



International Isotopes Inc.
& *International Isotopes Idaho Inc.*

03037509

July 9, 2007

Mr. Bruce Carrico
U.S. NRC
State Agreements and Industrial Safety Branch
Mail Stop 8 F5
Two White Flint North
11545 Rockville Pike
Rockville, MD 20852-2738

Subject: Application for Exempt Distribution of Irradiated Gemstones License

Dear Mr. Carrico,

International Isotopes Inc. is submitting an application for a license to authorize the distribution of irradiated gemstones to unlicensed individuals. There is notable concern in the gemstone industry that the availability of neutron irradiated gemstones, primarily blue topaz in the United States may be greatly reduced or all together eliminated, resulting in substantial financial losses for wholesalers and retailers of blue topaz jewelry. It is requested that this request be acted upon expeditiously so that the growing concern over the supply of neutron irradiated blue topaz in the gemstone industry can be stemmed and the financial losses kept to a minimum.

A completed NRC Form 313 and supporting documentation is enclosed for your review, as is check for \$8700.00 to cover the cost of the licensing application fee. I would also request that the contents of this application be considered proprietary.

Should you have any questions, please contact me by phone at (208) 524-5300 or by email at jjmiller@intisoid.com.

Sincerely,

John J. Miller, CHP
Radiation Safety Officer
International Isotopes Inc.
4137 Commerce Circle
Idaho Falls, ID 83401

JJM-2007-17

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NRC FORM 313
(10-2005)
10 CFR 30, 32, 33,
34, 35, 36, 39, and 40

U.S. NUCLEAR REGULATORY COMMISSION

APPLICATION FOR MATERIAL LICENSE

APPROVED BY OMB: NO. 3150-0120

EXPIRES: 10/31/2008

Estimated burden per response to comply with this mandatory collection request: 4.4 hours. Submittal of the application is necessary to determine that the applicant is qualified and that adequate procedures exist to protect the public health and safety. Send comments regarding burden estimate to the Records and FOIA/Privacy Services Branch (T-5 F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0120), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

APPLICATION FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

DIVISION OF INDUSTRIAL AND MEDICAL NUCLEAR SAFETY
OFFICE OF NUCLEAR MATERIALS SAFETY AND SAFEGUARDS
U.S. NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS:

IF YOU ARE LOCATED IN:

ALABAMA, CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, FLORIDA, GEORGIA, KENTUCKY, MAINE, MARYLAND, MASSACHUSETTS, MISSISSIPPI, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, NORTH CAROLINA, PENNSYLVANIA, PUERTO RICO, RHODE ISLAND, SOUTH CAROLINA, TENNESSEE, VERMONT, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:

LICENSING ASSISTANCE TEAM
DIVISION OF NUCLEAR MATERIALS SAFETY
U.S. NUCLEAR REGULATORY COMMISSION, REGION I
475 ALLENDALE ROAD
KING OF PRUSSIA, PA 19406-1415

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:

MATERIALS LICENSING BRANCH
U.S. NUCLEAR REGULATORY COMMISSION, REGION III
2443 WARRENVILLE ROAD, SUITE 210
LISLE, IL 60532-4352

ALASKA, ARIZONA, ARKANSAS, CALIFORNIA, COLORADO, HAWAII, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEVADA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, OREGON, PACIFIC TRUST TERRITORIES, SOUTH DAKOTA, TEXAS, UTAH, WASHINGTON, OR WYOMING, SEND APPLICATIONS TO:

NUCLEAR MATERIALS LICENSING BRANCH
U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
611 RYAN PLAZA DRIVE, SUITE 400
ARLINGTON, TX 76011-4005

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S. NUCLEAR REGULATORY COMMISSION JURISDICTIONS.

1. THIS IS AN APPLICATION FOR (Check appropriate item)

- A. NEW LICENSE
- B. AMENDMENT TO LICENSE NUMBER _____
- C. RENEWAL OF LICENSE NUMBER _____

2. NAME AND MAILING ADDRESS OF APPLICANT (Include ZIP code)

International Isotopes Inc.
4137 Commerce Circle
Idaho Falls, ID 83401

3. ADDRESS WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED

4137 Commerce Circle
Idaho Falls, ID 83401

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION

John J. Miller, CHP

TELEPHONE NUMBER

(208) 524-5300

SUBMIT ITEMS 5 THROUGH 11 ON 8-1/2 X 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL

a. Element and mass number, b. chemical and/or physical form; and c. maximum amount which will be possessed at any one time.

6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED.

7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING EXPERIENCE.

8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS.

9. FACILITIES AND EQUIPMENT.

10. RADIATION SAFETY PROGRAM.

11. WASTE MANAGEMENT.

12. LICENSE FEES (See 10 CFR 170 and Section 170.31)

FEE CATEGORY 31 AMOUNT ENCLOSED \$ 8,700.00

13. CERTIFICATION. (Must be completed by applicant) THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT, NAMED IN ITEM 2, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 30, 32, 33, 34, 35, 36, 39, AND 40, AND THAT ALL INFORMATION CONTAINED HEREIN IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

WARNING: 18 U.S.C. SECTION 1001 ACT OF JUNE 25, 1948 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

CERTIFYING OFFICER - TYPED/PRINTED NAME AND TITLE

Steve Lafin, President/CEO

SIGNATURE

DATE

7.6.07

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	AMOUNT RECEIVED	CHECK NUMBER	COMMENTS
			\$		
APPROVED BY				DATE	

022612

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5 RADIOACTIVE MATERIAL

5.a. Element and mass number

Isotopes with atomic numbers between 1 through 94 not to exceed a bulk concentration of 2 nCi/g (74 Bq/g)

5.b. Chemical and/or Physical Form

Neutron Irradiated Gemstones, (Topaz, quartz, beryl, diamonds)

5.c. Maximum amount which will be possessed at any one time

4 mCi

6 PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED

For exempt distribution within the United States and export

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The following background information is provided as outlined in NUREG-1556, Volume 8, Appendix G, *Information Needed from an Importer to Support Application for License Pursuant to 10 CFR 32.11 to Distribute Neutron-irradiated Gems to Persons Exempt from Licensing (February 25, 1988)*. It is important to note that the scope of Appendix G is limited to developing an application for an importer of irradiated gemstones, this application is also intended to authorize the exempt distribution of domestically irradiated gemstones which are exported and then subsequently imported into the United States as finished jewelry or gemstones that are cut and polished and ready for mounting.

It should also be noted that International Isotopes Inc. has been processing irradiated topaz gemstones for the last 7 years at an average rate of 650,000 carats per month. Given this experience the processing and analysis procedures associated with the release of topaz gemstones at the Thailand Office of Atoms for Peace (OAP) clearance level of 74 Bq/g has become quite robust. International Isotopes Inc. recommends that the United States Nuclear Regulatory Commission adopt the 74 Bq/g clearance level for irradiated gemstones in lieu of the exempt concentration levels currently listed in Title 10 §30.70 Schedule A. This level is consistent with the global market release criteria and poses no health risk to members of the general public.

The following documents are provided to support this application:

- International Isotopes Inc. Quality Assurance Manual – May 01, 2007
- Quantification of Phosphorous-32 and Sulfur-35 Activity Concentrations in Irradiated Topaz, I4-WP-001 Revision 1, February 22, 2002
- Radioactivity Concentration Inherent to Irradiated Topaz and Irradiation Canisters, I4-WP-002, March 07, 2001
- Blue Topaz Processing, I4-OP-17, March 3, 2007
- White Topaz and Diamond Processing, I4-OP-18, May 7, 2007
- Topaz Inventory and Control, I4-OP-19, October 24, 2003
- Blue Stone Counting, I4-OP-20, June 11, 2003
- Example of a Topaz release Certificate along with corresponding Earliest Ship Date Calculation Spread Sheets
- VARSKIN-MOD2 Dose Model for beta dose to skin, File-Topaz 5ct 003cm.OUT
- VARSKIN-MOD2 Dose Model for beta dose to skin, File-Topaz 5ct 4cm.OUT
- MicroShield v6.10 Dose Model Case Title: 5 Ct. topaz @ 0.1 cm
- MicroShield v6.10 Dose Model Case Title: 5 Ct. topaz @ 4 cm

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Guidance from Appendix G NUREG 1556 Volume 8

Background Information

1. Describe material to be distributed

a. The type of gems:

Primarily topaz, other gems – quartz, beryl, diamonds.

b. Extent to which gems have been processed before irradiation:

Only cut and polished gemstones will be released for exempt distribution at 2 nCi/g (74 Bq/g) within the United States. Rough cut gemstones that require additional processing will be released at the 2 nCi/g level and will be exported. These gemstones will be finished and then may be imported back into the United States. Gemstones that have been exported at the exempt distribution levels and are subsequently imported into the United States as cut and polished stones or mounted in jewelry will be considered releasable to persons exempt from licensing based on analysis performed prior to the initial export.

c. The type(s) and sequence of irradiation or other treatment to which the gems have been exposed before they are imported.

Neutron Irradiation Only – 10% to 20%

Neutron Irradiation followed by electron beam particle accelerator irradiation (< 10 MeV) – 70% to 80%

Electron beam particle accelerator irradiation only (< 10 MeV) – 10% to 20%

d. Where and by whom each irradiation or other treatment is performed.

Neutron irradiation conducted at the University of Missouri Research Reactor Center, located in Columbia Missouri. Electron beam accelerator treatment conducted by Iotron Industries Canada, Port Coquitlam, British Columbia or Iotron Limited, Oxfordshire, United Kingdom.

e. If gems are exposed to additional irradiation or treatment after importation, the type(s) and sequence and where and by whom each is performed.

Not Applicable

f. How gems are handled to ensure grouping according to geological origin of gems and type(s) of irradiation or treatment to which gems have been exposed (significant variations in induced radionuclides will result from differences in gems' origin and type(s) of irradiation or treatment received).

There are variations in the activation products of gemstones that are of different geological origin. However this does not affect the release criteria and is not a parameter

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worth tracking. International Isotopes Inc. maintains an extensive database which tracks the gemstones from the time that they are received at International Isotopes Inc. (as white stones) until they are released for export at a level below the 74 Bq/g clearance level. All gemstones processed through International Isotopes Inc. are grouped in packages of approximately 40,000 carats. The gemstones are assigned a specific Pack-code and are of a similar size, cut, finish and of the same geological origin. A Pack of gemstones is irradiated for a given number of hours to achieve the desired color. The irradiation time is much more important than the geological origin in regards to the radioactive properties of the irradiated gemstones. Each Pack is decontaminated following irradiation (Packs are cleaned prior to irradiation using nitric acid and D.I. water prior to irradiation) and then held for a period of time dependent on the irradiation hours before it is processed to allow for short-lived radioisotopes to decay. After the initial decay period the process to release the Pack begins. The first step is referred to as the quick-sort. The intent of the quick-sort is to ensure that the activity in the irradiated gemstones is homogenous. The stones are scanned using a shielded sodium-iodide probe. Stones that exhibit a count rate appreciably higher than the norm are removed from the pack and eventually disposed of as radioactive waste or held for decay so they may be reanalyzed at a later date. Following the quick sort the irradiated gemstones are analyzed via high-purity germanium detector and scintillation counting to identify gamma emitting isotopes and P-32 and S-35. The Pack is then held until the activity concentration of the highest bag is below 74 Bq/g and then subsequently exported.

- g. Identification of all radionuclides with physical half-lives greater than 2 hours (regardless of method of production) induced in gems and classification of each as either "major" or "minor" radionuclide depending on its contribution to total activity in gems to be distributed to persons who are exempt from licensing.

The table below provides a list of major and minor isotopes. Of the major isotopes, Ta-182 is typically the predominate isotope in irradiated topaz, regardless of geological origin. Mn-54 is typically the second most abundant followed by Sc-46. Cs-134 is usually not identified in irradiated topaz but is very common in irradiated beryl, which may be erroneously identified as topaz. International Isotopes Inc. removes irradiated beryl from the irradiated topaz. Beryl is visually identifiable following irradiation due to the resulting pink or yellow color of the stone. P-32 and S-35 are two isotopes identified in NUREG-5883 as being the only "likely" beta only emitters in irradiated gemstone. Definitive identification of these isotopes is not possible without destroying the gemstone. Therefore a conservative method of determining the relative activity of S-35 and P-32 is utilized. Details of the activity determination of P-32 and S-35 are provided in I4-WP-001, *Quantification of Phosphorous-32 and Sulfur-35 Activity Concentrations in Irradiated Topaz*.

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Major		Minor		Minor		Minor	
Isotope	Half-life	Isotope	Half-life	Isotope	Half-life	Isotope	Half-life
Sc-46	83.9 d	As-74	17.8 d	Hg-203	46.6 d	Sb-122	2.7 d
Mn-54	312.5 d	Ba-133	3905.5 d	Ir-192	74.0 d	Sb-124	60.2 d
Zn-65	243.8 d	Ce-139	137.5 d	Na-22	949 d	Sb-125	1011.1 d
Cs-134	751.9 d	Ce-141	32.5 d	Nb-95	35.0 d	Sn-113	115.1 d
Ta-182	114.5 d	Co-58	70.8 d	Pa-233	27.0 d	Sr-85	64.8 d
		Co-60	1923.6 d	Pm-151	1.2 d	18.6 d	72.3 d
Beta Only		Cr-51	27.7 d	Pm-151	Rb-86	18.6 d	Y-91
P-32	14.3 d	Fe-59	44.5 d	Re-183	70.0 d	Zr-95	64.0 d
S-35	87.9 d	Hf-181	42.4 d				

- h. How the information provided in response to Item B.1.g above was obtained and how NRC can be assured that this information is representative of gems imported in the future.

This information was obtained using guidance from NUREG/CR-5883, Health Risk Assessment of Irradiated Topaz, and nearly 7 years of operational data collected by International Isotopes Inc. which consists of the analysis of approximately 55 million carats of irradiated topaz. The University of Missouri Research Reactor, provided International Isotopes Inc. with archived analytical data. While there may be variations in the isotopic ratios and levels of activation associated with neutron irradiated gemstones from various geological origins and irradiation times, the isotopes identified in analysis remains consist. If an anomaly should occur it is readily identifiable.

- i. The requested possession limit determined by multiplying the maximum number of gems to be possessed at one time by the maximum total activity anticipated in any one gem.

4 mCi. Correlates to 10 million carats at 2 nCi/g (74 Bq/g).

2 Describe the handling of gems, including:

- a. Procedures used to ensure that each irradiated gem is free of removable contamination, including a description of sampling, monitoring, counting and statistical techniques used, specification of the criteria used to determine when gems are essentially “free of removable contamination” and a description of what will happen to gems exceeding the specified criteria.

Polishing compounds, oils and other contaminants are removed from the gemstones prior to irradiation by cleaning in an ultrasonic bath using 2.0 N nitric acid followed by two ultrasonic baths in de-mineralized water, this process is detailed in International Isotopes Inc. Operating Procedure, I4-OP-18. Following irradiation, the gemstones are cleaned in an ultra sonic bath in accordance with International Isotopes Inc. Operating Procedure, I4-OP-017, Blue Topaz Processing. After the final decontamination

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removable contamination levels are determined by running damp swabs through out the gemstones. A criterion of less than 1000 dpm/swab is used to indicate the stones are free of removable contamination. If the stones exceed the removable contamination level of 100 dpm/swab then a second attempt at decontamination is performed. If after a second attempt removable contamination levels exceed 1000 dpm/swab then the supervisor and Radiation Safety Officer determine the necessary actions to be taken. In some cases the topaz is simply placed into sealed plastic bags and allowed to decay for a period of time and then the decontamination process is repeated at a later date. In other cases, the decontamination method is adjusted by either using a harsher solution such as nitric acid or by extending the time in the ultrasonic bath.

- b. The processing of irradiated gems at the importer's facility and the sequence of these activities (e.g. counting of gems and storage for physical decay; mounting in rings, pendants or other settings)

International Isotopes Inc. prepares gemstones for irradiation, which includes pre-cleaning the stones and loading into irradiation canisters. After irradiation, International Isotopes Inc. removes the irradiated stones from the irradiation canisters, decontaminates the stones to remove surface contamination, sorts the stones to remove higher activity stones, counts the stones utilizing a high purity germanium detector to determine the activity concentration of gamma emitting radionuclides and plastic scintillation counters to determine the P-32 and S-35 activity concentrations. The gemstones are then held for physical decay over a period of time calculated based on the results of the counting analysis. Gemstones are not cut, polished or mounted at the International Isotopes Inc. facility. Refer to International Isotopes Inc. Operations Procedures I4-OP-17, 18, 19 and 20.

- c. The categories of unlicensed organizations to which irradiated gems will be transferred (e.g. wholesaler; manufacturing jeweler; retail jeweler; individual consumer)
Irradiated gemstones are transferred to wholesalers or jewelry manufactures.
- d. What will be done with gems whose concentrations exceed the criteria specified in response to Item C.2.e below (Alternatives include hold in storage for physical decay, transfer to a person specifically licensed to receive them, or disposal as radioactive waste in accordance with the requirements of 10 CFR Part 20 or equivalent regulations of an Agreement State).

Gemstones exceeding the criteria identified in C.2.e. are either disposed of as radioactive waste or held for physical decay below the release criteria.

Information Required by 10 CFR 32.11

1. Paragraph 32.11(a) requires that the general requirements of 10 CFR 30.33 be satisfied. To comply with this requirement (or equivalent requirements of Agreement States), the applicant will:

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- a. Explain how the facilities and equipment proposed in the application are adequate to protect health and minimize danger to life or property; specifically explain how irradiated gems will be stored and secured against unauthorized removal or, when not stored and secured, will be tended under constant surveillance and immediate control of a knowledgeable, responsibly person on the importer's staff.

International Isotopes Inc. is currently licensed by the United States Nuclear Regulatory commission to process irradiated gemstones for export, to distribute I-131, to manufacture sealed sources and to handle thousands of curies of Co-60. The infrastructure in place to support licensed operations governed by US NRC License, 11-27680-01 will be fully utilized to support licensed activities under the requested exempt distribution license. International Isotopes Inc. currently maintains an inventory of irradiated gemstones. When not in process the gemstones are stored in a vault or are contained in welded irradiation canisters. International Isotopes Inc. maintains a topaz database that tracks gemstones from the time they are received by International Isotopes Inc. until the time they are released.

- b. Identify by name the individuals who will be responsible for handling, irradiation, storing, counting, evaluating, and controlling the release of irradiated gems; correlate individuals' names with their responsibilities; and describe the training and experience of each of these individuals that assures protection of the public health and safety. The following individuals are currently involved in irradiated gemstone processing under NRC license 11-27680-01 and would perform the same activity under the proposed exempt distribution license. Refer to the attached operation procedures for a more detailed description of these tasks.

Name	Task	Training
John Miller	Radiation Safety Officer, Quick sorting, Counting and Analysis, Authorize Release	C.H.P., BS Radiation Protection, MS Environmental Engineering
Ben Young	Quick sorting, Counting and Analysis, Authorize Release	BS. Health Physics, Radiation Worker, OJT
Shawn Anderson	Supervisor, Canister Welding, Canister Milling, Decontamination	AI Welding, Radiation Worker, OJT
Miles Cook	Canister Welding, Canister Milling, Decontamination, Quick Sorting, Counting	AI Welding, Radiation Worker, OJT
Brent Mecham	Canister Welding, Canister Milling, Decontamination, Quick Sorting, Counting	AI Welding, Radiation Worker, OJT
Paula Rashotte	Quick Sorting, Counting	Radiation Worker, OJT
Phillip Williams	Quick Sorting	Radiation Worker, OJT
Ken Stone	Quick Sorting	Radiation Worker, OJT

While this application assigns specific tasks to individuals, International Isotopes Inc. has the authority to assign additional personnel to perform the above mentioned tasks so

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long as that individual has been specifically trained in that task.

- 2 Paragraph 32.11(b) requires that certain information be provided. If information on one or more points has already been provided, reference the previous response by section and item number or provide a complete response. To comply with 10 CFR 32.11 (b), the applicant will describe:

- a. The product or material into which byproduct material will be introduced.

See response to B.1.a above.

- b. The intended use of the byproduct material and the product or material into which it is introduced.

Byproduct material is introduced into gemstones subsequent to irradiation. Gemstones are irradiated to enhance the color of the gem. These gemstones are subsequently used in jewelry. Unusually large gemstones, (in excess of 100 carats) are typically used for display and are not intended for consumer use.

- c. The method of introduction.

See response to B.1.c and e. above.

- d. Initial concentration of byproduct material in the product or material.

This value varies greatly and depends on the irradiation hours. The maximum activity levels observed in irradiated gemstones analyzed for release has been as high as 20 nCi/g (740 Bq/g).

- e. Estimated maximum concentration of the radioisotopes in the product or material at the time of transfer to persons exempt from licensing.

2 nCi/g (74 Bq/g)

- f. Control methods to assure that no more than the specific maximum concentration is in the product at the time of transfer.

Irradiated gemstones are analyzed shortly after the end of irradiation which ensures the concentration of radioisotopes contained within the stones are much higher than the minimum detectable activity of the analysis. Release is not authorized until gemstones decay below 70 Bq/g which provides an added margin to ensure gemstones are less than 74 Bq/g.

- g. Estimated time interval between introduction and transfer of the product or material (i.e. between completion of all types of irradiation and transfer to unlicensed persons.)

This time interval will vary according to neutron irradiation hours. Topaz irradiated for 20 hours or less may be transferred to unlicensed persons at an activity concentration of 2 nCi/g approximately 15 days after irradiation. Topaz irradiated for 90 hours or more

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may be transferred to unlicensed persons at an activity concentration of 2 nCi/g approximately 180 to 600 days after irradiation. This however is not the time that it takes to get to the end consumer. Once the gemstones are released from the International Isotopes Inc. facility they either go to Iotron for electron beam irradiation or back to the supplier of the white stones. At a minimum it takes an additional 3 months to get the irradiated gemstone to market, although 1 additional year is a more likely estimate. Considering these times the minimum time a gemstone will reach the market would be 1 year after irradiation and may be as long as 3 years after irradiation.

3. Paragraph 32.11(c) requires applicants to provide reasonable assurance of the following:

- a. Concentrations of byproduct material at time of transfer will not exceed the concentrations in 10 CFR 30.70. **Note:** that the limit for a single radionuclide is given in 10 CFR 30.70; the limits for multiple radionuclides are calculated using the “sum of the ratios” method described in Note 2 of 10 CFR 30.70.

International Isotopes Inc. requests that the distribution of irradiated gemstones to unlicensed individuals be authorized at a total activity concentration of less than 2 nCi/g (74 Bq/g). The operating procedures implemented at the International Isotopes Inc. facility that govern, the processing, handling, analysis and release of irradiated gemstones will assure gemstones are not released below the 2 nCi/g criteria.

- b. Re-concentration of the byproduct material in concentrations exceeding those specified in 10 CFR 30.70 is not likely (e.g., in the case of gemstones, one could consider that neutron irradiation followed by accelerator-irradiation could increase the induced activity and thus be considered “re-concentration”).

Irradiated gemstones released by International Isotopes Inc. that are subsequently irradiated in an electron beam accelerator are done so in accelerators that operated below 10 MeV. Irradiations conducted at energies below 10 MeV are not expected to increase the radioactivity level of the gemstone.

- c. Use of concentrations lower than those specified in response to Item C.2.e are not feasible (e.g. why maximum values for a single radionuclide should not be lower; why values for multiple radionuclides should not be calculated by setting the “sum of the ratios” equal to a value less than unity).

Releasing irradiated gemstones when the “sum of the ratios” of activity concentration to exempt concentration is less than unity would result in extremely long release times (as high as 8 years) and would most likely result in the closure of the U.S. market.

Releasing irradiated gemstones at the exempt concentration limits for each of the radionuclides present, could theoretically result in the release of gemstones exceeding the 74 Bq/g criteria adopted by other countries.

- d. The product or material is not likely to be incorporated into any food, beverage, cosmetic, drug or other commodity or product designed for ingestion or inhalation by a human being.

The fact that these are gemstones provides reasonable assurance that they are not

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introduced into any food, beverage, cosmetic, drug or other commodity or product designed for ingestion or inhalation by a human being. Topaz would remain insoluble in the G.I. tract so inadvertent ingestion would result in a negligible dose

Information on Quality Assurance

1. Describe the radiation detection equipment and shielding associated with it that are to be used to identify and quantify the radioactivity induced in gems.
Thermo Scientific Series 900 Mini-Monitor with shielded NaI Probe utilized for qualitative analysis of irradiated gemstones to identify and remove outlier stones.

Canberra Gamma Analyst, High Purity Germanium (HPGe) gamma spectroscopy system, with Model GC2020 detector used for the detection and quantification of gamma emitting radionuclides present in irradiated gemstones.

NE Technology Delta 5 with BP7/4A 100 cm² Plastic (Anthracene or Perspex) Scintillation Probe for quantification of beta only emitters, P-32 and S-35 theoretically present in irradiated gemstones.

2. Specify the frequency, standards (including radionuclide, activity, and accuracy), and procedures used to calibrate such radiation detection equipment.
Thermo Scientific Series 900 Mini-Monitor calibrated annually by 3rd Party. Reference checked daily when in use by International Isotopes.

Canberra Gamma Analyst – Calibrated via counting system soft-ware by International Isotopes Inc. using NIST traceable multi-nuclide standards for the irradiated gemstone counting geometries. Daily quality assurance check used to verify the energy calibration, efficiency calibration and resolution (full-width at half maximum) when the system is in use.

NE Technology Delta 5 with BP7/4A calibrated annually by 3rd Party. Reference checked daily when in use by International Isotopes.

3. Describe counting procedures and how external measurements are converted to concentration values in terms of microcurie per gram. Your description should include but is not limited to:
Refer to International Isotopes Inc. Operating Procedure I4-OP-20, Blue Stone Counting for a description of the counting procedures. The counting techniques employed at International Isotopes Inc. determines activity concentration directly, there is no need to convert external measurements into units of activity per gram.
 - a. Selection of samples.
Irradiated topaz packs are sub-divided into 3 or 4 bags of approximately 5,000 to 10,000 carats. All stones are scanned individually during the quick sort process to remove outliers and non-topaz stones such as quartz or beryl using a shielded NaI probe. Following the quick sort, the bags are then analyzed in 1 liter or 500 milliliter Marinelli

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beakers in a Canberra Gamma Analyst, high purity germanium detector. For beta counting a random sample of 50 to 100 grams is selected from each of the bags associated with a lot. This mass coincides with the quantity of stones that will form a single layer of topaz on the beta sampling tray which is sandwiched between two plastic scintillation detectors.

- b. Maximum and minimum sample size (in terms of number of stones and mass)
Quick-sort: stones are scanned individually.

Gamma Spectroscopy: Samples range from 1700 to 2200 grams, (8500 to 11000 carats)
The number of individual stones is hard to quantify, may be as little as 50 stones or it may be as high as 50,000 stones, depending on the carat weight of the stone.

Beta Counting: Stones are arranged in a single layer on a sample tray that is sized to coincide with the 100 cm² active area of the scintillation probes. Sample weight ranges from approximately 25 grams (125 carats) to 100 grams (500 carats).

- c. Counting efficiency

Quick Sort: - Thermo Scientific Series 900 Mini-Monitor with shielded NaI Probe \approx 15%, Probe however is used in the counts per second mode and an efficiency correction is not utilized.

Gamma Spectroscopy HPGe Detector – 20% detector, efficiency dependent on emission energy, curve attached.

Beta Counting – Efficiency for S-35 \approx 15%, Efficiency for P-32 \approx 35%

- d. Counting times

Quick Sort: - Stones scanned at slow rate, held for 5 to 10 seconds when elevated count rate is detected.

Gamma Spectroscopy HPGe Detector – Live time = 600 seconds, real time varies with dead time.

Beta Counting – 120 seconds

- e. Counting geometry

Quick Sort: - Individual stones are scanned, 2π geometry.

Gamma Spectroscopy HPGe Detector – 500 milliliter or 1 liter Marinelli beakers.

Beta Counting – Stones in single layer on counting tray with area sized to coincide with the 100 cm² active area of the probe.

- f. Time of counting (in relation to completion of irradiation and transfer to unlicensed persons)

Varies with irradiation hours. May range from 7 to 45 days after the end of irradiation. Transfer to unlicensed persons dependent on activity concentration of stones. Range can be from 1 day to 2 years following counting, when released at 2 nCi/g.

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- g. Lower limits of detection
Quick Sort – Qualitative analysis LLD not recorded.
Gamma Spectroscopy - < 0.3 nCi/g (1 Bq/g)
Beta Counting – P-32 < 0.3 nCi/g (1 Bq/g) S-35 < 1.5 nCi/g (55.5 Bq/g) NOTE: LLD for beta counting highly dependent on stone size.
- h. Statistical methods for analyzing data, calculating background and lower limit of detection, and determining confidence levels.
Gamma Spectroscopy – Computer based system, background, LLD, confidence levels determined via Canberra’s Genie 2000 software.
Beta Counting – Refer to I4-WP-001 Revision 1 *Quantification of Phosphorous-32 and Sulfur-35 Activity Concentrations in Irradiated Topaz*, attached.
- i. Procedures for minimizing “false negatives” (i.e., failure to identify individual gems with radionuclide concentrations greater than those specified in response to C.2.e); and Gemstones are received as a “pack” by the supplier, the “pack” consists of gemstone from the same geological region, the same finish and similar carat weight. The “pack” remains together during the entire irradiation process. This ensures a certain level of homogeneity in the levels of induced radioactivity amongst the individual gemstones from the pack. Attempting to quantify activity concentration and identify radionuclides in a single gemstone is highly impracticable. Because the amount of radioactivity in a single gemstone is very small, the counting time needed to achieve an acceptable LLD would be excessive. The quick sorting process is the critical step in minimizing false negatives. By removing individual outlier stones identified during the quick sorting process the likelihood of an individual gem having an activity concentration greater than 2 nCi/gram is minimized.
- j. Sample calculations.
Refer to I4-OP-20 and I4-WP-002. Copies of Earliest Ship Date calculation sheets are provided for reference.
4. Specify who will be responsible for the QA program, and describe this individual’s training and experience in detection and analysis of low-levels of radioactivity. If this individual was identified in response to Item C.1.b, it is not necessary to repeat the individual’s qualifications, provided that the response to Item C.1.b includes a clear description of the persons’ training and experience in low-level counting techniques. The International Isotopes Inc. Radiation Safety Officer, John Miller, is responsible for the handling, processing, analysis and final release of irradiated gemstones. Mr. Miller has over 15 years experience as a health physicist, has been certified by the American Board of Health Physics since 1997 and has maintained his certification through continuing education in health physics.

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5. Describe the QA program used to assure reliable data including:
- a. The standards, frequency and procedures used to perform constancy tests on the counting systems.

Daily checks are performed on the gamma spectroscopy and beta counting systems daily when in use. The gamma spectroscopy check procedure is computer based and checks the system gain, (energy response curve) system efficiency (peak area) and resolution (full-width at half maximum) for the 661.7 keV Cs-137 (Ba-137m) and 1173.2 keV Co-60 peaks. Either the 500 ml or 1 l Marinelli beaker standard is used to conduct this check.

The daily check performed on the beta counting system utilizes a 1 uCi Cs-137 check source. Immediately after calibration the Cs-137 reference source is analyzed on the beta counting instruments to provide a response baseline. The baseline is recorded on the Daily Check Log Sheet. Instrument response must be within +/- 20% of the post calibration response.

- b. The methods and frequency of introducing "spiked"

Not conducted on a formal basis. However in the course of reviewing the gamma spectroscopy results of gemstone, the RSO has made the determination that based on the gamma spectrum, a hot stone or a few hot stones were missed during the quick sort process. This is usually indicative of the results of one bag being noticeably different than the results of the other 3 bags. This is usually manifested as elevated activity concentrations and a longer "real time" or a difference in the radionuclides identified. When this occurs the bag or bags the counting process is repeated beginning with the quick sort.

6. Provide a commitment that, during the term of the license, the applicant will comply promptly with requests from the NRC designed to monitor counting techniques. The general nature of these requests is outlined below:

- a. Upon request, the applicant will provide samples of irradiated gems to NRC for independent verification of radionuclide identity and concentration. NRC's request will be in writing, signed by the appropriate Regional Administrator or the Director, Office of Nuclear Material Safety and Safeguards. The request will specify who (i.e., NRC representative, NRC contractor or applicant) will select the samples for independent verification. After analysis, samples will be returned promptly to the applicant.

International Isotopes Inc. will provide samples of irradiated gemstones as requested by the NRC.

- b. Upon request, the applicant will analyze qualitatively, quantitatively, or both gems or groups of gems provided by NRC or its contractor. The request will be in writing; signed by the appropriate Regional Administrator or the Director, Office of Nuclear Material Safety and Safeguards; will specify the type of analysis requested and techniques to be followed; and will provide instructions for reporting results and for

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returning gems.

International Isotopes Inc. will analyze irradiated gemstones provided by and as requested by the NRC. Keep in mind however that departure from the established counting geometries utilized by International Isotopes Inc. for the analysis of irradiated gemstones would most likely result in erroneous results.

Information Needed to Support Request for Exemption from Portion 10 CFR 32.11(c)

Note that 10 CFR 32.11(c), among other things, prohibits the incorporation of exempt concentrations into products or materials designed for application to human beings. Neutron-irradiated gems with induced activity could be expected to be set in jewelry and worn by consumers, i.e., "applied to human beings". In order to grant licenses authorizing the distribution of these gems to unlicensed persons, it will be necessary to grant a limited exemption from the requirements of 10 CFR 32.11(c), as was directed by the Commission. Section 30.11 provides for the granting of exemptions.

1. To fulfill the requirements of 10 CFR 30.11, make a specific request for an exemption from that portion of 10 CFR 32.11 (c) that prohibits incorporation of exempt concentrations in products or materials designed for application to a human being. Your request may be worded as follows: "If NRC considers gems to be products intended for application to human beings, then an exemption from this portion of the requirements in 10 CFR 32.11 (c) is requested."

If NRC considers gems to be products intended for application to human beings, then an exemption from this portion of the requirements in 10 CFR 32.11 (c) is requested.

2. Using the worst case scenario, calculate the annual dose and assess the health risk to unlicensed persons. Calculate the dose at contact and at 4 cm jewelry (e.g. pendant) containing neutron-irradiated gems that is worn continuously (24 hours per day, 365 days per year). Assume the these gems contain those radionuclides (identified in response to B.2.g) with the longest physical half-lives and highest emissions at the maximum concentrations (identified in your response to Item C.2.e.) you propose to release to unlicensed persons. Dose calculations must consider all types of emissions (e.g. beta, gamma) from identified radionuclides.

The following parameters and assumptions were used in dose calculations:

Topaz Properties

Chemical Formula: $\text{Al}_2\text{SiO}_4(\text{FOH})_2$

Density: 3.55 g/cm^3

Gemstone Assumptions

Carat Weight: 5 ct (1 gram)

Stone Geometry: Sphere

Stone Volume: 0.282 cm^3

Stone Radius: 0.407 cm

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Radioactivity Assumptions

Activity Concentration: 2 nCi/g

Activity in Stone: 2 nCi

Isotopic Ratios in Gemstone

The following gamma emitting isotopes and activity in stone were used to model dose due to gamma emission utilizing MicroShield Version 6.10.

Isotope	Percent	Adjusted Percentage	Activity (nCi)
Sc-46	14.40%	14.40%	2.88E-01
Mn-54	48.75%	40.97%	8.19E-01
Zn-65	2.60%	2.60%	5.21E-02
Cs-134	1.07%	1.07%	2.14E-02
Ta-182	33.18%	40.97%	8.19E-01

The "worst case" activity was determined by first assuming that the activity of the stone is at the requested release criteria of 2 nCi/g when it is received by the consumer. The fractional percent of the five isotopes listed above was determined by taking the maximum concentrations for each isotope from over 10,000 counting records. The activity was then summed and the fraction from each isotope was determined. The fractional percentage was adjusted so that the two most predominate isotopes, Ta-182 and Mn-54 were equal. Activity in the stone determined by multiplying the adjusted percentage by 2 nCi/g by the mass of the stone (1 g).

No correction for decay during the course of the 1 year wearing period was made.

The following isotopes and activity in stone were used to model skin dose due to beta emission utilizing VARSKIN Mod 2.

Isotope	Percent	Activity (nCi)	Activity (uCi/cm ³)
Sc-46	25.11%	5.02E-01	1.783E-03
P-32	10.59%	2.12E-01	7.522E-04
Zn-65	4.54%	9.08E-02	3.225E-04
Cs-134	1.86%	3.73E-02	1.323E-04
Ta-182	57.89%	1.16E+00	4.110E-03

Note that Mn-54 is not included because there are no beta emissions associated with decay and the electron emission energy is below that which would contribute to dose. S-35 is emitted because the energy of the beta emission is very low which would not contribute significantly to the dose. Fractional percentages were calculated using the method describe above.

Dose Model Results

Beta Dose* (0.003 cm) ⁺	Beta Dose* (4 cm)	Gamma Dose (0.1 cm) ⁺	Gamma Dose (4 cm)
7.98E-01 rem/year	1.03E-02 rem/year	5.40E-01 rem/year	6.04E-03 rem/year

* Beta dose averaged over 1 square centimeter

+ Model limitations prevent "on-contact" dose rate calculations.

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It would be incorrect to consider the dose model results from a discreet source term (in this case the topaz pendent) as a dose delivered to the whole body. The results of these models could be applied to an isolated area of the body, such as the center of the chest. Assuming this same dose is delivered to the skin over a 10 cm² area (VARSKIN calculated dose over a 1cm² area and MicroShield calculates the dose at a discreet point), a comparison to the allowable occupational skin dose can be made to assess the health risk associated with the worse case scenario.

A skin dose of 50 rem per year averaged over 10 cm² (equivalent to 500 rem per year averaged over 1 cm²) is authorized for occupational radiation workers. The combined beta gamma dose delivered to the skin from a 5 carat topaz pendent worn continuously and in contact with the skin is estimated at 1.338 rem per year averaged over 1-cm² (negating decay) or approximately 0.27% that authorized for an occupational radiation worker.

Based on a study sponsored by the NRC and referenced below, the stochastic risks associated with the modeled exposure are of 8.8×10^{-11} and 4.3×10^{-8} for fatal and nonfatal skin cancers respectively.

The following excerpts from NRC 10 CFR Part 20 RIN 3150-AG25 Revision of the Skin Dose Limit are provided to complete the risk estimate.

In December 1999, the NCRP had published Report No. 130, "Biological Effects and Exposure Limits for 'Hot Particles'." In that report the NCRP recommended that the dose to skin at a depth of 70 μm (7 mg/cm²) from hot particles on skin (including the ear), hair, or clothing be limited to no more than 50 rads (0.5 Gy) averaged over the most highly exposed 10 square centimeters of skin. The averaging area of 10 square centimeters, recommended by the NCRP, is applicable to both the case when a DRP is on the skin or a very small area of skin is contaminated, and the case when a DRP is on clothing and moving about exposing an area on the order of 10 square centimeters or more. In the former case, averaging the very localized dose over 10 square centimeters results in a dose value that more appropriately reflects the risk associated with exposure of a small area. In the latter case, averaging a relatively uniform dose to the entire 10 square centimeters results in a dose limit that is equivalent to the current 50 rem over 1 square centimeter. Thus, the limit decreases as the exposed skin area increases to 10 square centimeters, consistent with the expectation that the risk of an effect increases with increasing area of skin exposed to a given dose level.

Dr. John Baum, Ph.D., an NRC consultant, reviewed the health effects implications of the NCRP recommendation. Dr. Baum wrote a technical paper entitled "Analysis of Potential Radiobiological Effects Related to a Unified Skin Dose Limit," that was published in the June 2001 issue (pp. 537-543) of the peer-reviewed journal Health Physics. In this paper, Dr. Baum estimated the probabilities and severity of both stochastic and deterministic effects for a wide range of exposure scenarios based on the research done by BNL and other research facilities, as well as information found in NCRP Report Nos. 106 and 130. Published data from experimental and

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epidemiological studies, as well as calculations of radial- and depth-dose distributions, show that skin exposures at the dose limit of 50 rem (0.5 Sv) SDE averaged over 10 cm² could result in **stochastic risks of 6.6 x 10⁻¹⁰ rem⁻¹ and 3.2 x 10⁻⁷ rem⁻¹ for fatal and nonfatal skin cancers respectively**, confirming that stochastic risks at the proposed limit are small.

Given exposures at the proposed skin dose limit, that is, 50 rem (0.5 Sv) averaged over 10 square centimeters, Dr. Baum estimated that the worst-case deterministic effects are a 5-percent probability of erythema if all of the dose (500 rem) were delivered to an area of 2.5 square centimeters, and a 50-percent probability that measurable dermal thinning would be observable if all of the dose were delivered to an area of 0.5 square centimeters. At this dose, no acute cell killing or skin ulceration was predicted for DRPs 3 or more millimeters off the skin because the dose is distributed over too large an area. The worst case probability of producing a barely detectable scab as a result of acute cell killing was estimated to be 10 percent for 60 Co or activated fuel DRPs located about 0.4 mm off the skin.

3. Provide similar calculations and assessments for gems that are outliers (i.e., gems with concentrations as much as twice the criteria you plan to use). Multiplying the dose model results provided in response Number 2 above by a factor of two would satisfy this requirement.

Two Times the Dose Model Results			
Beta Dose* (0.003 cm) ⁺	Beta Dose* (4 cm)	Gamma Dose (0.1 cm) ⁺	Gamma Dose (4 cm)
1.596 rem/year	2.06E-02 rem/year	1.08 rem/year	1.21E-02 rem/year

* Beta dose averaged over 1 square centimeter
 + Model limitations prevent "on-contact" dose rate calculations.

4. Submit a copy of the labeling or other information provided to consumers at point-of-sale of neutron irradiated gems that alerts purchasers of the presence of low-levels of radioactivity so that they can make an informed decision at time of purchase. International Isotopes Inc. does not distribute gemstones to consumers at the point of sale. Irradiated gemstones that are currently exported at the 74 Bq/g criteria contain the following statement on the Topaz Certificate of Release.

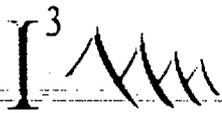
"In accordance with the Atomic Energy for Peace Act Ministerial Regulations, Officer of the Atomic Energy for Peace, Bangkok Thailand, a clearance level of 74 Bq/g is applied for irradiated gem stones produced from neutron irradiation, as such, the specific activity at time of shipment must not exceed 74 Bq/g".

A copy of a release certificate, along with the corresponding earliest ship date calculation sheets are provided for reference.

Supporting Documentation

- International Isotopes Inc. Quality Assurance Manual – May 01, 2007
- Quantification of Phosphorous-32 and Sulfur-35 Activity Concentrations in Irradiated Topaz, I4-WP-001 Revision 1, February 22, 2002
- Radioactivity Concentration Inherent to Irradiated Topaz and Irradiation Canisters, I4-WP-002, March 07, 2001
- Blue Topaz Processing, I4-OP-17, March 3, 2007
- White Topaz and Diamond Processing, I4-OP-18, May 7, 2007
- Topaz Inventory and Control, I4-OP-19, October 24, 2003
- Blue Stone Counting, I4-OP-20, June 11, 2003
- Example of a Topaz release Certificate along with corresponding Earliest Ship Date Calculation Spread Sheets
- VARSKIN-MOD2 Dose Model for beta dose to skin, File-Topaz 5ct 003cm.OUT
- VARSKIN-MOD2 Dose Model for beta dose to skin, File-Topaz 5ct 4cm.OUT
- MicroShield v6.10 Dose Model Case Title: 5 Ct. topaz @ 0.1 cm
- MicroShield v6.10 Dose Model Case Title: 5 Ct. topaz @ 4 cm

Quality Assurance Manual



International Isotopes Inc.

(Including International Isotopes Idaho Inc. subsidiary)

International Isotopes, Inc.

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CONTROLLED

INIS Quality Assurance Manual

Issue Date: May 1, 2007





International Isotopes Inc.

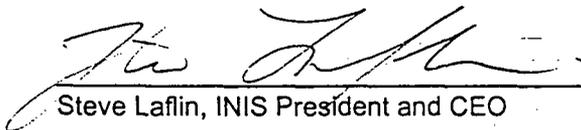
(Including International Isotopes Idaho Inc. subsidiary)

This Quality Assurance Manual states the policies, assigns the responsibility, and describes the program activities that affect the quality of services at International Isotopes Inc. (INIS). INIS are a supplier of nuclear medicine calibration and reference standards, radiochemicals for clinical or research applications, cobalt sources, transportation services, and high purity fluoride products. INIS also provides various products, sealed sources, and Radiological Services. INIS is committed to providing the best quality and professional products possible.

This manual provides all necessary controls as established by applicable industry standards described in this manual and is the top-level document that establishes the policies and requirements of the Quality Assurance Program. INIS performs quality-related tasks in compliance with contractual and regulatory quality requirements. Those requirements may be implemented through the application of the INIS Quality Assurance Program defined by this manual. In any case, compliance with the contractually imposed requirements is mandatory.

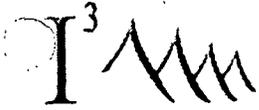
The President and CEO of INIS is assigned the authority and overall responsibility to conduct all activities consistent with the requirements of this manual. This accountability is carried out by all employees performing quality-affecting activities. Therefore, they will be trained on those quality requirements applicable to their work and are responsible for work performance in accordance with the procedures set forth herein. The Quality Assurance Representative reports to the President and CEO, and is assigned the responsibility to ensure implementation of this manual. The Quality Assurance Representative, and all personnel performing quality-related work in accordance with this manual, are responsible for, and have the authority and organizational freedom to, identify quality problems, initiate or recommend solutions through designated channels, and verify implementation of effective corrective action.

In summary, the entire INIS employee team is fully committed to the performance of the highest quality work consistent with the expectations of our clients and the requirements of this manual. It is incumbent on each of us to be open and candid, without fear of recrimination in bringing to management attention any instance of inferior work or behavior that would compromise the attainment of the highest level of quality in all of our products.


Steve Laffin, INIS President and CEO

5/1/2007
Date





International Isotopes Inc.
(Including International Isotopes Idaho Inc. subsidiary)

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Procedure Title: Organization

1.0 PURPOSE

This procedure describes the INIS organization and interrelationships in the performance of activities affecting quality.

2.0 GENERAL

2.1 INIS is a supplier of nuclear medicine calibration, and reference standards, radiochemicals for clinical or research applications, cobalt sources, transportation services, and high purity fluoride products. INIS also provides various isotope products, sealed sources, and Radiological services.

2.2 INIS is committed to providing the best quality and professional products possible. Project Managers/Leaders have responsibility for ensuring that INIS products and services meet all necessary requirements. To achieve this, effective and efficient management controls have been established to guide project performance and will be applied to each project as appropriate.



3.0 ORGANIZATION

3.1 ORGANIZATIONAL RELATIONSHIPS

The organizational chart (Figure 1) depicts the relationships of organizational units of INIS covered by this Quality Assurance (QA) Manual.

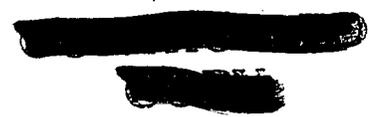
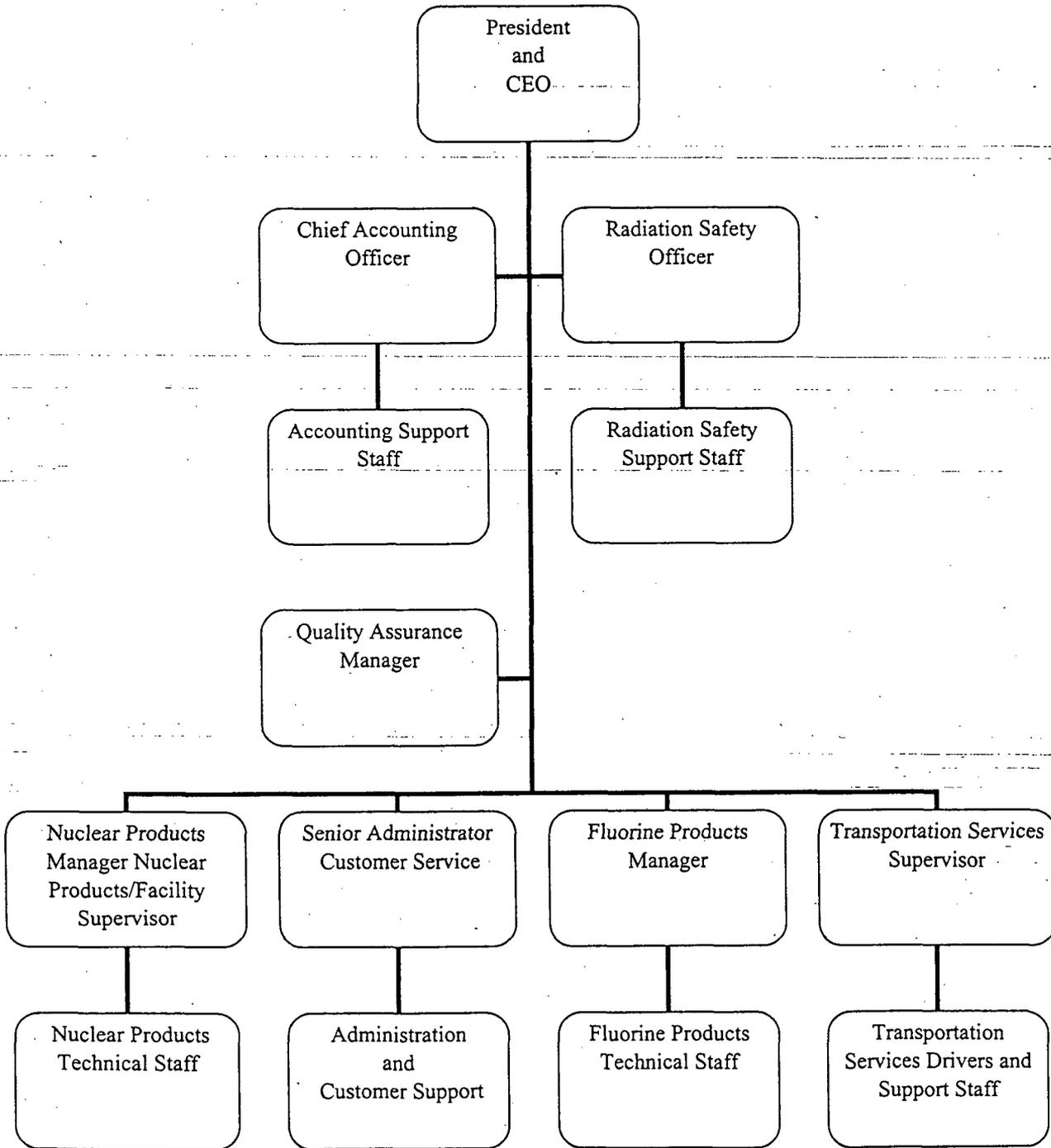




Figure 1, INIS Organizational Chart

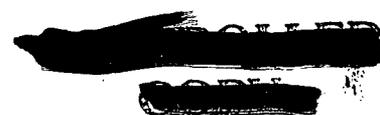




3.2 ORGANIZATIONAL RESPONSIBILITIES

The President and CEO of INIS has ultimate responsibility for the establishment and implementation of an effective and efficient QA Program to ensure that INIS products and services meet or exceed customer requirements, needs, and expectations. The responsibility for developing the QA Program and supporting its implementation has been delegated to the QA Manager. In implementing the INIS QA Program and in verifying that activities affecting quality have been correctly performed, the QA Manager, and all personnel supporting the QA Manager, function under the authority of the President and CEO. They shall have access to all work areas, personnel and documentation required to carry out their duties. When performing QA functions for a project, these QA personnel are to maintain independence from direct performance of project work, including cost and schedule considerations.

- 3.2.1 The responsibility for developing and maintaining this QA manual is assigned to the QA Manager. The QA Manager and the President and CEO of INIS are responsible for approving this manual and implementing procedures and changes thereto.
- 3.2.2 The responsibility for performing specific QA Program activities is assigned within the individual Quality Procedures (QPs) contained in this QA Manual.
- 3.2.3 Achieving quality in INIS products and services is the responsibility of the individual staff and project team members. Verification that quality has been achieved will be made by personnel independent of the initial work activity.
- 3.2.4 All project personnel have the authority to identify quality problems and to initiate, recommend, or provide solutions.
 - (a) The project Manager/Leader is required to address identified quality problems. Should the Project Manager's/Leader's response not adequately address the identified quality concerns, the project personnel involved are to submit their concerns to the next levels of management, including the President and CEO.
 - (b) The QA Manager is responsible for ensuring that identified project deficiencies are addressed by the appropriate project or corporate management personnel and that further activities are controlled until quality concerns are dispositioned or resolved. In carrying out these duties, the QA Manager will not be directly involved in the performance of project work.
 - (c) Should a situation arise where the QA Manager is involved in or responsible for the activities related to identified quality problems, the QA Manager shall identify a project QA Leader, who will report to the President and CEO and will investigate and resolve the identified concern.





- 3.2.5 The QA Manager is responsible for the conduct of periodic audits to ensure compliance with this QA Manual and assess its effectiveness.
- 3.2.6 The verification of quality achievement is assigned to personnel not involved in performing or supervising the work being verified. Any or all of this work may be delegated in writing to others but the responsibilities shall remain as noted above.

3.3 QUALITY ASSURANCE PRACTICES

- 3.3.1 QA, as addressed by INIS, is practical methodologies; personnel qualifications and assignments; and operating practices that ensure the cost-effective attainment of the required product and service quality, and the safe, efficient operation of the facility.
- 3.3.2 INIS designates a Product Manager, who is responsible for ensuring that:
- (a) Performance of direct QA functions complies with requirements of applicable regulations, codes, and standards.
 - (b) Direct work is performed by qualified individuals.
 - (c) The quality of direct work performed by INIS personnel satisfies INIS QA standards of excellence.
 - (d) Verification of the quality of work is accomplished; reports are documented; and records maintained in accordance with the necessary requirements.
- 3.3.3 The Product Manager and the QA Manager serve as the points of contact between INIS and the customer for quality-related matters.
- 3.3.4 The Product Manager and QA Manager have the authority and responsibility to identify quality problems related to work for which INIS is responsible and to cause their correction, including when necessary, the authority to stop work in order to prevent further performance of work of unacceptable quality.
- 3.3.5 The QA Manager may designate a QA Project Leader to represent him in directing the QA effort on the project and to exercise the necessary authority to fulfill all project QA requirements. When such delegation of authority is made, the assigned QA Project Leader's specific responsibilities include, as appropriate:
- (a) Serving as the communications contact between the customer and INIS for quality related matters.
 - (b) Ensuring the identification and documentation of all applicable quality-related requirements pertaining to the customer's activities for which INIS services have been contracted, including the identification of any requirements exceeding currently accepted practices.
 - (c) Assigning appropriately qualified INIS personnel to specific tasks.
 - (d) Determining the need for, and providing, any required job instruction or training.

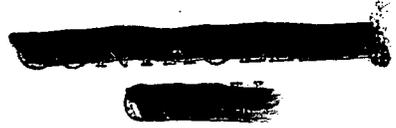


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- (e) Determining the need for, and where required, ensuring the adequacy and appropriateness of checklists, plans, guides, procedures, or other documents.
- (f) Providing continuous review of the work performed by INIS personnel to ensure its acceptability and conformance to INIS's contractual obligations.
- (g) Ensuring the completion of work in accordance with INIS's contractual requirements.

3.3.6 Resolution of differences of opinion between QA personnel and other personnel shall be accomplished through discussion and mutual agreement between participants. If mutual agreement cannot be reached, the dispute shall be resolved at the next appropriate level of management. The ultimate responsibility for resolution shall rest with the President and CEO.





Procedure Title: QUALITY ASSURANCE PROGRAM

1.0 PURPOSE

This procedure defines the scope and applicability of the INIS QA Program applied to products and services provided to customers by INIS.

2.0 SCOPE

2.1 PROGRAM APPLICABILITY

2.1.1 The INIS QA Program is a management system established to ensure that INIS products are safe and reliable and that those products and INIS services meet or exceed customers' requirements, needs, and expectations.

2.1.2 The QA Program applies to all INIS products and services using a graded approach, in accordance with the applicable contract, and at the earliest time consistent with the project schedule. The establishment of the program shall include consideration of the technical aspects of the activities affecting quality.

3.0 QA PROGRAM BASIS AND IMPLEMENTATION

3.1 PROGRAM BASIS

3.1.1 Project-specific quality standards/requirements not addressed may be implemented in supplementary manuals, procedures, and instructions.

3.1.2 It is INIS policy that its activities will comply fully with all applicable regulations, codes and standards to which the work is subject. INIS will not knowingly accept direction that would result in violation of any legal requirement.

3.2 QA PROGRAM IMPLEMENTATION

3.2.1 Quality-related activities shall be controlled and conducted using documented procedures (including instructions, drawings, process diagrams, or other appropriate documents). These procedures may be the procedures within this QA Manual, other manuals, or procedures developed by INIS.

- (a) The procedures used shall provide for accomplishment of quality-related activities under suitably controlled conditions. Examples of conditions to address include use of appropriate equipment, any environmental restriction, and verification that necessary prerequisites for the INIS activities have been met.
- (b) The procedures shall identify activity/task-specific training required; special processes and controls; test equipment or tools needed; and any special skills required.





4.0 GRADED APPLICATION

4.1 This section describes the graded application of the INIS QA Program, when a graded application is required, or as determined to be necessary by the Product Manager, with the concurrence of the QA Manager.

4.2 Risk is the fundamental consideration in determining to what extent the requirements of this manual apply. Certain activities, items, or processes may require extensive control measures while others may require only a limited degree of control. The control measures that are to be considered include procedural coverage, qualification and training, peer reviews, surveillances, audits, and assessments. The application of and degree to which these control measures are employed for an activity, item, or process is established through the risk assessment decision process.

4.3 The risk assessment decision process shall take into account such factors as:

- (a) Relative importance to safety, safeguards, and security
- (b) Magnitude of any hazard involved
- (c) Life cycle stage of the facility
- (d) Programmatic mission
- (e) Particular characteristics of the facility
- (f) Consequences of failure
- (g) Probability of failure
- (h) Complexity or uniqueness of design or fabrication techniques
- (i) Special controls
- (j) Ability to demonstrate functional compliance
- (k) Quality or safety history
- (l) Impact on the environment
- (m) Impact on cost, schedule, or both

5.0 ISSUANCE AND CONTROL OF THE QUALITY ASSURANCE MANUAL

5.1 The QA Manager is responsible for the preparation, control, and revision, and distribution of the QA Manual.

5.2 Each QA Manual section contains a revision number and the date of issuance and is approved and signed by the President and CEO and QA Manager.

5.3 The Administrative Assistant to the President and CEO shall be responsible for distribution of QA Manuals and section revisions to locations when required.

5.4 When a QA Manual section is revised, that section shall be reissued in its entirety with each page indicating the new revision number and shall be accompanied by a change in the table of contents. Revisions shall be reviewed and approved in the same manner as the original sections.

5.5 Site-specific changes or the generation of a project-specific manual will have the same approval cycle as this QA Manual.





5.6 Supplementary procedures or QA Manual sections, interface descriptions, etc., may be generated when required by conditions. Such special procedures shall apply only to the project for which they are prepared. Special procedures may be implemented in lieu of INIS QA Manual section for a specific project, when necessary, for the type or scope of the project or service provided. These revisions shall not affect the corporate issue QA Manual, other project specific procedures, or project-specific QA Manuals unless deemed necessary by the QA Manager.

6.0 TRAINING

6.1 INIS personnel performing activities affecting quality shall receive training/indoctrination to ensure that they are knowledgeable of the applicability, purpose, scope and implementation of this QA Manual as applied to the product; customer-specific quality program requirements; applicable regulatory requirements; product-specific instructions and procedures; and their job responsibilities and authority. Such indoctrination may be by formal classes or through completion of a required reading list. Training shall be provided as needed to achieve initial proficiency, maintain proficiency, and adapt to changes in the technology, methods, or job responsibility. Formal training, when applicable, includes instruction in principles and techniques of the activity being performed to the extent necessary to ensure competence in the activity. Indoctrination and training shall be documented.

6.2 The QA Manager is responsible for indoctrinating appropriate INIS management and supervisory personnel in the basis for, objective of, and methods for assuring quality of INIS work and for determining the appropriate method of indoctrinating and training company personnel.

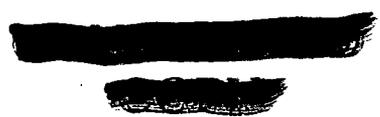
6.3 For activities requiring certification and qualification in accordance with QPs 2-2, training shall be accomplished and documented prior to performing those activities.

6.4 The extent of indoctrination and training shall be commensurate with the following:

- (a) The scope, complexity, and nature of the activity
- (b) The education, experience, and proficiency of the person

6.5 Ongoing training shall be conducted in a timely manner when applicable procedures, program manuals, regulations, codes, standards or requirements are added or revised, in order to ensure personnel are maintaining the ability to perform their assigned duties and responsibilities satisfactorily.

6.6 On-the-job training shall be conducted for those circumstances where the complexity, nature or extent of an activity requires training in order for personnel to understand and perform their assigned duties and responsibilities adequately.





- 6.7 The training of personnel shall be structured to provide necessary background in QA, and instructions/procedures appropriate for the performance of activities affecting quality and shall be documented.
- 6.8 Records of the implementation of indoctrination and training may take the form of attendance sheets, training logs, or personnel training records.
- 6.9 Qualifications and certification of audit and operating personnel is described QP 2-2.

7.0 QUALITY IMPROVEMENT

It is a basic concept of quality improvement that all work activities can be planned, performed, measured, and improved. Managers at all levels are responsible for creating an atmosphere where improvement is continuous and an integral part of the work activities. In achieving that, managers should encourage the development and exploration of new ideas. Managers are expected to increase staff awareness of the importance of quality and emphasize enhanced product and process safety and reliability, including the identification of nonconforming-items and potential areas for improvement.

- 7.1 Processes have been established by INIS to detect and prevent quality problems and to ensure quality improvement.

- 7.1.1 INIS products, services, and processes that do not meet established requirements shall be identified, controlled in accordance with this procedure and QP 15-1, Nonconformances, and corrected through the Corrective Action Process documented in QP 16-1. The process of correction includes identifying the causes of problems and preventing recurrence.

- 7.1.2 The QA Manager shall establish procedures to periodically perform a trend-analysis of nonconformances and corrective actions.

- 7.1.3 The combination of internal INIS audits and management reviews serve as tools for identifying opportunities for improvement.

- 7.2 Work process performance should be continuously measured and evaluated to identify improvement opportunities.

- 7.2.1 The Product Manager is responsible for managing process quality and identifying potential improvements to the QA Manager or the President and CEO. In project-specific training, the Product Manager shall emphasize the responsibility of each project team member understanding how the processes contribute to the success of the overall project effort.

- 7.2.2 The quality improvement activities described in paragraph 7.0 shall be supplemented by quality improvement reviews by Product Managers.





8.0 ANNUAL MANAGEMENT REVIEW

Management shall ensure performance of, as a minimum, an annual review that assesses the effectiveness of the QA Program to ensure the program is meaningful; effectively complies with applicable codes, standards and regulatory guides; and effectively implements the elements, as stated in this QA Manual. This requirement may be fulfilled by external customer reviews of the applicable portions of the QA Program. Records of such review shall be maintained.





Procedure Title: QUALIFICATION AND CERTIFICATION OF PERSONNEL

1.0 PURPOSE

This procedure establishes requirements and describes the procedure for developing, implementing and maintaining programs for the indoctrination and training of personnel to ensure a competent work force in performing activities affecting the quality of INIS services.

2.0 SCOPE

This procedure applies to all INIS personnel.

3.0 GENERAL REQUIREMENTS

3.1 QUALITY ASSURANCE PROGRAM FAMILIARIZATION

INIS normally employees personnel who are thoroughly trained and experienced in each technical field and who need only to be familiarized with the INIS QA Program requirements, or the appropriate procedures controlling the activities and the equipment, methods, and procedures used, to be able to perform their assigned tasks. Training programs are developed, as necessary, to keep pace with new requirements or advances in the state-of-the-art processes, methods and procedures.

3.2 QUALITY ASSURANCE PROGRAM INDOCTRINATION

The QA Manager is responsible for ensuring that personnel performing quality-related activities in accordance with this QA Manual and applicable requirements of each particular project are adequately trained in those QA procedures associated with their work assignment. The Project Manager/Leader is responsible for determining which approved procedures of this manual are applicable.

Indoctrination shall include the technical objective and requirements of the applicable codes and standards, and the QA program elements that are to be employed. Documentation of the QA Program indoctrination shall be retained in the appropriate INIS personnel/qualification file. The QA Manager or his designee will periodically assess INIS activities to ensure compliance with this manual.

3.3 NEW HIRES

INIS will perform background verifications to comply with Nuclear Regulatory Commission (NRC) security requirements. The INIS Radiation Safety Office is responsible for completing this requirement for each new hire.

3.4 INIS shall designate those activities that require qualified inspection and test personnel and the minimum requirements for such personnel. Personnel selected for performing inspection and test activities shall have experience and training commensurate with the scope, complexity, or special nature of the activities.

4.0 PROCEDURE

4.1 QUALIFICATION AND CERTIFICATION OF INSPECTION, EXAMINATION, AND TESTING PERSONNEL

4.1.1 INIS shall establish written procedures for the qualification of inspection and test personnel and for the assurance that only those personnel are permitted to perform inspection and test activities.





Procedure Title: WORK CONTROL

1.0 PURPOSE

This procedure establishes requirements and defines the procedure for controlling project work activities to ensure that they comply with the requirements of both the applicable contract and this QA Program.

2.0 SCOPE

This procedure applies to all INIS projects and products.

3.0 GENERAL

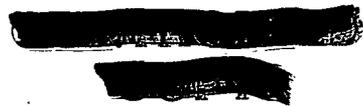
3.1 INIS products are planned, authorized, accomplished, and verified through a controlled process utilizing written instructions, procedures, or other appropriate means. The degree of complexity and detail in instructions and procedure is commensurate with the risk associated with the work being performed (as discussed in QP 2-1) and specific customer requirements.

3.2 The achievement of quality involves the integrated effort of the entire INIS organization. It begins with the individuals assigned to a product being responsible for the quality of the work they perform and to continuously strive for improvement. Management has the responsibility to provide the training, resources, and guidance necessary for the accomplishment of the work. Management has the important role of setting expectations for quality by creating an atmosphere in which personnel are motivated to perform at their very highest level and to constantly strive for improvement.

The President and CEO sets the overall priorities and work objectives for INIS including establishing the project organizational structures and overseeing the preparation and approval of the product procedures and budgets required to accomplish the priorities and objectives, and fulfill commercial sales contracts.

The Product Manager is responsible for planning; identifying the requirements imposed on the product; defining acceptable work performance; and ensuring that personnel working under their direction are provided the necessary direction and feedback on their performance. The product schedule, resources, and budget shall be considered when developing estimates for planning to ensure expectations can be readily achieved.

Product staff personnel are responsible for the quality of their work. When work instructions are unclear, or when refresher training is needed, the individual is to take the initiative to communicate the need for further training or clarification prior to performing work. Personnel are responsible for ensuring they have the prerequisite tools and documents necessary for performing assigned tasks.





4.0 PROCEDURE

4.1 CONTROL OF ACTIVITIES

4.1.1 Activities are controlled by appropriate procedures and instructions. It is the Product Manager's responsibility to ensure that procedures are developed in conformance with the requirements identified by INIS manuals, and customer instructions.

4.1.2 The Product Manager ensure that adequate controls are established over activities and that personnel are properly trained, qualified, and have the proper tools available prior to performing the work.

4.1.3 Procedures and instructions are prepared with a level of detail commensurate with the complexity and importance of the work or activity. To provide smooth transition in work processes involving more than one organization, process documents, shall define organizational interfaces and responsibilities, intermediate process steps, and expectations of the organizations.

4.1.4 Management involvement in the work and work processes keeps management current and creates an environment that encourages employees to improve the quality of the work and work processes. To meet work performance objectives and expectations, each individual must focus on his or her specific tasks and take responsibility for the quality of the work performed.

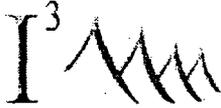
4.2 DEVELOPMENT/USE OF PROCEDURES

4.2.1 Generally, INIS activities are performed in accordance with Operational Procedures (OP) and Specification Documents (SD's).

4.2.2 Procedures utilized to control activities shall be reviewed by the Product Manager, QA Manager, Operations Staff, and the Radiation Safety Officer prior to their use to ensure that the procedures meet the applicable contractual, technical, and quality requirements, including the requirements of this Manual. The Principal reviewer (Product Manager) may determine the applicability of those additional reviews.

4.2.3 Procedures developed for specific products shall comply with the requirements of the applicable portions of this Manual. New procedures and procedural revisions shall be reviewed and approved, as a minimum, by the Product Manager and the QA Manager prior to their use.





Procedure Title: DESIGN CONTROL

1.0 PURPOSE

This procedure describes the method for INIS to maintain design control, ensure that applicable regulatory requirements are met, and ensure that the design basis is correctly translated into specifications, drawings, procedures, and instructions. Design Control includes provisions to ensure that appropriate quality standards are specified and included in design documents and that deviations from such standards are identified and controlled.

2.0 SCOPE

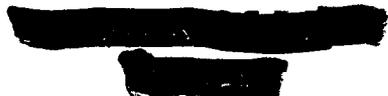
The scope of INIS activities related to design control includes:

- (a) Developing, updating or simplifying quality-related design control operational procedures (OP's) that are intended to meet customer requirements.
- (b) Performing or administering the QA portion of design document reviews.
- (c) Performing design control audits/surveillances to determine the adequacy of controls and conformance to requirements by the responsible organization
- (d) Overseeing of design services procured by INIS as part if an INIS project

3.0 PROCEDURES FOR CUSTOMER SERVICES RELATED TO DESIGN CONTROL
3.1 PERFORMING OR ADMINISTERING THE QUALITY ASSURANCE PORTION OF DESIGN DOCUMENT REVIEWS

3.1.1 The QA portion of design document review may include verification of:

- (a) Specification of design input requirements.
- (b) Satisfaction or resolution of design input requirements in the design output documents.
- (c) Documentation of design output and inclusion of appropriate quality standards and/or justification for deviation from such standards.
- (d) Appropriate qualitative and quantitative acceptance criteria.
- (e) Technical justification for the suitability of materials selected.
- (f) Definition and control of design interfaces (both organizationally and by component).
- (g) Compliance with applicable regulatory requirements.
- (h) Identification of characteristics essential to safe and proper functioning.





- (i) Definition of the authority and duties of persons/organizations performing design activities.
- (j) Verification of design adequacy by technically qualified individuals other than the designer.
- (k) Provision for control and review of design changes equivalent to the original design. Satisfactory evidence of implementation and effectiveness where applicable.

4.0 REQUIREMENTS

4.1 DESIGN INPUT

4.1.1 Applicable design inputs shall be identified and documented and their selection reviewed and approved by the responsible design organizations and other organizations in accordance with approved procedures. Design inputs are those criteria, parameters, bases, or other design requirements upon which the final design is based, such as design bases; performance requirements; regulatory requirements; codes; standards; environmental conditions and regulations; safety classes; and interfaces with new or existing structures/equipment.

4.1.2 Applicable design inputs shall be appropriately specified and correctly translated into design documents.

4.1.3 The design input shall be specified and approved on a timely basis and to the level of detail necessary to permit the design activity to be carried out in a correct manner and to provide a consistent basis for making design decisions, accomplishing design verification measures, and evaluating design changes.

4.1.4 Changes from approved design inputs, including the reason for the changes, shall be identified, documented, approved, and controlled.

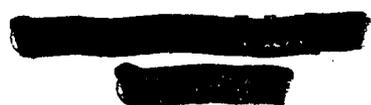
4.2 DESIGN PROCESS

4.2.1 The responsible design organization shall prescribe and document the design activities on a timely basis and to the level of detail necessary to permit the design process to be carried out in a correct manner and to permit verification that the design meets requirements.

4.2.2 Design documents shall be adequate to support system design, structure, or component construction and operation.

4.2.3 Design methods, materials, parts, equipment and processes that are essential to the function of the structure, system, or component shall be selected and independently reviewed for suitability of application.

4.2.4 Applicable information derived from experience (e.g., prior similar designs, design standards or methods, lessons learned), as set forth in reports or other documentation, shall be made available to cognisant design personnel.





4.2.5 The final design (approved design output documents and approved changes thereto) shall:

- (a) Be relatable to the design input by documentation in sufficient detail to permit design verification.
- (b) Identify assemblies and/or components that are part of the item being designed. When such an assembly or component part is commercial grade item that, prior to installation, is modified or selected by special inspection and/or testing to requirements that are more restrictive than the supplier's published product description; the component shall be represented as different from the commercial grade item in a manner traceable to a documented definition of the difference.

4.3 DESIGN VERIFICATION

4.3.1 Design adequacy shall be verified in accordance with approved procedures and by one or more of the following:

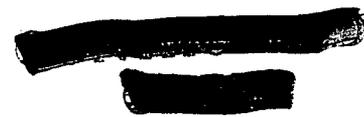
- (a) Performance of design reviews.
- (b) Use of alternate calculations.
- (c) Performance of qualification test.

4.4 DOCUMENTATION AND RECORDS

4.4.1 Design documentation and records that provide evidence that the design and design verification processes were performed in accordance with the requirements of this Manual, shall be collected, stored, and maintained in accordance with documented procedures.

4.4.2 The documentation shall include not only final design documents, such as drawings and specifications, and revisions thereto, but also documentation that identifies the important steps, including sources of inputs that support the final design.

4.4.3 After modification or extensive repair on equipment or systems, there shall be determination that as-built conditions are correctly and completely shown on the drawings, specifications, engineering change notices, and other equipment/systems descriptions.





Procedure Title: PROCUREMENT DOCUMENT CONTROL

1.0 PURPOSE

This procedure describes the controls employed by INIS to ensure that purchasing documents for items, products, or services within the scope of the INIS QA Program clearly describe what is required.

2.0 SCOPE

The scope of INIS quality-related activities related to procurement document control includes:

- (a) Performing or administering procurement document reviews for quality provisions, adequacy, and appropriateness.
- (b) Performing procurement document control audits to determine the adequacy of procedures and compliance thereto by responsible organizations.
- (c) Preparing, reviewing, and approving procurement documents for products or services related to INIS projects.

3.0 PROCEDURES FOR CONTROL OF INIS PROCUREMENT DOCUMENTS

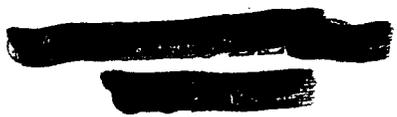
3.1 DEFINITION OF REQUIREMENTS

When specific projects involve the procurement of quality-related items or services, the necessary controls shall be applied to procurement documents. The scope of procurement activities and the requirements imposed shall be documented by the Project Manager/Leader in the Project Plan.

3.2 PROCUREMENT DOCUMENT CONTROL

3.2.1 Procurement documents shall be controlled to ensure the applicable requirements, design basis, and other requirements necessary to ensure adequate quality are included or referenced in documents for procurement of material, equipment, and services.

3.2.2 To the extent necessary, procurement documents shall require suppliers to have QA Programs consistent with the applicable requirements of this program, other applicable codes and standards. Measures shall be established for the control of procurement documents, including content, to ensure that only correct and complete procurement documents are used.





3.3 CONTENT OF PROCUREMENT DOCUMENTS

Procurement documents issued by suppliers shall include provisions for the following:

- 3.3.1 Scope of Work - A statement of the scope of work to be performed by the supplier shall be in the procurement documents.
- 3.3.2 Technical Requirements - Technical requirements shall be specified in the procurement documents. Where necessary, these requirements shall be specified by reference to specific drawings, specifications, codes, standards, regulations, procedures, or instructions; including revisions thereto, that describe the items or services to be furnished. The procurement documents shall provide for identification to test, inspection, and acceptance requirements to be used in monitoring and evaluating the supplier's performance.
- 3.3.3 Documentation Requirements - The procurement documents shall identify the documentation required to be submitted for information, review, or approval by INIS. The time of submittal shall also be established. When INIS requires the supplier to maintain specific QA records, the retention times and disposition requirements shall be prescribed.
- 3.3.4 Nonconformances - The procurement documents shall include INIS requirements for reporting and approving disposition of nonconformances (refer to QP-15-1, "Nonconforming Materials, Parts, or Components.")

3.4 PROCUREMENT DOCUMENT REVIEW

- 3.4.1 A review of the procurement documents and changes thereto shall be made to ensure that documents transmitted to the prospective supplier(s) include appropriate provisions to ensure that items or services will meet the specified requirements.
- 3.4.2 Reviews shall be performed and documented to provide objective evidence of satisfactory accomplishment of such reviews prior to award of purchase order or other similar procurement contract.
- 3.4.3 Changes made as a result of the proposal evaluations or pre-award negotiations shall be incorporated into the procurement documents.
- 3.4.4 Reviews shall be performed by personnel who have access to pertinent information, and who have an adequate understanding of the requirements and intent of the procurement documents.
- 3.4.5 QA Program controls to be applied for specific items and activities shall be defined using a graded approach.



Procedure Title: Document Control

1.0 PURPOSE

This procedure describes how INIS implements the measures for ensuring documents related to quality-affecting activities are reviewed for adequacy, approved for release by authorized personnel, and distributed to and used at the location where the prescribed activity is performed.

2.0 SCOPE

This procedure applies to quality-related documents associated with INIS projects where document control is required by the contract or applicable codes and standards.

3.0 PROCEDURE

3.1 GENERAL REQUIREMENTS AND RESPONSIBILITIES

3.1.1 The QA Manager is responsible for establishing document control requirements, including those for specific projects, where applicable. These requirements shall control the preparation, issue, and change of documents that specify quality requirements or prescribe activities affecting quality to ensure that correct documents are being employed. Approved procedures shall be established and shall include, as a minimum, the following:

- (a) Assignment of responsibility for preparing, reviewing, approving, and issuing documents.
- (b) Controlled documents and changes thereto are reviewed prior to release to ensure that technical and quality requirements are sufficiently, clearly, and accurately stated and authorized.
- (c) The distinction is made between minor (editorial) revisions and major revisions and any differences in the revision process for those two classifications of documents. Minor revisions shall not require the same review and approval as the original documents. To avoid possible omission of a required review, the type of minor change that does not require such a review and approval and the person(s) who can authorize such a decision shall be clearly delineated.
- (d) Major changes or revisions are reviewed and approved by the same organization(s) that performed the original review and approval unless other qualified organizations are designated in writing. The reviewing organization shall have access to pertinent background data or information upon which to base its approval.
- (e) Changes to instructions, procedures, drawings, and other applicable documents are promptly issued.
- (f) A historical file of all revisions shall be maintained as a quality record as specified by the QA Manager. For documents controlled by the INIS Document Control System, document revisions or changes will be handled and controlled as described in the INIS Document Change Procedure I4-OP-002.





- (g) Documents are identified and a document index, listing current revisions and changes, is maintained.
- (h) Documents are distributed promptly according to an established distribution list to ensure availability at the location where the activity will be performed prior to commencement of work.

3.1.2 Types of documents that are controlled include, but are not limited to, the following:

- (a) QA Manual
- (b) Quality procedures/instructions
- (c) Operating procedures
- (d) Specification Documents
- (e) Forms
- (f) Drawings

3.1.3 It shall be the responsibility of each individual using copies of controlled documents to verify, prior to use, the document is of the latest applicable revision.

3.1.4 Personnel issued controlled copies from the distribution point shall be responsible for their identification and control, including identification of obsolete documents "For Reference Only" or for their removal and disposition.

3.2 INIS ISSUED DOCUMENTS

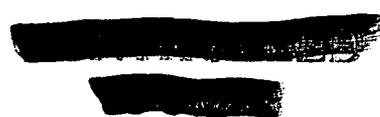
3.2.1 Documents generated by INIS in connection with activities shall be identified by subject and date. Distribution of such documents and changes shall be in accordance with this Section.

3.3 CONTROL OF QUALITY ASSURANCE MANUAL

3.3.1 The INIS QA Manual will be issued for distribution by the QA Manager.

3.3.2 This QA Manual may be distributed as a controlled or uncontrolled copy. Only controlled copies will be identified as such and registered to the recipient. Recipients of controlled copies shall be sent revisions for inclusion in their copies.

3.3.3 Revisions of this QA Manual will not be sent to holders of uncontrolled copies. Uncontrolled copies of this QA Manual will be current only at the time of their distribution.



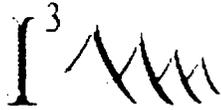


3.3.4 Each controlled copy of this QA Manual shall be uniquely identified and registered to the recipient by name, affiliation, and copy number. Recipients of controlled copies and subsequent revisions shall acknowledge receipt of the QA Manual and revisions.

4.0 **RECORDS**

The QA Manual is a quality record and shall be maintained in accordance with the requirements of QP 12-1, "Quality Assurance Records."





Procedure Title: CONTROL OF PURCHASED ITEMS

1.0 PURPOSE

This procedure describes the INIS control of purchased items, materials and services.

2.0 SCOPE

2.1 INIS services relating to purchased items quality-related controls include:

- (a) Developing, updating, or simplifying purchased item control procedures of specifications.
- (b) Performing evaluations of supplier's abilities to meet requirements as required.
- (c) Developing qualified supplier listings.
- (d) Investigating supplier problems.
- (e) Purchasing material, products or services for INIS projects.
- (f) Ensuring that purchased products or services conform to specified requirements through the performance of one or more of the above activities.

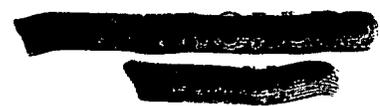
3.0 PROCEDURE

3.1 GENERAL PURCHASING//PROCUREMENT GUIDELINES

3.1.1 INIS uses General Procurement Procedure for routine supplies and materials.

3.1.1.1 See I4-OP-010

3.1.2 INIS will develop purchase specifications for materials and supplies used in quality related products and processes as determined by INIS Quality Manager. These purchase specifications will include all critical properties, receipt, inspection criteria approved vendors.





Procedure Title: IDENTIFICATION AND CONTROL OF MATERIALS, PARTS AND COMPONENTS

1.0 PURPOSE

This procedure describes measures for the proper identification, traceability, and control of materials, parts, and components including partially fabricated assemblies.

2.0 SCOPE

2.1 INIS services relating to identification and control of items include:

- (a) Developing, updating or simplifying controlling procedures for personnel use.
- (b) Conducting source surveillance or inspection in accordance with requirements.

3.0 PROCEDURE

3.1 INIS Project Manager/Leader shall ensure that procedures are established depicting requirements to be implemented for the identification, traceability, and control of materials, parts, and components, including partially fabricated assemblies or subassemblies. These procedures shall include requirements for, but shall not be limited to, the following:

- (a) Where practical, and required by codes, standards, or contractual documents, identification shall be maintained on items or in documents traceable to them in a manner which ensures that identification is established and maintained.
- (b) Preventing the use of defective, unapproved, incorrect or incomplete materials equipment, and precluding use of items whose shelf life or operating life has expired.
- (c) Unique identification and traceability of items by serial number, part number, batch, lot, or specified inspection, test, records, or other appropriate means.
- (d) Productions of an item at any stage from initial receipt through fabrication, installation, repair, modifications, and use can be traced to records such as applicable drawings, specifications, purchase orders, manufacturing and inspection documents, deviation reports, certified material test reports, or other pertinent applicable design specifying documentation.
- (e) Permanent physical identification on an item itself to the maximum extent possible, in a manner and location that will not impair or negate its intended use, quality, function, or service life; use of physical separation, procedural control, or other appropriate means where physical identification on the item is impractical or not sufficient.

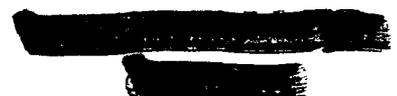




International Isotopes Inc.
(Including International Isotopes Idaho Inc. subsidiary)

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- (f) Correct identification of materials, parts, and components verified and documented on appropriate release documents, work packages, or controlling documents, and on materials prior to subdividing an item or material, and prior to release for fabrication, assembly, shipping and installation.
- (g) Train personnel performing quality activities, as required, to ensure understanding and proper implementation of this procedure and use of approved procedures to ensure that improper, uncontrolled, damaged, incorrect, or nonconforming material or items are not used or installed.
- (h) Perform audits, inspections, and surveillances, to ensure compliance to established procedures.
- (i) Maintain as quality records in accordance with QP 12-1 design, procurement and process documents establishing and attesting to proper identification of INIS furnished items.





Procedure Title: CERTIFICATION OF INSPECTION, EXAMINATION, SURVEILLANCE, AND TESTING PERSONNEL

1.0 PURPOSE

This procedure identifies the requirements for the certification of personnel who perform inspection, examination, surveillance and testing.

2.0 SCOPE

Services provided by INIS personnel performing inspections, examinations, surveillance, and testing include:

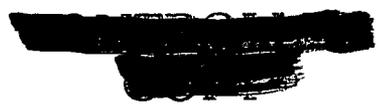
- (a) Visual weld examination, verification of product cleanliness, measurements of components, etc.
- (b) Bubble leak testing IAW.
- (c) Acting as the customers agent in the inspection, examination, surveillance, testing, and acceptance of customer items or contractor activities.

3.0 GENERAL REQUIREMENTS AND RESPONSIBILITIES

Personnel performing inspection, examination, surveillance, and testing activities for acceptance in accordance with this QA Manual or customer's QA program shall be as imposed by the contract documents.

3.1 PERSONNEL QUALIFICATIONS

QA/QC inspections, examinations, surveillances and nondestructive examinations (NDE) shall be performed by QA/QC specialists, technical specialists, engineers, and NDE technicians, who are qualified and certified in the discipline and/or method in which the activity is being performed.





Procedure Title: CONTROL OF MEASURING AND TEST EQUIPMENT

1.0 PURPOSE

This procedure describes the requirements for the control and calibration of measuring and test equipment that is used in the performance of inspections and examinations to ensure that these devices are of the proper range, type, and accuracy to verify conformance to establish requirements.

2.0 SCOPE

- 2.1 This procedure describes INIS activities in ensuring that equipment used is properly calibrated and identified and acceptable for use.
- 2.2 Measuring and test equipment used by INIS personnel shall be identified and controlled in accordance with the requirements of this QA Manual.
- 2.3 When commercial practices provide adequate accuracy for the application, measuring and test equipment, such as rules, tape measures, levels, and similar devices, are not subject to the requirements of this section.

3.0 GENERAL REQUIREMENTS AND RESPONSIBILITIES

- 3.1 Tools, gages, instruments, and other measuring and test equipment used for activities affecting quality, including process monitoring and data collection, shall be controlled and, at specified periods, calibrated and adjusted to maintain accuracy within necessary limits. The selection of measuring and test equipment shall be controlled to ensure that such items are of proper type, range, accuracy, and tolerance to accomplish the function of determining conformance to specified requirements.





Procedure Title: NONCONFORMANCE MATERIALS, PARTS, OR COMPONENTS

1.0 PURPOSE

This procedure describes how INIS implements the measures used for controlling materials, parts, systems and structures that do not conform to design and specification requirements and are normally detected through inspection, test, operation, surveillance or audit. These measures are to ensure only correct and acceptable items and processes are used.

2.0 SCOPE

2.1 INIS services relating to nonconforming items activities include:

- (a) Performing tasks involving the reporting of nonconforming items.
- (b) Developing, updating, or simplifying procedures for identification, control, and reporting of non-conformances.
- (c) Performing audits to determine the adequacy of procedures and performance effectiveness of responsible organizations.

3.0 GENERAL REQUIREMENTS AND RESPONSIBILITIES

3.1 When INIS services involve the identification/reporting of nonconforming items, the Project Manager/Leader shall ensure that such actions are performed in accordance with approved procedures that incorporate the following requirements.

3.1.1 General Requirements

- (a) Items that do not conform to specified requirements shall be controlled to prevent inadvertent installation or use. Controls shall provide for identification, documentation, evaluation, segregation (when practical), and disposition of nonconforming items.
- (b) Processes, services, or activities that do not conform to specified requirements shall be controlled, such that the output of the process, service, or activity is contained. This containment shall include identification, documentation, disposition, and correction (when the disposition is rework or repair).
- (c) Non-dispositioned items shall not be released for shipment.
- (d) Organizations affected by the nonconforming process, item/product, service, or activity shall be notified.

3.1.2 Identification Requirements

- (a) Identification of nonconforming items shall be by marking or tagging or by other methods that shall not adversely affect the end use of the item. The identification shall be legible, easily recognizable, and shall remain in place until removed by authorized personnel. If identification of each nonconforming item is not practical, the container, package or segregated storage area, as appropriate, shall be identified.

- (b) Identification of the output of a nonconforming process, service, or activity shall be identified by the use of a nonconformance report (NCR) as documentation.

3.1.3 Reporting Requirements

- (a) When a nonconformance is identified subsequent to product being shipped to a customer or recipient, INIS management shall evaluate whether the nonconformance is potentially reportable to the NRC under Part 21 of the NRC Rules and Regulations. Notification shall also be made to the customer of recipient.

3.1.4 Segregation of Items

- (a) Nonconforming items shall be segregated, when practical, by placing them in a clearly identified and designated hold area until properly dispositioned.
- (b) When segregation is impractical or impossible because of physical conditions such as size, weight, or access limitations, other precautions shall be employed to preclude inadvertent installation or use of nonconforming item.

3.1.5 Evaluation, Disposition, and Reexamination

- (a) The responsibility and authority for the evaluation and disposition of nonconforming items shall be defined.
- (b) Nonconforming characteristics shall be reviewed, and recommended dispositions of nonconforming items shall be proposed and approved in accordance with documented procedures and instructions. Further processing, delivery, installation, or use of nonconforming items shall be controlled pending an evaluation and an approved disposition by authorized personnel.
- (c) Personnel who perform evaluations to determine a disposition shall have demonstrated competence in the specific area they are evaluating, have an adequate understanding of the requirements, and have access to pertinent background information.
- (d) The disposition, such as accept, reject, repair, or rework, of the nonconforming shall be documented.
- (e) Technical justification for the acceptability of a nonconformance that is dispositioned as repair or accept shall be documented. Nonconformance disposition as repair or accept shall be subject to design control measures commensurate with those applied to the original design. The as-built records, if such records are required, shall reflect the accepted deviations.
- (f) Repaired or reworked items shall be re-examined in accordance with applicable procedure(s) and with the original acceptance criteria, including retesting when appropriate, unless the nonconforming item disposition has established alternate acceptance criteria.



Procedure Title: CORRECTIVE ACTION

1.0 PURPOSE

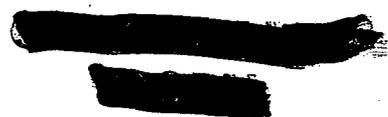
This procedure describes how INIS implements the measures used for ensuring that conditions adverse to quality are promptly identified and corrected to preclude repetition. In the case of significant conditions adverse to quality, the measures ensure that the cause of the conditions is determined and corrective action is taken to preclude repetition. In the case of the identification of conditions adverse to quality and plant safety, such as failure, malfunction, deficiencies, deviations, defective material and equipment, abnormal occurrences and nonconformances, the cause of the conditions and corrective action are documented and reported to appropriate levels of management.

2.0 SCOPE

- 2.1** This procedure applies to the initiation of action to correct deficiencies relating to programmatic breakdowns identified by QA audits or surveillances conducted by or for INIS management.
- 2.2** Deficiencies in INIS performance identified by a customer shall be resolved in accordance with contract requirements; however, in any such case, the requirement of Section 3.0 of this procedure shall be met.
- 2.3** INIS performs corrective action activities, including:
- (a) Developing, updating or simplifying procedures for corrective actions.
 - (b) Performing audits to determine the adequacy of corrective action procedures and performance effectiveness of responsible organizations.

3.0 GENERAL REQUIREMENTS AND RESPONSIBILITIES

- 3.1** The INIS corrective action system shall include the following general requirements:
- 3.1.1** Conditions adverse to quality shall be identified promptly and corrected as soon as practical.
 - 3.1.2** In the case of a significant condition adverse to quality, the cause of the condition shall be determined and corrective action taken to preclude recurrence.
 - 3.1.3** The identification, cause, and corrective action for significant conditions adverse to quality shall be documented and reported to appropriate levels of management; follow-up action shall be taken to verify implementation to this action.
- 3.2** Nonconformances and deficiencies that relate to procedural or programmatic breakdowns identified by an audit or surveillance performance by management shall be documented by QA personnel.





International Isotopes Inc.
(Including International Isotopes Idaho Inc. subsidiary)

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- 3.3 Actions to correct INIS deficiencies are the responsibility of the INIS official immediately in charge of the function in which the action is required.
- 3.4 Each Project Manager/Leader is responsible for maintaining an orderly file of all audit findings and nonconformances related to INIS services and for ensuring that the cause of each deficiency is determined, documented and corrected.
- 3.5 The QA Manager shall periodically review and evaluate customer complaints and INIS corrective action effectiveness.
- 3.6 The QA Manager and/or the Project Manager/Leader are responsible for coordinating specific activities relating to the CAR's.
- 3.7 Deficiencies identified by a customer audit or assessment shall be reviewed by the QA Manager, who shall be responsible for ensuring that as a minimum the requirements of the customer and of the procedure are met. The QA Manager shall evaluate any corrective action suggestions from the customer and ensure that such suggestions are appropriately addressed either by implementation by INIS or resolution with the customer.
- 3.8 The QA Manager shall periodically review and evaluate INIS corrective action effectiveness. This evaluation will encompass the actions taken and affected management, including the President when appropriate, shall be advised if adverse trends are noted that require further remedial action.
- 4.0 **RECORDS**
Completed INIS corrective action documentation is considered quality records and subjected to QP 12-1, Quality Assurance Records.





Procedure Title: QUALITY ASSURANCE RECORDS

1.0 PURPOSE

This procedure describes the requirements for the maintenance and retention of records to demonstrate achievement of required quality and effective operation of the INIS QA Program.

2.0 SCOPE

This procedure applies to quality assurance activities performed under the requirements of the INIS Quality Assurance Manual.

INIS services pertaining to activities that generate QA records include:

- (a) Developing, updating or simplifying records system and control procedures for personnel use.
- (b) Generating QA records as appropriate for quality-related services performed.
- (c) Performing audits to determine the adequacy of record control systems and the performance effectiveness of responsible organizations.

3.0 PROCEDURE

3.1 GENERAL REQUIREMENTS

3.1.1 QA records shall be specified, prepared, stored, maintained, preserved, and kept safe in appropriate facilities and retrievable. Measure shall be established to preclude entry of unauthorized personnel and to guard against larceny and vandalism. Records shall be protected against damage, deterioration, or loss. Measures shall be taken to provide for replacement, restoration or substitution of lost or damaged records.

3.1.2 Requirements and responsibilities for record transmittal, distribution, retention, maintenance, and disposition shall be established and documented.

3.1.3 Records shall be properly identified, indexed, and maintained to ensure retrievability.

3.1.4 QA records shall be classified as "lifetime" or "non-permanent". Lifetime records are required to be maintained for the life of the particular item. Non-permanent records are those required to show evidence that an activity was performed in accordance with applicable requirements.





Procedure Title: AUDITS

1.0 PURPOSE

This procedure defines how INIS documents the methods and requirements for performing audits. INIS uses a comprehensive system and periodic audits to ensure the implementation and effectiveness of the overall QA Program. Audits are performed internally and by customers, as required.

2.0 SCOPE

2.1 This procedure applies to the following types of audits performed:

- (a) Internal Audits: Audits conducted by INIS to verify compliance to the QA Manual, procedures and commercial customer contractual requirements.
- (b) External Audits: Audits conducted by INIS's customers to verify compliance with the contractual and procedural requirements.

2.2 External audits are formal and scheduled with advance notification (at least two weeks) to the organization being audited.

3.0 PROCEDURE

3.1 PERFORMANCE OF AUDITS

3.1.1 An audit of the INIS QA program will be performed, at a minimum of once per calendar year. This audit may consist of an internal audit as described in section 2.1(a) performed by INIS Quality Assurance or an external audit as described in 2.1(b) performed by a customer.

3.1.2 Planned and scheduled audits shall be performed to verify compliance with all applicable aspects of the QA Program, to verify effectiveness of QA program implementation, and to promote improvements. Audits shall be conducted in accordance with approved procedures and/or checklists to ensure thoroughness of the review. Checklists may be standardized or they may be prepared for specific audits. Audit results shall be documented and reported to and reviewed by responsible management. Follow-up action shall be taken where indicated. The group performing audits shall have sufficient authority and freedom to carry out its responsibilities.

3.1.3 Audits shall begin as early in the life of the activity as practical and shall be continued at intervals consistent with the schedule for accomplishing the activity.

3.1.4 Elements that have been selected for audit shall be evaluated against specified requirements. Objective evidence shall be examined to the depth necessary to determine their effective implementation.





3.1.5 Lifetime records shall meet one or more of the following criteria:

- (a) Records that would be of significant value in demonstrating that manufactured products meet requirements.
- (b) Records that would be of significant value in maintaining, reworking, repairing, replacing or modifying critical items within the plant, or manufactured products.
- (c) Records that would be of significant value in determining the cause of an accident or malfunction of an item within the plant.

3.1.6 Non-permanent records meet none of the criteria listed above, but shall be retained for a prescribed period of time, to produce evidence an activity was performed.

3.1.7 The generic records normally retained by INIS include the following:

- (a) Quality Assurance Manual
- (b) Operating Procedures
- (c) Specification Documents
- (d) Nonconformance Reports
- (e) Personnel Qualifications and Certifications, including completed examinations
- (f) Calibration records
- (g) Purchase Orders

These records will be maintained for two (2) years after completion of work.





- 3.1.5 Audits are performed by qualified personnel who do not have direct responsibility in the area being audited.
- 3.1.6 The responsible management of the activity being audited is apprised of the scope of the audit by the Lead Auditor or other appropriate audit personnel prior to the audit.
- 3.1.7 Objective evidence of quality-related practices, procedures and instructions, effectiveness of implementation, and the conformance with policy directives shall be evaluated. Audits shall include evaluation of work areas, activities, processes, services and items, and the review of documents and records, as applicable.
- 3.1.8 Audits shall be documented by auditing personnel and shall be reviewed by management having responsibility for the area being audited. Deficiencies identified by the audit team or individuals are documented and discussed with the responsible management of the audited function. The responsible management will receive a formal notification of the audit results. Conditions requiring prompt corrective action shall be reported immediately to management of audited organization.
- 3.1.9 Internal or external QA audits, or both, shall be scheduled in a manner to provide coverage and coordination with ongoing QA program activities. Audits are scheduled on the basis of the status and importance of the activities. Audits may be conducted without advance notice, should circumstances warrant. The audit schedule shall be reviewed periodically and revised as necessary to ensure that coverage is maintained current. Regularly scheduled audits shall be supplemented by additional audits of specific subjects when necessary to provide adequate coverage.
- 3.1.10 Audits conducted under the INIS Program are conducted on a continuing basis such that all applicable elements are addressed at intervals not exceeding two years.

3.2 PREPARATION

3.2.1 Audit Plan

The QA Manager shall develop and document an audit plan. This plan shall identify the audit scope, requirements, audit personnel, activities to be audited, organizations to be notified, applicable documents, schedule, and written procedures or checklists.

3.3 RESPONSE

- 3.3.1 Personnel supervision of the audited activity shall investigate adverse audit findings, schedule corrective action, including measures to prevent recurrence, and notify the appropriate organization in writing of action taken or planned.
- 3.3.2 The adequacy of audit responses shall be evaluated by the QA and INIS management.
- ### 3.4 FOLLOWUP ACTION
- 3.4.1 Followup action shall be taken to verify that corrective action is accomplished as scheduled.





International Isotopes Inc.
(Including International Isotopes Iduho Inc. subsidiary)

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3.5 RECORDS

3.5.1 Audit records shall include audit plans, audit reports, written replies, and the record of corrective action.

3.6 QUALIFICATION OF AUDITORS

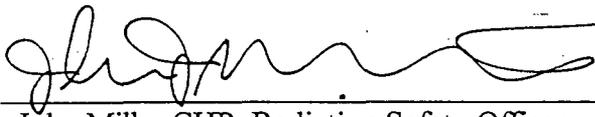
3.6.1 Auditors are trained as necessary and qualified in accordance with QP 2-2 of this Manual. The QA Manager or his designee is responsible for the assignment of the Audit Team Leader and team members, where applicable, who are qualified to perform each assigned task.



Quantification of Phosphorous-32 and Sulfur-35 Activity Concentrations in Irradiated Topaz

February 22, 2002

Prepared By:

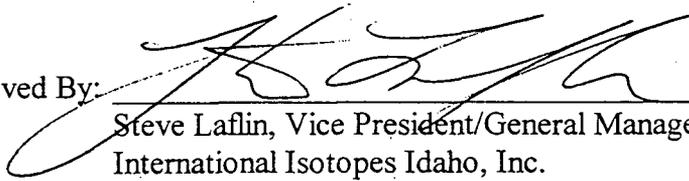


John Miller CHP, Radiation Safety Officer,
International Isotopes Idaho, Inc.

2/21/02

Date

Approved By:



Steve Laflin, Vice President/General Manager
International Isotopes Idaho, Inc.

2-21-02

Date

Quantification of Phosphorous-32 and Sulfur-35 Activity Concentrations in Irradiated Topaz

February 22, 2002

J. J. Miller

ABSTRACT

Clear topaz gemstones are subjected to neutron irradiation at the University of Missouri Research Reactor (MURR) to enhance the color thereby resulting in the activation of trace elements in the stones.

Several years worth of data collected by MURR identified eight major radionuclides (> 1% of exempt concentration) present in irradiated topaz. Of these, two, phosphorous-32 and sulfur-35, are pure beta emitters. The individual gamma emitting nuclides in irradiated topaz are easily identified and quantified by use of a high purity germanium detector. Quantification of pure beta emitters is more challenging. After 18 months of operation it became clear that the S-35 concentration calculated using the original counting methods was grossly overestimated.

This white paper revises the counting method utilized by International Isotopes Idaho to more accurately measure and quantify the P-32 and S-35 activity concentration in irradiated topaz.

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1.0 INTRODUCTION

Clear topaz gemstones are subjected to neutron irradiation at the University of Missouri Research Reactor (MURR) to enhance the color thereby resulting in the activation of trace elements in the stones.

Several years worth of data collected by MURR identified eight major radionuclides (> 1% of exempt concentration) present in irradiated topaz. Of these, two, phosphorous-32 and sulfur-35, are pure beta emitters. The individual gamma emitting nuclides in irradiated topaz are easily identified and quantified by use of a high purity germanium detector. An accurate determination of P-32 and S-35 activity in irradiated topaz is challenging for a number of reasons. [1]

- Both isotopes are pure beta emitters limiting the spectral analysis methodologies. An accurate analysis via liquid scintillation would require crushing (thereby destroying) the stones. Current technologies in mass spectroscopy are fiscally prohibitive.
- A detector sensitive to low energy beta radiation is required to measure S-35.
- A fraction of the beta radiation released within the stone will be attenuated before it can be detected.

The chosen methodology for P-32 and S-35 activity determination in topaz is analysis utilizing a plastic scintillation detector. A thin plastic scintillator (anthracene phosphor) has been chosen to limit the response of the detector to gamma ray emission. Although a plastic scintillator cannot distinguish between beta energies, multiple counts and the utilization of an absorber sized to attenuate all of the S-35 beta emissions can provide sufficient accuracy in determining the P-32 and S-35 activities in a sample containing a mix of the these isotopes.

An overestimation of the P-32 and S-35 activities will be introduced as a result of electron and beta emissions associated with gamma emitting radioisotopes present in the sample. This error is conservative in that the gamma emitting radioisotope activities will be quantified via gamma spectroscopy and no correction in the beta count will be made for these radioisotopes. However, grossly overestimating the S-35 concentration poses its own problems. Topaz with inflated S-35 concentrations must be held for decay several months longer than necessary. Correcting for the overestimation was accomplished by simply changing the absorber material and thickness used in the beta analysis. Changing from a thicker Lucite absorber to a thinner aluminum absorber was all that was necessary to achieve more accurate S-35 concentration. A correction factor was then developed to account for incomplete attenuation of the S-35 beta. This correction factor was determined empirically using the chosen absorber and a C-14 source.

2.0 SELF-ABSORPTION CORRECTION

Because topaz is a fairly dense material (3.55 g/cm^3), beta radiation will be attenuated within the stone. To quantify the S-35 and P-32 activities accurately, a correction must be made for self-absorption.

2.1 S-35 Self-Absorption Correction

S-35 emits a low energy beta ($E_{\max} = 0.167470$ MeV)[3] a correction factor for self-absorption must be made. The range of the S-35 beta in topaz remains constant and is calculated as follows [2]:

$$R = 0.412E^{(1.265-0.0954 \ln E)}$$

Where: R = Range in g/cm²

E = Maximum beta energy in MeV.

$$R = 0.412 * (0.16747)^{(1.265-0.0954 \ln(0.16747))} = 0.31687 \text{ g/cm}^2$$

$$0.31687 \text{ g/cm}^2 * 3.55 \text{ g/cm}^3 = 0.008926 \text{ cm}$$

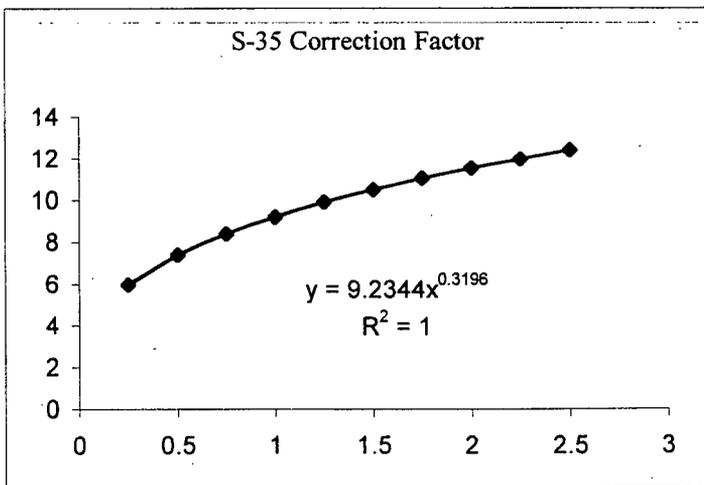
Both the size and shape of the stones play a role in the fraction of S-35 activity attenuated. For simplicity, all stones will be considered spheres. For a spherical geometry there is less surface area per volume thereby resulting in the maximum amount of self-absorption, therefore the calculated self-absorption correction factor will be conservative. The average carat size of the stones being counted will be used to determine the average stone radius for the topaz sample.

The S-35 activity measured by the detector results from the S-35 present in the outer volume of the stone defined by the surface area of the stone multiplied by a depth equal to the range of the S-35 beta particle (0.008926 cm). The S-35 contained in the inner volume of the stone defined by the sphere with radius equal to the stone radius less the range of the S-35 beta particle must be accounted for in the analysis. A correction factor equal to the ratio of actual stone volume to detectable stone volume can be used to determine the total S-35 activity.

The total S-35 activity can be calculated as follows:

$$\text{Total S-35 Activity} = \text{Measured S-35 Activity} * \frac{\text{Actual Stone Volume}}{\text{Detectable Stone Volume}}$$

Correction factors were determined for carat weights ranging in size from 0.25 carats to 2.5 carats. Correction factors were plotted against carat weight using Microsoft Excel. A trend line, corresponding equation and R² value were inserted.



carat wt.	SA factor
0.25	5.942
0.5	7.393
0.75	8.412
1	9.223
1.25	9.908
1.5	10.507
1.75	11.043
2	11.529
2.25	11.977
2.5	12.393

For spherical stones of carat weight x , an S-35 self-absorption correction factor y can be calculated as: $y = 9.2344x^{0.3196}$.

2.2 P-32 Self-Absorption Correction

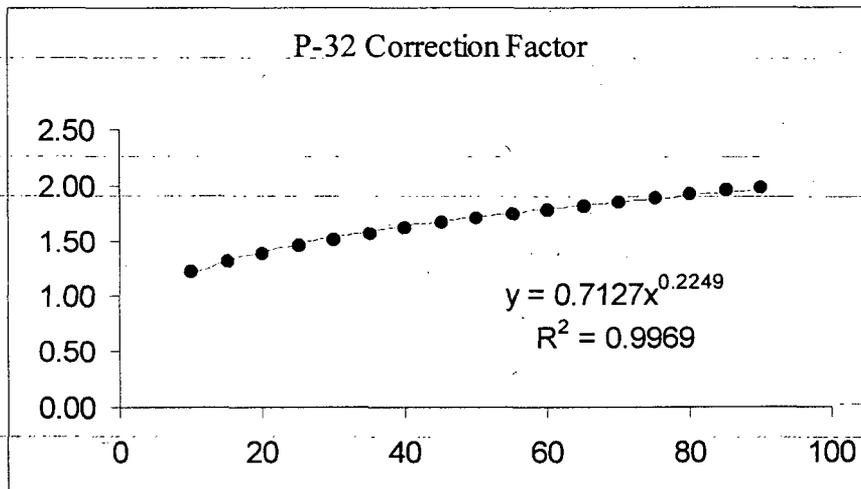
The energy of the P-32 beta ($E_{\max} = 1.709$ MeV) [3] is such that self-absorption is negligible in stone sizes up to about 4.5 carats.

The method of determining a P-32 self-absorption correction factor is the same as that used in developing the S-35 correction factor.

The range of the P-32 beta was calculated to be 0.223 cm.

Ratios of actual stone volume to detectable stone volume were calculated for stone weighing between 10 to 90 carats.

Correction factors were determined for carat weights ranging in size from 10 carats to 90 carats. Correction factors were plotted against carat weight using Microsoft Excel. A trend line, corresponding equation and R^2 value were inserted.



carat wt.	SA
10	1.22
15	1.31
20	1.39
25	1.46
30	1.52
35	1.57
40	1.62
45	1.67
50	1.71
55	1.75
60	1.79
65	1.82
70	1.86
75	1.89
80	1.92
85	1.95
90	1.98

For spherical stones of carat weight $x > 4.5$, a P-32 self-absorption correction factor (y) can be calculated as: $y = 0.7127x^{0.2249}$.

2.3 Correction to Account for Incomplete Absorption of S-35 Beta

The attenuation characteristics of the selected absorber was determined using a C-14 source and thin window proportional counter⁽¹⁾. The C-14 source was counted for 12 seconds with and without the absorber in place. The following data was collected:

Unshielded (counts)	Single Layer Aluminum (counts)	Double Layer Aluminum (counts)	
2681	383	31	
2814	392	26	
2853	405	36	
2877	405	30	
2905	417	31	
2911	419	21	
2918	429	22	
2930	442	31	
2955	461	26	
2969	466	24	
mean:	2881.30	421.90	27.80
σ:	84.17	27.77	4.76

(1) Absorber test performed at Idaho State University.

A double layer of aluminum foil has been selected as the absorber for use in the P-32/S-35 analysis. A double layer of aluminum attenuates approximately 99% of the S-35 (C-14) beta emission. At this percentage a correction factor to account for incomplete attenuation is not necessary.

3.0 GENERAL PROCEDURE TO DETERMINE P-32 AND S-35 ACTIVITY.

The general steps in determining the P-32 and S-35 activity concentration in topaz are as follows:

1. Count the topaz sample without the absorber yielding "Total Sample Count".
2. Count the topaz sample with the absorber in place yielding "Unabsorbed Count".
3. Calculate P-32 activity concentration by subtracting the instrument background count rate from the unabsorbed count rate and dividing by the P-32 efficiency of the instrument and weight of the sample and then multiply the results by the P-32 self-absorption correction factor.

$$P-32 \text{ Activity} = \frac{(\text{unabsorbed count rate} - \text{background count rate})}{\text{sample weight} * P-32 \text{ efficiency}} * P-32 \text{ self-absorption factor}$$

4. Calculate the "Absorbed Count Rate" by subtracting the unabsorbed count rate from the total count rate.
5. Calculate S-35 activity concentration by subtracting the instrument background count rate from the absorbed count rate, divide by the S-35 efficiency of the instrument and the weight of the sample and then multiply the results by the S-35 self-absorption correction factor.

$$\text{S - 35 Activity} = \frac{(\text{absorbed count rate} - \text{background count rate})}{\text{sample weight} * \text{S - 35 efficiency}} * \text{S - 35 self - absorption factor}$$

4.0 References

- [1] K. Nelson, J.W. Baum, *Health Risk Assessment of Irradiated Topaz*, NUREG/CR-5883, January 1993
- [2] B. Shleien, *The Health Physics and Radiological health Handbook*, Revised Edition, Scinta Inc., 1992
- [3] J. Parrington et. al., *Nuclides and Isotopes, Chart of the Nuclides*, Fifteenth Edition, General Electric Co. and KAPL, Inc., 1996

Radioactivity Concentrations Inherent to Irradiated Topaz and Irradiation Canisters

March 7, 2001

Prepared By:

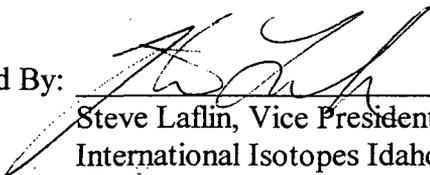


John Miller CHP, Radiation Safety Officer,
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3/7/01

Date

Approved By:



Steve Laflin, Vice President/General Manager
International Isotopes Idaho, Inc.

3-13-01

Date

Radioactivity Concentrations Inherent to Irradiated Topaz and Irradiation Canisters

March 7, 2001

J. J. Miller

ABSTRACT

International Isotopes of Idaho Inc. (I¹) is licensed by the Nuclear Regulatory Commission (NRC) to possess byproduct materials. The NRC license restricts the quantity of byproduct materials located at the facility at any one time. It is therefore necessary to have a method in place to inventory by-product material.

Currently, the bulk of byproduct material located at the I¹ facility is associated with irradiated topaz gemstone processing and is contained within the gemstones and the irradiation canisters. Because the quantity of irradiated topaz and the number of topaz irradiation canisters maintained at the I¹ facility will vary during operations, a simple method to estimate the quantity of byproduct material associated with irradiated topaz processing would aid in demonstrating compliance with NRC License restrictions.

This white paper develops a conservative correlation between the number of irradiation canisters and quantity of irradiated topaz to the amount of byproduct material contained within these media.

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1.0 INTRODUCTION

Clear topaz gemstones are subjected to neutron irradiation at the University of Missouri Research Reactor (MURR) to enhance the color. This process results in the activation of both the topaz irradiation canisters and the gemstones.

Several years worth of data collected by MURR identified eight major radionuclides (> 1% of exempt concentration) present in irradiated topaz. This data along with data regarding the radioactive material contained within topaz irradiation canisters may be used to estimate the quantity of byproduct material associated with irradiated topaz processing operations.

A simplified method of quantifying the amount of radioactivity associated with irradiated topaz and the topaz irradiation canisters would aid in demonstrating compliance with possession limits established in I⁴'s NRC License.

2.0 RADIOACTIVITY CONTAINED WITHIN IRRADIATION CANISTERS

The amount of radioactivity contained in topaz irradiation canisters will be estimated utilizing data provided to I⁴ by MURR, summarized in Table 2.1 below.

Table 2.1

Example of Irradiation Canister + Topaz Radioisotopes and Activities ~10 days from End of Irradiation

Nuclide	μCi	Nuclide	μCi	Nuclide	μCi
Na-22	2.55	Zr-95	15.9	Au-198	22.1
Sc-46	120	Ru-103	3.15	Au-199	18.9
Sc-47	8.19	Sn-113	3.21	Pa-233	53.9
Cr-51	1670	Sb-122	13.9	Tc-99m	2.3
Mn-54	1180	Te-123m	6.66	Cs-137	9.31
Co-58	178	Ce-141	1.37	Ba-140	8.87
Fe-59	396	Eu-152	19.1	C-14	2000
Co-60	977	Lu-177m	6.21	P-32	20
Zn-65	169	Hf-181	3.15	S-35	20
Nb-95	17.5	Ta-182	19.8		

Use of these activity values is considered conservative. Contractual restrictions ensure that all of the irradiation canisters in the facility will have an associated End of Irradiation (EOI) date greater than 10 days and only a few irradiation canisters will have an EOI equal to 10 days. The above values also include the radioactivity contained within the topaz.

3.0 RADIOACTIVITY CONTAINED WITHIN IRRADIATED TOPAZ.

The radioactivity contained within irradiated topaz was estimated using gamma spectroscopy and P-32/S-35 measurements from over 10,000 samples analyzed between the University of Missouri and I⁴. The maximum radioactivity concentration for the eight major radionuclides (**bold type**)

and the average radioactivity concentration of the minor radionuclides associated with irradiated topaz measurements are summarized in Table 3.1 below.

Table 3.1
Estimated Radioactivity Concentrations
Associated with Irradiated Topaz

Nuclide	μCi/g	Nuclide	μCi/g	Nuclide	μCi/g
Na-22	3.16E-5	Ce-141	1.81E-06	Nd-147	1.11E-06
Sc-46	4.41E-4	Co-58	2.84E-06	Pa-233	3.18E-06
Mn-54	1.49E-3	Co-60	7.23E-05	Rb-84	1.93E-05
Zn-65	7.98E-5	Cr-51	8.94E-06	Rb-86	2.74E-04
Cs-134	3.27E-5	Cs-132	4.34E-07	Re-183	3.24E-07
Ta-182	1.02E-3	Cs-137	3.36E-03	Sb-122	9.17E-07
P-32	1.86E-4	Eu-152	2.84E-05	Sb-124	9.89E-07
S-35	3.67E-3	Eu-154	8.95E-06	Sb-125	2.50E-06
Ag-110M	5.72E-06	Eu-155	1.58E-06	Sc-47	3.39E-06
As-74	5.65E-07	Fe-59	7.56E-06	Sn-113	4.89E-04
Au-198	3.10E-06	Hf-181	7.54E-07	Sr-85	1.08E-06
Ba-131	2.22E-06	Hg-203	2.39E-06	Te-121	1.94E-06
Ba-133	5.71E-07	Ir-192	4.65E-07	W-181	2.20E-05
Ca-47	2.14E-06	Nb-94	5.12E-07	Y-91	5.23E-04
Ce-139	1.59E-06	Nb-95	2.11E-06	Zr-95	2.22E-06

The estimated radioactivity concentrations are considered conservative in that the mean + 3σ has been used to estimate the concentrations of the major radionuclides and the average concentrations of the minor radionuclides were calculated based on the number of times each nuclide was detected and not based on the size of the sample.

4.0 Conclusions

The amount of byproduct material possessed by I⁴ at the Commerce Circle facility may be estimated based on the mass of irradiated topaz and number of topaz irradiation canisters stored in the facility using the radioactivity concentrations provided in Table 2.1 and Table 3.1. This approach will result in a conservative overestimation of the amount of byproduct material possessed at the Commerce Circle facility.

5.0 References

- [1] The Curators of the University of Missouri, Research Reactor Facility, NRC License 24-00513-36E Renewal Application, November 30, 1993
- [2] B. Shleien, *The Health Physics and Radiological health Handbook*, Revised Edition, Scinta Inc., 1992

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PRI Signature and Date:	Document Control Signature and Date:	Quality Assurance Signature and Date:	
<i>Steve Laflin</i> 5-3-07	<i>Lucinda Sherman</i> 5/3/07	<i>David J. [Signature]</i> 5/4/07	

1.0 PURPOSE

- 1.1 This procedure provides instruction for processing irradiated topaz (blue topaz) from opening the irradiation canister up to counting prior to shipment.

2.0 POTENTIAL HAZARDS

- 2.1 Exposure to radiation and radioactive contamination
- 2.1.1 The irradiation container will normally be allowed to decay to below 150 mR/hr before being opened.
- 2.1.2 A Radiological Work Permit (RWP) is required to work under this OP.
- 2.1.3 Continuous air monitor or air sampler shall be running as per the RWP or per RSO discretion.
- 2.2 General industrial hazards
- 2.2.1 Gloves, safety glasses, long pants, closed-toed shoes, and lab coat required for all can handling and work inside the mill.
- 2.3 Lab coat and latex gloves required while cleaning and drying stones.

3.0 APPLICABILITY AND LIMITATIONS

- 3.1 The Gemstone irradiation canister has been received from MURR
- 3.2 The technician opening the canister must have completed the training requirements for Blue Topaz Processing.

4.0 DEFINITIONS

None

5.0 RESPONSIBILITIES

- 5.1 Gemstone Supervisor: Identify and schedule the Gemstone irradiation canisters to be processed.
- 5.2 Technician: Coordinate with the Gemstone supervisor to process blue topaz.
- 5.3 Topaz Clerk: Coordinate with Technician and maintain the Topaz Inventory Database up to date.
- 5.4 Technician: Weigh and re-weigh any bag in process to ensure carat weight is properly tracked and material accountability is maintained.

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6.0 EQUIPMENT AND MATERIALS

- 6.1 Vertical Mill
- 6.2 Radiation survey instrument
- 6.3 Air sampler, as required
- 6.4 Contamination survey instrument
- 6.5 Topaz Cleaning Jug
- 6.6 Ultra Sonic Cleaner
- 6.7 Dish soap and De-Ionized Water
- 6.8 Form I4-38 Topaz Process Control Sheet. From here on referred to as Form 38.

7.0 INSTRUCTIONS**7.1 Opening the Gemstone Irradiation Canister**

- 7.1.1 Gemstone Supervisor: Coordinate with Topaz Clerk and determine which Irradiation Canisters needs to be opened. Obtain the Form 38's for those canisters, enter the EOI date on the Form 38's and give to the Technician along with any special instructions.
- 7.1.2 TECH: Using the proper instrument, survey each canister and write the highest contact reading in the proper space on the Form 38's.
- 7.1.3 TECH: Transport irradiation canisters to the Topaz Milling/Decontamination Room as directed by the Gemstone Supervisor.
- 7.1.4 TECH: Prepare the mill for operation by checking the level of the aluminum in the vacuum pre-filter and empty if the collection container is close to full. Inform the RSO if emptying is required.
- 7.1.5 TECH: Start the vacuum system, open the door and check the mill canister holder for loose chips. Vacuum as necessary.
- 7.1.6 TECH: Obtain an air sample as required by the RWP and in accordance with *I4-OP-13, Air Sampling*.
- 7.1.6.1 TECH: Mill the canister open as per the operators aid posted on the side of each mill.
- 7.1.7 TECH: When the use of this procedure is completed for the day, place any opened canisters back into shielded storage, vacuum all the loose chips from the milling box and wipe down the outside of the machine then perform a contamination survey of the work area.



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7.2 Unloading the Gemstone Irradiation Canister

- 7.2.1 TECH: Label the zip-lock bags used for the stone storage as shown on attachment 2. Include the weight of the bag (in red marker) and the pack code. The pack code is to be followed by a -01, -02, etc as the identifying bag numbers. Example B-202-001-01, B-202-001-02, etc.
- 7.2.2 TECH: Print the canister number on an index card or sticky note and post above the unloading tray. This card is to follow the stones through the washing process.
NOTE: Ensure HEPA Air-mover is operating prior to pouring the topaz out of the canister.
- 7.2.3 TECH: Remove the inner lid from the canister using a suction cup.
- 7.2.4 TECH: Notify the Gemstone Supervisor of any unusual conditions such as moisture or off-colored stones. Document findings in the comment section of the Form 38 and in the canister logbook located in the weld room.
- 7.2.5 TECH: Taking care not to chip the stones, unload the stones onto the unloading tray that has been lined with Terri-towels. If the can has dividers in it (as per the Form 38) take care to keep the stones separated. Wash, dry and bag each division separately.
- 7.2.6 TECH: Verify all topaz has been removed from the canister prior to returning the canister to storage or transferring the canister to the weld room for loading.
- 7.2.7 TECH: Transfer the stones from the unloading tray into the cleaning jugs with an even amount of stones in each jug. Transfer jugs to wash station.

7.3 Washing the Gemstones

- 7.3.1 TECH: Pour a couple of drops of dish soap into each Topaz Cleaning Jug then fill with DI water until the level is about 2 inches above the topaz. Install the lids.
- 7.3.2 TECH: Place the Topaz Cleaning Jugs into the ultra sonic cleaner, add DI water as necessary to fill the ultra sonic cleaner to the proper operating level
- 7.3.3 TECH: Operate the ultra sonic sink in accordance with the manufacturer's operating manual for ten (10) minutes.
- 7.3.4 TECH: Remove the Topaz Cleaning Jugs and decant the solution into the first, second or third funnel as appropriate.
- 7.3.5 TECH: Repeat steps 7.3.1 through 7.3.4 two times substituting soapy water with DI water.
NOTE: *A dehydrator may be used to accelerate the drying process.*
- 7.3.6 TECH: After the second rinse, carefully pour the topaz on the drying/quick sort tray or into the dehydrator trays. Allow stones to dry then perform a contamination survey of the stones to determine removable contamination levels.

NOTE: *Contact Gemstone Supervisor if after two decontamination attempts removable contamination levels on the stones exceed 1,000 dpm.*

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- 7.3.7 TECH: When removable contamination levels are less than 1,000 dpm/swab indicate the pack has been cleaned by placing a dated Blue Dot sticker on the storage bag and initialing and dating the "wash" block on the Form 38.
- 7.3.8 TECH: After the stones are dry and decontaminated fill the appropriate Marinelli beaker (500 ml or 1000ml) with stones and weigh (in carats). Write the weight of the stones on the zip-lock bag that has been pre-marked with the proper pack code and bag number. Gently pour the stones into the bag and seal the bag. See attachment 2.
- 7.3.9 TECH: Write bag numbers and weights in the proper blocks on the Form 38. Assign bin numbers for each bag and place the bag in that bin.
- 7.3.10 2ND TECH OR TOPAZ CLERK: IF sum of bag weights differ from loaded weight by more than 5 carats, weigh each bag of stones to verify the weight is correct. Verify that the pack code, weight, and bin numbers on each bag match those on the Form 38. Correct bag weights as necessary or document the difference is actual in the comment section of the Form 38.
- 7.3.11 TECH OR TOPAZ CLERK: Return the bins to their proper place in the vault.
- 7.4 Quick Sort**
- 7.4.1 TECH: Survey the blue Topaz with the Series 900 mini-monitor with shielded NaI(Tl) probe held \approx 1cm above the stones. Scan the stones with a scan rate of \approx 5cm/ sec. Remove any stone reading $>$ 1000 cps and place in the Hot Stone Waste Container.
- 7.4.2 TECH: Indicate the stones have been quick sorted by placing a dated Green Dot sticker on the storage bag initialing and dating the "quick sort" block on Form 38,
- 7.4.3 TECH: Place a white sticker on the top of a beaker lid and write the bin number and pack code number from the bag on it, then weigh the proper Marinelli beaker with that lid on the scale. Tare the beaker and place all the stones that passed the quick sort in the beaker and weigh. Record the post-processing weight on the Form 38. Line out the old weight on the bag and write the new weight on the bag if the weights are different. See attachment 2.
- 7.4.4 TECH: Convert the weight of the stones to grams by dividing by 5. Write the gram weight on the lid sticker. See attachment 2.
- 7.4.5 TECH: Verify the weight of the stones by weighing each beaker of stones and subtracting the beaker and lid weight located in the upper left hand corner of the sticker. Verify the weight on each bag and in the proper block on the Form 38. Divide the weight by 5 to verify the gram conversion. Then sign off the appropriate block on the Form 38.

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7.5 Counting Blue Topaz

- 7.5.1 TECH: Count Stones in accordance with I4-OP-20, Blue Stone Counting.
- 7.5.2 TECH: When the stones have been counted, initial and date the "Date counting complete" block on the Form 38 and return the stones to their appropriate bags and seal the bags.

7.6 Storing Blue Topaz

- 7.6.1 TECH: Return the Form 38 to the Topaz Clerk and return the packaged topaz to the storage vault. Initial and date the "packaged and returned to storage" block of the Form 38. Forward completed from 38 to the Topaz Clerk.
- 7.6.2 TOPAZ CLERK: Update the inventory database.

8.0 REFERENCES

None

9.0 ATTACHMENTS

- 9.1 Attachment 1 Form I4-38 Topaz Process Control Sheet
- 9.2 Attachment 2 Bag Labeling
- 9.3 Attachment 3 Blue Mill Operator Aide
- 9.4 Attachment 4 Old Mill Operator Aide

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9.1 Attachment 1: Form 38

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9.2 Attachment 2: Bag Labeling

Storage Bag

74.6 (Bag tare weight in red)	1425 (bin number)
B202-001-01 (Bag number)	
6268.0 (Bag weight)	
6240.0 (Post Process Weight (bag weight lined out))	

Marinellie Beaker Lid Label

(bin number) 1425
1248.0 (Post process wt. In grams)
B202-001-01 (bag number)



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9.3 Attachment 3: **Blue Mill Operator Aide**

1. Turn vacuum on prior to opening the doors. Ensure that the vacuum valve is in the up position.

2. Release air lock and slide the turntable assembly out till it stops.
3. Mount can on turntable, level and secure. Mark lid with a starting point and half way point.

4. Close plexiglass inclosure and push turntable assembly in slowly until it stops. Secure in place with the air lock switch. Close doors.

5. Rotate can until starting point is under the mill bit. Shut power off. Loosen turntable slide and move can in until bit is above the lid. Lower bit until it touches lid and zero the vertical depth gauge.
6. Raise bit and move can out until the bit clears the side of the can. Lower the bit down and move can in until it touches the bit. Zero the horizontal depth gauge. Raise bit and move can in approximately .1870". Secure the turntable slide. Some cans are a little different than others so you may need to adjust the bit in slightly near the end of the cutting to release the lid.

7. Start turntable rotation and mill bit. Turntable should rotate clockwise at full speed of 100. Slowly lower the bit until it starts to cut the weld. Complete one full revolution to remove any high spots and then lower bit a maximum of .010" each revolution. The lids are .1250" thick and should be loose after a maximum vertical depth of .1450".

8. Once lid is loose or can be pried up and removed. Turn mill off, open doors, release the turntable airlock, slide turntable out. Rotate the vacuum valve down and use vacuum hose on left side of the mill to vacuum up all the metal chips around the can. Remove lid and place in the Hot Lid Storage Can.

9. Remove the can from the mill and place near the tray to empty stones out.



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9.4 Attachment 4: **Old Mill Operator Aide**

1. Turn vacuum on prior to opening the doors. Ensure that the vacuum valve is in the proper position.
2. Lower and move the can holder forward such that the can may be placed in the holder without touching the mill bit.
3. Place the can in the can holder, close and secure the holder door. Any misalignment could result in damage to the can. Close the mill containment door.
4. Adjust the can so that the weld is aligned with the mill bit.
5. Turn the mill on and adjust the can height until the weld is just below the bit. Turn on the rotator and allow the can to turn one full revolution to check the mill bit alignment. Adjust the height and depth of the can as needed to mill off the weld and remove the lid.
6. Once lid is loose or can be pried up and removed. Turn mill off, open doors. Rotate the vacuum valve down and use vacuum hose on left side of the mill to vacuum up all the metal chips around the can. Remove lid and place in the Hot Lid Storage Can.
7. Remove the can from the mill and place near the tray to empty stones out.



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TITLE: White Topaz and Diamond Processing		Number: I4-OP-18	Effective Date: 5/7/07
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PRI Signature and Date: <i>Steve Laflin</i> 5/7/07	Document Control Signature and Date: <i>Linda Stroman</i> 5/7/07	Quality Assurance Signature and Date: <i>Qui</i> 5/7/07	

1.0 PURPOSE

1.1 This procedure provides instruction for processing raw topaz (white topaz) from the receipt of the raw stones to shipping loaded irradiation canisters to the Missouri University Research Reactor (MURR).

2.0 POTENTIAL HAZARDS

2.1 Exposure to radiation and radioactive contamination.

2.1.1 A Radiological Work Permit (RWP) is required to work under this OP.

2.1.2 Continuous air monitor or air sampler shall be running during canister welding, as per RWP or RSO discretion.

2.2 General industrial hazards associated with welding and lifting moderately heavy (50 lbs.) objects.

2.3 Handling acidic solutions and acetone.

2.3.1 Face shield, sleeves, gloves and apron required for handling nitric acid

3.0 APPLICABILITY AND LIMITATIONS

3.1 The irradiation canister has been received from MURR

3.2 The technician welding the canister must have completed the training requirements for canister welding.

4.0 DEFINITIONS

4.1 Clean Welding Area – A 5' X 5' zone around the Topaz irradiation can welder shall be posted as a "Clean Weld Area".

4.1.1 Dirt producing activities such as grinding will not be allowed in the immediate area surrounding the clean area when performing welding operations.

4.1.2 Welding equipment, tables and fixtures shall be cleaned with a lint free cloth moistened with acetone at the beginning of each shift in which welding will be performed.

4.1.3 All tools and materials used in the "Clean Weld Area" will be cleaned with a lint free cloth moistened with acetone at the time of entry.

5.0 RESPONSIBILITIES

5.1 Gemstone Supervisor: Identify and schedule the loading of the canisters.

5.2 Technician: Coordinate with the Gemstone Supervisor to process white topaz.



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- 5.3 Topaz Clerk: Coordinate with Technician and maintain the Topaz Inventory Database up to date.
- 5.4 Technician: Verify the cleanliness of the "Clean Weld Area" prior to welding Topaz Canisters.

6.0 EQUIPMENT AND MATERIALS

- 6.1 Series 400, 500, 600 or 700 aluminum Topaz Irradiation can.
- 6.2 TIG welder setup for aluminum fillet welding.
- 6.3 Helium pressure/vacuum chamber.
- 6.4 Transfer carts as needed.
- 6.5 Radiation and contamination survey instrumentation
- 6.6 Air sampler, as required.
- 6.7 Topaz Cleaning Jug
- 6.8 Ultra Sonic Cleaner
- 6.9 2.0 Molar HNO₃ and De-Ionized Water
- 6.10 Acetone

7.0 INSTRUCTIONS

7.1 Receipt of White Stones

- 7.1.1 Technician: At the time of receipt, inspect the package exterior for visible damage, open the package and examine the contents for damage. Inform the Gemstone Supervisor of any unusual conditions.
- 7.1.2 Technician: Complete *Form I4-39, White Stone Receipt Sheet* and forward to the Topaz Clerk upon completion of acid washing white stones and final weighing.
- 7.1.3 Topaz Clerk: Assign white pack storage bins and update the Topaz Inventory Data Base in accordance with *I4-OP-19, Topaz Inventory & Control*.

7.2 Acid Washing White Stones

- 7.2.1 Gemstone Supervisor: Direct the washing of white stones prioritizing stones based on customer demand.
- 7.2.2 TECH: Wash stones as follows:
 - 7.2.2.1 TECH: Place the white topaz in the Topaz Cleaning Jug, pour nitric acid (HNO₃) (approximately 2.0 N) into the Topaz Cleaning Jug so the acid level is about 2 inches above the topaz.



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7.2.2.2 TECH: If not already complete, fill the ultra sonic sink ½ full with DI-water.

7.2.2.3 TECH: Place the Topaz Cleaning Jug into the ultra sonic cleaner, add DI-water as necessary to fill the ultra sonic cleaner to the proper operating level.

7.2.2.4 TECH: Operate the ultra sonic sink in accordance with the manufacturer's operating manual for ten (10) minutes.

7.2.2.5 TECH: Remove the Topaz Cleaning Jug, install lid and decant the solution into the Used Acid Jug (for HNO₃) or into the Used Water Jug (for DI water) or recycle the solution as appropriate.

7.2.2.6 TECH: Repeat steps 7.2.2.1 through 7.2.2.5 substituting HNO₃ with DI water.

Note: *A heated dehydrator or hot air gun may be used to dry the stones.*

7.2.2.7 TECH: After the rinse, carefully pour the topaz on the drying tray and allow the stones to dry.

7.2.2.8 TECH: If the stones are to be placed in storage, ensure the bag number and bag weight are on the bag. In permanent marker, write on the bag "washed" and date on the outside of bag, and place in the correct storage bin.

7.2.3 TECH: If the white stones are going to be loaded immediately into a canister. Do not place in storage.

7.3 Loading Canister with White Stones.

CAUTION

FOR PROPER HEAT TRANSFER CHARACTERISTICS, THE CENTER POST MUST BE IN CONTACT WITH THE CANISTER LID

7.3.1 Gemstone Supervisor: Obtain a White Topaz inventory report from the Topaz Clerk. Direct the loading of canisters prioritizing which stones are to be loaded based on customer demand.

7.3.2 TECH: Retrieve white stones from storage if necessary. Ensure the stones have been pre-washed, if required.

7.3.3 TECH: Obtain a blank, *Form I4-38, Topaz Process Control Sheet* for each canister to be loaded.

7.3.4 TECH: Obtain empty canisters from the canister storage rack.

7.3.5 TECH: Inspect the canister prior to loading.

7.3.5.1 TECH: Prep the weld area as required

7.3.5.2 TECH: Verify the canister is empty, i.e. no liquids or foreign material.



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7.3.5.3 TECH: Check the condition of the lid surface area and overall condition of the canister. Check that the bottom screen slopes upward from the inner canister wall to the center post so that a sufficient air gap will exist at the bottom of the center post when the canister is loaded. Accept, repair or remove the canister from service as applicable.

NOTE: Center Post

Installation of Center Post is optional if material to be loaded into the can is too large to allow Center Post Installation, and/or upon customer request. If Center Post is not installed, document this in the designated "comments section" on I4 Form 38 and I4 Form 42.

7.3.5.4 TECH: Clean the inside of the can as necessary.

7.3.5.5 TECH: Neolube threaded fittings as needed.

7.3.6 TECH: Perform a contamination survey of the area to be welded to verify removable contamination levels are less than $2250 \mu\text{Ci}/100 \text{ cm}^2$ ($5000 \text{ dpm}/100 \text{ cm}^2$). If removable contamination levels exceed this value, decontaminate the canister with a lint free cloth moistened with acetone.

NOTE: *To maximize the quantity of stones that can be loaded into a canister, vibrate the canister or use rubber hammer to settle the stones as the canister is being loaded.*

7.3.7 TECH: Taking care not to chip the stones, carefully load the stones into the canister. Complete *Form I4-38, Topaz Process Control Sheet* as follows:

NOTE: Loading Diamonds

Diamonds may be loaded into Topaz container for irradiation if:

- 1) Diamonds are securely contained in separate aluminum packet or container;
- 2) Do not exceed 1000 grams (5000 cts) of diamonds per irradiation container;
- 3) Documentation of presence of diamonds and amount is on I4 Form 38 and I4 Form 43 (canister irradiation instructions).

7.3.7.1 TECH: If white stones from just a single pack are to be loaded into the canister, load the canister with-out separation screens and record the pack number(s) and bag weight(s) on *Form I4-38, Topaz Process Control Sheet*.

7.3.7.1.1 TECH: In the event that only a partial pack will fit into the canister, add what stones will fit in the canister and weigh the stones remaining in the pack. Determine the weight of stones that were loaded in the canister by subtracting the remaining stone weight from the original bag weight.

7.3.7.2 TECH: If white stones from multiple packs are to be loaded into the canister, load the canister with divider plates as follows:



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- 7.3.7.2.1 TECH: Place the separation screen over the stones which have been loaded, use the ring tool to place the compression ring over the center post and fully insert it to hold the separation screen in place. Repeat until the canister has been fully loaded.
- 7.3.7.2.2 TECH: Record the pack number(s) and bag weight(s) on *Form I4-38, Topaz Process Control Sheet*. Indicate separation screens and pack numbers on the canister drawing.
- 7.3.8 TECH: Screw the center post cap on the center ring and place the lid on the canister. The center post cap should just touch the lid when the lid is in place. Indicate completion on *Form I4-42, Canister Weld Checklist*.

7.4 Welding Canisters

- 7.4.1 Gemstone Supervisor: Verify the technician to perform welding has completed required training and is proficient with canister welding and the Clean Weld Area has been inspected that day.
- 7.4.2 TECH: Clean each canister to be welded with acetone. Initial the appropriate blank on *Form I4-42, Canister Weld Checklist* to indicate the cleaning for that canister is complete.
- 7.4.3 TECH: Transport the canister to the weld area as required.
- 7.4.4 TECH: Heat the canister lid with torch.
- Note: *A Constant Air Monitor (CAM) or air sampler is to be operated in the welding area during canister welding as required by the RWP or RSO.*
- 7.4.5 TECH: Place the canister lid on the can and weld all but the last 1/16th inch of the lid.
- 7.4.6 TECH: Place the canister in the helium chamber and evacuate to >20" Hg indicated vacuum.
- 7.4.7 TECH: Back fill the chamber with helium.
- 7.4.8 TECH: Repeat steps 7.4.6 and 7.4.7 two more times.
- 7.4.9 TECH: Weld the remaining 1/16th inch of the lid as soon as possible. Complete and initial the appropriate blanks on *Form I4-42, Canister Weld Checklist*.
- 7.4.10 TECH: Check the canister with the size gage and remove any excess weld as required. Complete and initial the appropriate blanks on *Form I4-42, Canister Weld Checklist*.
- 7.4.11 TECH: Place the canister in the helium chamber and pressurize to 20 PSIG with helium. Hold the pressure for 15 minutes.
- 7.4.12 TECH: Remove the canister from the helium chamber and place in the leak test chamber and observe the can for any bubbles. If bubbles are observed, the canister must be repaired or re-welded.
- 7.4.13 TECH: Remove canister from leak test chamber, clean with a lint free cloth, using a black Sanford permanent marker, record the canister number on the top and bottom of the canister then return the canister to its original storage location in the canister storage rack and up date the Canister Storage/Status Board. Forward the completed Form I4-38 to the Topaz Clerk. Forward the completed Form I4-42 to the Gemstone Supervisor.



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7.4.14 Gemstone Supervisor: Maintain the completed Form I4-42 with the canister to accompany shipment to MURR. Retain a copy of the Form I4-42 on file until the canister is returned for unloading.

7.4.15 Topaz Clerk: Up date the Topaz Inventory Data base and retain *Form I4-38, Topaz Process Control Sheet* on file for use when the canister is returned for blue topaz processing.

7.5 Shipping Loaded Canisters to MURR

7.5.1 Gemstone Supervisor: Complete *Form I4-43, Canister Irradiation Instruction Sheet*. Direct loading of Topaz canisters into shipping drums in accordance with I4-OP-22, Loading and Unloading Irradiation Shipping Drums.

7.5.2 Shipper: Prepare the canisters for shipping in accordance with *I4-OP-14, Shipment, Inspection and Receipt of Hazardous Material*.

7.5.3 Shipper: Include the completed *Form I4-43, Canister Irradiation Instruction Sheet*, and a completed *Form I4-42, Canister Weld Checklist* with the packing slip.

7.5.4 Forward a copy of the completed Form I4-43 to the Topaz Clerk.

7.5.5 Topaz Clerk: Up date the Topaz Inventory Data base.

8.0 REFERENCES

N/A

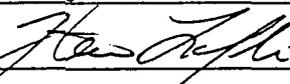
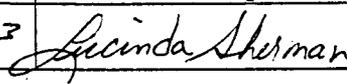
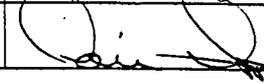
9.0 ATTACHMENTS

9.1 Form I4-38 Topaz Process Control Sheet

9.2 Form I4-42 Canister weld Checklist

9.3 Form I4-43 Canister Irradiation Instructions



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PRI:		Page:	Superseded Date:
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PRI Signature and Date:	Document Control Signature and Date:	Quality Assurance Signature and Date:	
 10-24-03	 10/24/03	 10/24/03	

1.0 PURPOSE

- 1.1 This procedure provides instruction for maintaining physical and electronic inventory for white and blue topaz.

2.0 POTENTIAL HAZARDS

- 2.1 Office environment type hazards; light lifting, reaching and computer use.

3.0 APPLICABILITY AND LIMITATIONS

- 3.1 Some Sections of this procedure may be performed concurrently and in conjunction with I4-OP-18, *White Topaz Processing* and I4-OP-17, *Blue Topaz Processing*.

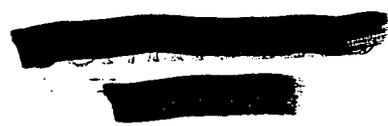
4.0 DEFINITIONS

- 4.1 *White Topaz*: Topaz which has not been irradiated, also referred to as white stones.
- 4.2 *Blue Topaz*: Topaz which has been irradiated, also referred to as blue stones.
- 4.3 *Pack Number*: A unique identifier code provide by the topaz supplier which indicates stone shape, irradiation time and owner.
- 4.4 *Bag Number*: A unique identifier code assigned to a Pack Division consisting of the "Pack Number" plus the sequential number assigned to the bag. For example, if a pack is divided into three bags, then the bag numbers associated with the pack would be "Pack Number-01", "Pack Number-02" and "Pack Number-03".

5.0 RESPONSIBILITIES

- 5.1 Topaz Clerk: Maintain the Topaz Inventory Database and-coordinate the physical storage of white and blue topaz. Generates reports from the Topaz Inventory Database as requested by the Topaz Technician.

6.0 EQUIPMENT AND MATERIALS





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- 6.1 Topaz Inventory Database
- 6.2 Form I4-38, Topaz Process Control Sheet
- 6.3 Form I4-39, White Stones Receipt Sheet
- 6.4 Form I4-40, Canister Irradiation History
- 6.5 Form I4-43, Canister Irradiation Instructions

7.0 INSTRUCTIONS

7.1 Receipt of White Stones

7.1.1 Receiver: Receive topaz from carrier.

7.1.1.1 Receiver: At the time of receipt, inspect the package exterior for visible damage, open the package and examine the contents for damage. Inform the Topaz Clerk of any unusual conditions.

7.1.2 Receiver: Complete *Form I4-39, White Stone Receipt Sheet* and forward to the Topaz Clerk.

7.1.2.1 Topaz Technician: Within 1 day of receipt, weigh the stones.

7.1.2.2 Topaz Technician: Compare the "Pack Ship Weight" and the "Pack Receipt Weight".

NOTE: *Topaz Clerk needs to notify customer of any discrepancies.*

7.1.2.3 Topaz Clerk: Record the number, inspection results, date returned (if applicable), the Customer ID and the pack ship and receipt weights in the Topaz Inventory Database.

7.2 White Stone Weight and Storage

Topaz Technician: Segregate divisions by sealing each division in individual bags. Assign each division a bag number consisting of the original pack number plus the sequential number assigned to the division. For example if a single pack is divided into three divisions, then the bag numbers associated with the pack would be "Pack Number-01", "Pack Number-02" and "Pack Number-03".

Note: *White stones will be pre-washed in accordance with I4-OP-18 White Topaz Processing.*

7.2.1 Topaz Technician: Assign storage locations for the white stones.

7.2.2 Topaz Clerk: Record the number of pack divisions, bag number, bag weight and bin numbers in the Topaz Inventory Database.

7.3 White Stone Canister Loading and Shipping

7.3.1 Topaz Clerk: From the Topaz Inventory Database, generate a Canister Loading Report upon request and forward to the Topaz Technician.

Note: *White stones will be loaded into the irradiation canisters in accordance with I4-OP-18 White Topaz Processing.*





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- 7.3.2 Topaz Clerk: Up date the Topaz Inventory Database by recording each pack number loaded into a canister using the information provided by the technician as indicated on the Topaz Process Control Sheet.
- 7.3.3 Topaz Clerk: When informed of a shipment by the Topaz Technician (or designee) up date the Topaz Inventory Database by recording the shipped date in the "White Topaz Ship Date" field of the Topaz Inventory Database.

7.4 Receipt of Blue Stones

- 7.4.1 Topaz Technician: Receive blue stones in accordance with *I4-OP-14, Shipment, Inspection and Receipt of Hazardous Material.*
- 7.4.2 Topaz Technician: Remove canisters from drums and place into the canister storage rack. Place the canister nameplate on the canister storage rack map. Forward completed *Form I4-44, Canister Irradiation History* to the Topaz Clerk.
- 7.4.3 Topaz Clerk: Record the Canister Number, End of Irradiation Date, Return Receipt Date and Canister Storage Location in the Topaz Inventory Database utilizing the data on *Form I4-44, Canister Irradiation History, and Form I4-38; Topaz Process Control Sheet.*

7.5 Blue Stones Processing, Counting and Storage

- 7.5.1 Topaz Clerk: From the Topaz Inventory Database, generate a Blue Stone report, upon request, and forward to the Topaz Technician.

Note: *Blue stones will be processed in accordance with I4-OP-17 Blue Topaz Processing. Processing data will be recorded on Form I4-38 Topaz Process Control Sheet. Blue stones will be counted in accordance with I4-OP-20 Blue Topaz Counting.*

- 7.5.2 Topaz Clerk: Record the bag number post processing weight in the Topaz Inventory Database utilizing the data provided on *Form I4-38 Topaz Process Control Sheet.* Verify the removed weight recorded on Form I4-38 matches the removed weight calculated by the database. Notify the Topaz Technician of any discrepancies.
- 7.5.3 Topaz Clerk: Record the "Actual Count Date" and "Earliest Blue Ship Date" in the Topaz Inventory Database.
- 7.5.4 Topaz Technician: Place the blue topaz bags into vault storage bins, note which bags went into which bins then have the Topaz Clerk update the Topaz Inventory Database accordingly.

7.6 Blue Stones Shipping

- 7.6.1 Topaz Clerk: From the Topaz Inventory Database, generate a Blue Stones to Ship report weekly, and forward to Topaz Technician.
- 7.6.2 Topaz Technician: Arrange for the shipment of blue stones. Retrieve blue topaz bags from the appropriate vault bins.
- 7.6.3 Topaz Clerk: Record the "Actual Blue Ship Date" for the bag numbers shipped in the Topaz Inventory Database, then generate a Customer Invoice from the database.





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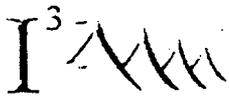
8.0 REFERENCES

- 8.1 Procedure I4-OP-18, White Topaz Processing
- 8.2 Procedure I4-OP-17, Blue Topaz Processing
- 8.3 Procedure I4-OP-20, Blue Topaz Counting

9.0 ATTACHMENTS

- 9.1 Attachment 1: Form I4-38, Topaz Process Control Sheet
- 9.2 Attachment 2: Form I4-39, White Stones Receipt Data
- 9.3 Attachment 3: Form I4-44, Canister Irradiation History
- 9.4 Attachment 4: Form I4-43, Canister Irradiation Instructions





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9.3

Attachment 3

Canister Irradiation History

Canister Irradiation History																												
Return completed form with packing slip to International Isotopes Idaho, Inc.																												
Date Shipped: _____		Drum ID: _____																										
<table border="1"><thead><tr><th>Canister Number</th><th>EOI Date</th></tr></thead><tbody><tr><td>1</td><td></td></tr><tr><td>2</td><td></td></tr><tr><td>3</td><td></td></tr><tr><td>4</td><td></td></tr><tr><td>5</td><td></td></tr><tr><td>6</td><td></td></tr><tr><td>7</td><td></td></tr><tr><td>8</td><td></td></tr></tbody></table>	Canister Number	EOI Date	1		2		3		4		5		6		7		8		<table border="1"><thead><tr><th>Comments</th></tr></thead><tbody><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr></tbody></table>	Comments								
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Completed by: _____ <small>Print Name Initial</small>																												
For International Isotopes Idaho, Inc. use.																												
Topaz Database Updated: _____ <small>Print Name Initial</small>																												



I⁴

International Isotopes Idaho Inc.
A Subsidiary of International Isotopes Inc.



TITLE: Blue Stone Counting		Number: I4-OP-20	Effective Date: 06/11/03
PRI: Steve Laflin		Page: 1 of 5	Superseded Date: 9/17/02
PRI Signature and Date: <i>Steve Laflin 6-16-03</i>	Document Control Signature and Date: <i>Lucinda Sherman 6/18/03</i>	Quality Assurance Signature and Date: <i>Devin [unclear] 6/19/03</i>	

1.0 PURPOSE

- 1.1 This procedure provides instruction for analyzing irradiated topaz (blue topaz) for radioactivity prior to shipment.

2.0 POTENTIAL HAZARDS

- 2.1 Electrical hazards, counting instrumentation operates at high voltages.
- 2.2 Pinching hazards, the Canberra Gamma Analyst is equipped with an automated sample changer.
- 2.3 Cryogenic hazards, the high purity germanium (HPGe) detector associated with the Canberra Gamma Analyst operates at liquid nitrogen temperatures. The system utilized at I⁴ is electronically refrigerated thereby removing the hazard of handling liquid nitrogen.

3.0 APPLICABILITY AND LIMITATIONS

- 3.1 The blue topaz has been processed in accordance with *I4-OP-17, Blue Topaz Processing*.
- 3.2 Daily performance checks have been completed and calibrations for the counting geometries selected are current.
- 3.3 Blue Topaz may only be counted for release by individuals trained in the operation of the instrumentation utilized for radioactivity determination.

4.0 DEFINITIONS

None.

5.0 RESPONSIBILITIES

- 5.1 Radiation Safety Officer (RSO): Review blue topaz analysis data for correctness and completeness and determine the earliest possible shipping date based on the radioactive decay rate. Ensure Quality Control Checks verify proper operation of the counting systems.
- 5.2 Counting Technician (CT): Perform radioactivity analysis of blue topaz as directed by this procedure.
- 5.3 Topaz Clerk: Coordinate with RSO and maintain the Topaz Inventory Database up to date.

6.0 EQUIPMENT AND MATERIALS

- 6.1 Canberra Gamma Analyst
- 6.2 Bicron DELTA 5B BP7/4A Beta Counting System



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6.3 Health Physics Instrument Technical Sheets and Job Aids, as necessary

6.4 Marinelli Beakers, and 125 ml Nalgene bottles.

6.5 Beta counting tray

6.6 Scale

7.0 INSTRUCTIONS

7.1 Determination of Gamma Emitting Radioisotopes

7.1.1 Count Technician (CT): Coordinate with Topaz Technician and analyze blue topaz which has been process in accordance with *I4-OP-17, Blue Topaz Processing*.

7.1.2 Verify the instrument calibration is in date. Contact the RSO if the instrument requires calibration. If not already complete, perform daily performance check in accordance with the instrument operator aid and manufacturer's instructions.

Note: *Stones will typically be counted by canister. Canisters may contain more than one bag number. Utilize Form I4-38, Topaz Process Control Sheet, to keep track of the bag numbers.*

7.1.3 Determine the optimum counting geometry based on the quantity of stones to be counted.

Note: *Three standard counting geometries are available for topaz counting, 1 liter and 500 ml Marinelli beakers and 125 ml Nalgene sample bottle. Use of counting geometries not identified in this procedure must be approved by the RSO.*

7.1.4 Tare balance with sample container, fill sample container with stones to be counted and weigh the filled sample container. Keep track of bag number, weight and sample container number.

7.1.5 Repeat step 7.1.4 until all the stones have been placed into a sample container.

7.1.6 Define a Sample Batch for the stones to be counted in accordance with the instrument operator aid and the manufacturer's instructions.

7.1.7 Load sample containers onto the sample carrousel and count the samples utilizing the instrument operator aid and the manufacturer's instructions.

7.1.8 When sample counting is complete print the count results in accordance with the instrument operator aid.

7.1.9 Maintain the stones segregated in their sample containers and transfer to the beta counting system.

7.2 P-32 and S-35 Determination

7.2.1 CT: Verify the instrument calibration is in date. If not already complete, perform daily performance check in accordance with the manufacturer's instructions and job aid.

7.2.2 Tare balance with a Beta counting tray.



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Note: *If stones from a single bag number are contained in more than one sample container, a representative sample of the smallest stones from the sample container having the highest radioactivity concentration shall be used to determine P-32 and S-35 concentration.*

7.2.3 Carefully pour the stones out of one sample container and onto the sorting tray, collect a representative sample of smallest stones.

Note: *Form I4-46, P-32/S-35 Activity Determination Work Sheet is available as a Microsoft Excel Spreadsheet. Use of the electronic spreadsheet is preferred in that calculations are performed via computer thereby reducing analyst error and calculation time.*

7.2.4 Completely fill the Beta counting tray with a single layer of stones.

7.2.4.1 Weigh the stones and record the weight in grams on Form I4-46.

7.2.4.2 Estimate the average stone size in carats and record on Form I4-46. (An overestimation of carat weight is more conservative).

7.2.4.3 Record the corresponding Sample ID from the Gamma Analysis Report on Form I4-46.

CAUTION: DO NOT LET TOPAZ COME INTO DIRECT CONTACT WITH THE MYLAR COVERING OF THE DETECTOR PROBE.

7.2.5 Slide the beta counting tray between the detector probes in the beta counting system. Count the sample for 120 seconds. Record the results in the "Total Counts" column of Form I4-46.

7.2.6 Record the "Total Counts" (counts registered by the top probe) and the "Unabsorbed Counts" (counts registered by the bottom probe) in the corresponding columns of Form I4-46.

7.2.7 Repeat Steps 7.2.2 through 7.2.6 until a beta analysis has been performed on stones from each sample container filled in Step 7.1.5.

7.2.8 Calculate P-32 and S-35 activity concentration as follows:

7.2.8.1 P-32 activity:

$$P-32 \text{ (Bq/g)} = \frac{\left(\left(\frac{\text{unabsorbed counts}}{\text{sample count time (seconds)}} \right) - (\text{Background count rate (cps)}) \right)}{P-32 \text{ } 2\pi \text{ efficiency} \times \text{sample weight in grams}}$$

7.2.8.2 S-35 activity:

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$$S-35 \text{ (Bq/g)} = \frac{\left(\left(\frac{\text{Total Counts} - \text{Unabsorbed counts}}{\text{sample count time (seconds)}} \right) - (\text{Background count rate (cps)}) \right)}{S-35 \text{ } 2\pi \text{ efficiency} \times \text{sample weight in grams}} \times S-35 \text{ S.A. Factor}$$

7.2.9 Calculate the minimum detectable activity concentration for each sample.

$$\text{MDA} = \frac{3 + 3.29 \sqrt{\text{RbTs} \left(1 + \frac{\text{Ts}}{\text{Tb}} \right)}}{\text{efficiency} \times \text{Ts} \times \text{sample wt.}} \times \text{S.A. Factor}$$

7.3 Earliest Shipping Date Calculation

7.3.1 Forward the HPGe Counting reports and Form(s) I4-46 to the RSO.

7.3.2 RSO: Review the reports for completeness. Input the counting data into the Topaz Decay spreadsheet. Forward reports and Form I4-46 to the Topaz Clerk.

7.3.3 Forward the Earliest Ship Date results to the Topaz Clerk:

7.3.4 Topaz Clerk: Determine earliest ship date and update the Topaz Inventory Data base.

7.3.5 Retain hard copy original Gamma Analyst Reports, Form I4-46s and Topaz Decay Spread Sheets for 3 years after the topaz associated with the above documents has been shipped.

8.0 REFERENCES

8.1 K. Nelson, J. W. Baum, *Health Risk Assessment of Irradiated Topaz*, NUREG/CR-5883, January 1992

8.2 B. Shleien, *The Health Physics and Radiological Health Handbook*, Revised Edition, July 1992.

8.3 U.S. Nuclear Regulatory Commission, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, NUREG-1507, Draft.

9.0 ATTACHMENTS

9.1 Form I4-46, P-32/S-35 Activity Determination Work Sheet



International Isotopes Idaho Inc.
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Topaz Certificate of Release

Customer: Quali-Tech

Shipping Address: Iotron Technologies, Inc
 ATTN: ALEX ENGLISH
 1425 KEBET WAY
 PORT COQUITLAM (VANCOUVER) BC
 CA V3C-6L3

Shipment Number: I4-2007-96, Box

Point of Origin: United States of America

COUNTING INSTRUMENTATION CALIBRATION DATA	
Model	Serial Number
Canberra Gamma Analyst	97-1784
Bicron DELTA5 w/ BP74A probe	467/1159
Bicron DELTA5 w/ BP74A probe	466/1158

Item No.	Lot ID	Date Assayed	Mass (grams)	Mass (carats)	S.A. at time of Shipment (Bq/g)
1	GS06-054-01	11/7/2006	1927.4	9637	<74.0
2	GS06-054-02	11/7/2006	1928.9	9644.5	<74.0
3	GS06-054-03	11/7/2006	1925.9	9629.5	<74.0
4	GS06-054-04	11/7/2006	1927.3	9636.5	<74.0
5	GS06-067-01	3/29/2007	1817.9	9089.5	<74.0
6	GS06-067-02	3/29/2007	1817.2	9086	<74.0
7	GS06-067-03	3/29/2007	1816.9	9084.5	<74.0
8	GS06-067-04	3/29/2007	1814.9	9074.5	<74.0

In accordance with the Atomic Energy for Peace Act Ministerial Regulations, Officer of the Atomic Energy for Peace, Bangkok Thailand, a clearance level of 74 Bq/g is applied for irradiated gem stones produced from neutron irradiation, as such, the specific activity at time of shipment must not exceed 74 Bq/g.

Validated By:  6/6/07
 John J. Miller, Radiation Safety Officer Date

Earliest Ship Date Calculator

Bag Number: GS06-0054-01

Assay Date: 11/07/06

Days to ESD	204
-------------	-----

Mass (grams): 1928

Earliest Ship date (ESD) 05/29/07

carats: 9640

Actual Ship date: 06/11/07

Days Decayed 217

Nuclide	half-life (days)	A1 (TBq)	A2 (TBq)	Activity concentration at time of assay (Bq/g)	Total Activity at time of Assay (Bq)	Activity concentration when shipped (Bq/g)	Total Activity when shipped (Bq)
Major Radionuclides							
Na-22	949.00	0.5	0.5	0.68	1307	0.58	1115
Sc-46	83.85	0.5	0.5	7.25	13980	1.21	2326
Mn-54	312.50	1.0	1.0	35.71	68845	22.07	42549
Zn-65	243.80	2.0	2.0	6.22	11991	3.36	6471
Cs-134	751.90	0.7	0.7	0.00	0	0.00	0
Ta-182	114.50	0.9	0.5	142.43	274597	38.30	73848
P-32	14.28	0.5	0.5	16.76	32313	0.00	1
S-35	87.90	40.0	3.0	0.00	0	0.00	0

Minor Radionuclides							
As-74	17.78	1.0	0.9	0.00	0	0.00	0
Ba-133	3905.50	3.0	3.0	0.00	0	0.00	0
Ce-139	137.50	7.0	2.0	0.00	0	0.00	0
Ce-141	32.50	20.0	0.6	0.46	887	0.00	9
Co-58	70.78	1.0	1.0	0.81	1555	0.10	186
Co-60	1923.55	0.4	0.4	0.00	0	0.00	0
Cr-51	27.70	30.0	30.0	1.58	3037	0.01	13
Fe-59	44.50	0.9	0.9	4.68	9024	0.16	307
Hf-181	42.39	2.0	0.5	0.00	0	0.00	0
Hg-203	46.59	5.0	1.0	0.00	0	0.00	0
Ir-192	74.02	1.0	0.6	0.00	0	0.00	0
Nb-95	34.97	1.0	1.0	0.00	0	0.00	0
Pa-233	27.00	5.0	0.7	0.00	0	0.00	0
Pm-151	1.18	3.0	0.5	0.00	0	0.00	0
Rb-86	18.60	0.5	0.5	1.22	2351	0.00	1
Re-183	70.00	5.0	5.0	0.00	0	0.00	0
Sb-122	2.72	0.3	0.3	0.00	0	0.00	0
Sb-124	60.20	0.6	0.6	0.16	303	0.01	25
Sb-125	1011.05	2.0	1.0	0.00	0	0.00	0
Sn-113	115.10	4.0	2.0	0.00	0	0.00	0
Sr-85	64.84	2.0	2.0	0.00	0	0.00	0
Tb-160	72.30	0.9	0.5	0.00	0	0.00	0
Y-91	58.50	0.6	0.6	0.00	0	0.00	0
Zr-95	64.02	2.0	0.8	0.00	0	0.00	0

217.94 420191

S.A. at time of shipment:	65.79
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126852.02

Shipment Approved By:

6/6/07
Date

Earliest Ship Date Calculator

Bag Number: GS06-0054-02

Assay Date: 11/07/06

Days to ESD	198
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Mass (grams): 1929

Earliest Ship date (ESD) 05/23/07

carats: 9645

Actual Ship date: 06/11/07

Days Decayed 217

Nuclide	half-life (days)	A1 (TBq)	A2 (TBq)	Activity concentration at time of assay (Bq/g)	Total Activity at time of Assay (Bq)	Activity concentration when shipped (Bq/g)	Total Activity when shipped (Bq)
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Major Radionuclides							
Na-22	949.00	0.5	0.5	0.56	1090	0.48	930
Sc-46	83.85	0.5	0.5	6.78	13082	1.13	2184
Mn-54	312.50	1.0	1.0	35.92	69286	22.22	42862
Zn-65	243.80	2.0	2.0	6.78	13071	3.66	7063
Cs-134	751.90	0.7	0.7	0.25	491	0.21	402
Ta-182	114.50	0.9	0.5	133.79	258089	36.07	69585
P-32	14.28	0.5	0.5	15.48	29861	0.00	1
S-35	87.90	40.0	3.0	0.00	0	0.00	0

Minor Radionuclides							
As-74	17.78	1.0	0.9	0.00	0	0.00	0
Ba-133	3905.50	3.0	3.0	0.00	0	0.00	0
Ce-139	137.50	7.0	2.0	0.00	0	0.00	0
Ce-141	32.50	20.0	0.6	0.46	890	0.00	9
Co-58	70.78	1.0	1.0	0.86	1654	0.10	198
Co-60	1923.55	0.4	0.4	0.00	0	0.00	0
Cr-51	27.70	30.0	30.0	1.85	3569	0.01	16
Fe-59	44.50	0.9	0.9	4.73	9118	0.16	313
Hf-181	42.39	2.0	0.5	0.00	0	0.00	0
Hg-203	46.59	5.0	1.0	0.00	0	0.00	0
Ir-192	74.02	1.0	0.6	0.00	0	0.00	0
Nb-95	34.97	1.0	1.0	0.00	0	0.00	0
Pa-233	27.00	5.0	0.7	0.00	0	0.00	0
Pm-151	1.18	3.0	0.5	0.00	0	0.00	0
Rb-86	18.60	0.5	0.5	0.00	0	0.00	0
Re-183	70.00	5.0	5.0	0.00	0	0.00	0
Sb-122	2.72	0.3	0.3	0.00	0	0.00	0
Sb-124	60.20	0.6	0.6	0.00	0	0.00	0
Sb-125	1011.05	2.0	1.0	0.00	0	0.00	0
Sn-113	115.10	4.0	2.0	0.00	0	0.00	0
Sr-85	64.84	2.0	2.0	0.00	0	0.00	0
Tb-160	72.30	0.9	0.5	0.00	0	0.00	0
Y-91	58.50	0.6	0.6	0.00	0	0.00	0
Zr-95	64.02	2.0	0.8	0.00	0	0.00	0

207.46 400200

S.A. at time of shipment:	64.06
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123562.83

Shipment Approved By: 6/6/07
Date

Earliest Ship Date Calculator

Bag Number: GS06-0054-03

Assay Date: 11/07/06

Days to ESD 199

Mass (grams): 1926

Earliest Ship date (ESD) 05/24/07

carats: 9630

Actual Ship date: 06/11/07

Days Decayed 217

Nuclide	half-life (days)	A1 (TBq)	A2 (TBq)	Activity concentration at time of assay (Bq/g)	Total Activity at time of Assay (Bq)	Activity concentration when shipped (Bq/g)	Total Activity when shipped (Bq)
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Major Radionuclides							
Na-22	949.00	0.5	0.5	0.48	918	0.41	784
Sc-46	83.85	0.5	0.5	7.09	13650	1.18	2278
Mn-54	312.50	1.0	1.0	34.53	66501	21.36	41131
Zn-65	243.80	2.0	2.0	6.58	12675	3.55	6847
Cs-134	751.90	0.7	0.7	0.00	0	0.00	0
Ta-182	114.50	0.9	0.5	138.89	267502	37.43	72087
P-32	14.28	0.5	0.5	18.39	35419	0.00	1
S-35	87.90	40.0	3.0	0.00	0	0.00	0

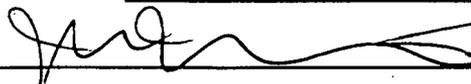
Minor Radionuclides							
As-74	17.78	1.0	0.9	0.00	0	0.00	0
Ba-133	3905.50	3.0	3.0	0.00	0	0.00	0
Ce-139	137.50	7.0	2.0	0.00	0	0.00	0
Ce-141	32.50	20.0	0.6	0.38	732	0.00	7
Co-58	70.78	1.0	1.0	0.78	1505	0.09	180
Co-60	1923.55	0.4	0.4	0.00	0	0.00	0
Cr-51	27.70	30.0	30.0	1.79	3446	0.01	15
Fe-59	44.50	0.9	0.9	4.97	9577	0.17	328
Hf-181	42.39	2.0	0.5	0.00	0	0.00	0
Hg-203	46.59	5.0	1.0	0.00	0	0.00	0
Ir-192	74.02	1.0	0.6	0.00	0	0.00	0
Nb-95	34.97	1.0	1.0	0.00	0	0.00	0
Pa-233	27.00	5.0	0.7	0.00	0	0.00	0
Pm-151	1.18	3.0	0.5	0.00	0	0.00	0
Rb-86	18.60	0.5	0.5	0.00	0	0.00	0
Re-183	70.00	5.0	5.0	0.00	0	0.00	0
Sb-122	2.72	0.3	0.3	0.00	0	0.00	0
Sb-124	60.20	0.6	0.6	0.00	0	0.00	0
Sb-125	1011.05	2.0	1.0	0.00	0	0.00	0
Sn-113	115.10	4.0	2.0	0.18	347	0.05	94
Sr-85	64.84	2.0	2.0	0.00	0	0.00	0
Tb-160	72.30	0.9	0.5	0.00	0	0.00	0
Y-91	58.50	0.6	0.6	0.00	0	0.00	0
Zr-95	64.02	2.0	0.8	0.00	0	0.00	0

214.06 412272

S.A. at time of shipment: 64.25

123752.55

Shipment Approved By: _____



6/6/07
Date

Earliest Ship Date Calculator

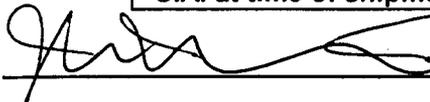
Bag Number: GS06-0054-04 **Assay Date:** 11/07/06 **Days to ESD** 206
Mass (grams): 1927 **Earliest Ship date (ESD)** 06/01/07
carats: 9635 **Actual Ship date:** 06/11/07 **Days Decayed** 216

Nuclide	half-life (days)	A1 (TBq)	A2 (TBq)	Activity concentration at time of assay (Bq/g)	Total Activity at time of Assay (Bq)	Activity concentration when shipped (Bq/g)	Total Activity when shipped (Bq)
Major Radionuclides							
Na-22	949.00	0.5	0.5	0.37	704	0.31	601
Sc-46	83.85	0.5	0.5	6.91	13309	1.15	2225
Mn-54	312.50	1.0	1.0	35.70	68790	22.09	42568
Zn-65	243.80	2.0	2.0	6.24	12026	3.37	6501
Cs-134	751.90	0.7	0.7	0.19	373	0.16	306
Ta-182	114.50	0.9	0.5	145.79	280928	39.34	75805
P-32	14.28	0.5	0.5	17.11	32971	0.00	1
S-35	87.90	40.0	3.0	0.00	0	0.00	0

Minor Radionuclides							
As-74	17.78	1.0	0.9	0.00	0	0.00	0
Ba-133	3905.50	3.0	3.0	0.00	0	0.00	0
Ce-139	137.50	7.0	2.0	0.00	0	0.00	0
Ce-141	32.50	20.0	0.6	0.57	1090	0.01	11
Co-58	70.78	1.0	1.0	0.73	1406	0.09	169
Co-60	1923.55	0.4	0.4	0.00	0	0.00	0
Cr-51	27.70	30.0	30.0	2.94	5674	0.01	25
Fe-59	44.50	0.9	0.9	4.80	9252	0.17	318
Hf-181	42.39	2.0	0.5	0.00	0	0.00	0
Hg-203	46.59	5.0	1.0	0.00	0	0.00	0
Ir-192	74.02	1.0	0.6	0.00	0	0.00	0
Nb-95	34.97	1.0	1.0	0.00	0	0.00	0
Pa-233	27.00	5.0	0.7	1.71	3300	0.01	13
Pm-151	1.18	3.0	0.5	0.00	0	0.00	0
Rb-86	18.60	0.5	0.5	0.00	0	0.00	0
Re-183	70.00	5.0	5.0	0.00	0	0.00	0
Sb-122	2.72	0.3	0.3	0.00	0	0.00	0
Sb-124	60.20	0.6	0.6	0.00	0	0.00	0
Sb-125	1011.05	2.0	1.0	0.00	0	0.00	0
Sn-113	115.10	4.0	2.0	0.00	0	0.00	0
Sr-85	64.84	2.0	2.0	0.00	0	0.00	0
Tb-160	72.30	0.9	0.5	0.00	0	0.00	0
Y-91	58.50	0.6	0.6	0.00	0	0.00	0
Zr-95	64.02	2.0	0.8	0.00	0	0.00	0

223.05 429824

S.A. at time of shipment: 66.71 128541.88

Shipment Approved By:  Date: 6/6/07

Earliest Ship Date Calculator

Bag Number: GS06-0067-01 **Assay Date:** 03/28/07 **Days to ESD** 17
Mass (grams): 1818 **Earliest Ship date (ESD)** 04/14/07
carats: 9090 **Actual Ship date:** 06/11/07 **Days Decayed** 75

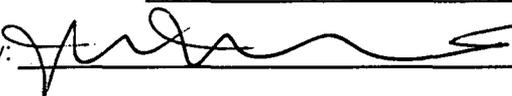
Nuclide	half-life (days)	A1 (TBq)	A2 (TBq)	Activity concentration at time of assay (Bq/g)	Total Activity at time of Assay (Bq)	Activity concentration when shipped (Bq/g)	Total Activity when shipped (Bq)
Major Radionuclides							
Na-22	949.00	0.5	0.5	0.17	308	0.16	292
Sc-46	83.85	0.5	0.5	6.31	11479	3.39	6163
Mn-54	312.50	1.0	1.0	21.94	39894	18.57	33762
Zn-65	243.80	2.0	2.0	3.35	6092	2.71	4919
Cs-134	751.90	0.7	0.7	3.51	6376	3.27	5949
Ta-182	114.50	0.9	0.5	38.13	69313	24.18	43954
P-32	14.28	0.5	0.5	1.98	3600	0.05	93
S-35	87.90	40.0	3.0	0.00	0	0.00	0

Minor Radionuclides							
As-74	17.78	1.0	0.9	0.00	0	0.00	0
Ba-133	3905.50	3.0	3.0	0.00	0	0.00	0
Ce-139	137.50	7.0	2.0	0.00	0	0.00	0
Ce-141	32.50	20.0	0.6	0.00	0	0.00	0
Co-58	70.78	1.0	1.0	0.00	0	0.00	0
Co-60	1923.55	0.4	0.4	0.00	0	0.00	0
Cr-51	27.70	30.0	30.0	0.00	0	0.00	0
Fe-59	44.50	0.9	0.9	1.14	2071	0.35	641
Hf-181	42.39	2.0	0.5	0.00	0	0.00	0
Hg-203	46.59	5.0	1.0	0.00	0	0.00	0
Ir-192	74.02	1.0	0.6	0.00	0	0.00	0
Nb-95	34.97	1.0	1.0	0.13	243	0.03	55
Pa-233	27.00	5.0	0.7	0.00	0	0.00	0
Pm-151	1.18	3.0	0.5	0.00	0	0.00	0
Rb-86	18.60	0.5	0.5	0.49	884	0.03	54
Re-183	70.00	5.0	5.0	0.00	0	0.00	0
Sb-122	2.72	0.3	0.3	0.00	0	0.00	0
Sb-124	60.20	0.6	0.6	0.00	0	0.00	0
Sb-125	1011.05	2.0	1.0	0.00	0	0.00	0
Sn-113	115.10	4.0	2.0	0.08	139	0.05	88
Sr-85	64.84	2.0	2.0	0.00	0	0.00	0
Tb-160	72.30	0.9	0.5	0.00	0	0.00	0
Y-91	58.50	0.6	0.6	0.00	0	0.00	0
Zr-95	64.02	2.0	0.8	0.00	0	0.00	0

77.23 140397

S.A. at time of shipment: 52.79

95968.39

Shipment Approved By:  6/6/07
Date

Earliest Ship Date Calculator

Bag Number: GS06-0067-02 **Assay Date:** 03/28/07 **Days to ESD** 75
Mass (grams): 1817 **Earliest Ship date (ESD)** 06/11/07
carats: 9085 **Actual Ship date:** 06/11/07 **Days Decayed** 75

Nuclide	half-life (days)	A1 (TBq)	A2 (TBq)	Activity concentration at time of assay (Bq/g)	Total Activity at time of Assay (Bq)	Activity concentration when shipped (Bq/g)	Total Activity when shipped (Bq)
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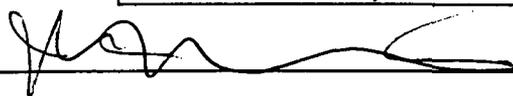
Major Radionuclides							
Na-22	949.00	0.5	0.5	0.18	333	0.17	315
Sc-46	83.85	0.5	0.5	5.98	10874	3.21	5840
Mn-54	312.50	1.0	1.0	21.03	38213	17.80	32342
Zn-65	243.80	2.0	2.0	2.42	4401	1.96	3554
Cs-134	751.90	0.7	0.7	0.00	0	0.00	0
Ta-182	114.50	0.9	0.5	59.22	107600	37.56	68248
P-32	14.28	0.5	0.5	1.68	3053	0.04	79
S-35	87.90	40.0	3.0	0.00	0	0.00	0

Minor Radionuclides							
As-74	17.78	1.0	0.9	0.00	0	0.00	0
Ba-133	3905.50	3.0	3.0	0.00	0	0.00	0
Ce-139	137.50	7.0	2.0	0.00	0	0.00	0
Ce-141	32.50	20.0	0.6	0.00	0	0.00	0
Co-58	70.78	1.0	1.0	0.00	0	0.00	0
Co-60	1923.55	0.4	0.4	0.00	0	0.00	0
Cr-51	27.70	30.0	30.0	0.00	0	0.00	0
Fe-59	44.50	0.9	0.9	1.04	1898	0.32	588
Hf-181	42.39	2.0	0.5	0.00	0	0.00	0
Hg-203	46.59	5.0	1.0	0.00	0	0.00	0
Ir-192	74.02	1.0	0.6	0.00	0	0.00	0
Nb-95	34.97	1.0	1.0	0.12	219	0.03	49
Pa-233	27.00	5.0	0.7	0.00	0	0.00	0
Pm-151	1.18	3.0	0.5	0.00	0	0.00	0
Rb-86	18.60	0.5	0.5	0.00	0	0.00	0
Re-183	70.00	5.0	5.0	0.00	0	0.00	0
Sb-122	2.72	0.3	0.3	0.00	0	0.00	0
Sb-124	60.20	0.6	0.6	0.00	0	0.00	0
Sb-125	1011.05	2.0	1.0	0.00	0	0.00	0
Sn-113	115.10	4.0	2.0	0.00	0	0.00	0
Sr-85	64.84	2.0	2.0	0.00	0	0.00	0
Tb-160	72.30	0.9	0.5	0.00	0	0.00	0
Y-91	58.50	0.6	0.6	21.46	38986	8.80	15992
Zr-95	64.02	2.0	0.8	0.00	0	0.00	0

113.14 205576

S.A. at time of shipment: 69.90 127008.10

Shipment Approved By: _____



6/6/07
Date

Earliest Ship Date Calculator

Bag Number: GS06-0067-03

Assay Date: 03/28/07

Days to ESD	28
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Mass (grams): 1817

Earliest Ship date (ESD) 04/24/07

carats: 9085

Actual Ship date: 06/11/07

Days Decayed 76

Nuclide	half-life (days)	A1 (TBq)	A2 (TBq)	Activity concentration at time of assay (Bq/g)	Total Activity at time of Assay (Bq)	Activity concentration when shipped (Bq/g)	Total Activity when shipped (Bq)
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Major Radionuclides							
Na-22	949.00	0.5	0.5	0.09	155	0.08	146
Sc-46	83.85	0.5	0.5	6.07	11026	3.25	5900
Mn-54	312.50	1.0	1.0	21.34	38766	18.04	32779
Zn-65	243.80	2.0	2.0	2.33	4230	1.88	3411
Cs-134	751.90	0.7	0.7	0.00	0	0.00	0
Ta-182	114.50	0.9	0.5	48.86	88776	30.91	56161
P-32	14.28	0.5	0.5	2.15	3907	0.05	99
S-35	87.90	40.0	3.0	0.00	0	0.00	0

Minor Radionuclides							
As-74	17.78	1.0	0.9	0.00	0	0.00	0
Ba-133	3905.50	3.0	3.0	0.00	0	0.00	0
Ce-139	137.50	7.0	2.0	0.00	0	0.00	0
Ce-141	32.50	20.0	0.6	0.21	383	0.04	76
Co-58	70.78	1.0	1.0	0.00	0	0.00	0
Co-60	1923.55	0.4	0.4	0.00	0	0.00	0
Cr-51	27.70	30.0	30.0	0.00	0	0.00	0
Fe-59	44.50	0.9	0.9	1.10	1997	0.34	615
Hf-181	42.39	2.0	0.5	0.00	0	0.00	0
Hg-203	46.59	5.0	1.0	0.00	0	0.00	0
Ir-192	74.02	1.0	0.6	0.00	0	0.00	0
Nb-95	34.97	1.0	1.0	0.08	139	0.02	31
Pa-233	27.00	5.0	0.7	0.00	0	0.00	0
Pm-151	1.18	3.0	0.5	0.00	0	0.00	0
Rb-86	18.60	0.5	0.5	0.00	0	0.00	0
Re-183	70.00	5.0	5.0	0.00	0	0.00	0
Sb-122	2.72	0.3	0.3	0.00	0	0.00	0
Sb-124	60.20	0.6	0.6	0.00	0	0.00	0
Sb-125	1011.05	2.0	1.0	0.00	0	0.00	0
Sn-113	115.10	4.0	2.0	0.00	0	0.00	0
Sr-85	64.84	2.0	2.0	0.00	0	0.00	0
Tb-160	72.30	0.9	0.5	0.00	0	0.00	0
Y-91	58.50	0.6	0.6	0.00	0	0.00	0
Zr-95	64.02	2.0	0.8	0.00	0	0.00	0

82.21 149379

S.A. at time of shipment:	54.61
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99219.46

Shipment Approved By: _____

6/6/07
Date

Earliest Ship Date Calculator

Bag Number: GS06-0067-04

Assay Date: 03/28/07

Days to ESD	30
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Mass (grams): 1815

Earliest Ship date (ESD) 04/27/07

carats: 9075

Actual Ship date: 06/11/07

Days Decayed 75

Nuclide	half-life (days)	A1 (TBq)	A2 (TBq)	Activity concentration at time of assay (Bq/g)	Total Activity at time of Assay (Bq)	Activity concentration when shipped (Bq/g)	Total Activity when shipped (Bq)
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Major Radionuclides							
Na-22	949.00	0.5	0.5	0.45	815	0.42	771
Sc-46	83.85	0.5	0.5	6.02	10925	3.23	5869
Mn-54	312.50	1.0	1.0	21.39	38831	18.11	32867
Zn-65	243.80	2.0	2.0	3.07	5581	2.48	4507
Cs-134	751.90	0.7	0.7	1.69	3060	1.57	2855
Ta-182	114.50	0.9	0.5	46.34	84113	29.40	53362
P-32	14.28	0.5	0.5	2.41	4374	0.06	114
S-35	87.90	40.0	3.0	0.00	0	0.00	0

Minor Radionuclides							
As-74	17.78	1.0	0.9	0.00	0	0.00	0
Ba-133	3905.50	3.0	3.0	0.00	0	0.00	0
Ce-139	137.50	7.0	2.0	0.00	0	0.00	0
Ce-141	32.50	20.0	0.6	0.00	0	0.00	0
Co-58	70.78	1.0	1.0	0.00	0	0.00	0
Co-60	1923.55	0.4	0.4	0.00	0	0.00	0
Cr-51	27.70	30.0	30.0	0.00	0	0.00	0
Fe-59	44.50	0.9	0.9	1.09	1983	0.34	615
Hf-181	42.39	2.0	0.5	0.00	0	0.00	0
Hg-203	46.59	5.0	1.0	0.00	0	0.00	0
Ir-192	74.02	1.0	0.6	0.00	0	0.00	0
Nb-95	34.97	1.0	1.0	0.39	713	0.09	161
Pa-233	27.00	5.0	0.7	0.00	0	0.00	0
Pm-151	1.18	3.0	0.5	0.00	0	0.00	0
Rb-86	18.60	0.5	0.5	0.00	0	0.00	0
Re-183	70.00	5.0	5.0	0.00	0	0.00	0
Sb-122	2.72	0.3	0.3	0.00	0	0.00	0
Sb-124	60.20	0.6	0.6	0.00	0	0.00	0
Sb-125	1011.05	2.0	1.0	0.00	0	0.00	0
Sn-113	115.10	4.0	2.0	0.00	0	0.00	0
Sr-85	64.84	2.0	2.0	0.00	0	0.00	0
Tb-160	72.30	0.9	0.5	0.00	0	0.00	0
Y-91	58.50	0.6	0.6	0.00	0	0.00	0
Zr-95	64.02	2.0	0.8	0.33	596	0.15	264

83.19 150989

S.A. at time of shipment:	55.86
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101384.01

Shipment Approved By:

6/6/07

Date

Program VARSKIN-MOD2

Topaz 5ct .003 cm

Spherical Source Geometry

Nuclide : Sc-46
1.8*X90 Distance : 6.804000E-02 cm
Average Beta Energy : 1.119000E-01 MeV
No gamma dose calculation
Source Strength : 5.030000E-04 uCi
Source Density : 3.550000 g/cm³
Diameter of Sphere : 8140.000000 um
Skin Depth : 7.000000 mg/cm²
Thickness of Cover : 0.000000E+00 mm
Air Gap Thickness : 3.000000E-03 mm
Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	2.45E-05
.0226	2.37E-05
.0451	1.23E-05
.0677	3.56E-06
.0903	1.35E-05
.1128	1.92E-05
.1354	2.02E-05
.1580	1.94E-05
.1805	1.80E-05
.2031	1.69E-05
.2257	1.57E-05
.2482	1.44E-05
.2708	1.33E-05
.2934	1.25E-05
.3159	1.17E-05
.3385	1.08E-05
.3611	9.99E-06
.3836	9.24E-06
.4062	8.57E-06
.4288	7.94E-06
.4514	7.29E-06
.4739	6.74E-06
.4965	6.24E-06
.5191	5.78E-06
.5416	5.34E-06
.5642	5.03E-06

The area of irradiation is larger than 1.0000 square cm

The beta dose rate averaged over 1.0000 square cm = 9.88E-06 rad/hr

Topaz 5ct 003 cm.OUT

The total beta dose averaged over 1.0000 square cm = 9.88E-06 rad

Program VARSKIN-MOD2

Spherical Source Geometry

Nuclide : P-32

1.8*X90 Distance : 6.395400E-01 cm

Average Beta Energy : 6.952000E-01 MeV

No gamma dose calculation

Source Strength : 2.120000E-04 uCi

Source Density : 3.550000 g/cm³

Diameter of Sphere : 8140.000000 um

Skin Depth : 7.000000 mg/cm²

Thickness of Cover : 0.000000E+00 mm

Air Gap Thickness : 3.000000E-03 mm

Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	1.21E-04
.0226	1.20E-04
.0451	1.17E-04
.0677	1.13E-04
.0903	1.07E-04
.1128	1.00E-04
.1354	9.60E-05
.1580	9.03E-05
.1805	8.47E-05
.2031	7.94E-05
.2257	7.42E-05
.2482	6.95E-05
.2708	6.46E-05
.2934	6.01E-05
.3159	5.60E-05
.3385	5.23E-05
.3611	4.88E-05
.3836	4.56E-05
.4062	4.26E-05
.4288	3.99E-05
.4514	3.73E-05
.4739	3.51E-05
.4965	3.29E-05
.5191	3.08E-05
.5416	2.90E-05
.5642	2.73E-05

The area of irradiation is larger than 1.0000 square cm

Topaz 5ct 003 cm.OUT

The beta dose rate averaged over 1.0000 square cm = 5.07E-05 rad/hr
The total beta dose averaged over 1.0000 square cm = 5.07E-05 rad

Program VARSKIN-MOD2

Spherical Source Geometry

Nuclide : Zn-65
1.8*X90 Distance : 5.958000E-02 cm
Average Beta Energy : 1.430000E-01 MeV
No gamma dose calculation
Source Strength : 9.100000E-05 uCi
Source Density : 3.550000 g/cm³
Diameter of Sphere : 8140.000000 um
Skin Depth : 7.000000 mg/cm²
Thickness of Cover : 0.000000E+00 mm
Air Gap Thickness : 3.000000E-03 mm
Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	1.02E-09
.0226	9.68E-10
.0451	3.90E-10
.0677	1.23E-10
.0903	5.38E-10
.1128	8.11E-10
.1354	8.54E-10
.1580	8.19E-10
.1805	7.68E-10
.2031	7.16E-10
.2257	6.59E-10
.2482	6.05E-10
.2708	5.63E-10
.2934	5.30E-10
.3159	4.93E-10
.3385	4.57E-10
.3611	4.22E-10
.3836	3.89E-10
.4062	3.59E-10
.4288	3.31E-10
.4514	3.06E-10
.4739	2.82E-10
.4965	2.59E-10
.5191	2.40E-10
.5416	2.24E-10
.5642	2.06E-10

The area of irradiation is larger than 1.0000 square cm

Topaz 5ct 003 cm.OUT

The beta dose rate averaged over 1.0000 square cm = 4.14E-10 rad/hr
The total beta dose averaged over 1.0000 square cm = 4.14E-10 rad

Program VARSKIN-MOD2

Spherical Source Geometry

Nuclide : Cs-134
1.8*X90 Distance : 1.663200E-01 cm
Average Beta Energy : 1.477000E-01 MeV
No gamma dose calculation
Source Strength : 3.700000E-05 uCi
Source Density : 3.550000 g/cm³
Diameter of Sphere : 8140.000000 um
Skin Depth : 7.000000 mg/cm²
Thickness of Cover : 0.000000E+00 mm
Air Gap Thickness : 3.000000E-03 mm
Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	3.77E-06
.0226	3.74E-06
.0451	3.63E-06
.0677	2.97E-06
.0903	2.87E-06
.1128	3.07E-06
.1354	3.00E-06
.1580	2.84E-06
.1805	2.64E-06
.2031	2.47E-06
.2257	2.32E-06
.2482	2.14E-06
.2708	1.98E-06
.2934	1.86E-06
.3159	1.73E-06
.3385	1.61E-06
.3611	1.50E-06
.3836	1.39E-06
.4062	1.30E-06
.4288	1.21E-06
.4514	1.13E-06
.4739	1.05E-06
.4965	9.82E-07
.5191	9.16E-07
.5416	8.56E-07
.5642	8.05E-07

Topaz 5ct 003 cm.OUT

The area of irradiation is larger than 1.0000 square cm

The beta dose rate averaged over 1.0000 square cm = 1.54E-06 rad/hr

The total beta dose averaged over 1.0000 square cm = 1.54E-06 rad

Program VARSKIN-MOD2

Spherical Source Geometry

Nuclide : Ta-182

1.8*X90 Distance : 1.047600E-01 cm

Average Beta Energy : 1.245000E-01 MeV

No gamma dose calculation

Source Strength : 1.159000E-03 uCi

Source Density : 3.550000 g/cm³

Diameter of Sphere : 8140.000000 um

Skin Depth : 7.000000 mg/cm²

Thickness of Cover : 0.000000E+00 mm

Air Gap Thickness : 3.000000E-03 mm

Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	7.15E-05
.0226	7.04E-05
.0451	5.88E-05
.0677	3.39E-05
.0903	4.87E-05
.1128	5.65E-05
.1354	5.78E-05
.1580	5.48E-05
.1805	5.13E-05
.2031	4.79E-05
.2257	4.48E-05
.2482	4.13E-05
.2708	3.81E-05
.2934	3.56E-05
.3159	3.32E-05
.3385	3.11E-05
.3611	2.86E-05
.3836	2.66E-05
.4062	2.46E-05
.4288	2.29E-05
.4514	2.12E-05
.4739	1.97E-05
.4965	1.83E-05
.5191	1.70E-05
.5416	1.58E-05
.5642	1.47E-05

Topaz 5ct 003 cm.OUT

The area of irradiation is larger than 1.0000 square cm

The beta dose rate averaged over 1.0000 square cm = $2.90E-05$ rad/hr

The total beta dose averaged over 1.0000 square cm = $2.90E-05$ rad

Irradiation time = $6.0E+01$ min

The beta dose rate for the 5 radionuclides, averaged over
1 square cm, = $9.11E-05$ rad/hr

The total beta dose for the 5 radionuclides, averaged over
1 square cm, = $9.11E-05$ rad

Topaz 5ct 4cm.OUT

Program VARSKIN-MOD2

5ct 4cm Topaz

Spherical Source Geometry

Nuclide : Sc-46
1.8*X90 Distance : 6.804000E-02 cm
Average Beta Energy : 1.119000E-01 MeV
No gamma dose calculation
Source Strength : 5.030000E-04 μ Ci
Source Density : 3.550000 g/cm³
Diameter of Sphere : 8140.000000 μ m
Skin Depth : 7.000000 mg/cm²
Thickness of Cover : 0.000000E+00 mm
Air Gap Thickness : 40.000000 mm
Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	1.36E-07
.0226	1.36E-07
.0451	1.35E-07
.0677	1.35E-07
.0903	1.35E-07
.1128	1.35E-07
.1354	1.35E-07
.1580	1.36E-07
.1805	1.36E-07
.2031	1.36E-07
.2257	1.36E-07
.2482	1.36E-07
.2708	1.36E-07
.2934	1.36E-07
.3159	1.36E-07
.3385	1.35E-07
.3611	1.35E-07
.3836	1.36E-07
.4062	1.36E-07
.4288	1.36E-07
.4514	1.35E-07
.4739	1.34E-07
.4965	1.34E-07
.5191	1.34E-07
.5416	1.34E-07
.5642	1.33E-07

The area of irradiation is larger than 1.0000 square cm

The beta dose rate averaged over 1.0000 square cm = 1.34E-07 rad/hr

Topaz 5ct 4cm.OUT

The total beta dose averaged over 1.0000 square cm = 1.34E-07 rad

Program VARSKIN-MOD2

Spherical Source Geometry

Nuclide : P-32

1.8*X90 Distance : 6.395400E-01 cm

Average Beta Energy : 6.952000E-01 MeV

No gamma dose calculation

Source Strength : 2.120000E-04 uCi

Source Density : 3.550000 g/cm³

Diameter of Sphere : 8140.000000 um

Skin Depth : 7.000000 mg/cm²

Thickness of Cover : 0.000000E+00 mm

Air Gap Thickness : 40.000000 mm

Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	6.43E-07
.0226	6.43E-07
.0451	6.43E-07
.0677	6.46E-07
.0903	6.47E-07
.1128	6.47E-07
.1354	6.47E-07
.1580	6.46E-07
.1805	6.45E-07
.2031	6.45E-07
.2257	6.45E-07
.2482	6.44E-07
.2708	6.45E-07
.2934	6.44E-07
.3159	6.43E-07
.3385	6.42E-07
.3611	6.41E-07
.3836	6.40E-07
.4062	6.38E-07
.4288	6.38E-07
.4514	6.37E-07
.4739	6.36E-07
.4965	6.36E-07
.5191	6.35E-07
.5416	6.35E-07
.5642	6.34E-07

The area of irradiation is larger than 1.0000 square cm

Topaz 5ct 4cm.OUT

The beta dose rate averaged over 1.0000 square cm = 6.36E-07 rad/hr
The total beta dose averaged over 1.0000 square cm = 6.36E-07 rad

Program VARSKIN-MOD2

Spherical Source Geometry

Nuclide : Zn-65
1.8*X90 Distance : 5.958000E-02 cm
Average Beta Energy : 1.430000E-01 MeV
No gamma dose calculation
Source Strength : 9.100000E-05 uCi
Source Density : 3.550000 g/cm³
Diameter of Sphere : 8140.000000 um
Skin Depth : 7.000000 mg/cm²
Thickness of Cover : 0.000000E+00 mm
Air Gap Thickness : 40.000000 mm
Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	5.67E-12
.0226	5.73E-12
.0451	5.72E-12
.0677	5.72E-12
.0903	5.72E-12
.1128	5.72E-12
.1354	5.72E-12
.1580	5.72E-12
.1805	5.71E-12
.2031	5.71E-12
.2257	5.68E-12
.2482	5.68E-12
.2708	5.67E-12
.2934	5.66E-12
.3159	5.65E-12
.3385	5.65E-12
.3611	5.64E-12
.3836	5.63E-12
.4062	5.63E-12
.4288	5.62E-12
.4514	5.61E-12
.4739	5.61E-12
.4965	5.60E-12
.5191	5.57E-12
.5416	5.56E-12
.5642	5.55E-12

The area of irradiation is larger than 1.0000 square cm

Topaz 5ct 4cm.OUT

The beta dose rate averaged over 1.0000 square cm = 5.60E-12 rad/hr
The total beta dose averaged over 1.0000 square cm = 5.60E-12 rad

Program VARSKIN-MOD2

Spherical Source Geometry

Nuclide : Cs-134
1.8*X90 Distance : 1.663200E-01 cm
Average Beta Energy : 1.477000E-01 MeV
No gamma dose calculation
Source Strength : 3.700000E-05 uCi
Source Density : 3.550000 g/cm³
Diameter of Sphere : 8140.000000 um
Skin Depth : 7.000000 mg/cm²
Thickness of Cover : 0.000000E+00 mm
Air Gap Thickness : 40.000000 mm
Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	2.09E-08
.0226	2.09E-08
.0451	2.09E-08
.0677	2.09E-08
.0903	2.08E-08
.1128	2.08E-08
.1354	2.07E-08
.1580	2.06E-08
.1805	2.06E-08
.2031	2.06E-08
.2257	2.05E-08
.2482	2.05E-08
.2708	2.05E-08
.2934	2.05E-08
.3159	2.05E-08
.3385	2.04E-08
.3611	2.03E-08
.3836	2.03E-08
.4062	2.02E-08
.4288	2.02E-08
.4514	2.02E-08
.4739	2.02E-08
.4965	2.02E-08
.5191	2.02E-08
.5416	2.02E-08
.5642	2.01E-08

Topaz 5ct 4cm.OUT

The area of irradiation is larger than 1.0000 square cm

The beta dose rate averaged over 1.0000 square cm = 2.02E-08 rad/hr

The total beta dose averaged over 1.0000 square cm = 2.02E-08 rad

Program VARSKIN-MOD2

Spherical Source Geometry

Nuclide : Ta-182

1.8*X90 Distance : 1.047600E-01 cm

Average Beta Energy : 1.245000E-01 MeV

No gamma dose calculation

Source Strength : 1.159000E-03 uCi

Source Density : 3.550000 g/cm³

Diameter of Sphere : 8140.000000 um

Skin Depth : 7.000000 mg/cm²

Thickness of Cover : 0.000000E+00 mm

Air Gap Thickness : 40.000000 mm

Irradiation Time : 60.000000 min

Calculated Results:

Radial Distance (cm)	Dose Rate (rad/hr)
.0000	3.89E-07
.0226	3.93E-07
.0451	3.94E-07
.0677	3.89E-07
.0903	3.89E-07
.1128	3.93E-07
.1354	3.89E-07
.1580	3.93E-07
.1805	3.92E-07
.2031	3.92E-07
.2257	3.92E-07
.2482	3.91E-07
.2708	3.91E-07
.2934	3.90E-07
.3159	3.90E-07
.3385	3.89E-07
.3611	3.89E-07
.3836	3.88E-07
.4062	3.88E-07
.4288	3.87E-07
.4514	3.87E-07
.4739	3.86E-07
.4965	3.85E-07
.5191	3.85E-07
.5416	3.84E-07
.5642	3.83E-07

Topaz 5ct 4cm.OUT

The area of irradiation is larger than 1.0000 square cm

The beta dose rate averaged over 1.0000 square cm = $3.85E-07$ rad/hr

The total beta dose averaged over 1.0000 square cm = $3.85E-07$ rad

Irradiation time = $6.0E+01$ min

The beta dose rate for the 5 radionuclides, averaged over
1 square cm, = $1.18E-06$ rad/hr

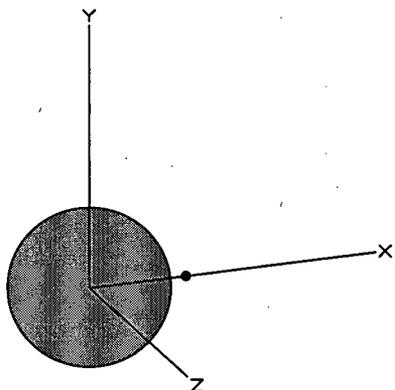
The total beta dose for the 5 radionuclides, averaged over
1 square cm, = $1.18E-06$ rad

MicroShield v6.10 (6.10-0033)
International Isotopes Inc.

Page : 1
 DOS File : topaz_2nCiperg.ms6
 Run Date: July 6, 2007
 Run Time: 1:37:08 PM
 Duration : 00:00:00

File Ref: _____
 Date: _____
 By: _____
 Checked: _____

Case Title: 5 Ct topaz @ 0.1 cm
Description: 2 nCi/g at max concentrations observed
Geometry: 6 - Sphere



	Radius	Source Dimensions	0.407 cm	0.2 in
		Dose Points		
# 1	X	Y	Z	
	0.507 cm	0 cm	0 cm	
	0.2 in	0.0 in	0.0 in	
		Shields		
	Shield Name	Dimension	Material	Density
	Source	.282 cm ³	Topaz	3.55
	Transition		Air	0.00122
	Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>µCi/cm³</u>	<u>Bq/cm³</u>
Cs-134	2.1400e-011	7.9180e-001	7.5778e-005	2.8038e+000
Mn-54	8.1900e-010	3.0303e+001	2.9001e-003	1.0730e+002
Sc-46	2.8800e-010	1.0656e+001	1.0198e-003	3.7733e+001
Ta-182	8.1900e-010	3.0303e+001	2.9001e-003	1.0730e+002
Zn-65	5.2100e-010	1.9277e+001	1.8449e-003	6.8260e+001

Buildup
The material reference is : Source

Integration Parameters	
Rho (Radial)	10
Angle	10

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>		<u>Exposure Rate</u>	
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	2.293e+01	1.549e-02	1.650e-02	1.328e-03	1.415e-03
0.03	2.477e-01	1.507e-03	1.957e-03	1.493e-05	1.939e-05
0.04	7.538e-02	7.795e-04	1.052e-03	3.448e-06	4.654e-06
0.06	2.466e+01	4.389e-01	6.092e-01	8.717e-04	1.210e-03
0.08	8.294e-01	2.046e-02	2.716e-02	3.237e-05	4.298e-05
0.1	4.973e+00	1.560e-01	1.998e-01	2.387e-04	3.057e-04
0.15	2.999e+00	1.442e-01	1.749e-01	2.375e-04	2.880e-04
0.2	4.816e+00	3.126e-01	3.651e-01	5.518e-04	6.444e-04
0.3	1.103e+00	1.092e-01	1.228e-01	2.072e-04	2.329e-04
0.5	5.571e-01	9.371e-02	1.017e-01	1.839e-04	1.996e-04
0.6	9.625e-01	1.956e-01	2.100e-01	3.817e-04	4.099e-04
0.8	4.170e+01	1.141e+01	1.208e+01	2.170e-02	2.298e-02
1.0	4.931e+01	1.699e+01	1.784e+01	3.131e-02	3.289e-02
1.5	1.228e+00	6.419e-01	6.653e-01	1.080e-03	1.119e-03

Page : 2
DOS File : topaz_2nCiperg.ms6
Run Date: July 6, 2007
Run Time: 1:37:08 PM
Duration : 00:00:00

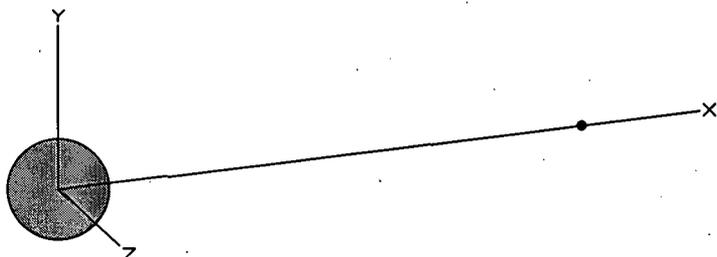
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
2.0	1.279e-06	8.980e-07	9.244e-07	1.389e-09	1.429e-09
TOTALS:	1.564e+02	3.052e+01	3.242e+01	5.814e-02	6.176e-02

MicroShield v6.10 (6.10-0033)
International Isotopes Inc.

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 DOS File : topaz_2nCiperg.ms6
 Run Date: July 6, 2007
 Run Time: 1:30:42 PM
 Duration : 00:00:00

File Ref: _____
 Date: _____
 By: _____
 Checked: _____

Case Title: 5 Ct topaz @ 4 cm
Description: 2 nCi/g at max concentrations observed
Geometry: 6 - Sphere



Source Dimensions
 Radius 0.407 cm 0.2 in

Dose Points

#	X	Y	Z
# 1	4.407 cm 1.7 in	0 cm 0.0 in	0 cm 0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	.282 cm ³	Topaz	3.55
Transition		Air	0.00122
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	curies	becquerels	μCi/cm ³	Bq/cm ³
Cs-134	2.1400e-011	7.9180e-001	7.5778e-005	2.8038e+000
Mn-54	8.1900e-010	3.0303e+001	2.9001e-003	1.0730e+002
Sc-46	2.8800e-010	1.0656e+001	1.0198e-003	3.7733e+001
Ta-182	8.1900e-010	3.0303e+001	2.9001e-003	1.0730e+002
Zn-65	5.2100e-010	1.9277e+001	1.8449e-003	6.8260e+001

Buildup
The material reference is : Source

Integration Parameters

Rho (Radial)	10
Angle	10

Results

Energy MeV	Activity photons/sec	Fluence Rate		Exposure Rate	
		No Buildup MeV/cm ² /sec	With Buildup MeV/cm ² /sec	No Buildup mR/hr	With Buildup mR/hr
0.015	2.293e+01	1.634e-04	1.742e-04	1.401e-05	1.494e-05
0.03	2.477e-01	1.647e-05	2.153e-05	1.632e-07	2.133e-07
0.04	7.538e-02	8.593e-06	1.172e-05	3.801e-08	5.182e-08
0.06	2.466e+01	4.862e-03	6.833e-03	9.657e-06	1.357e-05
0.08	8.294e-01	2.269e-04	3.046e-04	3.591e-07	4.820e-07
0.1	4.973e+00	1.732e-03	2.240e-03	2.650e-06	3.427e-06
0.15	2.999e+00	1.602e-03	1.958e-03	2.638e-06	3.224e-06
0.2	4.816e+00	3.475e-03	4.083e-03	6.134e-06	7.206e-06
0.3	1.103e+00	1.215e-03	1.372e-03	2.304e-06	2.603e-06
0.5	5.571e-01	1.043e-03	1.135e-03	2.048e-06	2.229e-06
0.6	9.625e-01	2.177e-03	2.345e-03	4.250e-06	4.577e-06
0.8	4.170e+01	1.271e-01	1.349e-01	2.417e-04	2.565e-04
1.0	4.931e+01	1.892e-01	1.992e-01	3.488e-04	3.672e-04
1.5	1.228e+00	7.155e-03	7.426e-03	1.204e-05	1.249e-05

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
2.0	1.279e-06	1.001e-08	1.032e-08	1.548e-11	1.596e-11
TOTALS:	1.564e+02	3.400e-01	3.620e-01	6.468e-04	6.887e-04