
**Registry of Radioactive
Sealed Sources and Devices**

**Safety Evaluation
of C-164 Sealed Source**

IS/TR 1824 C164 (3)

Effective Date: - 3 MAY 2005

**Registry of Radioactive Sealed Sources and Devices
Safety Evaluation of C-164 Sealed Source****Signatures**

Prepared by: Blain m
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Date: 05/04/19

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M.A. Charette, Manager, Regulatory Affairs

Date: 05/04/19

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Date: 05/04/25**Document History**

Date	Version	Comments	Prepared by	Reviewed by	Approved by
Feb 02	1	DCN: A1362-D-09A	V. Eichler	M.A. Charette	M. Krzaniak
Mar 02	2	DCN: A1362-D-10A	V. Eichler	M.A. Charette	M. Krzaniak
Apr 05	3	DC: 19736			

**REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
SAFETY EVALUATION OF SEALED SOURCE**

SUMMARY DATA

SOURCE TYPE: Gamma Gauge Source
Industrial Radiography Source

MODEL: C-164

MANUFACTURER/DISTRIBUTOR: MDS Nordion, a Division of MDS (Canada) Inc.
(formerly Nordion International Inc. and Atomic
Energy of Canada Ltd.)
447 March Road
Ottawa, ON
Canada K2K 1X8

ISOTOPE: Antimony-124
Cobalt-60
Iridium-192

MAXIMUM ACTIVITY: 37 GBq (1.0 curies)
1.85 TBq (50 curies)
18.5 TBq (500 curies)

LEAK TEST FREQUENCY: 6 months

PRINCIPAL USE: (D) Gamma Gauge
(A) Industrial Radiography

CUSTOM SOURCE: ☐ YES ☒ NO

DESCRIPTION

The sealed source model C-164 is a single encapsulated fusion welded source that is used in self-contained, portable detectors such as a Beryllium Analyzer. The C-164 source may also be used for industrial radiography where the source remains in the device. The C-164 source may contain up to 1.0 Ci of antimony-124, or up to 50 Ci of cobalt-60, or up to 500 Ci of iridium-192, in pellet form.

The model C-164 capsule is constructed of stainless steel (Type 304L). It consists of two parts; a hexagonal shaped receptacle having a maximum outside dimension of 0.250 inches across the flats, a maximum overall length of 0.325 inches and a nominal wall thickness 0.015 inches, and a plug having a maximum outside diameter of 0.238 inches and 0.270 inches in height. After the source is loaded, the two parts are threaded together via #8-36 UNF thread and fusion welded.

The isotope material is in pellet form, either 1 mm, 2 mm or 3 mm in diameter. Nominal thickness may range between 1 and 2 mm. With 1 mm and 2 mm diameter pellets, a cylindrical spacer made of aluminum is used to hold the isotope in position.

As required by ANSI/HPS N43.6-1997 [1] and ISO 2919:1999(E) [2] sealed sources used in Gamma Gauges must meet performance classification E43232. It is reasonably foreseeable that this source could be used in industrial radiography (source in device) applications, which have a performance classification requirement of E43313.

The C-164 prototypes have been tested and classified to E64334 as prescribed in ANSI/HPS N43.6-1997 [1] and ISO 2919:1999(E) [2]. This classification meets and/or exceeds the requirements for both applications.

The C-164 sealed source is certified as Special Form Radioactive Material by the Canadian Nuclear Safety Commission (CNSC) under the certificate number CDN/0021/S-96 (See Appendix E).

DRAWINGS

USNRC Registration drawing G616401-001, Issue A for the C-164 Sealed Source is attached as Appendix A. It includes a design envelope that is greater than current manufacturing practices.

Technical Illustration drawing IS/SS 1809 C164, Issue 2 for the C-164 Sealed Source is attached as Appendix B. This design indicates current manufacturing practices.

CONDITIONS OF USE

The C-164 source is designed primarily for use in portable detectors with the source secured in the device. The Detector is hand carried by trained technical personnel. Typical environmental conditions are:

Temperature:	-40°C to 80°C
Pressure:	Atmospheric
Vibration:	None
Corrosion:	Range from none to mildly corrosive vapor

The estimated physical life of C-164 sources is theoretically infinite, with respect to the design and structural integrity of the source containment, provided the source is not used in adverse conditions. The typical life of the source loaded to maximum activity is approximately 2 months with antimony-124, 6 months when loaded with iridium-192, and 25 years with cobalt-60.

LABELLING

The C-164 source is engraved on its outer surface in the following manner:

- MDSN (an abbreviation for MDS Nordion). (Under the previous revision it was 'NII').
- DA (D is MDS Nordion's identification for antimony-124, and A is the identification for C-164 sources) or
CA (C is MDS Nordion's identification for cobalt-60, and A is the identification for C-164 sources) or
BL (B is MDS Nordion's identification for iridium-192, and L is the identification for C-164 sources)
- xxx (a unique serial number)
- Trefoil Symbol

TESTING OF PROTOTYPES

The C-164 source has been tested and classified to the level of E64334 as prescribed in ANSI/HPS N43.6-1997 [1] and ISO 2919:1999(E) [2].

The C-164 capsule has an internal free volume of 0.006 cm^3 . This small volume makes it difficult to validate leak test methods. To overcome this concern, some C-164 test specimens were therefore made with a body length elongated by 0.156 in. (3.96 mm). See Appendix A for the C-164 source configuration. Furthermore, no active or inactive material was placed inside the elongated test specimens. This provided an overall internal volume of 0.047 cm^3 , which is much more practical for leakage testing.

It is submitted that the test specimens with elongated bodies and with no active/inactive contents provided the same or worse conditions for testing than the standard C-164 specimen would provide. This is justified as follows:

Temperature and Pressure Tests

The use of longer test specimens has no (positive or negative) bearing on test results. The rationale is as follows:

Tangential (hoop) stress inside the cylinder is defined as:

$$\sigma_1 = pd/2t \quad [3]$$

Longitudinal stress inside the cylinder is defined as:

$$\sigma_2 = pd/4t \quad [3]$$

Where:

p = internal pressure

d = inside diameter of the cylinder

t = wall thickness

As the internal pressure, diameter and wall thickness is the same for the actual C-164 and the elongated C-164 test specimen, the tangential or longitudinal stresses will also be the same. The length of the cylinder, though different, does not affect the stress.

Vibration Test

With regard to the vibration test, the mass of the test specimens was within 4% of the mass of the actual C-164 sources. This had no bearing on test set-up or results.

Puncture Test

The extent of deformation of the C-164 wall is dependent upon the end conditions. For puncture tests on the window, the end support is the same. For a puncture test on the side, the increased length of the capsule results in less support at the mid-height of the containment. Therefore, puncture tests on an elongated capsule will yield results equal to or worse than the results observed on full scale C-164's.

Impact Test

Use of specimens with elongated bodies was overly conservative, especially in a vertical orientation. The rationale is as follows:

Applying the Euler equation for compression of a rounded column:

$$P_{cr} = n\pi^2 EI/L^2 \quad [3]$$

Where:

P_{cr} = Critical Load [lb.]
 n = End Condition constant; ~1.2 for one end rounded, one end fixed
 E = Modulus of Elasticity; 27.6×10^6 psi for stainless steel
 I = Moment of Inertia; $\pi/64 \times (D^4 - d^4)$ for tubing and $\pi/64 \times D^4$ for round bar [in.⁴]
Where $D = 0.156$ in. and $d = 0.125$ in.
 L = Body length; 0.200 in. for actual C-164 source and 0.356 in.
for elongated specimen (this represents the thin wall
tubing length of the specimen)

The intent of this calculation is to demonstrate that when performing impact tests in the direction parallel to the axis of the specimen, the elongated test specimen will be more susceptible to the compression loads.

By entering the values:

- a) Assuming that the standard C-164 filled with a metallic pellet(s) is equivalent to a solid bar, the calculated critical compression load would be $P_{cr} = 237,569$ lbs.
- b) Assuming that the standard C-164, though filled with a metallic pellet(s), is a thin wall tubing, the calculated critical compression load would be $P_{cr} = 139,635$ lbs.
- c) For the elongated specimen with no active or inactive source inside, the thin wall tubing option only was considered. The calculated critical compression load is $P_{cr} = 44,071$ lbs.
- d) The ratio for $P_{cr \text{ C-164}} / P_{cr \text{ specimen}}$ based on assumption a) is 5.39 and based on assumption b) is 3.17.

It is therefore submitted that the actual ratio is somewhere between the 3.17 and 5.39 range, and likely closer to 5.39 because of limited clearances between pellet(s) and tube wall.

Appendix C contains a copy of MDS Nordion Classification Certificate No.104 and all testing work sheets.

Safety Analysis Summary

The C-164 sealed source has an ANSI/HPS N43.6 -1997 designation of ANSI 96E64334. Correspondingly, the C-164 sealed source has an ISO 2919:1999(E) designation of ISO/98/E64334.

This exceeds the performance classification requirements for gamma gauges and industrial radiography (source to be used in device). It is concluded that these sources are fit for use in both applications.

OPERATIONAL EXPERIENCE

MDS Nordion has manufactured well over 400 C-164 sealed sources since 1969. There have been no known written or verbal reports indicating leakage or other defects pertaining to the C-164 sources.

RADIATION LEVELS

A C-164 source containing 1.0 Curies of antimony-124 would be expected to yield the following dose rates.

Distance from Source	Radiation Level	
	R/hr	Sv/hr
100 cm	0.941	0.00941
30 cm	10.5	0.10
10 cm	94.1	0.941

A C-164 source containing 50 Curies of cobalt-60 would be expected to yield the following dose rates.

Distance from Source	Radiation Level	
	R/hr	Sv/hr
100 cm	65	0.65
30 cm	722	7.22
10 cm	6,500	65

A C-164 source containing 500 Curies of iridium-192 would be expected to yield the following dose rates.

Distance from Source	Radiation Level	
	R/hr	Sv/hr
100 cm	232	2.32
30 cm	2,577	25.8
10 cm	23,200	232

QUALITY ASSURANCE

MDS Nordion maintains an ISO 9001 compliant quality assurance and control program, which has been deemed acceptable for licensing purposes by the USNRC under Quality Assurance Program No. 0703 which expires July 31, 2010.

All MDS Nordion C-164 sealed source(s) quality requirements for design, manufacturing, inspection and testing are carried out in accordance with the ISO 9001 Quality System. To assure these requirements, Technical Specifications have been prepared and are available for inspection purposes.

IS/TS 0010 C000	Technical Specification for Radioisotopes and Sources
IS/OP 0040 C000	Engraving Procedure

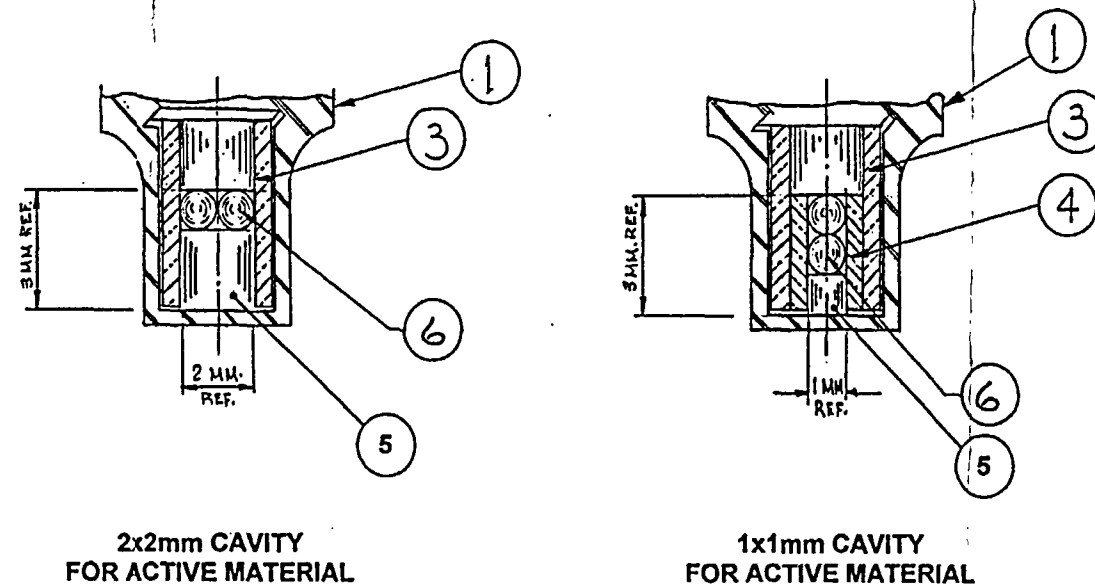
Critical elements of these specifications are summarized in Appendix D.


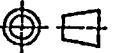
Documented policies and procedures are maintained to ensure that all purchased components, materials, and services conform to specified requirements.

REFERENCES

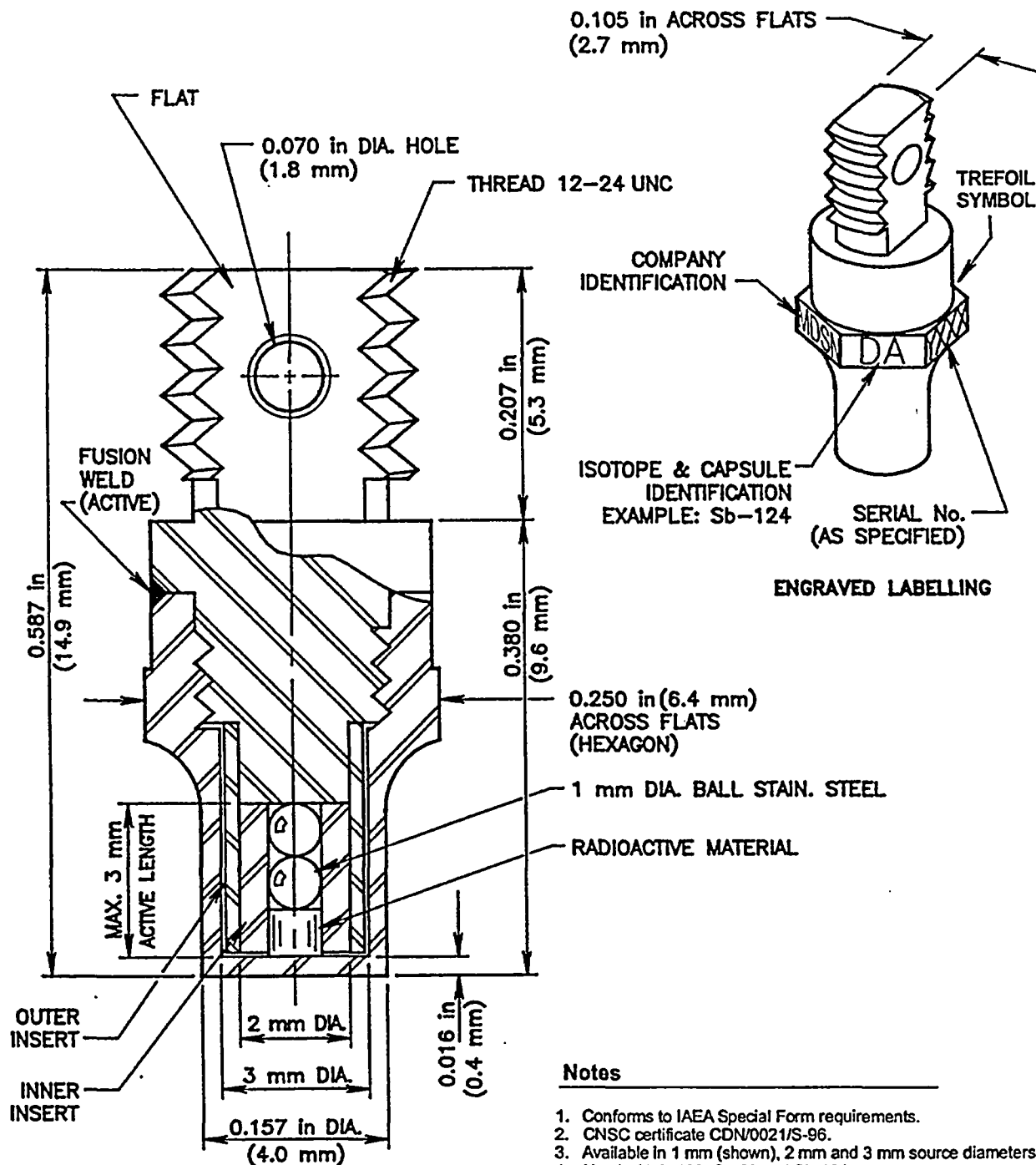
1. ANSI/HPS N43.6-1997 American National Standard "Sealed Radioactive Sources – Classification"
2. ISO 2919:1999 (E) International Standard "Radioactive Protection – Sealed Radioactive Sources – General Requirements and Classifications"
3. Mechanical Engineering Design J. E. Shigley, McGraw-Hill Book Company

APPENDIX A
USNRC Sealed Source Registration Drawing
G616401-001



- | | | | | | | |
|--|------------------|----------|---|--------------|-------------|--|
| 7 | | | | | | |
| 6 | A/R | | | | | 1mm DIA BALL, STAINLESS STEEL |
| 5 | A/R | | | | | ACTIVE MATERIAL, SEE NOTE 2 |
| 4 | A/R | | | | | INSERT, ALUMINUM ALLOY, TYPE 6061-T6 ASTM B211 |
| 3 | A/R | | | | | INSERT, ALUMINUM ALLOY, TYPE 6061-T6 ASTM B211 |
| 2 | 1 | | | | | PLUG, STAINLESS STEEL, TYPE 304L ASTM A276 |
| 1 | 1 | | | | | RECEPTACLE, STAINLESS STEEL, TYPE 304L ASTM A276 |
| ITEM
NO. | QUANTITY | PART NO. | ASSY | PWG
SIZE | DESCRIPTION | |
| BILL OF MATERIALS | | | | | | |
| ISSUE | DESCRIPTION | DATE | DRAWN | DTD
APPL. | ENGR | DRAWN
JEMahoney |
| A | DCN# A1362-D-05A | | | | | DATE
2001OCT11 |
| | | | | | | DTD APPL
R.Vesudry |
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| | | | | | | CIVIL ENGR |
| | | | | | | PHYSICS |
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| <div>  </div> | | | | | | |
| <div> TITLE
 C-164 SEALED SOURCE ASSY
 INFORMATION DRAWING </div> | | | | | | |
| THIS DRAWING IS THE PROPERTY OF MDS NORDION INC. AND IS
SUBMITTED FOR CONSIDERATION ON THE UNDERSTANDING THAT
THERE SHALL BE NO EXPLOitation OF ANY INFORMATION HEREIN
EXCEPT WITH THE SPECIFIC WRITTEN CONSENT OF MDS NORDION INC. | | | UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.
TOLERANCES: DECIMALS ANGLES SURFACE
.XX ± .03 ±1
.XXX ±0.015 63/ | | | |
| B120006-031
USED ON | | | SIZE C DWG NO. G616401-001 ISSUE A
SCALE 8:1 SHEET 1 OF 1 | | | |

APPENDIX B
Technical Illustration Drawing
IS/SS 1809 C164 (2)



SCALE 8:1

Notes

1. Conforms to IAEA Special Form requirements.
2. CNSC certificate CDN/0021/S-96.
3. Available in 1 mm (shown), 2 mm and 3 mm source diameters.
4. Used with Ir-192, Co-60 and Sb-124 sources.

MDS Nordion

447 March Road, P.O. Box 13500
Kanata, Ontario, Canada, K2K 1X8
Tel: (613) 592-2790 • Fax: (613) 592-6937

TITLE

C-164 Sealed Source

REF. IS/SS 1809 C164
DWG. A05488

REVISED Oct 03

DCN A2678-D03-A

DATE Oct 2001

No.

C-164

ISSUE

2

DRAWN CHECKED APPROVED

JG VE MK

MSHEET 1 OF 1

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APPENDIX C

**MDS Nordion Sealed Source Classification Tests
Certificate No. 104**



CERTIFICATE

SEALED SOURCE CLASSIFICATION DESIGNATION AND PERFORMANCE

Sealed sources are classified in accord with standards established by
THE AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) and
THE INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

CERTIFICATE NO: 104
CAPSULE MODEL: C-164

DATE: 02-01-29
CONTENTS: Co-60 , Ir-192 or Sb-124 pellets.

DRAWING: A05488
CAPSULE MATERIAL: 304L Stainless Steel
ENCAPSULATION: Single

OVERALL DIAMETER: 0.157" (Max. dimension 0.250" A/F)
OVERALL LENGTH: 0.587"

PERFORMANCE CLASSIFICATION ⁽¹⁾

ANSI 97E64334

ISO/99/E64334

CLASSIFIED PERFORMANCE STANDARD ⁽²⁾

TEST	CLASS	METHOD	REMARKS
TEMPERATURE	6	TEST	PASS
EXTERNAL PRESSURE	4	TEST	PASS
IMPACT	3	TEST	PASS
VIBRATION	3	TEST	PASS
PUNCTURE	4	TEST	PASS

(1) See definition on reverse side

(2) See Table 1. Performance Standards on reverse side

COMMENTS: Capsule integrity evaluated by Helium leak tests (ANSI/HPS N43.6 – 1997, Annex A, paragraph A2.2.6) and Liquid Nitrogen Bubble Test as per ISO 9978 6.2.4..

It is hereby certified that the described sealed source meets the requirements and classification specified in American National Standard N43.6-1997 "Sealed Radioactive Sources, Classification" and in International Standard, ISO 2919-1999(E), "Radiation Protection – Sealed Radioisotope Sources – General Requirements and Classification.

Tested by *Kellan Sedhan*
Title Materials Technologist
Date *29th January 2002*

Approved *M. Dugan*
Title Manager, Package Engineering
Date *01 FEB 2002*

REFERENCES

⁽¹⁾ DEFINITION - CLASSIFICATION DESIGNATION:

The classification of a sealed source shall be designated by the code ANSI followed by two digits to indicate the year of approval of the American National Standard used to determine the classification followed by a letter and five digits.

The letter shall be either a C or an E. The letter C designates that the contained activity does not exceed the maximum levels established by ANSI. The letter E designates that the contained activity exceeds the maximum levels established by ANSI.

The first digit shall be the class number which describes the performance standards for temperature.

The second digit shall be the class number which describes the performance standards for external pressure.

The third digit shall be the class number which describes the performance standards for impact.

The fourth digit shall be the class number which describes the performance standards for vibration.

The fifth digit shall be the class number which describes the performance standards for puncture.

⁽²⁾ TABLE 1 - PERFORMANCE STANDARDS:

TEST	CLASS						
	1	2	3	4	5	6	X
Temperature	No Test	-40°C (20 min) +80°C (1h)	-40°C (20 min) +180°C (1h)	-40°C (20 min) +400°C (1h) and thermal shock 400°C to 20°C	-40°C (20 min) +600°C (1h) and thermal shock 600°C to 20°C	-40°C (20 min) +800°C (1h) and thermal shock 800°C to 20°C	Special Test
External Pressure	No Test	25 kN/m ² abs. (3.6 lbf/in ²) to atmosphere	25 kN/m ² abs. to 2 MN/m ² (290 lbf/in ²) abs.	25 kN/m ² abs. to 7 MN/m ² (1015 lbf/in ²) abs.	25 kN/m ² abs. to 70 MN/m ² (10153 lbf/in ²) abs.	25 kN/m ² abs. to 170 MN/m ² (24 656 lbf/in ²) abs.	Special Test
Impact	No Test	50 g (1.8oz) from 1 m (3.28 ft) and free drop ten times to a steel surface from 1.5 m (4.92 ft)	200 g (7 oz) from 1 m	2 kg (4.4 lb) from 1 m	5 kg (11 lb) from 1 m	20 kg (44 lb) from 1 m	Special Test
Vibration	No Test	30 min 25 to 500 Hz at 5 g peak amp.	30 min 25 to 50 Hz at 5 g peak amp. and 50 to 90 Hz at 0.635 mm amp. peak to peak and 90 to 500 Hz at 10 g	90 min 25 to 80 Hz at 1.5 mm amp. peak to peak and 80 to 2000 Hz at 20g	Not Used	Not Used	Special Test
Puncture	No Test	1 g (15.4 gr) from 1 m (3.28 ft)	10 g (154 gr) from 1 m	50 g (1.76 oz) from 1 m	300 g (10.6 oz) from 1 m	1 kg (2.2 lb) from 1 m	Special Test

MDS NORDION

CAPSULE TESTING WORK SHEET

DATE: 01-12-18

TEST: Temperature

CLASS: 6

CAPSULE DESCRIPTION: Sealed Source MODEL: C-164

CONTENT: Co-60 , Ir-192 or Sb-124 pellets.

DRWG. REFERENCE: A05488

CAPSULE MATERIAL: 304L Stainless Steel ENCAPSULATION: Single

OUTSIDE DIAMETER: 0.157" OVERALL LENGTH: 0.587"
(Max dimension 0.25"A/F)

LEAK TEST TYPE: Liquid Nitrogen Bubble Test RESULTS: Pass
and Helium Pressurization Test

COMMENTS: Two C-164 capsules serial numbers 02 and 04 were subjected to the temperature test. The test capsules were manufactured to a length of 0.734" to ensure 0.047cm³ of free air space.

Test: The capsules were held at -40°C for thirty minutes followed immediately by heating at 800°C for one hour. The sources were removed from the furnace and air cooled at ambient temperature. The sources were then placed in the 800°C furnace for 15 minutes and transferred directly into water at 20°C, (described in ANS N43.6-1997, section 7.2.).

The capsules were helium leak tested (ANSI/HPS N43.6-1997: A.2.2.6.1, A2.2.6.2 and A2.2.6.3) following the temperature test . Capsule serial numbers 02 and 04 had leak rates of 5.4E-8 std. cc/sec and 6.2E-8 std. cc/sec respectively after 1 minute and 1.8E-8 std. cc/sec and 2.0E-8 std. cc/sec after 30 minutes. This latter leak rate was due to the surface condition after the class 6 temperature and thermal shock test.

Results were confirmed using the liquid nitrogen bubble test was used for testing the integrity of the capsules as per ISO 9978 6.2.4.

The capsules were placed in liquid nitrogen for more than 5 minutes. The capsules were then transferred to methanol and observed for at least 1 minute. No bubbles were observed.

Visual examination at 20x showed no observable cracks or similar defects.

See figure 1.

CONDUCTED BY: Hela Sholan
Materials Technologist

APPROVED BY: Miguel
Manager Package Eng.

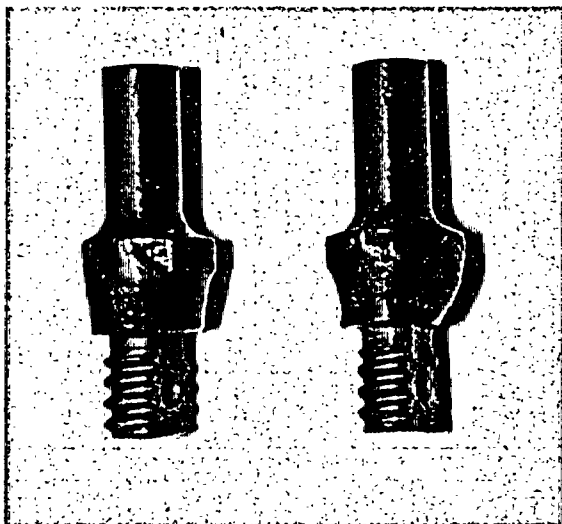


Figure 1:Discoloration from temperature test.

MDS NORDION

CAPSULE TESTING WORK SHEET

DATE: 01-12-18

TEST: External Pressure

CLASS: 4

CAPSULE DESCRIPTION: Sealed Source MODEL: C-164

CONTENT: Co-60 , Ir-192 or Sb-124 pellets.

DRWG. REFERENCE: A05488

CAPSULE MATERIAL: 316L Stainless Steel ENCAPSULATION: Single

OUTSIDE DIAMETER: 0.157" OVERALL LENGTH: 0.587"
(Max dimension 0.25"A/F)

LEAK TEST TYPE: Liquid Nitrogen Bubble Test RESULTS: Pass
and Helium Pressurization Test

COMMENTS Two C-164 capsules serial numbers 06 and 07 were subjected to the external pressure test. The test capsules were manufactured to a length of 0.734" to ensure 0.047cm³ of free air space.

Test: The capsules were held at the 25kn/m² for two periods of five minutes each with the pressure being returned to atmospheric between each period. The capsules then underwent 7MN/m² for two periods of five minutes each with the pressure being returned to atmospheric between each period (for the high pressure test water was used as a test medium).

The capsules were helium leak tested (ANSI/HPS N43.6-1997: A.2.2.6.1, A2.2.6.2 and A2.2.6.3) following the external pressure test. Capsule serial number 06 and 07 each had a leak rate less 0.1E-9 std. cc/sec after 1 minute. After 30 minutes serial number 06 had a leak rate of 2.2E-9 std. cc/sec and serial number 07 had a leak rate of less than 0.1E-9 std. cc/sec.

The capsules also passed the liquid nitrogen bubble test as per ISO 9978 6.2.4.

The capsules were placed in liquid nitrogen for a period of at least 5 minutes. The capsules were then transferred to methanol and observed for a period of at least 1 minute. No bubbles were observed.

Visual examination at 20x showed no observable cracks or similar defects.

CONDUCTED BY: Kelvin Hoelzer
Materials Technologist

APPROVED BY: Myra D
Manager, Package Eng.

MDS NORDION

CAPSULE TESTING WORK SHEET

DATE: 01-12-20

TEST: Impact

CLASS: 3

CAPSULE DESCRIPTION: Sealed Source

MODEL: C-164

CONTENT: Co-60 , Ir-192 or Sb-124 pellets.

DRWG. REFERENCE: A05488

CAPSULE MATERIAL: 304L Stainless Steel

ENCAPSULATION: Single

OUTSIDE DIAMETER: 0.157"

OVERALL LENGTH: 0.587"

(Max dimension 0.25"A/F)

LEAK TEST TYPE: Liquid Nitrogen Bubble Test
and Helium Pressurization Test

RESULTS: Pass

COMMENTS Four C-164 capsules serial numbers 07, 05, 01 and 03 were impact tested. Serial numbers 01 and 03 had previously passed the puncture test. The test capsules were manufactured to a length of 0.734" to ensure 0.047cm³ of free air space.

Test: The capsules were impact tested to ANSI Class 3 (200g from 1m) as described in ANSI/HPS N43.6-1997, paragraphs 7.4.1, 7.4.2 , 7.4.3 and 7.4.4.

Serial number 07 and 05 were impact tested on the window face. There was a small amount of compression.

Serial numbers 01 and 03 were impact tested on the side of the capsule. Serial number 03 had some minor visible damage (see figure 2).

The capsules were helium leak tested (ANSI/HPS N43.6-1997: A.2.2.6.1, A2.2.6.2 and A2.2.6.3) following the impact test. Capsules serial number 07, 01 and 03 had a leak rate less 0.1E-9 std. cc/sec and capsule 05 had a leak rate of 0.6E-9 std. cc/sec at 1 minute. At 30 minutes each capsule had a leak rate of less than 0.1E-9 std. cc/sec.

The capsules also passed the liquid nitrogen bubble test as per ISO 9978 6.2.4.

The capsules were placed in liquid nitrogen for a period of at least 5 minutes. The capsules were then transferred to methanol and observed for a period of at least 1 minute. No bubbles were observed.

Visual examination at 20x showed no observable cracks or similar defects.

See figure 2.

CONDUCTED BY:


Materials Technologist

APPROVED BY:


Manager, Package Eng.

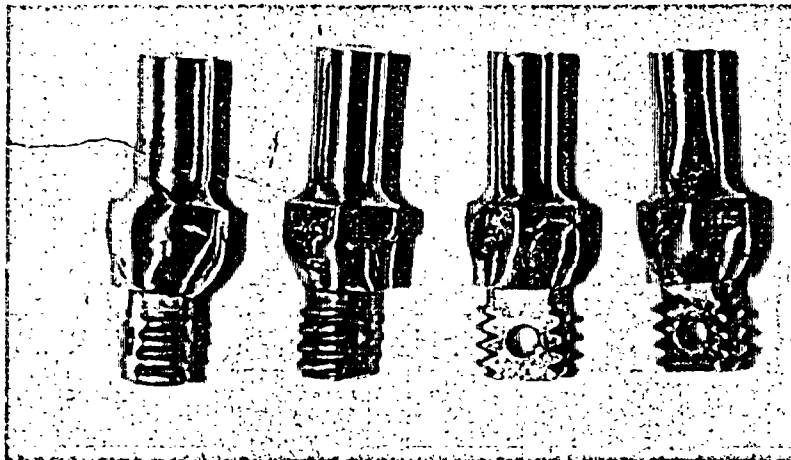


Figure 2: Serial numbers 07, 05 were impacted on the window face (L.H.S.).
Serial numbers 01, 03 were impacted on the side of the capsule.

MDS NORDION

CAPSULE TESTING WORK SHEET

DATE: 01-12-19

TEST: Vibration

CLASS: 3 (ANSI)

CAPSULE DESCRIPTION: Sealed Source MODEL: C-164

CONTENT: Cobalt , Iridium or Antimony pellets.

DRWG. REFERENCE: A05488

CAPSULE MATERIAL: 304L Stainless Steel ENCAPSULATION: Single

OUTSIDE DIAMETER: 0.157" OVERALL LENGTH: 0.587"
(Max dimension 0.25"A/F)

LEAK TEST TYPE: Liquid Nitrogen Bubble Test RESULTS: Pass
and Helium Pressurization Test

COMMENTS Two C-164 capsules serial numbers 09 and 10 were vibration tested. The test capsules were manufactured to a length of 0.734" to ensure 0.047cm³ of free air space.

Test: The capsules were vibration tested to ANSI Class 3 as per ANSI/HPS N43.6-1997, paragraphs 7.5.1, 7.5.2 and 7.5.3.

See attached report (Ortech Report No. 01-03-M0611).

Capsules serial number 09 and 10 each had a leak rate less 0.1E-9 std. cc/sec at 1 minute. Capsules serial number 09 and 10 each had a leak rate less 0.1E-9 std. cc/sec at 30 minutes.

Visual examination at 20x showed no observable cracks or similar defects.

CONDUCTED BY: Helel Sadan
Materials Technologist

APPROVED BY: M. Y. ...
Manager, Package Eng.

ANSI104VIB

Vibration Testing of Two C-164 Source Capsules

A Report to:

MDS Nordion
447 March Road
P.O. Box 13500
Kanata, Ontario
Canada, K2K 1X8

Attention:

Ms. Helen Sheehan

Telephone:

(613) 592-3400

Fax:

(613) 592-6937

Report Number:

01-03-M0611
3 Pages, 4 Appendices

Date:

December 19, 2001

BODYCOTE MATERIALS TESTING CANADA INC.

STANDARD TERMS AND CONDITIONS OF CONTRACT ("the Conditions")

INTERPRETATION

1. In these Conditions the following expressions shall (unless the context requires) have the following meanings:
"Client" means the person, firm or company to whom a Quotation is addressed or for whom a Test or any Services are carried out;
"Company" means Bodycote Materials Testing Canada Inc.;
"Contract" means the contract for the supply of Services and/or the carrying out of a Test of which these Conditions form part;
"Price" means the price stated in the Quotation, or otherwise agreed with the Client together with all other sums due pursuant to these conditions;
"Proposal" means the Company's proposal of which these Conditions form part;
"Quotation" means the Company's quotation (whether written or oral) of which these Conditions form part;
"Report" means any report, recommendation or the like issued by the Company in respect of the Services;
"Sample" means any material supplied by the Client to form the basis of a Test;
"Services" means the services specified in the Quotation;
"Test" means any testing, analysis, assay or the like specified in a Quotation;
"Test Certificate" means any test certificate, recommendation or the like issued by the Company in respect of a Test.

QUOTATION

2.1 The Quotation constitutes an offer by the Company to provide Services and/or carry out a Test subject to the Conditions and is open for acceptance for ninety days only from the date thereof unless stated otherwise on the written quotation or proposal.

2.2 Except in accordance with these Conditions no variation of the Contract will be accepted unless agreed in writing.

2.3 No condition, statement or representation contained in any advertisement or brochure or in any trade or promotional circular or other literature, nor the terms or conditions of any trade association or other body, or which would or might but for this sub-paragraph be implied or incorporated by custom or trade, usage, negotiations, course of dealing or otherwise shall be deemed to be incorporated in the Contract and all of the same are hereby expressly excluded from the Contract.

PRICE

3.1 The Price is based on information available to the Company at the date of the Quotation. If during the period of the Contract there shall be any variation in the cost of materials, labour or otherwise to the Company, the Price may, in the absolute discretion of the Company, be adjusted to take account of such variation.

3.2 In addition to the amount specified in the Quotation the following shall be payable if appropriate:

- (i) any applicable value added tax, sales tax, use tax, etc.;
- (ii) all bank charges;
- (iii) package, insurance, freight and storage charges incurred on behalf of the Client, whether on the Company's premises or elsewhere, and to include storage charges on the Company's premises, if any Sample or materials supplied by the Client are not removed within seven days of the date of notification to the Client that they are ready for collection;
- (iv) insurance incurred by the Company in its absolute discretion in respect of any property belonging to the Client in the possession of the Company;
- (v) the cost of all sub-contractors employed by the Company unless included in the Quotation; and
- (vi) any additional costs incurred by the Company in accordance with these Conditions.

PAYMENT

4.1 The Price shall be paid to the Company in full without any deduction, set-off or counterclaim within thirty days of the date of the Company's invoice and in default of payment within thirty days the Company may suspend further Services and/or Tests being carried out for the Client and the amount outstanding from time to time shall bear interest (both for and after any judgment) at a rate of 2% per month until payment in full is made (a part of a month being treated as a full month for the purpose of calculating interest).

4.2 All payments due to the Company shall be payable within the specified time irrespective of whether or not the Client has recovered payment from a third party and, for the avoidance of doubt, but without prejudice to the generality of the foregoing, this includes payments of fees due to the Company acting as experts or as expert witnesses when instructed by solicitors acting for a party to a dispute.

4.3 The Company reserves the right not to initiate work until acceptable credit terms have been established. Terms may include, payment of outstanding invoices, prepayments outlined in the Quotation and/or submission of a completed credit application by the Client including a release to allow the Company to draw upon a third party credit checking agency.

EXECUTION OF TESTS

5.1 The Test shall be carried out singly unless prior written instructions from the Client are received for replicates or unless the Company considers replicates are necessary or desirable. The Company reserves the right to charge for replicates even if the original result is confirmed.

5.2 The Client shall supply as much information as possible about each Sample in order to assist in achieving an efficient Service. Where Samples are incorrectly described and the Company is involved in additional work, the Company reserves the right to charge for such additional work.

5.3 Unless specific prior instructions in writing are received by the Company, the Test shall be carried out on the Sample in the state in which the Sample is received. The Company reserves the right to charge for any work required to be carried out to the Sample prior to the performance of any Test.

5.4 Methods of carrying out the Test shall be at the sole discretion of the Company unless specific prior instructions in writing are received by the Client specifying a particular procedure. Charges for such special procedures will be negotiated between the Company and the Client prior to carrying out the test.

5.5 A general description of the method used in the Test shall be given verbally on request. Where written descriptions of detailed procedures are requested, whether as part of the Test Certificate or issued separately, the Company reserves the right to make an additional charge. If the method needed in the Test represents the end product of development work carried out at the Company's expense, the method shall only be revealed at the discretion of the Company.

5.6 If special standards or equipment are used in the Test, they shall be invoiced in addition to the charge of the Test itself.

5.7 The Company may, at its sole discretion, undertake to give priority in carrying out a particular Test. A surcharge may be imposed by the Company for the carrying out of priority work. (Details of these arrangements will be issued by the Company on request.)

SAMPLES SUBJECT OF LEGAL PROCEEDINGS

6. The Client shall notify the Company in writing if the services to be performed are in support of pending or contemplated litigation prior to the Company commencing the services. If that fact is not disclosed to the Company, the Company shall not necessarily be prepared to provide expert testimony. Should the Company be legally compelled to perform other work such as giving of evidence under a summons to witness the Client shall pay a fee based on standard hourly rates in effect.

DISCLAIMER OF LIABILITY

7.1 The Company's total liability (if any) to the Client (excepting always liabilities in respect of personal injury or death caused by the negligence or willful misconduct of the Company), whether in Contract, delict, quasi delict, or otherwise in respect of any loss, direct or indirect or consequential, or damage (howsoever caused) directly or indirectly arising from any breach of Contract, or from any negligent act or omission of the Company or its servants, agents, or contractors, or from any breach by the Company or its servants of any duty owed to the Client in connection with the Contract shall be limited to the Price.

7.2 Services and/or Tests are undertaken in good faith, to a reasonable standard of care and on a confidential basis. Reports and Test Certificates are issued on the basis of information known to the Company at the time the Sample and/or the Test are carried out. Although the Company will use all reasonable endeavours to ensure the accuracy of the Company's achievements depend, inter alia, on the effective co-operation of the Client, its staff, and on the information submitted to the Company. Save as required by law, no representation or warranty, whether expressed or implied or otherwise as to the accuracy of a Test Certificate or a Report is given by the Company. In consequence, all Reports and Test Certificates are prepared on the basis that:

(i) there is no responsibility to any person or body other than the Client;

(ii) they are not carried out for any particular purpose and no statement is to be deemed, in any circumstances to be or give rise to a representation, undertaking, warranty or contractual condition unless specifically stated; and

(iii) they are determined solely by the professional analysis undertaken by the Company's staff on each individual Contract in any forecasts by the Company of the results is an estimate only and the Company is entitled to be paid the Price irrespective of the results or conclusions reached.

7.3 All time limits, if any, are estimates and no undertaking is given to carry out the Services and/or Tests or to dispatch any Test Certificate within any period of time.

7.4 The Company shall not be responsible for the consequences of any delay in carrying out the Services and/or Tests or in delivering the Report and/or Test Certificate arising from any strike, lockout, trade dispute, accident, fire, inclement weather, flood, tempest, war, or act of God or any other matter or thing outwith its control.

7.5 Neither the Company nor any of its directors, officers, employees, or agents shall be liable to the Client for any amount exceeding the Price arising from the inaccuracy of the results set out in a Test Certificate or Report hereunder.

OBLIGATIONS OF CLIENT

8.1 The Client shall not reveal or make available the details of any Report or Test Certificate to any third party without first obtaining the prior written consent of the Company.

8.2 The Client shall be bound to indemnify the Company in writing prior to the carrying out of any Test that a sample is of a dangerous or unstable nature and shall indemnify the Company from and against all loss or damage suffered by the Company, including, without prejudice to the generality of the foregoing, all damage to the Company's property and all claims in respect of injury to or death of any of the Company's employees, sub-contractors or agents or of any third party, directly or indirectly arising from or in connection with the failure of the Client to inform the Company of the dangerous or unstable nature of a Sample.

8.3 The Client shall indemnify the Company from and against all loss or damage suffered or incurred by the Company, whether in or at the instance of the Client or its employees or agents or third parties or otherwise directly or indirectly arising from or in connection with the carrying out of the Services and/or Tests except to the extent such loss or damage is caused by the negligence or willful misconduct of the Company.

8.4 Unless otherwise agreed the Client will be responsible for providing a safe system of work for the Company and its employees while providing services and the Client shall be responsible for all costs necessarily required in discharging this obligation and shall indemnify the Company, its employee, sub-contractors and agents in respect of all claims, costs, damages, and loss suffered as a result of any breach by the Client hereof.

RISK AND PROPERTY IN RELATION TO TESTS

9.1 The risk of damage to the Sample shall remain with the Client at all times.

9.2 Samples of a stable nature shall be retained for thirty days from the date of their receipt and then destroyed unless otherwise agreed to in writing. Samples shall be returned to the Client only if prior instructions in writing in that regard are received by the Company and the Client shall be charged for all costs associated therewith (including carriage).

9.3 Where Samples are, in the sole opinion of the Company, too bulky or too unstable to allow long storage time, it will be at the absolute discretion of the Company as to the length of time such Samples are kept.

9.4 All copyright in chart records and other scientific, documentary or primary data produced during any Test and in all Reports or Test Certificates shall belong to and remain the property of the Company.

9.5 The Report or Test Certificate refers only to the particular samples, units, materials, instruments and/or other subject used and referred to in it, and is limited by the tests and/or analyses performed. Similar articles may not be of like quality, and other testing and/or analysis programs might be desirable and might give different results.

OWNERSHIP, COPYRIGHT AND PATENTS IN RELATION TO SERVICES

10.1 Ownership and copyright in the Report and any other Reports, results, or information established or collated by the Company in the course of the Services shall remain with the Company until the Client has discharged all its obligations under the Contract, including payment of the price, whereupon the title, ownership and copyright shall pass to the Client unless the Company is forced to part with any such results, reports or information of any nature to any body exercising its statutory powers.

10.2 The Client hereby warrants that it will not use the Report or any other reports, results, or information supplied by the Company for the purposes of advertisement or publication to third parties. Any such use of the Report or other reports, results or information is permitted under the Contract only with the prior consent of the Company who shall have the right to increase the Price where it consents to such advertisement and/or publication. If consent is granted the Report or Test Certificate may be reproduced only in its entirety.

10.3 All inventions arising from the Contract and any applications for Patents for like protection, whether in Canada or elsewhere shall be the property of the Client (once all payments due to the Company under contract have been discharged), but the Company shall be free to apply them or any information gained to work outside the specific field in which the development for the Client took place.

10.4 Unless otherwise indicated by the Client in writing, it is understood that electronic transfer (including fax, email, etc.) of the Quotation, Report or Test Certificate by the company is acceptable.

SUB-CONTRACTING

11. The Company shall be entitled, in its absolute discretion, to sub-contract the whole or any part of the Service and/or Test.

TERMINATION

12.1 The Client shall not terminate the Contract without the written consent of the Company which may be subject to such terms as in the Company's absolute discretion including compensating the Company for all loss it may suffer as a result of termination.

12.2 The Company may terminate the Contract and any other contract with the Client forthwith, without prejudice to any other right or remedy available to the Company and without the Company incurring any liability to the Client, in the following circumstances:

(i) if the Client shall commit a breach of any terms of the Contract or any other contract with the Company unless such breach is capable of remedy and the Client has failed to comply with a notice regarding remedy within the period specified in the said notice;

(ii) without prejudice to the foregoing, if the Client fails to make payment of the Price within the specified time;

(iii) the Client makes any voluntary arrangement with its creditors or becomes subject to an administrator order or (being individual or firm) becomes bankrupt or (being a company) goes into liquidation otherwise than for the purposes of amalgamation or reconstruction;

(iv) an encumbrance takes possession of, or a receiver is appointed, of any of the property or assets of the Client;

(v) the Client ceases, or threatens to cease, to carry on business; or

(vi) the Company reasonably believes that any of the events mentioned at (iii), (iv), and (v) above is about to occur in relation to the Client and notified the Client accordingly.

12.3 Notwithstanding that the Company terminates the Contract, all other rights existing shall remain in force, including the right to suspend all further Services and/or Tests to be made under the Contract or any other contract with the Client (and in such event the Client shall not be released from any of its obligations to the Company under the Contract or any other contract) and the right for the Company to receive full compensation for its loss under the Contract or any other contract with the Client.

NOTICES

13. All notices to be served by one party on the other shall be deemed duly delivered or served forty-eight hours after posting if posted by first class or airmail pre-paid post to the address of the other party.

GENERAL

14. In the event of one or more of the provisions of these Conditions being held by a competent authority to be invalid, illegal, or unenforceable, in whole or in part, the validity, legality or enforceability of the remaining provisions of these Conditions and the remainder of the provision in question shall not be affected thereby.

15. No waiver by the Company of any breach of the Contract by the Client shall be considered as a waiver of any subsequent breach of the same or any other provision.

16. The construction, validity, and performance of the Contract shall be governed by the laws of the Province in which the Laboratory issuing the Report or Test Certificate is located. Any claims made against the Company will only be heard in a Canadian Court of Law.

1.0 INTRODUCTION

This report contains the results from the vibration testing of the simulated source capsules type C-164. The vibration test was carried out as specified in ANSI Vibration (section 7.5, Class 3). A total of two (2) capsules were tested simultaneously.

The samples submitted to Bodycote Ortech were identified as follows:

MDS Nordion Model Number	MDS Nordion S/N	Bodycote Ortech Identification
C-164	9M	01-03-M0611-1
C-164	10M	01-03-M0611-2

2.0 TEST EQUIPMENT

- LDS Vibration Test system – Asset No. 13756
- Data Physics Vibration Controller – Asset No. 13630
- Kistler 4 channel coupler/signal conditioner – MII No. B04882.
- PCB Accelerometer – MII No. B02936 calibrated.
- PCB Accelerometer – MII No. B03886 calibrated.
- Toe clamps and associated hardware.

3.0 PROCEDURES

All testing was performed at ambient laboratory conditions.

Due to the small size of the samples an accurate resonance search could not be performed. To determine the first mode response of the larger sample, a modal analysis was carried out using IDEAS Master Series modal analysis tool.

The two sample capsules were attached to an aluminum circular fixture in which the samples were secured through the mounting holes. The samples were mounted such that the end of the capsules would be free. The mounting fixture with two capsules attached was secured to the vibration platform of the LDS shaker

3.1 VIBRATION TESTING

The natural frequency of each capsule was also calculated analytically using IDEAS Master Series modeling and analysis tool. The first mode response of each capsule was found to be approximately 17528.52 Hz assuming that each capsule is solid.

A copy of the model analysis is shown in Appendix B.

The following assumptions were made for the calculations:

Material properties and dimensions of the capsules were specified in drawing No. A05488, titled C-164 Sealed Source Assembly see Appendix C.

Since the natural frequencies were well above the 500Hz limit set in the specification, no fixed frequency dwell was performed.

The two C-164 capsules were subjected to a sinusoidal vibration with the following characteristics: Sweep from 25 to 50 Hz at a constant peak acceleration of 5g's, 50 to 90 Hz at a constant peak to peak displacement of 0.635mm, and 90 to 500 Hz at a peak acceleration of 10g's. The samples were subjected to 30 minutes of the sweeps in each of the two orthogonal directions employing a logarithmic sweep rate of 10 minutes per sweep.

Vibration test set up in the radial direction is shown in Photograph 1, in Appendix A.

Vibration test set up in the longitudinal direction is shown in Photograph 2, in Appendix A.

During the sweeps, an additional accelerometer was attached to the end of one of the long capsules for response measurement. Due to the small size of the samples, the response measurement was affected by the added mass of the accelerometer. No resonance was detected in the test frequency range from 25 to 500Hz.

Copies of the vibration controller plots are shown in Figures 1 and 2, in Appendix D.

4.0 DISCUSSION


The two C-164 sealed source capsules were subjected to a sinusoidal vibration test per class 3 of paragraph 3 of a specification supplied by the client. The vibration sweeps were performed in the longitudinal direction and the radial direction. An accurate resonance search was not feasible due to the small size of the samples. Accurate response measurement requires that the sample is at least ten times the mass of the accelerometer being applied.

Since the first mode response was found to be significantly higher than the 500Hz limit specified in the specification no fixed frequency dwell was conducted. It should be noted that the response of any system is largely dependent on the fixing method being applied.


During the vibration tests, the response accelerometer was attached to the end of one of the long capsules. No first mode response was detected between 25 and 500Hz. A copy of the sine sweep waveforms from the vibration controller is included in appendix A at the end of this report.

Leak testing of the simulated source capsules will be performed at MDS Nordion as required by the client. The samples were returned to the client following the completion of the vibration tests.

Reported by:


Dan Udovic
Project Technologist
Mechanical and Product Testing

Reviewed by:

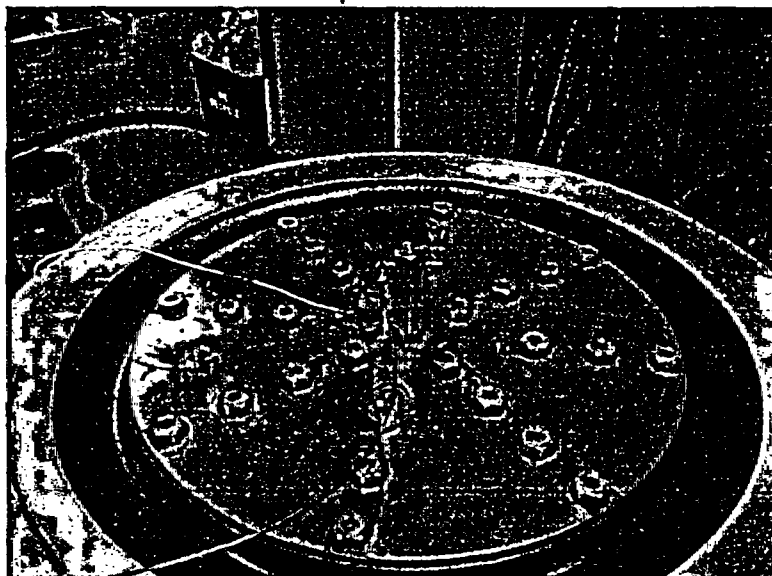

Brian O'Connor P.Eng
Manager
Mechanical and Product Testing

This report refers only to the particular samples, units, material, instrument, or other subject used and referred to in it, and is limited by the tests and/or analyses performed. Similar articles may not be of like quality, and other testing and/or analysis programs might be desirable and might give different results.

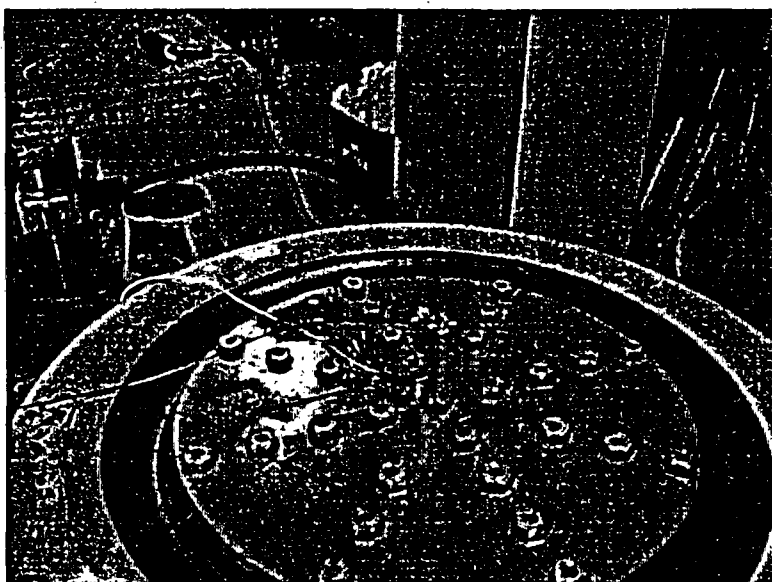
APPENDIX A

Photographs

(1 Page)



Photograph #1
Longitudinal Direction Test Set up



Photograph #2
Radial Direction Test Set up

Bodycote Ortech

*Vibration Testing of Two C-164 Capsules
For MDS Nordion*

*Appendix B
Report No 01-03-M611*

APPENDIX B

(1 Page)

Copy of Model Analysis

I-DEAS 8 m2: Ortech : akanade : /scratch/akanade/camco/pin_vib.mfl

27-Nov-01 16:21:09

Units : IN

Database: /scratch/akanade/camco/pin_vib.mfl

View : No stored Workb_View

Task : Post Processing

Model: Fem1

Active Study: DEFAULT FE STUDY

Display : No stored Option

Model/Part Bin: Main

Parent Part: Part2

/scratch/akanade/camco/pin_vib.mfl

RESULTS: 1- B.C. 2,NORMAL_MODE 1,DISPLACEMENT_1

MODE: 1 FREQ: 17528.52

DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 4.00E+01

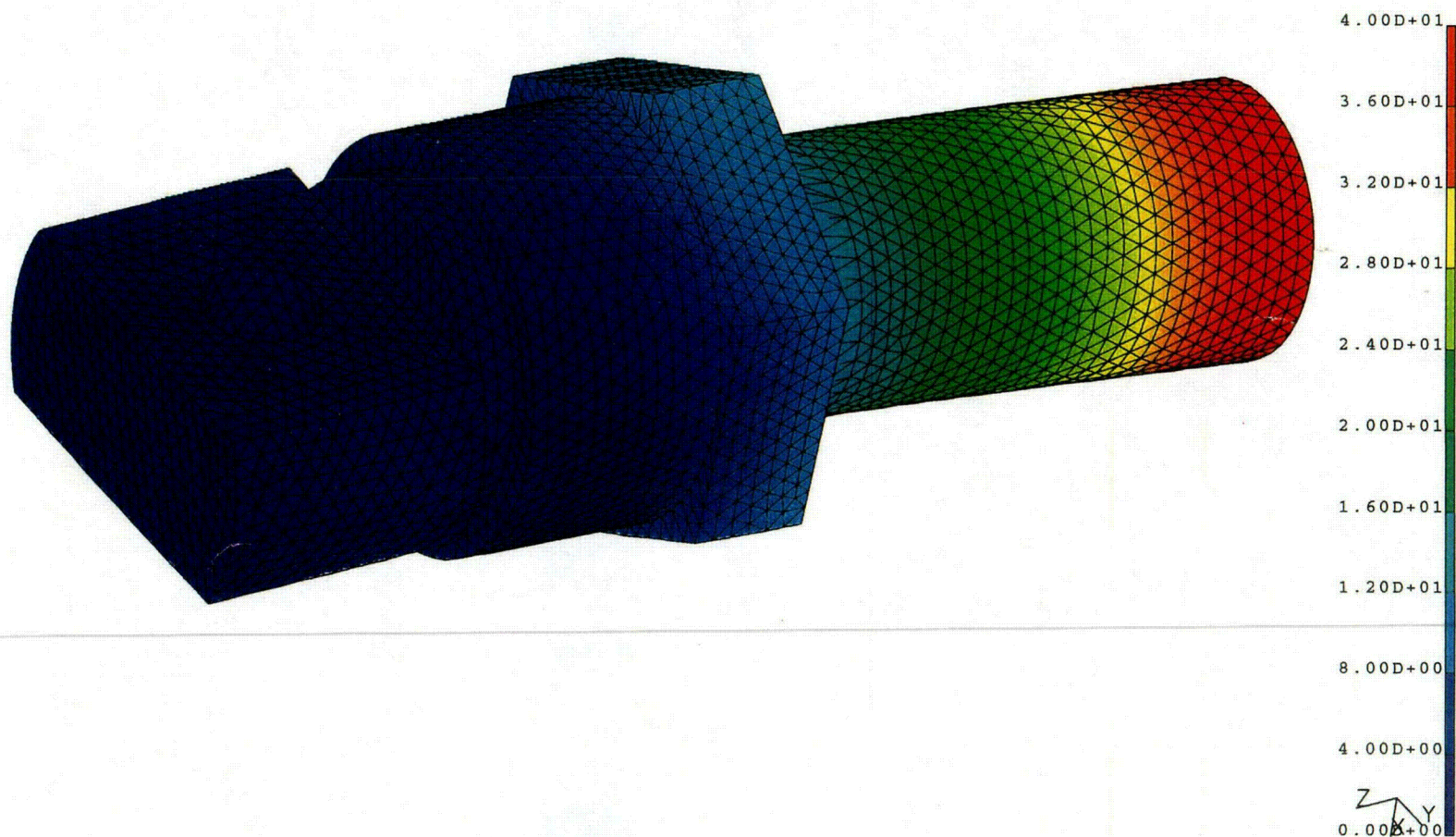
DEFORMATION: 1- B.C. 2,NORMAL_MODE 1,DISPLACEMENT_1

MODE: 1 FREQ: 17528.52

DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 4.00E+01

FRAME OF REF: PART

VALUE OPTION: ACTUAL



C01

Bodycote Ortech

*Vibration Testing of Two C-164 Capsules
For MDS Nordion*

*Appendix C
Report No 01-03-M611*

APPENDIX C

(1 Page)

Copy of Drawing No. A05488

[illegible]

APPENDIX D

(2 Pages)

Vibration Controller Plots

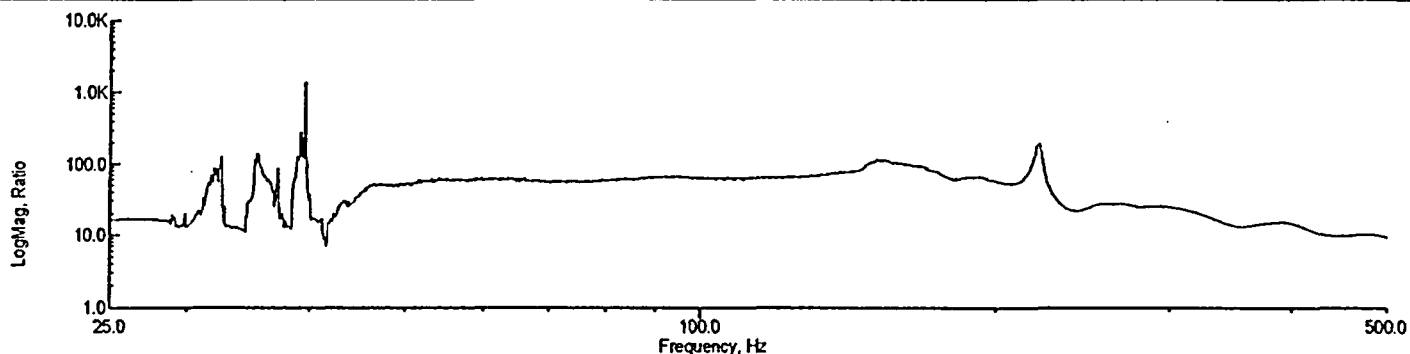
Bodycote Materials Testing Canada Inc.
Vibration Testing for MDS Nordion
Sinusoidal Sweep from 25Hz to 500Hz and back to 25Hz
Longitudinal Direction
Sample Numbers 01-03-M0611 -1 S/N M9 and -2 S/N M10

Accel: 4.9976 g
Displ: 0.15638 in p-p
Freq: 25.00 Hz

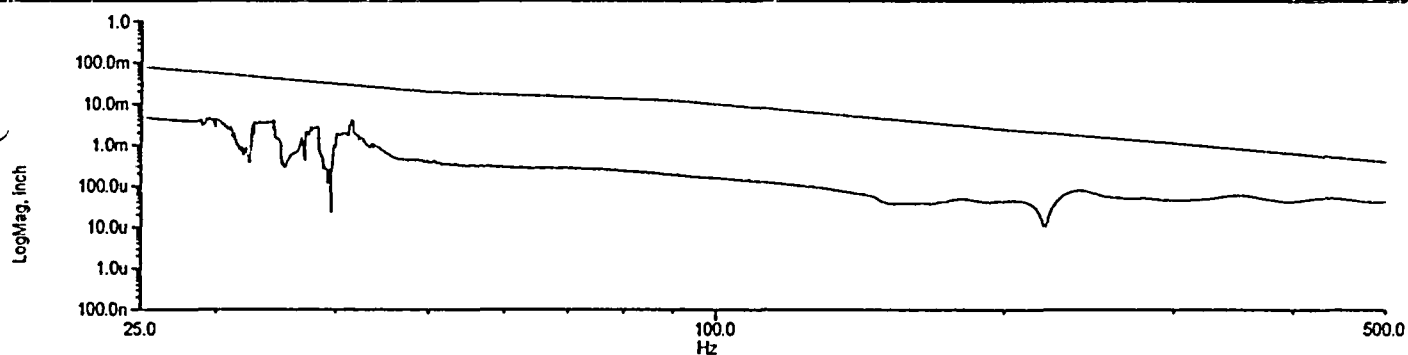
Drive: 0.1689 V-pk
Total Time: 00:10:21
Status: Review

Run State: Auto
Loop: Closed
Checks: Enabled

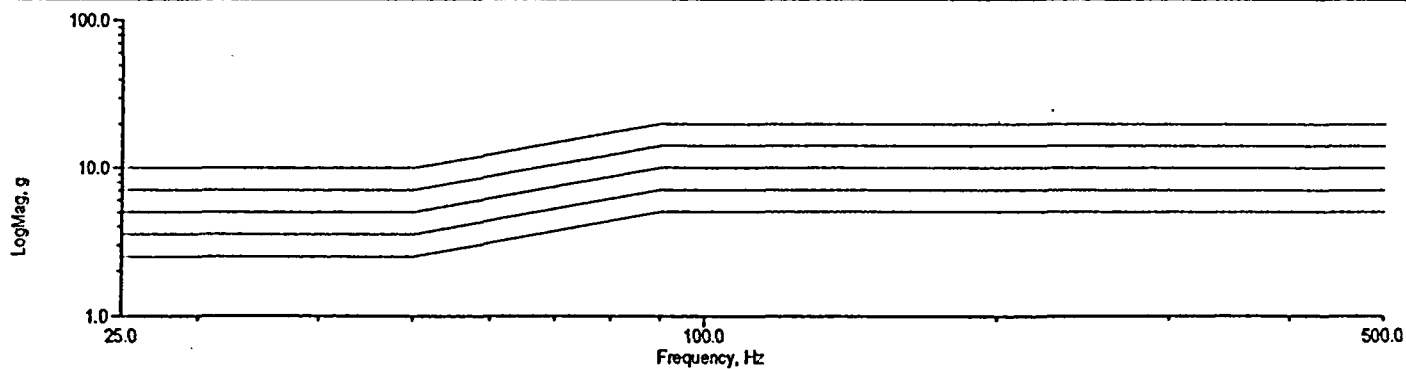
Measurement1/Measurement2



"Measurement1(displ)"; "Measurement2(displ)"



Reference; Control; AlarmLow ...



t Started: 10:24:55 AM 12/4/01
t Stopped: 10:35:19 AM 12/4/01

Channel 1: Control signal mounted on vibration platform in direction of thrust. Channel 2: Measurement response signal mounted on sample #2 S/N M10.

Figure 1

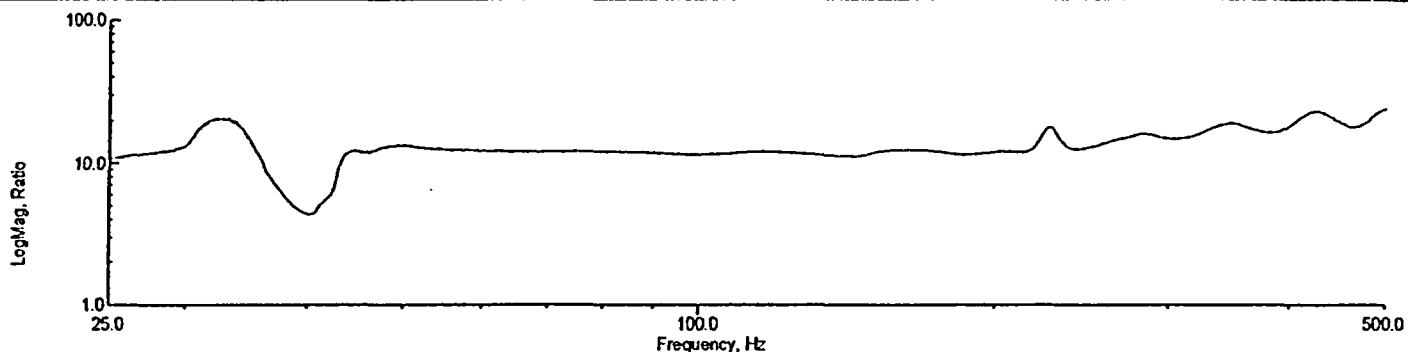
Bodycote Materials Testing Canada Inc.
Vibration Testing for MDS Nordion
Sinusoidal Sweep from 25Hz to 500Hz and back to 25Hz
Radial Direction
Sample Numbers 01-03-M0611 -1 S/N M9 and -2 S/N M10

Accel: 5.0024 g
Displ: 0.15654 in p-p
Freq: 25.00 Hz

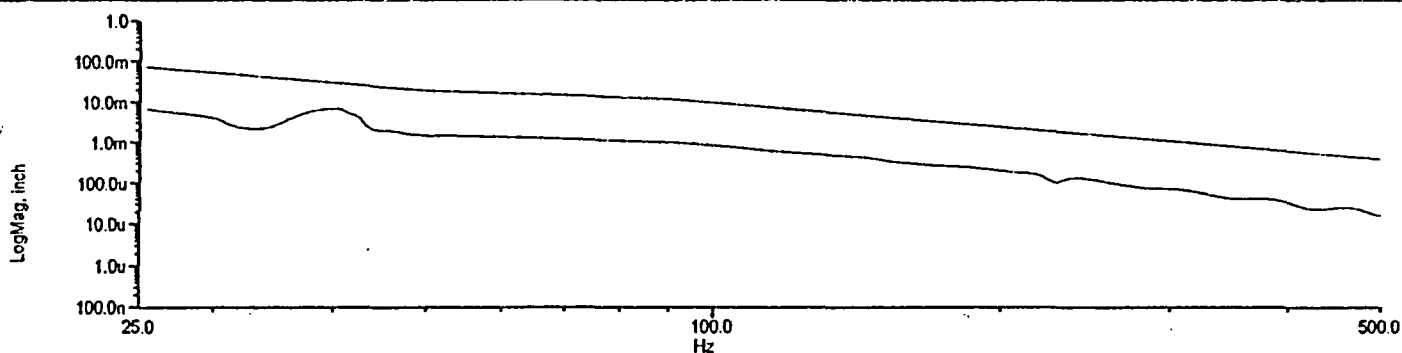
Drive: 0.1688 V-pk
Total Time: 00:10:21
Status: Review

Run State: Auto
Loop: Closed
Checks: Enabled

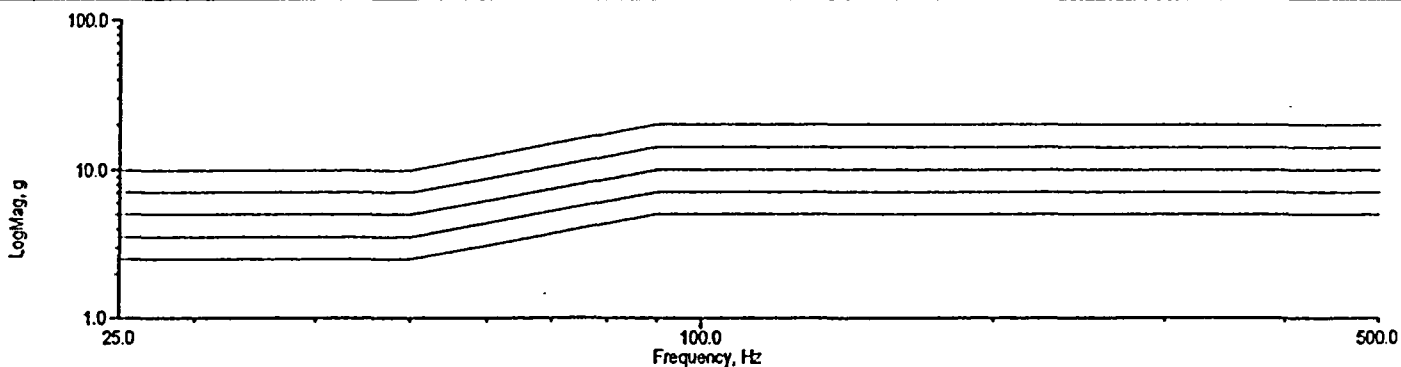
Measurement1/Measurement2



"Measurement1(displ)"; "Measurement2(displ)"



Reference; Control; AlarmLow ...



Started: 11:15:40 AM 12/4/01
Stopped: 11:26:05 AM 12/4/01
Channel 1: Control signal mounted on vibration platform in direction of thrust. Channel 2: Measurement response signal mounted on sample #2 S/N M10.

Figure 2

CAPSULE TESTING WORK SHEET

DATE: 01-12-19

TEST: Puncture CLASS: 4

CAPSULE DESCRIPTION: Sealed Source MODEL: C-164

CONTENT: Co-60 , Ir-192 or Sb-124 pellets.

DRWG. REFERENCE: A05488

CAPSULE MATERIAL: 304L Stainless Steel ENCAPSULATION: Single

OUTSIDE DIAMETER: 0.157" OVERALL LENGTH: 0.587"
(Max dimension 0.25"A/F)

LEAK TEST TYPE: Liquid Nitrogen Bubble Test RESULTS: Pass
and Helium Pressurization Test

COMMENTS Two C-164 capsules serial numbers 01 and 03 were puncture tested. The test capsules were manufactured to a length of 0.734" to ensure 0.047cm³ of free air space.

Test: The capsules were puncture tested to ANSI/ISO Class 4 (50 grams from 1m) as described in ANSI/HPS N43.6-1997, paragraphs 7.6.1, 7.6.2 and 7.6.3..

The capsules were positioned horizontally and puncture impacted on the side of the capsule near the end of the plug (see figure 3). The capsules were positioned vertically and puncture impacted on the window (see figure 4).

The capsules were helium leak tested (ANSI/HPS N43.6-1997: A.2.2.6.1, A2.2.6.2 and A2.2.6.3) following the puncture test . Capsules serial number 01 and 03 each had a leak rate less 0.1E-9 std. cc/sec at 1 minute. Capsule serial number 01 had a leak rate of 2.6E-9 std. cc/sec and 03 a leak rate of 3.2E-9 std. cc/sec at 30 minutes.

The capsules also passed the liquid nitrogen bubble test as per ISO 9978 6.2.4.

The capsules were placed in liquid nitrogen for a period of at least 5 minutes. The capsules were then transferred to methanol and observed for a period of at least 1 minute. No bubbles were observed.

Visual examination at 20x showed no observable cracks or similar defects.

CONDUCTED BY:

Kelvin Ladan
Materials Technologist

APPROVED BY:

Miguel
Manager, Package Eng.

ANSI104PUNCT

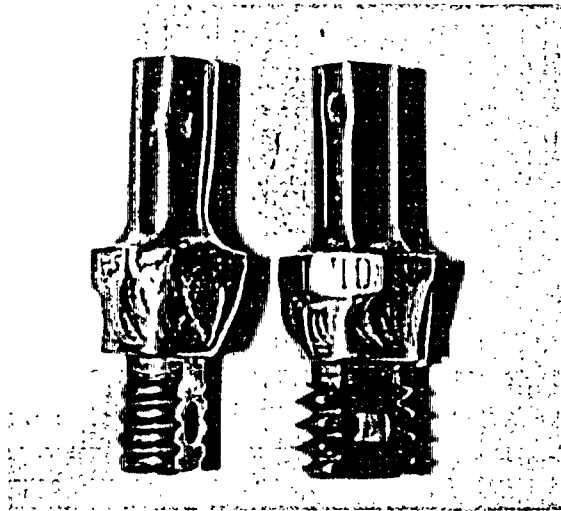


Figure 3: S/N 03 and 01 puncture impacted on the side of the capsule.



Figure 4: S/N 03 and 01 puncture impacted on the window of the capsule.

APPENDIX D

Critical Elements of the Technical Specifications

MANUFACTURE OF INACTIVE COMPONENTS

All stainless steel components of the C-164 are fabricated and cleaned in accordance with a manufacturing, inspection and test plan. Handling of all materials and components is such that scratching, denting or marking of any kind is minimized. Completed components are stored in a manner that ensures that they will not become damaged or distorted during transit and storage. Incoming inspection is completed on capsule components in accordance with written procedures.

ACTIVE WELDING

Active assembly and welding is completed in accordance with written manufacturing procedures. Cleaning, assembly and decontamination requirements are specified.

Assembled C-164 sources are inspected for overall integrity and are leak tested. Dry wipe tests are also carried out to ensure that the level of contamination on the assembled source is less than 5 nanocuries (185 becquerels).

In-process controls are designed to determine if the C-164 weld penetration requirements are satisfied. A test weld on a dummy capsule is carried out by each individual welder at the start of each production run, batch, shift or day. A test weld is also performed prior to and immediately following a change in the weld configuration (i.e. new electrode, gap set-up etc.)

Visual defects such as, but not limited to, voids, pinholes and blowholes are regarded as anomalies and do not require the destructive testing of the previously manufactured capsules. However, if two or more visual defects appear in any batch, that batch is considered non-conforming and the capsules are to be dispositioned.

TRACEABILITY

Individual subassemblies are uniquely identified and individually packed. They are traceable back to the material supplier's certifications.

APPENDIX E

**Special Form Radioactive Material Certificate
No. CDN/0021/S-96, (Rev. 0)**



Certificate

for

Special Form Radioactive Material

Certificate Number CDN/0021/S-96, (Rev. 0)	Issue Date December 3, 2003	Expiry Date November 30, 2007	CNSC File 30-A2-187-0
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The special form radioactive material identified below is certified by the Canadian Nuclear Safety Commission pursuant to paragraph 21(1)(h) of the *Nuclear Safety and Control Act* and Section 7 of the *Packaging and Transport of Nuclear Substances Regulations*, and to the 1996 edition of the IAEA *Regulations for the Safe Transport of Radioactive Material*.

CAPSULE IDENTIFICATION

Manufacturer	MDS Nordion
Make/Model	C-164 and XC-234

CAPSULE DESCRIPTION

The C-164 as further illustrated in Drawing No. A05488 (Issue F); and XC-234 as further illustrated in Drawing No. A07516 (Issue F), are single encapsulated fusion welded sealed sources. The C-164 has a height of 14.9 mm. The radioactive contents are contained within a 4 mm diameter cylinder. Additional features include a threaded end and a 6.4 mm A/F hexagonal surface that facilitate installation. The XC-234 is cylindrical with a maximum diameter of 6.1 mm and a maximum height of 9.8 mm.

An illustration of the sealed sources are shown on attached Drawing Nos. C-164 (Issue 2) and XC-234 (Issue 1).

AUTHORIZED RADIOACTIVE CONTENTS

Each capsule is authorized to contain not more than 1850 GBq (50 Ci) of cobalt 60 or 18.5 TBq (500 Ci) of iridium 192 or 37 GBq (1 Ci) of antimony 124, in the form of solid metal pellets.




Certificate Number CDN/0021/S-96, (Rev. 0)	Date of Issue December 3, 2003	Expiry Date November 30, 2007	CNSC File 30-A2-187-0
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QUALITY ASSURANCE

Quality Assurance for the design, manufacture, testing, documentation, use, maintenance and inspection of the capsule shall be in accordance with:

- MDS Nordion Procedure No. IN/QA 0562 A000 (3)* "Sealed Source Quality Plan"
- *Canadian Packaging and Transport of Nuclear Substances Regulations*
- *IAEA Regulations*

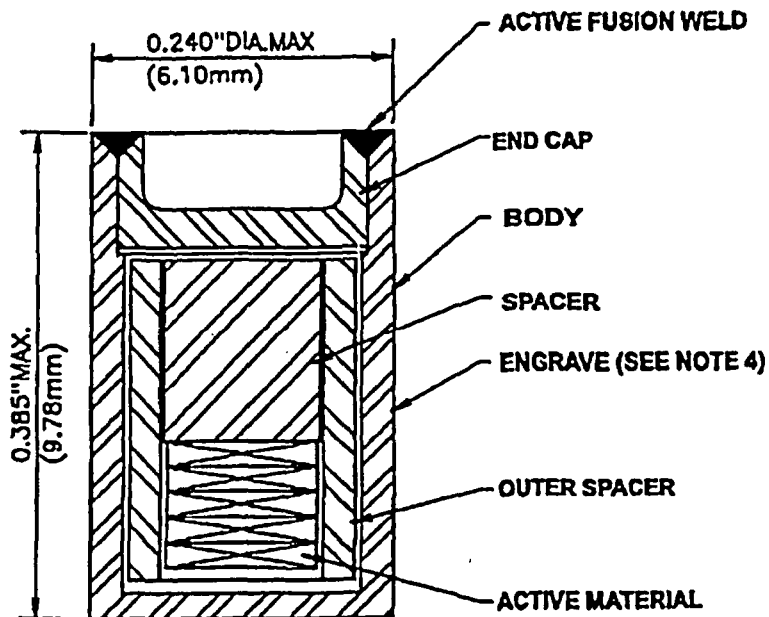
* or latest current revision



P. Nelson
Designated Officer pursuant to Subsection
37(2)(a) of the *Nuclear Safety and Control Act*

NOTES

Revision 0: December 2, 2003. Original issue.



Notes

1. Conforms to IAEA Special Form requirements.
2. CNSC certificate CDM0021/5-D6.
3. Capsule Material: Stainless Steel, Type 316L.
4. Capsule Engraved: MDSN
B D
Serial No. (As Specified)

MDS Nordion

447 March Road, P.O. Box 13600
Kanata, Ontario, Canada, K2K 1X8
Tel: (613) 592-2700 • Fax: (613) 592-6837

TITLE

XC-234 Capsule Assembly

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REF. 18/93 1877 C234
A07818

REVISED OCT 83 DCN A2878-003-A

DATE OCT 2003

No. **XC-234**

ISSUE

DRAWN
JC

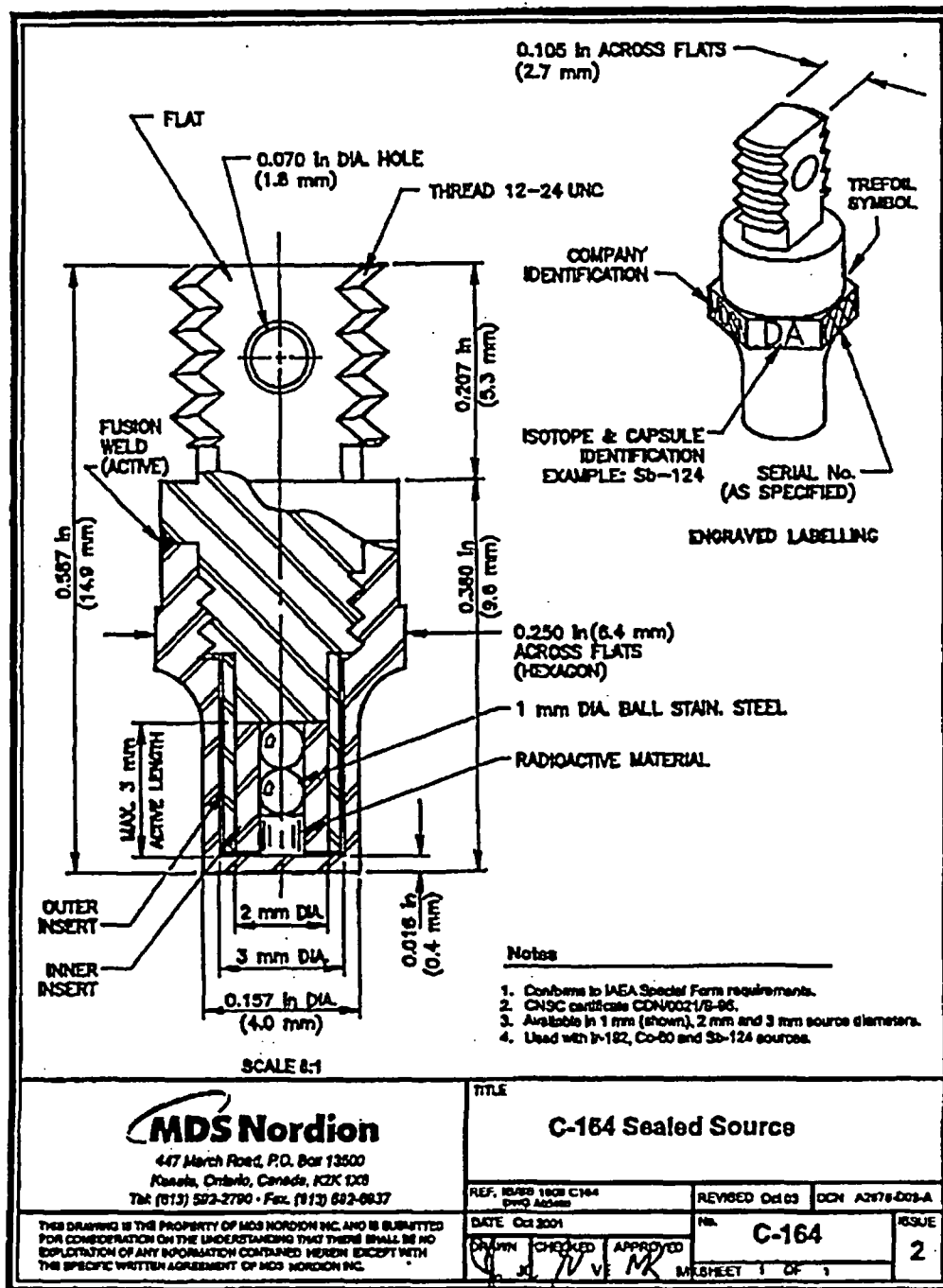
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APPROVED
JC

BY JC

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SHEET 1 OF 1





Certificat

pour
matière radioactive sous forme spéciale

Numéro du certificat CDN/0021/S-96 (Rev. 0)	Date d'émission 3 décembre 2003	Date d'expiration 30 novembre 2007	Dossier de la CCSN 30-A2-187-0
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La matière radioactive sous forme spéciale, décrite dans le présent certificat, est certifiée par la Commission canadienne de sûreté nucléaires, en vertu de l'alinéa 21(1)(h) de la *Loi sur la sûreté et la réglementation nucléaire* du Canada, de l'article 7 du *Règlement sur l'emballage et le transport des substances nucléaires* du Canada et du *Règlement de transport des matières radioactives* de l'Agence internationale de l'énergie atomique (édition de 1996, révisée).

IDENTIFICATION DE LA CAPSULE

Fabrication **MDS Nordion**
Marque/modèle **C-164 et XC-234**

DESCRIPTION DE LA CAPSULE

La capsule C-164 montrée au dessin n° A05488 (version F) et la capsule XC-234 qui apparaît au dessin n° 07516 (version F) sont des sources encapsulées, scellées et soudées par fusion. La capsule C-164 est haute de 14,9 mm, les substances radioactives qu'elle referme sont contenues dans un cylindre d'un diamètre de 4 mm. Pour faciliter son installation, elle possède une extrémité filetée et une bague hexagonale dont les plats sont large de 6,4 mm. La capsule XC-234 est cylindrique, son diamètre maximal est de 6,1 mm et sa hauteur maximale 9,8 mm. Les sources scellées sont montrées sur les dessins, ci-joints, n° C-164 (version 2) et n° XC-234 (version 1).

CONTENU RADIOACTIF AUTORISÉ

Les capsules ne peuvent contenir plus de 1 850 GBq (50 Ci) de cobalt 60 ou 18,5 TBq (500 Ci) d'iridium 192 ou 37 GBq (1 Ci) d'antimoine 124, sous forme de pastilles métalliques solides.



Numéro du certificat CDN/0021/S-96 (Rév. 0)	Date d'émission 3 décembre 2003	Date d'expiration 30 novembre 2007	Dossier de la CCSN 30-A2-187-0
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ASSURANCE DE LA QUALITÉ

L'assurance de la qualité pour la conception, la fabrication, les épreuves, l'établissement des documents, l'utilisation, l'entretien et l'inspection du capsule doit être en conformité avec :

- Procédure n° IN/QA 0562 A000 (3)*, *Sealed Source Quality Plan*, de MDS Nordion
- *Règlement sur l'emballage et le transport des substances nucléaires* du Canada
- *Règlement de l'AIEA*

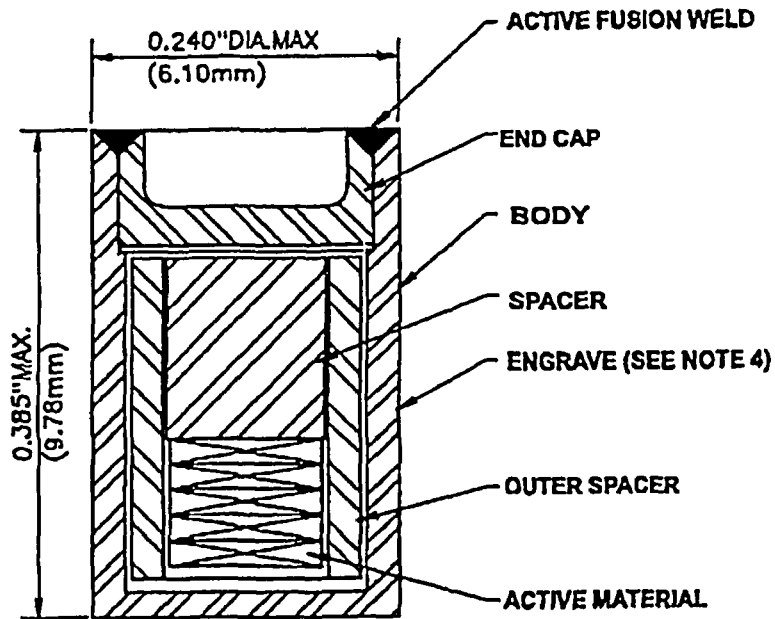
* ou sa version la plus récente.

P. Nelson

Agent désigné en vertu de l'alinéa 37(2)(a) de la
Loi sur la sûreté et la réglementation nucléaires

NOTES

Révision 0 : 2 décembre 2003, version originale.



Notes

1. Conforms to IAEA Special Form requirements.
2. CHSC certificate CDN0021/S-96.
3. Capsule Material: Stainless Steel, Type 316L.
4. Capsule Engraved: MDSN
B D
Serial No. (As Specified)

MDS Nordion

447 March Road, P.O. Box 13500
Kamato, Ontario, Canada, K2K 1X8
Tel: (613) 692-2790 • Fax: (613) 692-6937

TITLE

XC-234 Capsule Assembly

REF. 15/23 1977 C334
A07819

REVISED OCT 83 DCN A2678-003-A

DATE OCT 2003

No. **XC-234**

ISSUE

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SHEET 1 OF 1

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