NRC Form 374
(5-84)

U.S. NUCLEAR REGULATORY COMMISSION

MATERIALS LICENSE

Amendment No. 01

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974 (Public Law 93-438), and Title 10, Code of Federal Regulations, Chapter I, Parts 30, 31, 32, 33, 34, 35, 40 and 70, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess, and transfer byproduct, source, and special nuclear material designated below; to use such material for the purpose(s) and at the place(s) designated below; to deliver or transfer such material to persons authorized to receive it in accordance with the regulations of the applicable Part(s). This license shall be deemed to contain the conditions specified in Section 183 of the Atomic Energy Act of 1954, as amended, and is subject to all applicable rules, regulations and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

Licensee	
1. General Atomics P.O Box 85608 2. San Diego, California 92138	In accordance with letter dated March 16, 1989 3. License number 04-14395-02E is amended in its entirety to read as follows:
	4. Expiration date June 30, 1993
	5. Docket or Reference No. 030-29179

6. Byproduct, source, and/or special nuclear material	7. Chemical and/or physical form	8. Maximum amount that licensee may possess at any one time under this license
A. Any byproduct with atomic numbers between 1 - 94	A. Irradiated processed Topaz	A. No possession limit

9. Authorized use

A. In accordance with Section 32.11, 10 CFR Part 32, distribution of processed Topaz containing byproduct material to persons exempt from licensing pursuant to Section 30.14, 10 CFR Part 30 or equivalent regulations of any Agreement State.

CONDITIONS

10. Licensed material shall be distributed only at the licensee's facilities located at 10955 John Jay Hopkins Drive, San Diego, California.

11. Licensed material shall be distributed by, or under the supervision of, Dr. Junaid Razvi or Dr. William Whittemore.

12. This license does not authorize possession or use of licensed material.

13. a. The licensee shall file periodic reports as specified in Section 32.12, 10 CFR Part 32.

b. The licensee shall file a report by November 1, 1989 and a new report at intervals not to exceed 14 months, listing the names and license numbers of all gems transferred pursuant to Section 30.41 of 10 CFR Part 30.

230112 9210050337 XA 5/27/94 index date M Cooper and FOR

MATERIALS LICENSE
SUPPLEMENTARY SHEET

License number
04-14395-02E

Docket or Reference number
030-29179

Amendment No. 01

CONDITIONS

14. Only finished topaz, which do not require cutting, grinding, or polishing after irradiation are authorized for distribution to persons exempt from licensing.

15. Notwithstanding the requirements of Section 32.11(c) of 10 CFR Part 32, the licensee may use the approach described in Appendix 5.0 "Assay of Large Samples of Gemstones, Using High Resolution Semiconductors Detector" contained in their September 14, 1988 letter, to assign concentration values for isotopes not included in Schedule A, of 10 CFR 30.70, except for Na-22 which shall be 0.4 nanocurie per gram.

16. Notwithstanding the requirements of Section 32.11(c) of 10 CFR Part 32, the licensee may distribute processed topaz for the purpose of being worn by human beings.

17. Except as specifically provided otherwise in this license, the licensee shall conduct its program in accordance with the statements, representations, and procedures contained in the documents including any enclosures, listed below. The Nuclear Regulatory Commission's regulations shall govern unless the statements, representations and procedures in the licensee's application and correspondence are more restrictive than the regulations.

A. Applications dated September 9, 1988, w/enclosures.
B. Letter dated September 14, 1988.
C. Letter dated March 16, 1989.
D. Letter dated December 12, 1989, w/enclosures.
E. Letter dated January 18, 1990, w/enclosures.
F. Telefax dated January 22, 1990.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

DATE January 24, 1990

BY _____
Medical, Academic, and Commercial
Use Safety Branch
Division of Industrial and Medical
Nuclear Safety, NMSS
Washington, D. C. 20555

GENERAL ATOMICS

HPS

Log Mar. 1
Remitter
Check No. 3205624
Amount $ 120 Refunded 760
Fee Category 3I
Type of Fee AMD
Date Check Rec'd. 3/20/89
Date Completed 3/21/89
By: D. Kimbrough

March 16, 1989
315-1359

U.S. Nuclear Regulatory Commission
Medical, Academic, and Commercial Use
Safety Branch
Mail Stop OWFN-6H3
ATTN: Mr. Michael Lamastra
Washington, D.C. 20555

Subject: Docket No. 030-29179; NRC Materials License No. 04-14395-02E: Amendment to License

References:
1. Keith E. Asmussen letter GEN-1266 to U.S. NRC Medical, Academic, and Commercial Use Safety Branch, ATTN: Mr. Michael Lamastra, dated September 9, 1988.
2. Enclosure 2 to Michael A. Lamastra's letter to Keith E. Asmussen dated March 3, 1988, i.e., "Information Needed From a Domestic Reactor to Support Application for License Pursuant to 10 CFR 32.11 to Distribute Neutron-Irradiated Gems to Persons Exempt from Licensing (February 25, 1988)."

Dear Mr. Lamastra:

The subject license was issued to General Atomics (GA) in October 1988 based upon information submitted in support of GA's application dated September 9, 1988 (Reference 1). This information included responses to the requests for information stated in the NRC's staff-prepared guidance document (Reference 2). The purpose of this letter is to amend certain of those responses to reflect recent developments at GA. These developments are described below.

First, GA has acquired a two-section L-Band linear accelerator (LINAC) manufactured by Applied Radiation Corporation. This machine has been registered with the State of California and is being installed in the main accelerator building of GA's linear accelerator complex. Among its intended uses is the irradiation of gemstones. (Note: Until the recent acquisition of this accelerator, GA's linear accelerator complex had been in a shutdown condition since circa 1983.)

Second, there have been two personnel promotions and a transposition of certain of their responsibilities. Dr. William Whittemore has been promoted from physicist-in-charge of GA's TRIGA Reactors Facility to the new position of Director, Irradiation Services. Irradiation Services is a new operating unit of GA's TRIGA Group. It includes GA's TRIGA Reactors Facility plus GA's Linear Accelerator Facility. The latter facility is not yet operational, but is expected to be later this year.

10955 JOHN JAY HOPKINS DRIVE, SAN DIEGO, CA 92121-1194 P.O. BOX 85608, SAN DIEGO, CA 92138-5608 (619) 455-3000

RECD 3-21-89

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In his new position, Dr. Whittemore will continue to serve as training coordinator for the TRIGA Reactor Facility and as the associate physicist-in-charge.

Concurrent with Dr. Whittemore's promotion, Dr. Junaid Razvi was promoted from associate physicist-in-charge to manager and physicist-in-charge of GA's TRIGA Reactors Facility.

Accordingly, GA hereby requests that the information submitted in support of obtaining the subject license be amended to reflect the above changes. The specific items of information affected are listed below, along with a description of the corresponding changes. The representations are identified using the information categorization format established in the staff-prepared guidance document (Reference 2). It is noted that with the exception of items B.2.b and B.2.c., all requests for information in Reference 2 are with regard to neutron irradiation.

Item A.3. Section A, "Basic Information," Item 3, should be revised to include Dr. Junaid Razvi and to reflect Dr. Whittemore's new title and phone number. This item is thus revised to read:

> Dr. Keith E. Asmussen, Manager
> Licensing, Safety and Nuclear Compliance
> (619) 455-2823
>
> or
>
> Dr. Junaid Razvi
> Manager and Physicist-in-Charge
> General Atomics' TRIGA Reactors Facility
> (619) 455-2441 or -3277
>
> or
>
> Dr. William Whittemore
> Director, Irradiation Services
> (619) 455-3276 or -3277

Item B.2.b. Section B, "Background Information," Item 2.b, should be revised to include reference to the possible use of GA's linear accelerator in the treatment of gemstones. Thus, item B.2.b is revised to read:

> The gems will be treated at GA by one or more types of ionizing radiation, including neutrons, electrons or other electromagnetic radiation. Though the types of radiation and their sequence may vary if more than one type of irradiation is used, the typical sequence would be neutron exposure followed by accelerator treatment. All neutron irradiated topaz will be subject to the quality assurance procedures described in Part D of the license application (and other supporting documents) prior to distribution to persons exempt from licensing.

Item B.2.c. Section B, Item 2.c, should be revised to indicate that the gems will be subjected to one or more types of radiation at GA. Accordingly, item B.2.c is revised to read:

> As indicated in B.2.b, the gemstones will be subjected to one or more types of radiation at GA. If it is deemed necessary to transfer neutron irradiated material for treatment elsewhere, it will be transferred to (a) unlicensed facilities or persons only after it meets all the criteria for distribution, or (b) facilities or persons who are licensed to receive the irradiated material.

Item C.1.b. Section C, "Information Required by 10 CFR 32.11," Item 1.b, should be revised to reflect the above described promotions and transpositions of responsibilities. The first paragraph of this item is thus revised to read:

> Dr. Junaid Razvi, Manager, TRIGA Reactors Facility at General Atomics, will have direct overall responsibility for all processes starting with the handling and irradiation of gemstones and leading to their release to persons exempt from licensing under the conditions of this license. In his absence or whenever designated, Dr. William L. Whittemore, Director, Irradiation Services, at General Atomics, will have this responsibility.

Enclosed is a check in the amount of $120 for the administrative fee associated with this request.

If you should have any questions, please contact me at (619) 455-2823 or Drs. Razvi or Whittemore at (619) 455-3277.

Very truly yours,

Keith E. Asmussen

Keith E. Asmussen, Manager
Licensing, Safety and
Nuclear Compliance

KEA/mk
Enclosure: Check No. 3205624 for $120

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

APR 0 3 1989

General Atomics
ATTN: Keith E. Asmussen
P. O. Box 85608
San Diego, CA 92138-5608

REFUND OF APPLICATION FEE

1. BACKGROUND:

Check Received March 23, 1989

Application Dated March 16, 1989

Check Number 3205624

Check Amount $120

2. REFUND:

Amount $60

This refund is now being processed and will be sent as soon as possible.

3. REASON FOR REFUND:

Overpayment of amendment fee for application dated March 16, 1989 for License 04-14395-02E as specified in fee Category 3I ($60) of Section 170.31, 10 CFR 170.

/s/

Glenda Jackson 4/4/89
License Fee Management Branch
Division of Accounting and Finance
Office of the Controller

SHIPPING ORDER

FORM GA 211 (REV. 8/88)

GENERAL ATOMICS

P.O. BOX 85608 ZIP CODE 92138
10955 JOHN JAY HOPKINS DR.
SAN DIEGO, CALIFORNIA 92121

Rec'd 1-22-90.

PLEASE REFER TO THIS NUMBER IN ALL CORRESPONDENCE ETC. PERTAINING TO ANY ITEMS BELOW.

SHIPPING ORDER NO. 225525

SHIPPING ORDER PACKING LIST

HOW SHIPPED	REQUIRED ARRIVAL DATE	CUSTOMER PURCHASE ORDER NO.	DEPT. NO.	WORK ORDER NO.
COLLECT ☐ PREPAID ☒	1/19/90		176	9176 200

SHIP TO:

Ms. Cynthia Jones

U.S. Nuclear Regulatory Commission
Medical, Academic, & Commercial Use
Safety Branch

Mail Stop OWFN-6H3

Washington, DC 20555

REASON FOR SHIPMENT/F.O.B. TERMS/L/C NO.

ITEM	QUANTITY	ITEM DESCRIPTION	PROPERTY NO.	SERIAL NO.	INSURANCE VALUE
		Revised Pages to Amendment Request			
		Materials License No. 04-14 395-02E			

EST. TOTAL WEIGHT & SIZE:

SPECIAL INSTRUCTIONS FOR SHIPPING DEPT.: Via Federal Express

K. E. Asmussen — DEPT. APPROVAL (TYPE OR PRINT & SIGN)

1/18/90 — DATE

SHIPPING DEPARTMENT USE ONLY

CARRIER AND B/L NO.	DATE	NO. OF PIECES	WEIGHT	PACKING-CUBIC SIZE	ESTIMATED COST

EXPORTING CARRIER	DATE OF EXIT	PORT OF EXIT	EXPORT LICENSE	QUANTITY

REMARKS:

PACKING LIST

SHIPPED BY

RECEIVED BY

DATE

COMPANY NAME

GENERAL ATOMICS

January 18, 1990
GEN:90:1501/F315

rec'd 1-22-90

Ms. Cynthia Jones
U. S. Nuclear Regulatory Commission
Medical, Academic, and Commercial Use
Safety Branch
Mail Stop OWFN-6H3
Washington, DC 20555

SUBJECT: Docket NO. 030-29179; Materials License No. 04-14395-02E
Revised Pages to Amendment Request

REFERENCE: 1) Asmussen, Keith E., Letter No. 315-1491 to Ms. Cynthia Jones, dated December 12, 1989, Re: Request for License Amendment

Dear Ms. Jones:

Pursuant to our recent telephone discussions regarding General Atomics' (GA's) referenced request for a license amendment, enclosed are a number of pages from that application which have been revised. The enclosed pages are all marked "Revised 12/22/89" and should be used to replace the corresponding pages of the referenced amendment request which are marked "Revised 12/11/89".

Please note that an Item 5 has been added to page 44 (Appendix 1.0). Item 5 is "Procedure for Custody and Control of Unreleased Gemstones". Similarly, the text on page 34 has been revised to further clarify how control and custody of unreleased neutron irradiated gemstones will be assured.

The revisions on pages 27, 34 and 44 are identified by a ruled-line in the right-hand margin. Revised page 53 replaces a page that was inadvertently left blank in the referenced submittal. The enclosed Appendix 5 replaces in its entirety the version of this appendix that was submitted with the referenced request. The aforementioned revisions resulted in changes to the pagination of Appendix 6. Therefore, an unrevised but re-paged Appendix 6 is also enclosed.

If you have any further questions regarding the above, please contact me at (619) 455-2823 or Dr. Junaid Razvi at (619) 455-2441.

Very truly yours,

Keith E. Asmussen

Keith E. Asmussen, Manager
Licensing, Safety and
Nuclear Compliance

KEA:shs

Enclosures: as stated

10955 JOHN JAY HOPKINS DRIVE, SAN DIEGO, CA 92121-1194 P.O. BOX 85608, SAN DIEGO, CA 92138-5608 (619) 455-3000

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$$S_n = \sqrt{\frac{\Sigma_i^N (x_{avg} - x_i)^2}{(N-1)}} \quad \ldots\ldots\ldots (2)$$

The value of the true arithmetic mean X_{avg} for the parent group in the batch (Step I) will be very similar to that determined from 50 samples. An estimate to 95% confidence level of the difference $| X_{avg} - x_{avg} |$ for a single sided distribution is given as:

$$\frac{k' S_n}{\sqrt{N}} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

where values of k' are close to 2.0. Typical values of k' are given in Table 3 and are values from a one sided, standard Student t-distribution table.

If n = 10, then $S_n = S_{10}$. The standard deviation S_{ind} for the individual stones in the batch (eg. ~ 1000 grams) is then given as:

$$S_{ind} = \sqrt{10}\, S_{10} \quad \ldots\ldots\ldots\ldots (4)$$

To satisfy the release requirements, two statistical conditions must be met; one concerning the average activity for the individual stones in the whole batch, and one related to the standard deviation for the individual stones.

(a) $$x_{avg} + \frac{k' S_{ind}}{\sqrt{N}} \leq L_{max} \quad \ldots\ldots\ldots\ldots (5)$$

7. Gemstones irradiated in GA's TRIGA Reactors will be controlled as radioactive material until such time as the results of the above described QA program for their release demonstrate they meet the approved criteria for release to unrestricted use. These unreleased gemstones will be kept segregated from gemstones that have been released, and from other gemstones that were never irradiated in the TRIGA Reactors.

The control and custody of unreleased neutron irradiated gemstones will be assured by:

- Administrative controls,
- Training/instructions,

and one or more of the following types of controls:

- color coding
- sealed (tamper indicating) packages or equivalent.

Administrative control of custody will be implemented through the keeping of records of irradiated but unreleased gemstones transferred from the TRIGA Reactors Facility, e.g., their destination, date of transfer, date returned, date released, etc. Further, only appropriately personnel who are listed on the corresponding Work Authorization (WA) or Radiological Work Permit (RWP) will be authorized to handle the irradiated gemstones.

Neutron irradiated but unreleased gemstones will only be allowed to leave the TRIGA Facility for other processing or handling in sealed (or equivalent) and/or color-coded packages. All such gemstones must subsequently pass the above described QA program prior to GA releasing them to unrestricted use. All personnel at GA who are involved with the handling of these gemstones will be instructed as to the importance and necessity of maintaining absolute control of such gemstones.

APPENDIX 1.0.

List of

Standard Operating Procedures

for Topaz Irradiation and its

QA Program

Background

1. Preparation, Loading and Accountability Procedures for Gemstone Irradiations in Mark F Reactor.

2. Removal, Storage and Accountability Procedures for Irradiated Gemstones from Mark F Reactor.

3. Washing of Irradiated Gemstones.

4. Quality Assurance Program for Release of Irradiated Gemstones

   4.1 Procedure for Sorting and Prescreening of Irradiated Gemstones using NaI(Tℓ) Hole-Through Detectors.
   - o Sorting Procedures
   - o Sample Preparation Procedures
   - o Prescreening Procedures

   4.2 Procedure for Specific Activity Determination of Irradiated Gemstone Batches using High-Resolution Gamma-Ray Counting.
   - o Sampling Procedures
   - o Sample Preparation and Assay Procedures
   - o Data Analysis Procedures

   4.3 Procedure for Total Activity Measurements on Irradiated Gemstone Batches using NaI(Tℓ) Hole-Through Detectors.
   - o Sampling Procedures
   - o Counting Procedures
   - o Data Analysis Procedures

   4.4 Procedure for Final Beta Screening of Irradiated Gemstones.
   - o GM Screening Procedures
   - o Investigation Procedures for Abnormal Beta Emitters

   4.5 Procedure for Transfer of Irradiated Topaz from General Atomics Facilities.

   4.6 Measurement Control Procedure.

5. Procedure for Custody and Control of Unreleased Gemstones.

GAMMA RAY SPECTRAL ANALYSIS

PROGRAM VERSION: GAIT-100 (4-22-88) DETECTOR: GE-LI#2

SAMPLE: BACKGROUND DETECTOR #2 EMPTY CAVE

REQUESTOR'S NAME:	W. WHITTEMORE	SPECTRUM FILE:	SPEC B0000
SAMPLE GEOMETRY:	SH=0	REQUEST NUMBER:	1590
COUNT DATE:	3/30/88	START TIME:	12:40:12
GAIN (KEV/CH):	0.2550215	INTERCEPT (KEV):	-0.429
LIVE TIME (MIN):	119.683	REAL TIME (MIN):	120.000
SENSITIVITY:	4.0	TOTAL CPM:	513
CALCULATION MODE:	LD	LIBRARY SEARCH:	0
CHANNEL RANGE:	30 - 3192	# OF PEAKS FOUND:	7

PEAK INTEGRATION DATA

NUCLIDE	PEAK CHANNEL	ENERGY KEV	CPM	SIGMA %	HW KEV	TW/HW	ERROR KEV
AC-228GD<	2276.00	795.76	0.205	-1.00	2.17	0.00	0.37
CS-134 < *	2276.00	795.76	0.205	-1.00	2.17	0.00	0.00
MN-54 <	2492.00	814.31	0.199	-1.00	2.20	0.00	0.00
AC-228GD< *	2492.00	814.91	0.199	-1.00	2.20	0.00	-0.37
SC-46 <	2655.00	389.25	0.174	-1.00	2.24	0.00	0.00
ZN-65 <	3330.00	1115.52	0.166	-1.00	2.38	0.00	0.00
CO-60 <	3502.00	1172.21	0.179	-1.00	2.42	0.00	0.00
TA-182 <	3646.00	1221.38	0.159	-1.00	2.45	0.00	0.00
FE-59 <	3855.00	1291.56	0.122	-1.00	2.49	0.00	0.00

DPM COMPUTATION DATA

LIBRARY FILE: APS_LONG EFFICIENCY FILE: EFF S025

DIVISOR = 1.000000E 00 SAMPLE

DAYS DECAYED = 0.0000 3/30/ 0 12:00:00

NUCLIDE	ENERGY	HALF LIFE	MICROCI PER SAMPLE	2 SIGMA ERROR	DPM PER SAMPLE	2 SIGMA ERROR
SC-46	389.25	83.78 D	5.101E-06	-1.90E-07	1.177E 01	-2.15E-01
MN-54	814.83	312.14 D	5.403E-06	-1.99E-07	1.200E 01	-2.40E-01
FE-59	1291.56	44.55 D	1.275E-05	-2.55E-07	2.930E 01	-5.66E-01
CO-60	1172.21	5.27 Y	7.290E-06	-1.46E-07	1.618E 01	-3.24E-01
ZN-65	1115.52	243.94 D	1.267E-05	-2.52E-07	2.814E 01	-5.63E-01
CS-134	795.76	2.06 Y	6.514E-06	-1.30E-07	1.446E 01	-2.59E-01
TA-182	1221.38	114.97 D	2.481E-05	-4.96E-07	5.508E 01	-1.10E 00
AC-228GD	795.76	>9999.00 Y	1.225E-04	-2.47E-06	2.741E 02	-5.49E 00
AC-228GD	814.31	>9999.00 Y	2.127E-04	-4.25E-06	6.942E 02	-1.39E 01

APPENDIX 5.0

Assay of Large Samples of Gemstones Using High Resolution Semiconductor Detector

The Ge(Li) [or equivalent HpGe] high resolution detector used in the determination of radionuclide concentrations in irradiated gemstones is mounted on a vertical cryostat. The available detectors have gamma sensitivities ranging between 5 and 20 percent. The diameters of the outer container will vary between 2.75 inches and 3.0 inches.

The design of a holder for the assay of a large number of gemstones in Step K1 (Figure 1 of Application) (eg., ~50 1-gram stones) is based on experimental measurements made with a specially assembled source containing approximately 0.08 μCi Cs-13.7 (662 keV) and 0.13 μCi Co-60 (1173, 1333 keV). The source holder for these measurements was a small polyethylene cap with inside diameter of about 8 mm and about one-half millimeter thickness between the source and the gemstone holder. A survey was made in four quadrants and at various heights to arrive at the curvature shown in Figure 1.

The relative sensitivity as a function of position is 44% of the sensitivity for a single stone placed in the usual location used for measurements on a single stone. The value (44%) is an average at each location of the sensitivities for the gamma rays from cesium and cobalt.

A test run for 44 gemstones weighing about 50 grams was made using the large sample holder. Tables 1 and 2 present the pertinent Ge(Li) data. In addition to the routine isotope callouts (Table 1) the spectroscopist provided results of his inspection and additional calculations that also identified weak Co-60 and Zn-65 components (Table 2). The absence of additional gamma lines for Eu-154 and Se-75 allowed the spectroscopist to line out these possibilities. A summary of the results was derived by the spectroscopist from Tables 1 and 2 and is given below:

Nuclide	nCi/g	10 CFR30.70 Limits (nCi/g)	Ratios
Ta-182	50×10^{-3}	0.40	0.125
Sc-46	2.7×10^{-3}	0.40	0.0068
Mn-54	3.5×10^{-3}	1.0	0.0035
Co-60	0.7×10^{-3}	0.50	0.0014
Zn-65	1.7×10^{-3}	1.0	0.0017
Cs-134	2.3×10^{-3}	0.09	0.026
Na-22	2.7×10^{-3}	(1.0)*	0.0027

*See discussion below.

$$\Sigma = 64 \times 10^{-3} \frac{nCi}{g} \qquad \Sigma = 0.167 << 1.00$$

These data demonstrate that for this batch, the "sum of ratios" is less than unity, with a total specific activity of 0.064 nCi/g. It is also apparent that stones with this same distribution of radioactive components could have specific activity as large as 0.383 nCi/g and still satisfy the release criteria - i.e.,

$$\frac{1.00}{0.167} \times 0.064 = \underline{0.383 \text{ nCi/g}}$$

This maximum specific activity is called L_{max} as used in Equations 5 and 6 on page 27 of the Application.

The assay methodology using a large holder with approximately 50-gram samples of gemstones for the Ge(Li) count (Step K1) has improved the sensitivity of detection level for the minor radioactive components in the

stones. Simultaneously, this has increased the possibility of identifying isotopes (at these very low levels of concentrations) not previously found in assays of one-gram samples. Furthermore, this increases the likelihood of finding an occasional isotope not included in Schedule A of 10CFR30.70. The "catchall" level of 10^{-6} μCi/gram is considered inappropriate for this application because it is arbitrarily small. Consider the case of Na-22 which is an isotope not listed in Schedule A and found at a level of 2.7 picocurie/gram in the reported data. In the following we illustrate a suitable approach for handling this and similar cases that may arise in the future.

In the particular case of Na-22, it is omitted from Schedule A even though it can be produced by nuclear reactors. This is well known to workers experienced with sodium cooled reactors. Its threshold for (n, 2n) production is about 12.5 Mev with the cross section as a function of neutron energy given in BNL-325 (1). The fraction of all fast neutrons from a reactor fueled with U-235 above about 13 Mev is 1.103×10^{-4} (2). Since the fast flux at the location of the gemstone irradiation is about 10^{12} nv, the portion of this fast flux suitable for tnis (n, 2n) reaction is about

$$\phi \ (E > 13 \text{ Mev}) = 1.1 \times 10^{8} \text{ nv.}$$

An activation of 2.7×10^{-3} nCi/grams corresponds to an activation of ~ 5.0 dps for the 50 gram sample of stones:

$$\text{Act} = (N\sigma)\ \phi \left[1-e^{0.693t/T_{1/2}}\right] \quad \ldots\ldots\ldots\ldots \quad (1)$$

where Act = activation of Na-23 to produce Na-22,
$(N\sigma)$ is the number of atoms of Na-23 in the 50 gram sample of stones, and σ is the effective (n, 2n) cross section,

σ = 1.1×10^{8} nv, and

t = 4 weeks or 0.077 yr.

$T_{1/2}$ = 2.6 yr.

From equation (1) we see that

$$(N\sigma) = 2.24 \times 10^{-6} \text{ cm}^{-2}.$$

If the average cross section above 12.5 Mev were as small as 1 millibarn, then $N = 2.24 \times 10^{21}$ atoms of Na-23 (~ 90 milligrams). A more reasonable average cross section might be as large as 10 millibarns, for which the mass of Na-23 would be only 9 milligrams. To find such a small admixture of Na-23 (9-90 milligrams) in a 50 gram sample of stones cannot be considered unreasonable, although it is unusual from all past experience.

The question now arises on how to arrive at a reasonable 10CFR30.70 limit for the Na-22 isotope. As demonstrated above, Na-22 can be produced by reactors from Na-23 and therefore, should be listed in Schedule A. To arrive at a suitable limit for this application, we have compared its gamma and beta radiation with other isotopes present and which may have similar half lives and/or emissions. These are compared in the following listing:

Isotope	$T_{1/2}$	γ Energies (keV)	β_{max} (Mev)	30.70 Limits nCi/g
Ta-182	0.32 yr	59, 67, 1121 1189, 1221	0.522	0.40
Sb-125	2.8 yr	176, 428, 601, 636	0.612	1.0
Zn-65	243.8d	1116	β^+ 0.325	1.0
Sc-46	83.3d	889, 1120	0.357	0.4
Na-22	2.6 yr	511, 1275	β^+ 0.545	----

For the case of Na-22 we first note that it cannot be ingested or inhaled because it resides within the completely insoluble topaz crystal. Next, we note from the above listing that on the basis of half life, Na-22 most nearly matches Sb-125 with a release limit of 1.0. We also note that the 1275 keV line of Na-22 matches the 1116 keV line of Zn-65 which also has a release limit of 1.0. Further, the range for positrons with E_{max} of 545 keV that are emitted by Na-22 is very much the same as the betas from the far more prevalent isotope, Ta-182, as well as Sb-125. In other words, even the smallest stones are infinitely thick for the Na-22 positrons. Because of the similarities in the half lives and emitted radiations between Na-22 and Sb-125, we believe a reasonable release limit for this minor component can be taken as that for Sb-125, i.e., 1.0 nCi/g.

References:

1. Neutron Cross Sections, BNL-325, Vol. 1, Suppl. 2, Second Edition (May, 1964).
2. H. Etherington, Ed., Nuclear Engineering Handbook, First Edition (1958), p. 7-91.

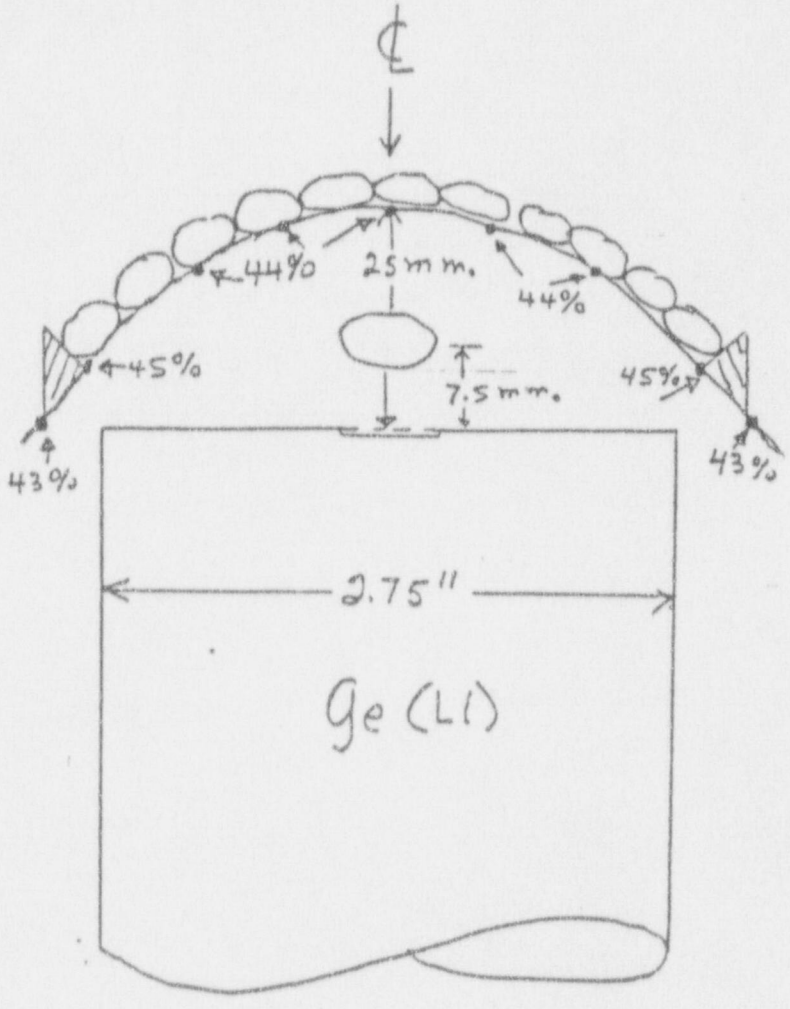

Fig. 1. Sketch roughly to scale showing dome shaped holder. This surface of revolution accommodates about 50 1 gram stones. For this holder the detector has about 44% of the sensitivity for a single stone placed at the usual (7.5 mm) position. Measured sensitivies are shown.

TABLE 1

GAMMA RAY SPECTRAL ANALYSIS

PROGRAM VERSION: GAIT-109 (4-22-88) DETECTOR: GE(LI)#2

SAMPLE: TRIGA STONES IN PLASTIC HOLDER

REQUESTOR'S NAME:	M. WHITTEMORE	SPECTRUM FILE:	SPEC.B4091
SAMPLE GEOMETRY:	STONE HOLDER	REQUEST NUMBER:	1590
COUNT DATE:	9/ 8/88	START TIME:	8:41:14
GAIN (KEV/CH):	0.3348937	INTERCEPT (KEV):	-0.646
LIVE TIME (MIN):	119.867	REAL TIME (MIN):	120.000
SENSITIVITY:	3.5	TOTAL CPM:	1068.
CALCULATION MODE:	AI	LIBRARY SEARCH:	4
CHANNEL RANGE:	90 - 3192	# OF PEAKS FOUND:	22

PEAK INTEGRATION DATA

NUCLIDE		PEAK CHANNEL	ENERGY KEV	CPM	SIGMA %	HM KEV	TW/HM	ERROR KEV
TA-182		177.44	58.78	7.329	9.98	2.87	1.83	-0.52
TA-182		203.22	67.44	27.779	3.84	1.68	2.25	-0.14
TA-182		257.98	84.19	2.841	18.72	1.76	1.96	-0.16
TA-182		299.98	98.01	15.642	5.18	1.81	1.78	-0.26
TA-182		340.41	112.16	4.528	24.16	1.87	1.93	-0.24
TA-182		456.71	152.10	9.015	6.86	1.82	1.79	-0.17
TA-182		468.78	156.05	4.665	12.44	1.86	1.78	-0.32
TA-182		537.13	179.24	4.177	13.86	1.72	2.25	-0.15
TA-182		591.83	198.16	2.549	19.66	2.22	1.78	-0.19
SC-46	*	593.62	198.16	2.549	19.66	2.22	1.78	-0.44
TA-182		664.76	221.98	7.612	7.12	1.67	1.86	-0.12
TA-182		684.74	229.14	1.284	17.66	1.81	1.75	0.02
TA-182		790.46	264.07	2.363	13.26	1.78	1.37	0.00
SC-46	*	790.46	264.07	2.361	13.26	1.78	1.37	-0.58
B-511		1527.38	511.03	7.419	3.39	2.22	1.39	0.03
CS-134		1807.72	604.75	1.747	16.16	1.78	1.96	0.09
CS-134		2377.38	795.52	1.542	13.75	2.51	1.61	-0.24
MN-54		2495.37	835.04	2.269	16.38	2.48	1.72	0.21
SC-46		2657.18	889.28	1.567	15.88	2.26	1.77	-0.05
SC-46		3149.97	1121.24	8.866	4.72	2.16	1.91	0.72
TA-182	*	3149.97	1121.24	8.866	4.72	2.16	1.91	-0.03
TA-182		3382.76	1189.15	1.579	6.22	2.52	2.15	0.12
TA-182		1648.94	1221.39	5.946	4.58	2.24	2.01	-0.02
TA-182		1679.57	1231.29	2.168	9.41	2.43	1.64	0.20
NA-22		1838.22	1274.74	1.269	14.72	2.62	1.49	0.19
NA-22	*	2308.22	1274.74	1.268	14.72	2.62	1.49	0.05
BKG		4165.25	1461.25	1.014	6.12	2.44	1.34	0.00

DPM COMPUTATION DATA

LIBRARY FILE: APS.LONG EFFICIENCY FILE: EFF.STONES

DIVISOR = 5.000000E 01 GRAM

DAYS DECAYED = 15.3620 8/22/88 12:00:00

NUCLIDE	ENERGY	HALF LIFE	MICROCI PER GRAM	2 SIGMA ERROR	DPM PER GRAM	2 SIGMA ERROR
B-511	511.03	>9999.00 Y	6.339E-06	8.19E-07	1.519E 01	1.82E 00
NA-22	1274.74	2.60 Y	2.679E-06	6.20E-07	5.947E 00	1.40E 00
SC-46	889.28	83.78 D	2.677E-06	8.51E-07	5.943E 00	1.89E 00
SC-46	1121.24	83.78 D	1.947E-05	1.94E-06	4.322E 01	4.09E 00
MN-54	835.04	312.14 D	3.479E-06	7.64E-07	7.724E 00	1.70E 00
TA-182	198.16	113.42 D	7.418E-05	2.92E-05	1.647E 02	6.40E 01
TA-182	264.07	113.42 D	2.677E-06	7.15E-07	5.943E 00	1.59E 00
CS-134	604.75	2.06 Y	1.953E-06	6.36E-07	4.362E 00	1.41E 00
CS-134	795.52	2.06 Y	2.568E-06	7.06E-07	5.701E 00	1.57E 00
B-511	1274.74	8.50 Y	7.481E-06	1.76E-06	1.661E 01	2.90E 00
TA-182	58.78	114.97 D	4.554E-05	9.06E-06	1.011E 02	2.01E 01
TA-182	67.41	114.97 D	2.782E-05	2.85E-06	9.293E 01	5.89E 00
TA-182	84.68	114.97 D	4.272E-05	1.68E-05	9.484E 01	3.55E 01
TA-182	99.01	114.97 D	3.716E-05	2.85E-06	8.248E 01	8.55E 00
TA-182	112.36	114.97 D	2.527E-05	1.57E-05	5.610E 01	3.50E 01
TA-182	152.10	114.97 D	4.257E-05	5.67E-06	9.451E 01	1.26E 01
TA-182	156.05	114.97 D	3.347E-05	1.23E-05	7.431E 01	2.74E 01
TA-182	179.24	114.97 D	5.212E-05	1.41E-05	1.157E 02	3.14E 01
TA-182	198.16	114.97 D	6.351E-05	2.69E-05	1.521E 02	5.99E 01
TA-182	221.98	114.97 D	4.634E-05	6.79E-06	1.029E 02	1.51E 01
TA-182	229.14	114.97 D	4.411E-05	1.15E-05	9.791E 01	2.56E 01
TA-182	264.07	114.97 D	4.257E-05	1.14E-05	9.450E 01	2.53E 01
TA-182	1121.24	114.97 D	5.295E-05	7.09E-06	1.175E 02	1.13E 01
TA-182	1189.15	114.97 D	5.065E-05	6.10E-06	1.124E 02	1.40E 01
TA-182	1221.26	114.97 D	4.395E-05	4.53E-06	1.109E 02	9.99E 00
TA-182	1231.29	114.97 D	4.179E-05	4.20E-06	9.721E 01	1.33E 01

TABLE 2

PEAK INTEGRATION DATA

NUCLIDE	PEAK CHANNEL	ENERGY KEV	CPM	SIGMA %	HM KEV	TW/HM	ERROR KEV
ZN-65	2212.00	1115.22	0.438	17.46	1.47	1.35	-0.30
CO-60	2505.00	1173.16	0.358	20.62	0.33	10.00	-0.05
CO-60	2999.00	1332.23	0.267	22.75	0.65	3.05	-0.24

DPM COMPUTATION DATA

LIBRARY FILE: APS.LONG EFFICIENCY FILE: EFF.STONES
DIVISOR = 5.060000E 01 GRAM
DAYS DECAYED = 15.8E20 8/22/88 12:00:00

NUCLIDE	ENERGY	HALF LIFE	MICROCI PER GRAM	2 SIGMA ERROR	DPM PER GRAM	2 SIGMA ERROR
CO-60	1173.16	5.27 Y	7.139E-07	2.94E-07	1.585E 00	6.54E-01
CO-60	1332.23	5.27 Y	6.13sE-07	2.79E-07	1.362E 00	6.20E-01
ZN-65	1115.22	243.94 D	1.744E-0F	6.09E-07	3.871E 00	1.35E 00

4. Possess requisite skill and experience to be able to combine the QA assay program with the standard Health Physics Department Procedures for release/transfer of low levels of radioactive materials.

Training and experience required:

In addition to Company requirements for a Health Physics Technician*, this person must be able to operate, calibrate, use and prescribe maintenance as required for all specialized NaI(Tl) and G-M probes used for the reference QA program. This person must have ability to communicate effectively with all levels of personnel involved with the prescreening and QA assay program.

- Ge(Li) Assay (Steps K1, L1, M).

Normally performed by a scientist or engineer with professional experience in solid state radiation detectors. Direct experience with Ge(Li) and/or HpGe detectors and with the associated analysis equipment for isotopic callouts is required:

1. B.S. in subject area or equivalent education; or relevant work experience spanning several years (e.g., three to five).

2. A knowledge of computer programming and usage is highly desirable.

3. Ability to apply basic knowledge, adapt standard techniques, and utilize instruments, tools, and equipment normally associated with the specialized field of precision isotopic analysis is required.

4. Must be able to analyze results of Ge(Li) assay and recognize abnormal results when present.

5. Prepares reports and make alternative recommendations when the output results suggest the presence of deviate results.

*General Atomics Health Physics Technician qualifications include a high school diploma or equivalent, and a minimum of two years applicable work experience and/or training related to nuclear activities, including at least three (3) weeks of specific on-the-job training.

APPENDIX 6.0

Minimum Qualifications for
Personnel in QA Program

- Prescreening with NaI(Tl) (Step H).

  - Normally performed by Technician Level Personnel under limited supervision. The following are typical of the tasks this person would perform:

    1. Performs daily control measurements on counting equipment on days when QA assays are made and maintains control charts;

    2. Notifies management immediately when performance of counting system is outside the established control limits;

    3. Collects process QA counting data, reduces data and performs simple algebraic computations, prepares reports using QA forms.

    Training or Experience Required:

    Ability to read and understand detailed instructions; to write legibly and record precise information and perform simple algebraic computations.

    Training or experience in experimental operations such as normally acquired in military or technical schools, or equivalent on-the-job experience.

- Final QA Assay with NaI(Tl) (Steps K2, L2, I1) and with G-M Probe (Step N).

  - Normally performed by Health Physics Technician. Under general supervision following written or verbal instructions, performs most tasks on own cognizance. In addition to other duties as Health Physics Technician, this person will perform the tasks associated with using calibrated NaI(Tl) detectors and G-M probe to assure compliance with 10CFR30.70 release criteria. Typical tasks are:

    1. Performs daily control measurements on counting equipment on days when QA assays are to be made; in addition, performs instrument calibration.

    2. Maintains control charts and recognizes when measurements are out of control. Obtains technical assistance or makes adjustments on own cognizance to reestablish control.

    3. Analyzes the process data to calculate averages and standard deviations; compares batch test results against 10CFR30.70 limits (Step I1). Prepares summary reports.

R1201020 LICENSING TRACKING SYSTEM DATE: 03/22/89
PAGE: 1

LTS WORKSHEET

DOCKET NO : 03029179 LICENSE NO : 04-14395-02E STATUS: 0

MAIL CONTROL: 020781 RECEIPT DATE : 890321 ACTION TYPE: 4

FED. GOVT : N INST. CODE : 14395 LICENSE REGION: 0

ISSUE DATE: 881014 ORIGINAL DATE: 881014 EXPIRATION DATE: 19931031

NAME : GENERAL ATOMICS

DEPT/BUREAU: _____

BUILDING : _____

STREET : P. O. BOX 85608

CITY : SAN DIEGO STATE: CA ZIP: 92138

CONTACT PERSON: DR. KEITH ASMUSSEN PHONE: (619) 455-2823

PRIMARY PGM CODE : 03251 SECONDARY PGM CODES: _____

INSPECTION REGION: 5 PRIORITY CODE: 5 INSPECTION CATEGORY: E

RADIATION SAFETY OFFICER: DR. JUNAID RAZVI

STATES WHERE USE IS AUTHORIZED: 1

0 - ALL LISTED STATES
1 - SAME AS STATE IN ADDRESS
2 - ALL STATES
3 - NON-AGREEMENT STATES

AUTHORIZED STATES: _____ (USE ONLY IF ABOVE IS ZERO)

REPORTING IDENTIFICATION SYMBOL: _____

APPROVAL FOR: REDISTRIBUTION: N STORAGE ONLY: N
TEMPORARY JOB SITES: N INCINERATION: N
BURIAL: N

EXEMPTIONS: (1)_____ (2)_____

MATERIAL TYPE : ______ FORM CODE: ___ AGGREGATE CODE: ___
MODEL NUMBER : ______
DESCRIPTION : ______ NPA
TOTAL QUANTITY : ______ UNIT: ___
OTHER : _ # SOURCES: ___

MATERIAL TYPE : ______ FORM CODE: ___ AGGREGATE CODE: ___
MODEL NUMBER : ______
DESCRIPTION : ______
TOTAL QUANTITY : ______ UNIT: ___
OTHER : _ # SOURCES: ___

MATERIAL TYPE : ______ FORM CODE: ___ AGGREGATE CODE: ___
MODEL NUMBER : ______
DESCRIPTION : ______
TOTAL QUANTITY : ______ UNIT: ___
OTHER : _ # SOURCES: ___

MATERIAL TYPE : ______ FORM CODE: ___ AGGREGATE CODE: ___
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OTHER : _ # SOURCES: ___

MATERIAL TYPE : ______ FORM CODE: ___ AGGREGATE CODE: ___
MODEL NUMBER : ______
DESCRIPTION : ______
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OTHER : _ # SOURCES: ___

MATERIAL TYPE : ______ FORM CODE: ___ AGGREGATE CODE: ___
MODEL NUMBER : ______
DESCRIPTION : ______
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OTHER : _ # SOURCES: ___

MATERIAL TYPE : ______ FORM CODE: ___ AGGREGATE CODE: ___
MODEL NUMBER : ______
DESCRIPTION : ______
TOTAL QUANTITY : ______ UNIT: ___
OTHER : _ # SOURCES: ___

NAME AUTHORIZATION

ADDRESS WHERE MATERIAL IS USED OR POSSESSED

BUILDING:
ROOM:
STREET:
CITY:
STATE:

BUILDING:
ROOM:
STREET:
CITY:
STATE:

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ROOM:
STREET:
CITY:
STATE:

BETWEEN:

License Fee Management Branch, ARM
and
Regional Licensing Sections

(FOR LFMS USE)
INFORMATION FROM LTS

Program Code: 03251
Status Code: 0
Fee Category: 3I
Exp. Date: 19931031
Fee Comments: IRRADIATED_GEMSTONES

LICENSE FEE TRANSMITTAL

A. REGION HQ

1. APPLICATION ATTACHED
   Applicant/Licensee: GENERAL ATOMICS
   Received Date: 890321
   Docket No: 3029179
   Control No.: 020781
   License No.: 04-14395-02E
   Action Type: Amendment

2. FEE ATTACHED $120.-
   Amount:
   Check No.: 3205624

3. COMMENTS

Signed M. Moriarty
Date 3-22-89

B. LICENSE FEE MANAGEMENT BRANCH (Check when milestone 03 is entered / ✓)

1. Fee Category and Amount: 3I $60

2. Correct Fee Paid. Application may be processed for:
   Amendment
   Renewal
   License

3. OTHER

Signed S. Kemberling
Date 4/4/89