

Keene State College
Center for Environmental BioGeoChemistry
Radiation Protection Program
Revised January 21, 2009

XRF System Manager

Timothy T. Allen, Professor of Geology and Environmental Studies

Mailstop 2001, Keene State College, Keene, NH 03435

e-mail: tallen@keene.edu

office: 603-358-2571

lab: 603-358-2582

home: 603-355-3280

mobile: 603-209-9222

Introduction

The Keene State College (KSC) Center for Environmental BioGeoChemistry (CEB) is equipped with a fully-automated scanning wavelength-dispersive X-ray fluorescence (XRF) spectrometer for the qualitative and quantitative elemental analysis of rock, mineral, sediment and other types of samples. The instrument is currently located in room 237 of the Science Center on the Keene State College campus.

The instrument is a Rigaku ZSX 100e, manufactured by Rigaku Industrial Corporation in Japan, and imported, marketed, installed, and serviced by Rigaku/MSI, Inc. of The Woodlands, Texas.

Ionizing radiation is produced within the XRF spectrometer and over-exposure to such radiation could potentially be very harmful or even lethal, both to those exposed and/or to their potential future offspring. The XRF spectrometer is classified as an analytical X-ray machine, whose use is regulated by the State of New Hampshire (NH), Department of Health and Human Services (DHHS), Bureau of Radiological Health (BRH). The NH DHHS/BRH has issued the *New Hampshire Rules for the Control of Radiation* (the Rules), as authorized by state law, which includes requirements for registrants to develop a Radiation Protection Program.

This document describes the Radiation Protection Program (RPP) of the KSC Center for Environmental BioGeoChemistry. The goal of the RPP is to keep radiation exposures to users and the general public to levels "as low as reasonably achievable" (ALARA). Our RPP consists of two components: (1) the design and features of the XRF spectrometer itself, and (2) policies regarding access to, as well as operation and maintenance of the XRF spectrometer.

The XRF System Manager is responsible for developing and promulgating training, operating and maintenance procedures and ensuring that they are followed; as well as for keeping records of all use, maintenance, inspections, and the like. He works in con-

sultation with other Qualified Users, the Dean of Sciences, and the KSC Environmental Health and Safety Officer.

Documentation of training, operating and maintenance procedures, equipment manuals, and maintenance and other records are kept in binders on a shelf in the lab, along with a copy of the *New Hampshire Rules for the Control of Radiation*. Additionally, some of this information is available via the lab's web-site (<http://academics.keene.edu/enst/CEB/>). DHHS/BRH Form 5, our Analytical X-ray Machine Registration Certificate, and Emergency Contact Information, are posted in the lab. Signs warning "Caution X-Rays," with the Radiation Symbol, are posted at all entrances to the lab room, and on the instrument near the "X-ray On" warning light, and near the system power switch among other places. The XRF System Manager, together with the KSC Environmental Health and Safety Officer, is responsible for maintaining all signage, labelling, and postings.

XRF Spectrometer Design

The design of the instrument is such that all x-ray beams are contained within the spectrometer housing, a very heavy metal casting, which is normally under vacuum. It is physically impossible for anyone to place any part of their body in the x-ray beam under normal operating conditions (nor is there any need to do so).

Additionally, safety interlock switches are installed on the covers of the instrument, and an interlocked "X-ray On" light is mounted on the top cover. Safety interlocks are also incorporated into the X-ray generator for cooling water temperature, pressure, flow, conductivity, as well as for tube filament current and other system parameters.

The manufacturer of our XRF spectrometer—Rigaku Industrial Corporation (Japan)—certifies that radiation leakage from our instrument is less than 1 microSievert per hour (see serial-numbered ZSX Instrument Inspection Report, attached). A quick informal radiation survey conducted at the time of first installation (using a CD700 survey meter borrowed from the Chemistry Department) revealed no detectable levels of radiation. Subsequent surveys using that and other survey meters have confirmed that result.

At an exposure rate of 1 microSievert per hour, if one worked full-time (8 hours a day, 5 days a week, for 50 weeks a year) in close proximity to the instrument (operating under normal conditions at full power), their exposure to radiation would be less than 2 millirem/year.

This is less than 0.04% of the regulatory annual Occupational Dose Limit (total effective dose equivalent) (for radiation workers); less than 0.4% of the annual dose limit for the Embryo/Fetus of (voluntarily) Declared Pregnant Females (Occupational); and less than 2% of the annual dose limit for members of the public.

Just for comparison, one would receive approximately a four millirem dose of radiation flying in an airplane to the west coast and back, and approximately a six millirem dose from a dental x-ray.

Given these low levels of radiation exposure, and the fact that it is extremely unlikely that any user (faculty, staff or student) would spend all, or even a majority, of their working hours in close proximity to the instrument, personal dosimetry (e.g. film or thermoluminescent dosimeter (TLD) badges) will not be issued.

It is expected that the dose received by members of the public (e.g. in adjacent hallways and rooms) should be negligible, as these areas are further away from the instrument and there are substantial walls separating these areas from the space housing the XRF instrument.

Normal Procedures

Normal Operating Procedures involve loading samples into sample cups and placing these into the Automatic Sample Changer, then entering sample identification information and selecting analytical conditions at the computer terminal. Analysis, including sample loading into the spectrometer, is fully automated and controlled from the computer terminal. These operating procedures may be carried out independently by Qualified Users (including the System Manager), or others under the direct supervision of the System Manager or designee.

Normal Maintenance Procedures include, checking the water levels and filters in the heat exchanger every 3-6 months, changing the oil in the vacuum pumps every 6 months, changing bottles of P10 or Helium gas as necessary (every 3 to 4 months), replacing ion exchange cartridges in the heat exchanger (24-36 months), as well as automatically aging the X-ray tube, carrying out PHA adjustments, and conducting monitoring analyses and drift correction, all done via the computer terminal. None of these procedures require access to the interior of the spectrometer.

Maintenance procedures requiring access to the interior of the spectrometer include replacing blown Flow Proportional Counter Windows as necessary (~12 months), or cleaning the sample chamber (as necessary). In both cases one would turn the X-rays off, as they are not needed for carrying out these procedures. All maintenance procedures are carried out only by the System Manager, or service personnel from Rigaku/ MSC or other qualified vendor.

The safety devices (e.g. cover interlock switches) shall not be bypassed by users. Very rarely, service personnel from Rigaku/ MSC or other qualified vendor might have a need to bypass the safety devices during service or upgrade installation (for example, adjusting the alignment of the analyzing crystal), subject to authorization from the System Manager and the policies of their organization.

Users

Qualified Users of the XRF spectrometer include: the XRF System Manager, and other Faculty, Staff, advanced Students, and Visiting Scientists, who have received safety and operations training, and have demonstrated competence to the satisfaction of the System Manager such that they are allowed to operate the instrument independently without direct supervision of the System Manager. All other users will only use the instrument under the direct supervision of the System Manager or qualified designee.

In addition, service personnel from Rigaku/MSC or other qualified vendor, may also have access to the instrument during installation, maintenance, service, repairs, or upgrades.

The safety training for Qualified Users will include a review of this RPP and related documents (see next paragraph), and instruction on the safety features of the instrument, as well as how to turn X-rays, or the instrument itself, off. By accepting the designation of "Qualified User," such users are acknowledging that they understand that ionizing radiation is produced within the XRF Spectrometer, and that over-exposure to such radiation could potentially be very harmful or even lethal, both to them and/or to their future potential offspring. They are also accepting their obligation to follow the NH Rules and KSC policies and procedures, as well as to promptly inform the XRF System Manager about anything which may lead to unnecessary radiation exposure or which is, or may lead to, a violation of the Rules or of KSC policies and procedures.

The NH Rules, *National Bureau of Standards Handbook 111: Radiation Safety for X-Ray Diffraction and Fluorescence Analysis Equipment*, and the article by R. Jenkins and D. J. Haas, 1973, "Hazards in the Use of X-Ray Analytical Instrumentation," *X-Ray Spectrometry*, Vol. 2, No. 3., p. 14.1.1-14.1.8, will be also made available for users to read, shelved together with this RPP in the lab and posted on the lab's web-site.

Review of the Radiation Protection Program

Review of this RPP will be carried out whenever requested by any user, but at least once every five years. Reviewers shall include the XRF System Manager, the Dean of Sciences, and the KSC Environmental Health and Safety Officer. Reviews will be documented by the dated signatures of all reviewers on an appropriate form. The System Manager will circulate a copy of the RPP to each reviewer, collect their comments and make edits as appropriate, and collect the required signatures. A meeting of the reviewers may be called by any one of them. All copies of the RPP document shall incorporate the revision date on all pages.

Questions or comments should be directed to the XRF System Manager (contact information given on the first page).

RPP Review Form

My signature indicates that I have reviewed the Radiation Protection Program for the Keene State College Analytical Geochemistry Laboratory, dated January 25, 2004. Any comments or suggestions have been forwarded to the XRF System Manager

Timothy T. Allen, XRF System Manager Date

Gordon Leversee, Dean of Sciences Date

Sylvie Rice, Environmental Health and Safety Officer Date

Record of Comments and Revisions:

Keene State College

FULLY AUTOMATED
SEQUENTIAL X-RAY SPECTROMETER

ZSX 100e

INSPECTION REPORT

Ser. No. : YR01039

Power : 200V-60Hz

Date : November. 9. 2001

Approved by

T. Fukuzaki

Checked by

K. Sakata

Inspected by

G. Naite

RIGAKU INDUSTRIAL CORPORATION

Rigaku

1. Construction and Appearance

| | Inspection Item | Contents | Inspection Standard | Judgement |
|---|-----------------|--|--|------------------|
| 1 | Construction | Refer to the specifications in the order. (Construction and Amount) | To fill the Construction Parts List of the order | passed |
| 2 | Appearance | Visually only | It is not scratched ,stained or in any way arranged or changed in appearance. The parts which are fixed on the panel should be the designated.. | passed passed |

2. Safety Check

| | Inspection Item | Contents | Inspection Standard | Judgement |
|---|--|--|--|-----------|
| 1 | Leak of X-ray | Measure the X-ray leak dose with a Survey meter at the maximum load. 4kW (60kV-66mA) 3kW (60kV-50mA) | X-ray leak from the equipment should be 1 μ Sv/h or less. | passed |
| 2 | Safety Switch for X-ray Shut Down Switch | When each microswitch on the door, X-ray tube and sample chamber is working. | When each microswitch on the door, X-ray tube and sample chamber is working, X-ray should be turned off. | passed |
| 3 | Display lamp for X-ray | When a lamp is out. | X-ray should not be turned on. | passed |



検査合格証
CERTIFICATE OF INSPECTION

CAT. NO. 3110

SERIAL NO. YR01039

| | |
|--|--|
| <input checked="" type="checkbox"/> 仕様性能検査 |  |
| Performance <i>T. Kaito</i> | Passed |
| <input checked="" type="checkbox"/> 総合検査 |  |
| Overall Inspection <i>A. Yamashita</i> | Passed |

理学電機工業株式会社
品質管理部 検査課

Inspection Section
RIGAKU CORPORATION