UNIVERSITY OF MISSOURI-COLUMBIA

Research Reactor Facility

Research Park
Columbia, Missouri 65211
Telephone (314) 882-4211
FAX [314] 882-3443

March 13, 1992

US Nuclear Regulatory Commission
Region III
799 Roosevelt Road
Glen Ellyn, IL 60137

ATTN: Mr. L. Robert Gregor, Chief
Docket No. 50-186
Reactor Programs Branch

Dear Mr. Gregor:

This refers to the request made in your cover letter accompanying Inspection Report No. 50-186/91006(DRSS). You asked that we address the concern expressed in the inspection in regard to our external exposure control program and two higher than normal extremity exposures for a pneumatic tube operator. Your original request was to advise you in writing within thirty days of the corrective actions we have taken or plan to take on this matter. On January 29, 1992, Mr. C. McKibben, Associate Director, and Dr. S. Langhorst, MURR Health Physics Manager, discussed with you by phone our desire to have additional time in which to reply to your request. Our reason for making this request was that during this time we would be finalizing MURR's application for a broad scope materials license. This additional time gave us the opportunity to make our long term corrective actions for this type of research under the reactor license (R-103) consistent with how we proposed to handle similar work under the requested materials license. You agreed to our request for additional time and asked that we refer to this phone discussion in our reply.

First, we would like to correct a few minor items contained in the Inspection Report No. 50-186/91006(DRSS) to prevent future misunderstanding. Dr. James Rhyne is the Director of MURR, a position he has held since joining the University in December 1990, and not the Interim Director. Under the Environmental Monitoring Program section (5.d.), semiannual sampling of vegetation, water and soil are gathered at predetermined locations. Milk is not sampled.

During the inspection referenced above, an NRC inspector reviewed the monthly MURR ALARA reports. In the May 1991 and September 1991 ALARA reports, the extremity doses received by a senior experimenter in the MURR Nuclear Analysis Program (NAP Group) were reviewed. These extremity doses for May and September were 4390 mrem and 3600 mrem, respectively. This individual's extremity dose for the second calendar quarter was 4710 mrem (25% of quarterly limit) and for third calendar quarter was 3630 mrem (19% of quarterly limit). In investigating the circumstances of these two exposures, the inspector raised questions concerning the prejob evaluation of the irradiations resulting in the two exposures and the reliance placed on the more than twenty years of experience of this senior experimenter in performing pneumatic tube irradiations. Generic questions were also raised in regard to the extent of administrative and monitoring checks in place to control personnel exposures associated with MURR pneumatic tube irradiations.

Background Information

A pneumatic tube system (p-tube) is utilized at MURR for the purpose of providing short neutron irradiations (typically < 1 hr) of small samples, primarily for neutron activation analysis (NAA). The laboratory p-tube dispatch terminals are located within ventilated hoods with the irradiation position of the system located 150 mm below the reactor core center line near the region of maximum flux in the reflector. The system is operated at a negative pressure with the exhaust air being released through the facility stack. The outer irradiation containers, or "rabbits," are high density polyethylene capsules having an inside diameter of 23.8 mm and a usable length of 79 mm. Samples are typically sealed into a second high density polyethylene container and placed at a fixed position inside the rabbit. Minimum travel time from the p-tube irradiation position to the laboratory terminal is 4 seconds, allowing for detection of short half life activity in the samples.

The irradiations in question are controlled under Reactor Utilization Request (RUR) No. 254 which allow experimenters to irradiate small samples using the p-tube for times ranging from a few seconds to a maximum of one hour, provided activity limits are not exceeded. Procedures and limits governing the use of the p-tube reside in the MURR Standard Operating Procedures (SOP Section VIII.3.). While the experimenter has the control over setting irradiation times and for sample insertion and retrieval, the control of the blower system lies with the control room operators. Prior to irradiation, the experimenter must contact the control room, provide information on the irradiation(s) they will be performing and request that the operators allow the irradiation by initiating the blower system.

Individuals must have prior p-tube authorization to perform these p-tube irradiations and Reactor Operations maintains a list in the control room of approved experimenters for each RUR authorizing p-tube irradiations. The Group Leader of the Nuclear Analysis Program is a principal experimenter for RUR No. 254 and is responsible, along with his senior personnel, in developing and controlling the NAA research programs conducted under this RUR. Individuals seeking approval to be authorized to use the p-tube must be approved by the principal experimenter, by the Health Physics Manager, and finally by the Reactor Manager prior to being allowed to conduct any p-tube irradiations without direct supervision by an authorized individual.

Extremity Exposures and Associated Experiments

The greatest number of p-tube irradiations performed under RUR 254 are for selenium trace element analyses in support of epidemiological studies on human and animal health. Each sample is encased in a small high density polyethylene vial and irradiated one at a time. The typical protocol involves a 5 second irradiation at approximately 8×10^{13} n/cm^2-sec, 15 second decay and 25 second gamma count in order to measure activity of the Se-77m (17.4 second half life). This protocol is performed by the experimenter quickly removing the sample, which is still contained in its small high density polyethylene vial, from the p-tube rabbit. The majority of the activity produced from this irradiation is contained in the rabbit. P-tube experimenters wear TLD ring badges with the sensitive part of the badge turned towards the inside of the hand so that the TLD faces the rabbit as the experimenter opens the rabbit and retrieves the sample vial. Over ten years of experience in developing and utilizing this protocol has provided dose rate data to characterize these irradiations and the associated personnel dose data. The typical personnel exposure from this protocol has been reasonable for the work performed.

Assignment of these trace element projects involving p-tube irradiation are made by the NAP Group Leader and his senior staff with careful consideration to personnel dose. Projects are usually assigned to individuals on a "start to finish" basis. That is the individual prepares the samples for irradiation, irradiates the samples while gathering the associated data, and does the data reduction associated with the assigned project. This "start to finish" assignment technique not only provides dose control by limiting the number of irradiations assigned, but also provides consistency for sample/data control and gives the individual a variety of tasks. Assignments of 600 to 700 irradiations in a month under this protocol have resulted in extremity doses of typically 250 to 300 mrem.

Individual's Higher than Usual Extremity Exposures for May and September 1991

Development of new protocols or evaluation of irradiation techniques/materials utilizing NAA experiments are conducted by the senior NAP staff who have many years experience in performing a wide variety of such irradiations. It was during two such instances of developmental work and evaluation that one of the senior members of the NAP group received higher than normal extremity exposures.

The May extremity dose resulted from a series of irradiations made for a preliminary study to determine the accuracy and precision attainable for the analysis of water and human nail specimens for fluorine (F). An analysis known as cyclic instrumental neutron activation analysis (CINAA) was being utilized. The protocol was very similar to the selenium NAA protocol with an irradiation time of 7 seconds, decay time of 10 seconds and a 10 second count time to measure F-20 (11.03 second half life), but slight differences in irradiation, decay and count times were not considered significant related to extremity dose. However, this protocol involves re-irradiation of the samples (cyclic irradiation) to maximize the signal to noise ratio in determining F content in the presence of other activation products. An initial study of this NAA method for F analysis was conducted in June 1989 when 537 rabbits were irradiated via CINAA using a 5 second irradiation time, a 10 second decay, a 10 second count time and recycle of rabbits after 2.5 minute decay. The resultant extremity dose from this June 1989 project was 280 mrem (1.5% of allowable limit).

The study performed in May 1991 involved approximately 350 sample duplicates and standards. The analysis protocol was modified to allow a 7 second irradiation and to allow 2.5 hour decay for rabbits before reuse to minimize the extremity dose to the experimenter. A total of about 2000 irradiations were planned for the project. The total extremity dose for the project was expected to range between 1000 - 2000 mrem and was planned to be shared between the NAP Group Leader (over 15 years experience in NAA at MURR) and this senior experimenter (over 20 years experience in NAA at MURR). Right after the start of the study, the NAP Group Leader had to shift his attention to another major project. The senior experimenter with the knowledge of the NAP Group Leader decided to perform all the irradiations because of her ability to quickly retrieve the samples from the rabbits. This would result in less hand exposure than having one of the less experienced members of the group do the job. A total of 1721 irradiations were made over a week long period at the beginning of the month. Following completion of the study, this senior experimenter reported to the Health Physics Group to alert them of the higher than normal number of p-tube irradiations performed for this study and the expected higher than normal extremity dose for that individual. The senior experimenter also told HP personnel that work had been scheduled so that she would not be doing further p-tube irradiations that month.

Dose results for the May badges indicated this senior experimenter had received 4370 mrem extremity dose, or approximately twice the upper limit of what had been expected. In reviewing the May dose report the HP manager noted this hand exposure. In discussions with the senior experimenter, the NAP Group Leader and HP Manager investigated the cause of the higher than normal dose which was judged to be due to the higher number of rabbits handled with the short decay time and was documented in the group's May ALARA report. The HP Manager verbally asked the senior experimenter to alert the HP Group prior to performing a future study of this type and to involve them in dose assessment. The senior experimenter reported that another study of this type was not currently scheduled and that the HP Group would be consulted when one is.

In September 1991, this senior experimenter conducted a "rabbit test" to evaluate the integrity of two new types of rabbits, both of a slightly modified rabbit design and one made of a new high-purity source of high density polyethylene. The evaluation was being made to determine whether these changes would improve the integrity of the rabbits and allow for an increased number of uses. NAP group members perform an evaluation of new high density polyethylene stock material to test for unwanted contaminants which could cause excess activation resulting in higher dose rates. They then perform a test of this type to evaluate new batches of rabbits for integrity and to check for contaminants present in the polyethylene that may have been introduced during manufacturing. The test was planned for the senior experimenter to run 20 p-tube irradiations of each of the 36 "new type" and "old type" rabbits (total of 720 irradiations). The experimenter noted a slightly higher (<20% increase) than normal dose rate reading from the "old type" rabbits, but continued with the runs. Noting a higher than normal increase on the personnel pocket chamber, the experimenter thought there was a problem with the pocket chamber and consulted the HP Group. The HP Group did not observe a problem with the pocket chamber but asked her to closely monitor the pocket chamber reading to see if she had further problems. Observing an increase in dose on an assistant's pocket chamber, the senior experimenter stopped the test at a total of 213 irradiations and reported this to the HP Group. The senior experimenter also reported to the HP Group that she expected her extremity dose to be higher than normal for that month. The resultant extremity dose for the senior experimenter was 3600 mrem.

No further tests of this type were scheduled and an investigation by the senior experimenter was immediately initiated to determine the cause of this higher than normal dose rate from the "old type" rabbits. The investigation by the senior experimenter that same day revealed these "old type" rabbits contained higher than normal aluminum contamination, a problem that has been observed in the past for both rabbits and vials. This contamination of aluminum likely resulted from use of a mold-release agent, which when irradiated produces Al-28 (2.24 minute half life). With this short half life, handling of these rabbits immediately following irradiation, as needed in the selenium and fluorine analyses and as was done in the rabbit tests, would result in higher than normal extremity dose, especially when large numbers of samples are handled. Boxes containing these rabbits had been uncovered following the rearrangement of NAP supplies during a supply area housecleaning done in April 1991.

Hence, the higher than expected extremity dose obtained in the September 1991 rabbit test can likely be attributed to these "old type" rabbits manufactured in 1985. These 1985 rabbits were produced prior to the more comprehensive testing of stock material that was initiated in 1987, and prior to the NAP group requiring the manufacturer to purge the injection molding equipment of mold release agents (i.e., Al_2O_3), before making rabbits and vials for MURR. It is also considered that these 1985 rabbits may have contributed to the extremity dose obtained in the May fluorine measurements.

Areas of Concern and Corrective Actions

One area of expressed concern was the reliance placed upon the considerable experience of the NAP Group to control the radiological aspects of their experiments. Work under RUR 254 does allow a wide range of possible extremity doses which has been controlled by agreements made between the NAP experimenters and the HP Manager and Reactor Manager to limit the less experienced experimenters to the routine, well established irradiation protocols, and to allow only the senior experimenters to conduct the developmental and evaluation protocols. The administrative structure of p-tube authorizations under the various RURs is being evaluated and modified to formalize these experimenter restrictions. This will establish the types of irradiations an individual may be approved to run and identify these individuals to the control room operators and to the HP Group. It will also establish the maximum number of irradiations that can be allowed. Projects requiring a greater number of irradiations will require additional preiob evaluations involving the HP Group.

The slight aluminum contamination contained in the 1985 batch of high density polyethylene rabbits raised another area of concern. New batches of rabbits can contain contaminants making them unacceptable for some irradiation protocols. The September tests conducted on the new design of high density polyethylene rabbits were in part performed to make this evaluation. This type of evaluation had been rigorously applied to sample vials and more recently applied to rabbits. Information concerning activatable contaminants in rabbits manufactured in the 1980s had not been clearly attached to the rabbit stores. Nor had the extent of the knowledge been well documented. The NAP Group is now clearly marking all boxes of rabbits or vials after the batch is tested for trace contaminants. This also pertains to the 1985 rabbits which are marked as being prohibited from use in the analysis of short half life nuclides.

Even with this evaluation, the question remains as to how the p-tube experimenter knows during the course of p-tube irradiations when there may be a problem, especially with these short irradiations involving short decay times. To strengthen the awareness of the p-tube experimenter and to improve documentation of the irradiations, the p-tube log sheet used in the laboratory to additionally record the p-tube irradiations has been modified to record such things as the checks made of proper dosimetry, operation of the room frisker, and periodic readings of the experimenter(s) pocket chambers. Additional monitoring equipment is also currently being evaluated to provide alarm capabilities to give the experimenter indication of higher than expected dose rates and/or cumulative dose received during a series of irradiations. Evaluation is ongoing to determine the appropriate alarm levels to provide this additional "safety net" for the control of reasonable extremity exposures. The evaluation of modifications to protocols, handling techniques and equipment also continue for all p-tube irradiation projects.

It was mentioned in the inspection report that RUR 254 had not been evaluated to verify its continued applicability to current NAA work. Such a review was made in June 1990 with the principal experimenter and the Reactor Manager. The HP Group has typically not been included in this review when no changes have been requested. This is a weakness in the overall periodic review of this type of work. The HP Group is now included in the periodic review of the RURs. Also with the establishment of a MURR-specific broad scope license, a more formal review criteria in evaluating radiation safety for handling radioactive material under the reactor license or materials licenses is being put into place. This is to better document the necessary controls and user responsibilities in planning and conducting procedures involving radioactive materials.

If you have any questions concerning this report, you may contact Dr. Sue Langhorst at (314)882-5227 or Mr. Charlie McKibben at (314)882-5204.

Sincerely,

Susan M. Langhorst

Susan M. Langhorst, PhD, CHP
Manager, Health Physics

Endorsement:
Reviewed and Approved

J. Charles McKibben
Associate Director

xc: Director of Nuclear Reactor Regulation, NRC ✓
Reactor Advisory Committee
Reactor Safety Subcommittee
Isotope Use Subcommittee