER CLOSED" light should be illuminated).

- ρ 8. Feed x-ray shutter solenoid and Kevex generator power cords outside of end station using nearest labyrinth.
- ρ 9. Connect LEMO cable (*plug "K"*) to digital timer circuit.
- ρ 10. Ensure that shutter control box is switched to "DISABLE X-RAY SHUTTER".
- ρ 11. Plug shutter control box into digital timer circuit (*plug "L"*).
- ρ 12. Plug x-ray wand shutter solenoid cable into shutter control box (*plug "M"*).
- ρ 13. Connect digital timer circuit to AC power.
- ρ 14. Connect Kevex generator to AC power.

CHECKED BY SBC STAFF MEMBER OPERATING KEVEX GENERATOR: BEAMLIN _____

ρ Frank Rotella ρ Marianne Cuff ρ Youngchang Kim ρ Jerzy Osipiuk

SIGNATURE: _____

BEGIN MEASUREMENT OR ASSEMBLY: END MEASUREMENT OR DISASSEMBLY:

Date _____ Time _____ Date _____ Time _____

DOSIMETER READINGS: Initial _____ Final _____

REMARKS: _____

Appendix C.6.5

Safety interlock verification checklist for the Kevex X-ray generator SBC/APS sector 19 beamlines

(see next page)

- ρ 1. Verify that all labyrinths in the end station are secure and that no **Configuration Control Work Permit** or **Configuration Change Work in Progress** sign is posted in the locked beamline bulletin board or on the end station door.

- ρ 2. Assemble the Kevex 3067 x-ray generator and interlock system as specified in **KEVEX X-RAY GENERATOR ASSEMBLY CHECKLIST – SBC/APS SECTOR 19 BEAMLINES**.

- ρ 3. Verify end station door microswitch circuitry (**X-RAYS OFF**).

- ρ 4. Verify x-ray shutter/timer operation (**X-RAYS OFF**):
 - ρ a. Digital timer circuit and x-ray shutter.
 - ρ b. Shutter enable switch.
 - ρ c. Green "SHUTTER CLOSED" light.
 - ρ d. Red "SHUTTER OPEN" light.

- ρ 5. Verify Kevex 3067 x-ray generator operation (**X-RAYS ON**):
 - ρ a. "X-RAY ENABLE" keyswitch.
 - ρ b. Amber "KEY SWITCH" light.
 - ρ c. Green "STANDBY" light.
 - ρ d. "X-RAY ON" button.
 - ρ e. "CALIBRATION X-RAYS ON" light.
 - ρ f. Red "KEVEX X-RAY GENERATOR ACTIVATED" light on outside wall of end station.

- ρ 6. Verify "START SEARCH"/"SEARCH COMPLETE" circuitry (**X-RAYS ON**):
 - ρ a. "SEARCH COMPLETE" button.
 - ρ b. "START SEARCH" button.

ρ c. White "START SEARCH" light.

ρ 7. Verify end station door microswitch circuitry (*X-RAYS ON*).

ρ 8. Verify "KEVEX X-RAY GENERATOR ACTIVATED" light fail-safe (*X-RAYS ON*).

ρ 9. Verify entire generator and safety interlock system (*X-RAYS ON*).

CHECKED BY SBC STAFF MEMBER VERIFYING SYSTEM OPERATION: BEAMLIN_____

ρ Frank Rotella
Osipiuk

ρ Marianne Cuff

ρ Youngchang Kim

ρ Jerzy

SIGNATURE: _____ Date_____ Time_____

ESH-HP REP: _____ Date_____ Time_____

REMARKS: _____

**SAFETY INTERLOCK VERIFICATION CHECKLIST FOR THE KEVEX X-RAY
GENERATOR
SBC/APS SECTOR 19 BEAMLINES**