International Isotopes Inc.

March 4, 2008

Mr. Rick Boyle

U.S. Department of Transportation
Office of Hazardous Materials Technology
PHH-23 Radioactive Materials
1200 New Jersey Ave., SE East Building, 2nd Floor
Washington, D.C. 20590-0001

Subject: Request to Revalidate AUS/2007-13/B(U)-96

Dear Mr. Boyle,

In accordance with Title 49 Code of Federal Regulations §173. 473 *Requirements for foreign-made packages*, International Isotopes Inc. requests the Department of Transportation (DOT) evaluate the Analogue & Digital Measurements P/L Model 1860A Type B(U) package, certificate number AUS/2007-13/B(U)-96 for revalidation and subsequent use for import in and export from the United States. After revalidation International Isotopes Inc. requests to be acknowledged as a Registered User of this cask. The following documents in electronic format are provided to support this request:

Certificate_AUS-2007-13B(U)0-96.pdf
AD_M_QA_Manual.pdf
Model1860_Safety_Analysis_Rev1_10.pdf

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

Sincerely,

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

JJM-2008-05

CERTIFICATE OF APPROVAL OF A PACKAGE DESIGN

AUS/2007-13/B(U)-96

1. TYPE OF CERTIFICATE

This is a package design approval certificate for transport of radioactive material.

2. COMPETENT AUTHORITY IDENTIFICATION MARK

AUS/2007-13/B(U)-96

3. CERTIFICATE ISSUE DATE AND EXPIRY DATE

The issue date of this certificate is 14 December 2007. The expiry date of this certificate is 14 December 2010.

4. TRANSPORT RESTRICTIONS

a. All users of this certificate shall comply with the limits and restrictions as described in the Analogue and Digital Measurements P/L Model 1860A Type B(U) Package Safety Analysis, Revision 1.10 of 28 September 2007.
b. The Analogue and Digital Measurements P/L Model 1860A package design is only authorized for transport by road and rail.

5. NATIONAL AND INTERNATIONAL REGULATIONS

The 1860A package design is authorised as a B(U) type package in accordance with the requirements of the:

a. Code of Practice for Safe Transport of Radioactive Material 2001, Radiation Protection Series No. 2 issued by the Australian Radiation Protection and Nuclear Safety Agency,
b. International Atomic Energy Agency, Regulations for the Safe Transport of Radioactive Material 2005 Edition (TS-R-1).

6. CONSIGNOR OBLIGATIONS

This certificate does not relieve the consignor from compliance with any requirement of the government of any country through or into which the package will be transported.

7. PACKAGE IDENTIFICATION

a. Designer: Analogue and Digital Measurements P/L, Australia
b. Model: 1860A

8. PACKAGE DESCRIPTION AND DESIGN

The 1860A package and drawings are described in Appendix 1, 3 and 4 respectively. The package containment system is described in Appendix 1.

9. AUTHORIZED RADIOACTIVE CONTENTS

The 1860A package is not authorised to contain fissile material. The authorized radioactive contents of the 1860A package are described in Appendix 2 and are only to be in solid special form.

10. OPERATIONAL CONTROLS

All users of this certificate shall comply with the operational controls for preparation, loading, carriage, unloading and handling of the consignment, and stowage provisions for the safe dissipation of heat, as well as use of the packaging and specific actions to be taken prior to shipment as described in the Analogue and Digital Measurements P/L Model 1860A Type B(U) Package Safety Analysis, Revision 1.10 of 28 September 2007 from A&DM.

11. ACTIONS PRIOR TO SHIPMENT

All users of this certificate shall register their identity in writing with the relevant competent authorities prior to the use of this certificate and shall certify that they possess the instructions necessary for preparation of the package prior to shipment.

12. QUALITY ASSURANCE

All records of Quality Assurance activities required by paragraph 310 of the Australian Radiation Protection and Nuclear Safety Agency, Code of Practice for Safe Transport of Radioactive Material 2001, Radiation Protection Series No. 2 or paragraph 306 of the International Atomic Energy Agency, Regulations for the Safe Transport of Radioactive Material 2005 Edition (TS-R-1), shall be appropriately maintained and made available to relevant competent authorities.

13. NOTIFICATION AND REGISTRATION OF SERIAL NUMBERS

Package serial numbers shall be documented and maintained in an appropriate quality format by all users of this certificate. Should a package be disposed of or if there is a change of package ownership, this must be notified to the relevant competent authorities. Accordingly, the party relinquishing ownership of a package shall forward the name of the new owner to the relevant competent authorities.

14. EMERGENCY ARRANGEMENTS

All users of this certificate shall comply with emergency arrangements as described in the Analogue and Digital Measurements P/L Model 1860A Type B(U) Package Safety Analysis, Revision 1.10 of 28 September 2007 from A&DM.

ISSUED at SYDNEY, this 14th day of December 2007.

John Loy
Chief Executive Officer
Australian Radiation Protection and Nuclear Safety Agency

Designated Competent Authority for the Commonwealth of Australia for inland surface transport

Certificate Number:	Certificate Expiry Date:	ARPANSA File:
AUS/2007-13/B(U)-96	**14 December 2010**	**S2007/00531**

SUMMARY OF THE CERTIFICATE ISSUES

Revision Number	Issue Date	Expiry Date	Certificate Identification	Reason for Revision
0	14 December 2007	14 December 2010	AUS/2007-13/B(U)-96	First publication

14/12/07

APPENDIX 1

1. DESCRIPTION OF THE PACKAGE

The 1860A package is designed, fabricated, inspected, tested, maintained and used in accordance with the report Model 1860A Type B(U) Package Safety Analysis, Revision 1.10 of 28 September 2007 from Analogue and Digital Measurements P/L . The 1860A package consists of six configurations, namely, A to F.

The package, composed of a cylindrical core with conic ends and an outer cylindrical crumple structure, are both made of stainless steel grade 316 and presented in Appendix 3 and 4. The package shielding material consists of lead, tungsten and stainless steel.

1.1 CONTAINMENT SYSTEM

The cylindrical attenuating package inner core with conic ends and an internal drawer with end caps constitute the "containment system". The crumple structure consists of twelve stainless steel fins welded onto the containment system with stainless steel mesh welded onto the fins exterior. The two crumple structure ends are attached with stainless steel bolts to the fins.

1.2 DRAWER SYSTEM

The transported radioactive material is placed in a drawer in the centre of the package and it is accessible from both ends. The drawers are not pressurized.

1.3 SPECIFICATIONS

The primary measurements and configurations specifications of the 1860A package are as follows:

Shape:	Cylindrical body containing cylindrical inner core with conic ends
Unloaded Mass:	980 to 1020 kg
Max. Dimensions (L x W x H):	907 mm x 867 mm x 869 mm
Max. diameter of outer crumple structure	768 mm
Max. diameter of inner cylindrical core with conic ends	460 mm
Configuration A	64 mm Round Drawer, Point Source, Lead filled, 980 kg
Configuration B	64 mm Round Drawer, Point Source, Ø150 mm and 100 mm long Tungsten Attenuator + Lead filled shell, 990 kg
Configuration C	64 mm Round Drawer, Point Source, Ø200 mm and 100 mm long Tungsten Attenuator + Lead filled shell, 1000 kg
Configuration D	64 mm Round Drawer, Pencil Source, Ø200 mm and 210 mm long Tungsten Attenuator + Lead filled shell, 1020 kg
Configuration E	75 mm Square Drawer, Point Source, 135 mm square and 100 mm long Tungsten Attenuator + Lead filled shell, 990 kg
Configuration F	75 mm Square Drawer, Point Source, 185 mm square and 100 mm long Tungsten Attenuator + Lead filled shell, 1000 kg

APPENDIX 3

GENERAL DRAWING OF THE 1860A PACKAGE

Figure Withheld Under 10 CFR 2.390

DRAWN Lachlan Grogan	27/02/2006	Analogue & Digital Measurements P/L http://admeasure.com.au	
ENGINEERING CHECKED ETP	23/11/2007	Project / Model 1860A	
DRAWING QA CHECK Lachlan Grogan	23/11/2007	Component Number 1860A-01-000	
TOLERANCE (UNLESS SPECIFIED)	N/A mm	Component Description Transport Cask Assembly	
APPROVED By Lachlan Grogan at 3:48 pm, Nov 26, 2007		Drawing Description General Layout - All Configurations	
		SIZE A3 SCALE N.T.S DWG NO 1860A-01-000-02 SHEET 1 OF 2 REV 3	

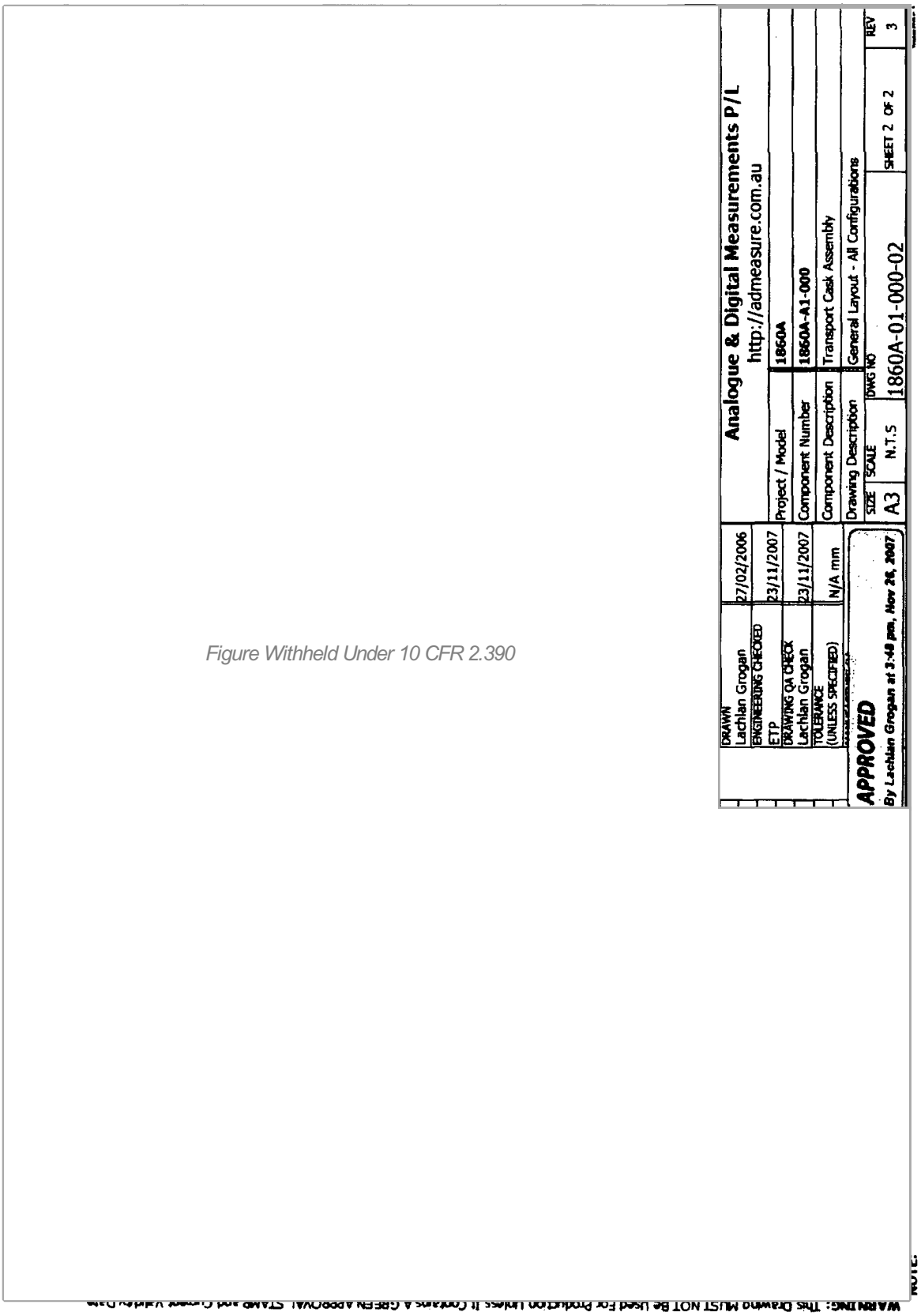
WARNING: This Drawing MUST NOT Be Used For Production Unless It Contains A GREEN APPROVAL STAMP And Current Validity Date

14/12/07

Certificate Number:	Certificate Expiry Date:	ARPANSA File:
AUS/2007-13/B(U)-96	14 December 2010	S2007/00531

APPENDIX 4

CONFIGURATIONS 'A' TO 'F' DRAWINGS OF THE 1860A PACKAGE



14/12/07

Certificate Number:	Certificate Expiry Date:	ARPANSA File:
AUS/2007-13/B(U)-96	**14 December 2010**	**S2007/00531**

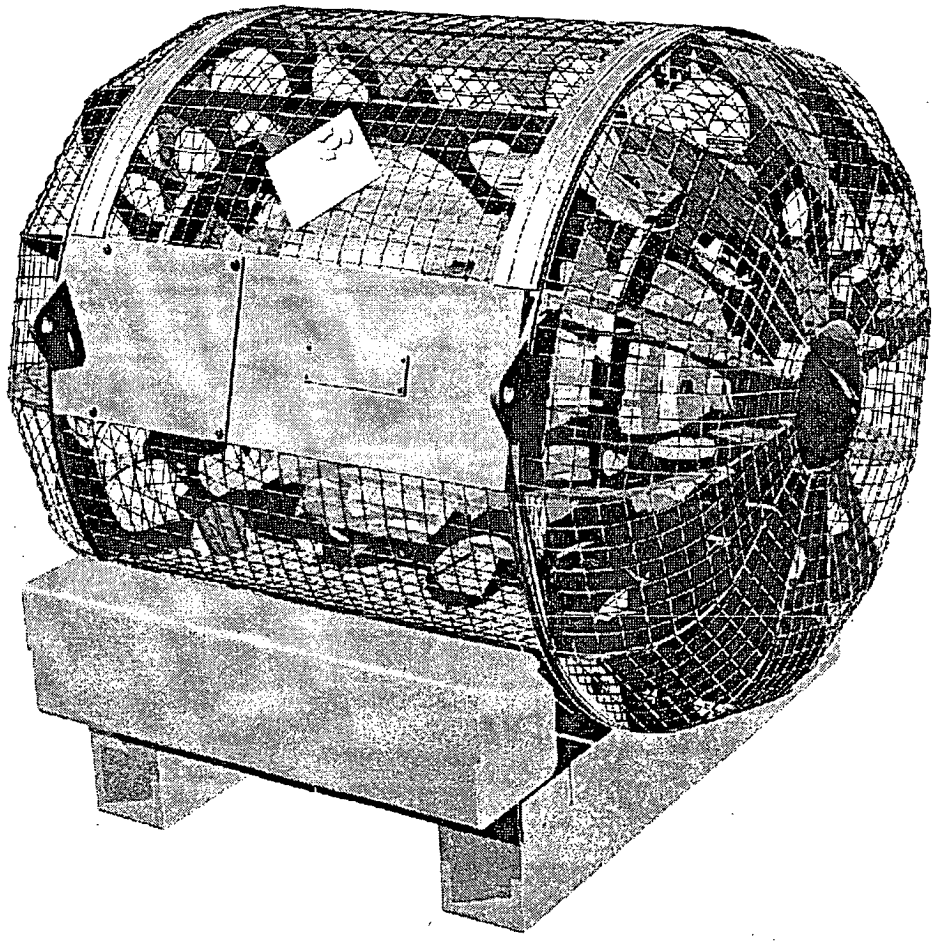
Analogue & Digital Measurements P/L
ABN: 57 005 531 484

http://admeasure.com.au
sales@admeasure.com.au

27 Cumberland Drive
Seaford, 3198
Victoria Australia

Ph: 03 8770 6500
Fax: 03 8770 6590

MODEL 1860 TYPE B(U) PACKAGE SAFETY ANALYSIS, REVISION 1.10



Document Identifier:

Master_Manual_Safety_Analysis.odm

Location:

C:\admwork\Model1860\Documents\Library\Master_Manual\

Contributors:

Kieren Grogan, Nuclear Australia (kieren@nuclearaustralia.com.au)

Ted Parrott, Equipment Safety Systems (ted@eqss.com.au)

Abstract:

This document forms the safety analysis for the model 1860 type B(U) radiation transport cask.

Document Status:

Working Version, Source Safe Revision 2.3.21

Working Version, Current Document Revision 1.10

Submission Information:

Current document revision 1.10. Compiled and submitted to ARPANSA on 28th September 2007

Revision History

Revision History for this document. This section only notes major contributions by the editors. Further information may be found in VSS.

Revision	*Author*	*Notes*
1.0	Kieren Grogan	Initial document construction
1.1	Kieren Grogan	Addition of supporting documentation of the following appendices 1. Design Calculations 2. Emergency Response
1.2	Kieren Grogan	General Format for ARPANSA Submission
1.3	Kieren Grogan	Document reconstruction after ARPANSA meeting. Safety Analysis incorporate Detailed discussions and reference extensively to the following documents. Previously created in the first submission, required sections as discussed in IAEA requirements. 1. Design Calculations (Converted to electronic format) 2. Detailed Design 3. Users Manual 4. Quality Assurance 5. Emergency Response 6. All Mechanical Drawings
1.4	Kieren Grogan	Dynamic references to all appropriate documentation used in aid of the safety analysis. Each document in the set has been referenced, such that the order of documents no longer matters, all links and references remain constant. All link and references check for accuracy and dynamic stability.
1.5	Kieren Grogan	Addition of design calculations, reformat into electronic version. Layout of equation enhanced to reduce complexity.
1.6	Kieren Grogan	1. Removal of special from specifications. See Model 1860 Type B(U) Package Specifications on page 19 2. Update 226Ra Transport Index in equation summary. See Configuration C on page 49 3. Included a summary of all equations in design calculations section of safety analysis. See Design Calculations Summary on page 47

Revision	*Author*	*Notes*
		4. Addition of tie down point stress analysis, refer to Tie Down Point Stress Analysis on page 85. 5. Addition to equations of configurations A to F, addition for transport index calculation for maximum approved loadings as given in the package specifications (package data sheet). See Model 1860 Type B(U) Package Specifications on page 19 6. Dose rate decreased by a factor of 3 Page 89 equation. See maximum loading for each pencil on page 132 7. Emergency response objected modified to include statement that the emergency response plan must be carried at all times during transport. See carried with the package at all times on page 157 8. Page 86 design calculations, configuration D, equation 1, addition of transport index 1 meter from the package. See Calculation 1, Field From End Source on page 128
1.7	Kieren Grogan	1. Model 1860 Users manual page 190, addition of travel documents include package users manual & emergency response plan and each shipment. See Travel Documents on page 241 2. Model 1860 users manual section of source loading, addition of procedure for source loading / unloading from transport cask to transport cask to satisfy an emergency condition where a source may need to be transferred from a damaged cask. See Cask to Cask Transfer on page 269 3. Emergency response transport incident drop paragraph 5 refer to cask to cask transfer procedure. See field transfer to a new cask on page 164 4. All equations that use attenuation data from the Amersham curves in appendix 2 have been referenced back to appendix 2. Addition supporting reference information has been added to design calculations and appendix 2. See Material Attenuation on page 81 and all

Revision	*Author*	*Notes*
		throughout design calculations where attenuation data is used. 5. Addition of applicable standards Applicable Standards on page 21.
1.8	Kieren Grogan	1. Revamp of cask to cask transfer procedure to include the use of specific tools. Also to state procedure should only be made by A&DM engineers. See Cask to Cask Transfer on page 269 2. Inclusion of special tool drawings within drawing set. See *Drawing Section "Special Tools"* 3. When the package is loaded, a radiation survey is required before shipment, also the transport index must be calculated overview of procedures added. See Radiation Field Survey & Transport Index on page 238, also see obtain the Transport Index on page 246. 4. Inclusion of instructions for emergency situations where device tamper has occurred. See Transport incident (Tamper) on page 169. 5. Inclusion of instructions and procedures for emergency response when high contamination is found. See Transport Incident (High Contamination) on page 171 6. Inclusion of instructions for wipe test procedure in users manual. See Wipe Testing on page 242. 7. General format and edit.
1.9	Kieren Grogan	1. Inclusion of staffing level and required staff skill level. See Operator Skills on page 257. 2. Reference to the requirement of the emergency response plan. See Travel Documents on page 241 3. Inclusion of creditable accident analysis. See Credible Accident Analysis. on page 65 4. Justification of why test 727(c) is void. See 727(c) on page 224 5. Inclusion of 728(b) thermal calculations. See Thermal Analysis, Cooling of the Package, IAEA Clause 728(b) on page 97. See Thermal Test Calculation (IAEA regulation 728b) on

Revision	*Author*	*Notes*
		page 58. See Applicable Destructive Tests on page 226. 6. Reference definition on compliance method, of reasoned argument. See section Test Procedures on page 213. 7. Various inclusions of "O ring" changed to "metalflex gasket", reflecting the design changes as in Non Special Form Pressure Seal on page 46.
1.10	Kieren Grogan	1. Specific heat coefficient of lead units changed to kJ/kg/K. See 0.129kJ/Kg.K on page 97 2. Included thermal calculation for attenuator temperature after 30mins. See average temperature of the lead attenuator on page 98 3. Include the of internal source, in the thermal calculation for 728(b). See Attenuator temperature on page 97 4. Inclusion of the Properties of Lead. See Appendix 3. 5. Impact calculations to justify drop test 727(c). See Impact Analysis IAEA Clause 727(c) on page 89 6. Inclusion of drop test 727(c) calculation conclusion in Safety Analysis. See Drop Test Calculation (IAEA regulation 727c) on page 57 7. Inclusion of thermal calculation results & reference to design equations. See Package Thermal Analysis on page 47 8. Inclusion of top fin stress analysis and simulation results. See Top Fin Structural Analysis & Simulation on page 48 9. Updated package size specifications. See Size and Weight on page 33 and 19 10.Update of revision number / documentdetails. 11.Inclusion of internal pressure warning throughout upload procedures. See Source Up-Loading (Hot Cell) on page 259 12.Inclusion of stacking hazards. See Stacking on page 252 13.Update of of maximum loading values in Ci. SeeModel 1860 Type B(U) Package Specifications on page 19

Controlled Document

DO NOT make copies of this document. The latest version of this document (Master_Manual_Safety_Analysis) may be obtained from the following location(s):

Location	*Path*
1 - VSS	₩admwork₩model1860₩documents₩library₩
2 - Server	₩₩eqss-server-01₩admwork₩model1860₩documents₩library₩
3 - Web	http://admeasure.com.au

This document has been issued to the following parties:

Issue	*Party*	*Reason*
1	ARPANSA	Safety Analysis, for type B(U) package approval
2	ARPANSA	Document Revision 1.10. Submitted on the 28th September 2007

Documentation Conventions

The list below highlights important documentation conventions.

Text presented in this manner is intended to provide the user with some general information. The user should ensure information presented in this manner is clearly understood.

Text presented in this manner provides the user with information to assist in completion of the current procedure being explained.

Text presented in this manner indicates that further actions are required by the user.

Text presented in this manner indicates that a failure to follow directions could result in damage to equipment, loss of information, bodily harm, or loss of life.

Important Information

Information contained in this publication regarding this device(s) applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications.

ANALOGUE & DIGITAL MEASUREMENTS P/L MAKE NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE.

ANALOGUE & DIGITAL MEASUREMENTS P/L disclaims all liability arising from this information and its use. ANALOGUE & DIGITAL MEASUREMENTS P/L's products as critical components in life support systems is not authorized except with express written approval by ANALOGUE & DIGITAL MEASUREMENTS P/L. No licenses are conveyed, implicitly or otherwise, under any ANALOGUE & DIGITAL MEASUREMENTS P/L intellectual property rights.

Table of Contents

Applicable Standards....21
Forward....21
Manufacturing & Documentation Standards....21
Manufacturing Material Standards....21
Lifting and Tie Down Equipment Standards....22
Lifting and Tie Down Mechanical Design Standards....22
Transportation Standards....23

Reason for the Design....24

Concept and Definition....25
Design Criteria, IAEA Requirements....25
General Requirements for all packages....25
General Requirements for Air Transport....26
General Requirements for Type A Packages....27
General Requirements for Type B(U) Packages....28
Design Criteria, Commercial Requirements....29
Design Parameters....30

Design....32
Design And Documentation Standards....32
Construction Material....32
Size and Weight....33
Isotope Attenuation....35
Attenuating Material (Lead)....35
Attenuating Material (Tungsten)....35
Attenuating Configurations....35
Crumple Shield....38
End Shields....41
Fork Lift Skid Design....43
End Caps & Wipe Testing Ports....44
Shine Shields....45
Non Special Form Pressure Seal....46

Design Calculations Summary....47
Lifting Stress Analysis....47
Tie Down Points Stress Analysis....47
Package Thermal Analysis....47
Top Fin Structural Analysis & Simulation....48
External Radiation Levels & Transport Index....48
Configuration A....48
Configuration B....48

Configuration C....49
Configuration D....49
Configuration E....50
Configuration F....50

Quality Assurance....52
Design....52
Manufacture....52
Testing....53
Documentation....53
Product Usage....53
Maintenance & Inspection....53

Design Testing....54
Design Features for Incident Survival....54
Prototype Construction....55
Materials....55
Fabrication....55
Destructive Testing....56
Demonstration of Compliance....56
Destructive Tests....57
Test Schedule....58
Test Equipment....58
Drop Test Procedure (IAEA regulation 722)....58
Drop Test Procedure (IAEA regulation 727a)....58
Drop Test Procedure (IAEA regulation 727b)....58
Drop Test Calculation (IAEA regulation 727c)....58
Thermal Test Procedure (IAEA regulation 728a)....59
Thermal Test Calculation (IAEA regulation 728b)....59
Official Destructive Test Report....60
Test Report Purpose....60
Test Report Scope....60
Test Report Conclusions....60

Operational....61
First Use Testing....61
Conditions of Normal use....63
Maximum Contents....64
General Transportation of the Package....65
Transportation (Forklift)....65
Transportation (Crane)....65
Transportation (Road)....65
Transportation (Air)....65

Credible Accident Analysis....66

Collision....66
Fire....68

Perceived Hazards....71
Leaking Source....71
Source Uploading and Downloading....72
Field Transfers....74
Transport Hazards....75
Communications....76
Drop Incident....76
Fire Incident....77
Theft Incident....77
Tamper Incident....77

Inspection & Maintenance....78
Pre Transport Inspection....78
Dispatch Inspection Check List....79
Dispatch Documentation Check List....80
Maintenance....81

Detailed Design Calculations....82
Material Attenuation....82
Calculation Constants....83
Attenuating Material Data....83
Air Kerma....83
Practical Limits....83
Lifting Stress On Top Support Fin....84
Calculation 1, Lifting Hole Strength....84
Calculation 2, Weld Strength....85
Tie Down Point Stress Analysis....86
Impact Analysis IAEA Clause 727(c)....90
Overview....90
Energy absorbed by crumple fins....91
Package Deformation....97
Conclusion....97
Thermal Analysis, Cooling of the Package, IAEA Clause 728(b)....98
Calculation....98
Conclusion....102
Configuration A, Equations for 60Co....103
Loading Calculations....103
Transport Index for Approved Loading of 1080Ci....105
Configuration A, Maximum Loading for 137Cs....106
Loading Calculations....106
Transport Index for Approved Loading of 27000Ci....108
Configuration A, Maximum Loading for 226Ra....109

Loading Calculations....109
Transport Index for Approved Loading of 1000Ci....111
Configuration A, Maximum Loading for 192Ir....112
Loading Calculations....112
Transport Index for Approved Loading of 50000Ci....114
Configuration B, Maximum Loading for 60Co....115
Loading Calculations....115
Transport Index for Approved Loading of 3100Ci....117
Configuration B, Maximum Loading for 137Cs....117
Loading Calculations....117
Transport Index for Approved Loading of 27000Ci....117
Configuration B, Maximum Loading for 226Ra....118
Loading Calculations....118
Transport Index for Approved Loading of 1000Ci....118
Configuration B, Maximum Loading for 192Ir....118
Loading Calculations....118
Transport Index for Approved Loading of 50000Ci....118
Configuration B, Maximum Side Loading for 60Co....119
Loading Calculations....119
Configuration C, Maximum Loading for 60Co....121
Loading Calculations....121
Transport Index for Approved Loading of 12160Ci....123
Configuration C, Maximum Loading for 137Cs....123
Loading Calculations....123
Transport Index for Approved Loading of 27000Ci....123
Configuration C, Maximum Loading for 226Ra....124
Loading Calculations....124
Transport Index for Approved Loading of 1000Ci....124
Configuration C, Maximum Loading for 192Ir....124
Loading Calculations....124
Transport Index for Approved Loading of 50000Ci....124
Configuration C, Maximum Side Loading for 60Co....124
Loading Calculations....124
Configuration D, Maximum Loading for 60Co....125
Loading Calculations....125
Transport Index for Approved Loading of 15100Ci....127
Configuration D, Maximum Loading for 137Cs....127
Loading Calculations....127
Transport Index for Approved Loading of 27000Ci....127
Configuration D, Maximum Loading for 226Ra....128
Loading Calculations....128
Transport Index for Approved Loading of 1000Ci....128
Configuration D, Maximum Loading for 192Ir....128
Loading Calculations....128

Transport Index for Approved Loading of 50000Ci....128
Calculation 1, Field From End Source....129
Calculation 2, Field Strength from 60Co Pencil....131
Calculation 3, Maximum Loading Through End from 60Co Pencil....132
Configuration E, Maximum Loading for 60Co....135
Loading Calculations....135
Transport Index for Approved Loading of 1080Ci....137
Configuration E, Maximum Loading for 137Cs....137
Loading Calculations....137
Transport Index for Approved Loading of 27000Ci....137
Configuration E, Maximum Loading for 226Ra....138
Loading Calculations....138
Transport Index for Approved Loading of 1000Ci....138
Configuration E, Maximum Loading for 192Ir....138
Loading Calculations....138
Transport Index for Approved Loading of 50000Ci....138
Configuration F, Maximum Loading for 60Co....139
Loading Calculations....139
Transport Index for Approved Loading of 3100Ci....141
Configuration F, Maximum Loading for 137Cs....141
Loading Calculations....141
Transport Index for Approved Loading of 27000Ci....141
Configuration F, Maximum Loading for 226Ra....142
Loading Calculations....142
Transport Index for Approved Loading of 1000Ci....142
Configuration F, Maximum Loading for 192Ir....142
Loading Calculations....142
Transport Index for Approved Loading of 50000Ci....142

Detailed Design....143
Reason For Design (Local)....143
Reason For Design (International)....143
Design Solution....144
Design Investigation....146
Specifications....146
Construction Materials....147
Stage One Decisions....148
Size and Weight....148
Calculations....148
Attenuating Material....148
Radiation Attenuation....149
Crumple Shield....149
End Shields....149
Heat Transfer....149

Rigidity....150
Lifting Points....150
Forklift Skids....150
Tie-Down Points....150
Placarding....150
Initial Drawings....151
Decision to build the prototype....151
Suppliers....151
Construction....151
Regulators....152
Test Laboratory....152
IATA Test Requirements....152
Change of the Design Code....152
IAEA TS-R-1....153
IAEA TS-R-1 General Requirements....153
IAEA Test Requirements....153
Decision to Test....153
Testing....154
Test Results....154
Radiation Management....154
Engineering Training Manual....154
IAEA TS-R-1 Quality Assurance....155
A&DM Q.A. Program....155
Variations....155
Sequential QA....155
Review....155

Emergency Response Plan....157
Introduction....157
Background....157
Objective....158
Responsibilities of Consignors and Carriers....159
Chain of Communications....160
Transport Incident (Drop)....163
Transport incident (Fire)....166
Transport incident (Theft)....169
Transport incident (Tamper)....170
Transport Incident (High Contamination)....172

Quality Assurance Programme....173
Introduction....173
Document Requirements....173
Structure Composition....174
QAP - Design....175
Development Cycle....175

Design Methodologies....176
Responsibilities of the Engineers....177
Regulatory Authority Compliance....178
Organisational Interfaces....178
Performance inputs....179
Outputs (Design Regulation Compliance)....179
Verification....180
Control Of Changes....181
Technical Drawings....182
Mark Number....182
Approved for Manufacture....182
Drawing Numbering System....182
Drawing Number....183
Design Flow Control....184
QAP - Manufacture....189
Purchasing....189
Direct Shipping....189
Qualified Vendors....189
Subcontractors....189
Material Suppliers....190
Tungsten....190
Fasteners....190
Stainless Steel....190
Subcontractors....191
Laser Cutting....191
Machining....191
Sheet Fabrication....191
Lead Pouring....191
Product Design....192
Fabrication....192
Procedure for Ordering Materials and Vendor Parts....193
Engineering....193
Purchasing....193
Receipt of Materials....193
Construction Procedures....194
Ordering Of Component Parts....194
Manufacturing Of Component Parts....194
Assemblies....195
QAP - Testing....196
Design Testing....196
QAP - Documentation....197
Documentation Standards....197
QAP - Use....198
Requirements Before Use....198

User Manual Documentation....198
QAP - Maintenance & inspection....199

Maintenance And Inspection Manual....200
Introduction....200
General Warning....201
Inspection and Maintenance....202
Pre Transport....202
Pre Transport Check List - Unloaded (UN2908)....203
Post Transport Check List - Unloaded (UN2908)....204
Pre Transport Check List - Loaded (UN2916)....205
Post Transport Check List - Loaded (UN2916)....206
End of Mission Inspection....208
Tool Box Content Inspection....209
Dispatch Documentation Check-list....210
Dispatch Inspection Check-list....211
Post Transport....212
Minor Repairs....212
Major Repairs....213

Test Procedures....215
Introduction....215
Demonstration of Compliance....215
Test Selections and Justification....216
General Requirements for all Packages....217
Additional Requirements for Air Transport....219
Requirements for Type A Packages....220
Requirements for Type B(U) Packages....222
Preparation of Package Before Testing....224
Testing for Normal Transport Conditions....225
Testing for Transport Accident Conditions....226
Applicable Destructive Tests....228
Destructive Testing Procedure....229
Purpose....229
Scope....229
Test Schedule....229
Equipment....230
Equipment Set up....231
Drop Test # 1 Procedure....232
Drop Test # 2 Procedures....232
Drop Test # 3 Procedure....234
Thermal Test Procedure....234

Engineering Users Manual....236
Introduction....236

Sections....237
General Warning....238
First Use, Maximum Activity Determination....239
Radiation Field Survey & Transport Index....240
Conducting the Field Survey....240
Calculating the Transport Index....240
Standard Radiation Field Survey Form....241
Tool Box Accessory's....242
Travel Documents....243
Wipe Testing....244
Pre-shipment Checks, Outbound Empty (UN2908)....245
Pre-Shipment Checks, Return Empty (UN2908)....246
Receival Checks, Empty (UN2908)....247
Pre-Shipment Checks, Outbound Loaded (UN2916)....248
Receival Checks, Loaded (UN2916)....250
End of Mission Inspection....252
Transport....254
Fork Lift Handling....254
Crane Handling....255
Cask Tie Down (Road Transport)....256
Cask Tie Down (Air Transport)....257
Operator Skills....258
Overview....258
Staffing Level....258
Prerequisite Experience....259
Source Up-Loading (Hot Cell)....260
Source Down-Loading (Hot Cell)....263
Water Bath Downloading....265
Water Bath Uploading....266
Therapy Head Transfer (Upload)....267
Therapy Head Transfer (Download)....268
Cask to Cask Transfer....269

Model 1860 Type B(U) Package Specifications

Date	7th June 2007
Type	Type B(U) Transport Cask
Model	1860
Manufacture	Analogue & Digital Measurements Pty Ltd
Model number(s)	1860A through to 1860F

Maximum Loading

Isotope	Max Loading (Ci)	Max Loading (TBq)	Physical Form	Special Form Certification	Package Configuration
^{137}Cs	27027	1000.00	Solid	Yes	A -> F
^{60}Co	1081	40.00	Solid	Yes	A
^{60}Co	3108	115.00	Solid	Yes	B
^{60}Co	12162	450.00	Solid	Yes	C
^{60}Co	15135	560.00	Solid	Yes	D
^{60}Co	1081	40.00	Solid	Yes	E
^{60}Co	3108	115.00	Solid	Yes	F
^{192}Ir	50000	1850.00	Solid	Yes	A -> F
^{226}Ra	1000	37.00	Solid	Yes	A -> F

Energy dissipation	250 W

Size and Weight

Package Configuration	Dimensions LxWxH (mm)	Unloaded Mass (Kg's)
Model 1860A	907 x 867 x 869	980
Model 1860B	907 x 867 x 869	990
Model 1860C	907 x 867 x 869	1000
Model 1860D	907 x 867 x 869	1020
Model 1860E	907 x 867 x 869	990
Model 1860F	907 x 867 x 869	1000

The 1860 transport cask has been designed to meet and exceed the general use, functionality and testing requirements for a type B(U) package as specified in the *International Atomic Energy Agency Safety Standard Series document, "The Regulations for the Safe Transport of Radioactive Material 1996 Edition (As Amended 2003)"*

This document outlines the facets of the design, the steps taken to meet the design requirements as specified by the IAEA, and the procedures developed to ensure safe use under all conditions of transport and general use.

Applicable Standards

Forward

The standards used in the design, construction and general operation of the model 1860 type B(U) package are current at the date of the package approval. Users of the package should not act on the basis of the standards quoted in this documentation without reference to the applicable laws, regulations and standards that apply in the specific locality intended for use of the package.

Manufacturing & Documentation Standards

The procedures and standards used in the manufacture of the model 1860 type B(U) package are as set out in the Analogue and Digital Measurements Quality Assurance manual. The Analogue and Digital Measurements Quality Assurance manual is constructed around the following standards. The design of the package follows the standards and regulations as set out by the IAEA.

Standard	Description
ISO 9001-2000	Quality management systems. For documentation, design through to production, encompasses the entire design life cycle.
IAEA TS-R-1 Section 6 of "Regulations for the safe transport of Radioactive Materials"	Section 6 defines the design criteria for the model 1860 type B(U) package. Refer to Design Criteria, IAEA Requirements on page 25 for a description of the applicable regulations.

Manufacturing Material Standards

The materials used in the manufacture of the model 1860 type B(U) package comply with the following standards.

Standard	Description.
ASTM A240/A240M	Standard for stainless steel plate.
ASTM A276	Standard for stainless steel bar.
ISO 3506	Standard for fasteners.

Lifting and Tie Down Equipment Standards

Use of all lifting equipment should be conducted in accordance with the national applicable standards where the package is located, and in conjunction with transportation company standards and internal policies which in most cases exceed the national applicable standards. Equipment supplied with the cask to enable compliant lifting and tie down meet the following standards.

Standard	Description
AS 1666	Standard for wire rope slings
AS 1353	Standard for webbing slings
AS 2741	Standard for lifting and tie down shackles
AS 2319	Standard for tie down turn buckles
AS 2321	Standard for metal tie down chains

Lifting and Tie Down Mechanical Design Standards

The lifting and tie down mechanical design is compliant with the following standards.

Standard	Description
NRC 10CFR71.45	Lifting and tie down standards for all packages.
NRC 10CFR71.45(a)	Lifting attachment that is a structural part of the package.
NRC 10CFR71.45(b1)	Tie down devices that are a structural part of the package.
NRC 10CFR71.45(b2)	All non tie down points to be rendered inoperable for tie down.
NRC 10CFR71.45(b3)	Tie down points to survive failure of the device under excessive load.

The NRC 10CFR71.45 standard for the lifting and tie down points on all packages requires compliance with parts a and b of the standard above.

Standard 10CFR71.45(a) requires any lifting attachment that is a structural part of the package must be designed with a minimum safety factor of three. Refer to Lifting Stress On Top Support Fin. on page 83 for lifting lug calculation results, for proof for standard compliance.

Standard 10CFR71.45(b1) requires all tie down devices that are a structural part of the design must be capable of withstanding a vertical force 2 times the weight of the package, a horizontal force 10 times the weight of the package, and a horizontal transverse force 5 times the weight of the package. Refer to Tie Down Point Stress Analysis on page 85 for calculation results, for proof for standard compliance.

Standard 10CFR71.45(b2) requires any other structural part of the package that could be used to tie down the package be rendered inoperable for tying down the package during transport. Compliance to this standard is made through the general design of the package. Such that the design does not include and other structural part that may be used for tying down the package. See *Drawing Section 1860A-A1* for overview of package assembly.

Standard 10CFR71.45(b3) requires that failure of the device under excessive load would not impair the ability of the package to meet requirements 10CFR71.45(a), 10CFR71.45(b1) and 10CFR71.45(b2). The package consists of four tie down lugs on the side of the package and two lifting lugs below the outer mesh on the top of the package.

- The top lifting lugs are protected by the outer mesh.
- The side tie down lugs are constructed form 8mm stainless steel plate, see *Drawing Section 1860A-01, Drawing Number 1860A-01-181-03*. These lugs have been designed to withstand the high forces on the package during transport. These lugs have been proven to stay intact after destructive testing. See ANSTO destructive test report section, page 15 and 16.

Transportation Standards

The transport of the model 1860 type B(U) package must comply in best practice with the following regulations.

Regulation	Description
IATA "Dangerous Goods Regulations" Section 1.1.2	Section 1.1.2 references to the IAEA Section 5 of "Regulations for the safe transport of Radioactive Materials"
IAEA Section 5 of "Regulations for the safe transport of Radioactive Materials"	Section 5 states the requirements and controls for transport. From start to finish.

Reason for the Design

Analogue and Digital Measurements Pty Ltd here after referred to as A&DM require a type B(U) radiation transport package to carry out a series of projects both nationally and internationally. An international search for a compliant type B(U) transport container revealed a world wide problem. The search revealed hundreds of marooned sources in their current location, as there is no compliant transport cask in which to ship them to a repository or recycle laboratory. A problem of transport with the reloading of existing equipment with new sources and the disposal of the old, coupled with the supply of new equipment containing radioactive materials also presented itself.

Ongoing discussions with A&DM business associates around the world indicated a need for a radiation transport cask that could transport up to 12000Ci of ^{60}Co point sources and up to 15000Ci of ^{60}Co in pencil form. Further research showed that Australia has a limited number of applications and by itself does not justify the expenditure of developing the radiation transport cask and associated equipment. However, our American affiliate is currently using a US -WC6 Type B Transport Cask for work in the USA and Mexico. It was estimated that the A&DM Model 1860, would enable them to complete up to 30 reloads per year with their current resources.

A&DM understand that there is a growing concern that orphan sources may fall into the hands of terrorist organisations, thus there is an urgent need to provide a safe method of transport which currently cannot be carried out due to lack of suitable equipment. The concept is that the Model 1860 design will be adaptable to many of these issues and the extensive engineering experience accompanying the design will enhance the ability to create a solution to the current issues.

The transport cask with the use of appropriate tools and procedures will enable large special form sources to be moved between a source fabrication laboratory and a field application, in the event of a source change over the cask is used to return the spent source to the laboratory for isotope recovery or disposal.

The radiation shielding properties of the Model 1860 are designed to exceed the largest ^{60}Co Source required for radiation therapy centres and laboratory irradiators. While the shielding properties of the cask would allow it's use with extremely large sources of ^{137}Cs, ^{241}Am, ^{90}Sr and ^{190}Ir practical limitations determine the maximum activity of the isotope that can physically fit into the internals of the type B(U) package.

Concept and Definition

Design Criteria, IAEA Requirements

General Requirements for all packages

The cask design criteria was developed to meet and exceed the general requirements for all type B(U) packages. The general requirements are taken directly from the *IAEA Regulations for the Safe Transport of Radioactive Material TS-R-1.* These requirements are given below in Table 1: IAEA General Design Requirements. A copy of the design requirements can be found in appendix 8 and appendix 9.

IAEA Requirement	*IAEA Reference*
606	*Regulations for the Safe Transport of Radioactive Material.* Page 76.
607	*Regulations for the Safe Transport of Radioactive Material.* Page 76.
608	*Regulations for the Safe Transport of Radioactive Material.* Page 76.
609	*Regulations for the Safe Transport of Radioactive Material.* Page 76.
610	*Regulations for the Safe Transport of Radioactive Material.* Page 76.
611	*Regulations for the Safe Transport of Radioactive Material.* Page 76.
612	*Regulations for the Safe Transport of Radioactive Material.* Page 76.
613	*Regulations for the Safe Transport of Radioactive Material.* Page 77.
614	*Regulations for the Safe Transport of Radioactive Material.* Page 77.
615	*Regulations for the Safe Transport of Radioactive Material.* Page 77.
616	*Regulations for the Safe Transport of Radioactive Material.* Page 77.

Table 1: IAEA General Design Requirements

General Requirements for Air Transport

The cask design criteria was developed to meet and exceed the general requirements for air transport, the requirements are sourced directly from the *IAEA Regulations for the Safe Transport of Radioactive Material TS-R-1.*These requirements are given below in Table 2: IAEA General Design Requirements for Air Transport.

IAEA Requirement	*IAEA Reference*
617	*Regulations for the Safe Transport of Radioactive Material.* Page 77.
618	*Regulations for the Safe Transport of Radioactive Material.* Page 77.
619	*Regulations for the Safe Transport of Radioactive Material.* Page 77.

Table 2: IAEA General Design Requirements for Air Transport

General Requirements for Type A Packages

The cask design criteria was developed to meet and exceed the general requirements for type A Packages the requirements are sourced directly from the *IAEA Regulations for the Safe Transport of Radioactive Material TS-R-1.*These requirements are given below in Table 3: IAEA General Design Requirements for Type A Packages.

IAEA Requirement	*IAEA Reference*
634	*Regulations for the Safe Transport of Radioactive Material.* Page 81.
635	*Regulations for the Safe Transport of Radioactive Material.* Page 81.
636	*Regulations for the Safe Transport of Radioactive Material.* Page 81.
637	*Regulations for the Safe Transport of Radioactive Material.* Page 81.
638	*Regulations for the Safe Transport of Radioactive Material.* Page 81.
639	*Regulations for the Safe Transport of Radioactive Material.* Page 81.
640	*Regulations for the Safe Transport of Radioactive Material.* Page 81.
641	*Regulations for the Safe Transport of Radioactive Material.* Page 81.
642	*Regulations for the Safe Transport of Radioactive Material.* Page 82.
643	*Regulations for the Safe Transport of Radioactive Material.* Page 82.
645	*Regulations for the Safe Transport of Radioactive Material.* Page 82.
646	*Regulations for the Safe Transport of Radioactive Material.* Page 82.

IAEA Requirement	*IAEA Reference*
647	*Regulations for the Safe Transport of Radioactive Material.* Page 82.
648	*Regulations for the Safe Transport of Radioactive Material.* Page 82.
649	*Regulations for the Safe Transport of Radioactive Material.* Page 83.

Table 3: IAEA General Design Requirements for Type A Packages

General Requirements for Type B(U) Packages

The cask design criteria was developed to meet and exceed the general requirements for type B(U) Packages the requirements are sourced directly from the *IAEA Regulations for the Safe Transport of Radioactive Material TS-R-1*.These requirements are given below in Table 4: IAEA General Design Requirements for Type B(U) Packages.

IAEA Requirement	*IAEA Reference*
651	*Regulations for the Safe Transport of Radioactive Material.* Page 83.
652	*Regulations for the Safe Transport of Radioactive Material.* Page 83.
653	*Regulations for the Safe Transport of Radioactive Material.* Page 83.
654	*Regulations for the Safe Transport of Radioactive Material.* Page 83.
655	*Regulations for the Safe Transport of Radioactive Material.* Page 83.
656	*Regulations for the Safe Transport of Radioactive Material.* Page 84.
657	*Regulations for the Safe Transport of Radioactive Material.* Page 85.
658	*Regulations for the Safe Transport of Radioactive Material.* Page 85.
659	*Regulations for the Safe Transport of Radioactive Material.* Page 85.

IAEA Requirement	*IAEA Reference*
660	*Regulations for the Safe Transport of Radioactive Material.* Page 85.
661	*Regulations for the Safe Transport of Radioactive Material.* Page 85.
662	*Regulations for the Safe Transport of Radioactive Material.* Page 85.
663	*Regulations for the Safe Transport of Radioactive Material.* Page 85.
664	*Regulations for the Safe Transport of Radioactive Material.* Page 85.

Table 4: IAEA General Design Requirements for Type B(U) Packages

Design Criteria, Commercial Requirements

The Model 1860 Type B(U) package is designed primarily for commercial use in both the national and international realm as discussed in Reason For Design (Local) on page 142 and in Reason For Design (International) on page 142. The commercial requirements of the Model1860 were developed by the A&DM design engineers, the commercial requirements are general design aspects to maximize usability and reduce costs to the company. These requirements are given below in Table 5: Commercial Design Requirements.

Commercial Requirement	*Description*
1	The package is to be light weight to minimise the cost of transport.
2	The attenuator must be suitable for the adaptation of either a round or square source draw.
3	The package is to be able to carry either point or pencil sources.
4	Variation of heavy metals to optimise the exterior field strength verses cost of manufacture and transport.
5	Allow for close coupling to equipment in reload situations to minimise the risks at the time of source transfer
6	Incorporate test ports to enable quick and easy source integrity testing on receipt and dispatch of the package
7	Multiple lifting and tie down methods for all areas of transport

Table 5: Commercial Design Requirements

Design Parameters

From the IAEA design requirements and the commercial design requirements a table of design parameters / features was formulated. These features shown below in Table 6: Design Parameters are referenced directly from Design Solution on page 143.

Feature	*Description*
1	Meet all the requirements for type B(U) package design.
2	Be suitable for transport by air (this requirement dictates a low surface temperature rise at maximum source activity).
3	Minimum weight/size for the maximum activity to obtain the lowest transport costs possible.
4	The design must be so designed, that the physical structure is capable of easy decontamination cleaning.
5	Be able to accommodate various internal configurations.
6	The design must be capable of handling point sources up to 12000 Ci ^{60}Co which is the maximum size source for therapy head reloads.
7	The design must be capable of handling pencil sources up to 15000 Ci ^{60}Co
8	The design must be capable of being constructed with variations to the internal attenuating material to minimize the cost of manufacture for a cask with less than the design maximum capability.
9	The design must be capable of being constructed with variations to the internal attenuating material to minimize the transport index for special circumstances.
10	The design must be capable of being mated to existing equipment to enable easy transfer of sources/source drawers.
11	In the event of damage to the cask it must be easily repaired to enable a shipment to continue.
12	Tie-down points for road or container use must be positioned so that damage cannot occur to the cask during normal use and be simple enough to not require lengthy explanation of use.
13	For air transport the cask has to have the additional tie down provision to use webbing straps
14	The cask must have provision to be lifted using a crane i.e. lift points for connection of shackles.
15	The cask must be capable of being handled with a fork lift.

Feature	*Description*
16	Labelling procedures must be relatively easy to use but difficult to deface.
17	Labelling must be such that it cannot be lost during disaster extremes.
18	Provision must be made to affix to either side a name plate with isotope description, this name plate must have the same qualities as the placarding.
19	Protective devices at the ends must be removable.
20	Any tools, tie down or special equipment must be carried on board.
21	End access plates must be tamper proof.
22	Access at each end to enable internal wipe testing.
23	Submersible to an excess of 2500 Kpa

Table 6: Design Parameters

Design

Design And Documentation Standards

The Model 1860 type B(U) package is designed, constructed and documented in accordance with the best practices from the Analogue & Digital Measurements Quality Assurance System. The development cycle adhered to is given in the Model 1860 Quality Assurance program QAP – Design on page 174.

All drawings meet the quality standards as express in Technical Drawings on page 181 and data revision control is enforced according to the Control Of Changes on page 180. In addition the design construction steps can be found in appendix 7.

Construction Material

To meet the package design parameters and the physical construction requirements to withstand the IAEA destructive testing requirements in Testing for Transport Accident Conditions on page 224 a suitable material was required. After considerable discussion with the Australian Stainless Steel Development Association it was decided the transport cask would be constructed from 316 stainless steel. Material specifications on 316 stainless steel can be found in appendix 5, the main design reasons for using 316 stainless steel are as given below in Table 7: 316 Stainless Steel Characteristics.

Characteristic	*Description*
1	316 stainless steel will not go brittle at cryogenic temperatures thus able to survive IAEA test clause 727(a) given in Testing for Transport Accident Conditions on page 224
2	316 stainless steel is extremely resistant to corrosion.
3	Stainless steel has a relatively low thermal conductivity which will slow the diffusion of heat into the core, to help meet IAEA test clause 728(a) given in Applicable Destructive Tests on page 226
4	316 stainless steel is readily available in tube, pipe, rod, bar, sheet, plate and mesh.
5	316 stainless steel can be welded using common methods (rod, tig, mig) and is high on the list of relative material ability.
6	316 stainless steel is available from a variety of mills with quality assurance certification to its composition.
7	316 stainless steel bolts with Q.A. traceability are readily available.

Table 7: 316 Stainless Steel Characteristics

Size and Weight

Weight is one of the prime design parameters to maximize the economic efficiency of the package, as the cost of air freight for class 7 material ranges from $USD 10.00 to $USD 20.00 per kilogram.

For this reason the concept of building a very strong and rigid package that could withstand the forces of the 9M drop test as specified in Drop Test # 3 Procedure on page 232 , the design also opted for the more elegant approach of controlling the deceleration using crumple zones that would collapse on impact. These crumple zones determine the overall size of the package, the package dimensions are as shown below.

The size of the package is constant through out all configurations, and the dimensions are as shown below in Table 9: Package Dimensions, additional information can be found in drawing section *1860A-01 Drawing 1860A-01-000-01.*

The weight differs from package to package. The reason for this is that each configuration has different internal attenuator material. The different configuration weight specifications are as shown below in Table 8: Configuration Weights.

Package Configuration	*Dimensions LxWxH (mm)*	*Unloaded Mass (Kg's)*
Model 1860A	907 x 867 x 869	980
Model 1860B	907 x 867 x 869	990
Model 1860C	907 x 867 x 869	1000
Model 1860D	907 x 867 x 869	1020
Model 1860E	907 x 867 x 869	990
Model 1860F	907 x 867 x 869	1000

Table 8: Configuration Weights

Description	Image
Front view of the package with all relevant dimensions	Figure Withheld Under 10 CFR 2.390
Side view of the package with all relevant dimensions	Figure Withheld Under 10 CFR 2.390

Table 9: Package Dimensions

Isotope Attenuation

As the cask is predominantly to be moved by air freight, the size and weight of the attenuating material is of prime consideration. The two attenuation materials used in the Model 1860 transport cask, through out its variants 1860A through to 1860F is lead and high grade 97% tungsten.

Attenuating Material (Lead)

Use of lead as the attenuating material alone would result in a larger heavier and more cumbersome package than the initial commercial design specification allowed for, using lead as the primary attenuating material would impose on some of the commercial design requirements when larger sources are to be moved. The 1860A has a 100% lead attenuator as this configuration is used for transporting sources of smaller activity, compared to the 1860B, 1860C, 1860D, 1860E and 1860F configurations. Which can transport larger activities and incorporate additional tungsten attenuation.

Attenuating Material (Tungsten)

For configurations 1860B, 1860C, 1860D, 1860E and 1860F, high grade 97% tungsten is used for additional attenuation around the draw tube, central to the location of the isotope. The tungsten has a higher density than that of the lead, increasing the maximum isotope activity the package can carry without increasing its size, nor increasing its weight be a large percentage.

Attenuating Configurations

Each package configuration consists of a standard attenuator case which is lead filled, enclosed within the attenuator case is additional source holding configurations for each type of package. The standard attenuator case is shown below in Illustration 1: Standard Attenuator Case. The mechanical drawing assembly can be found in *Drawing section 1860A-01, Drawing 1860A-01-018-00.*

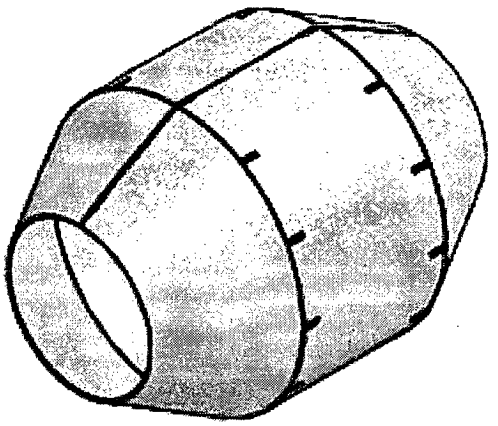
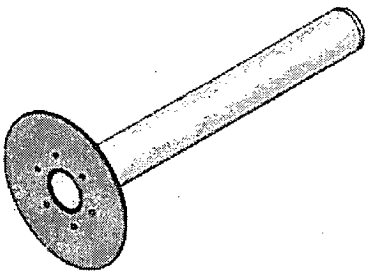
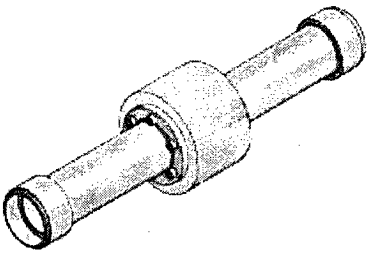
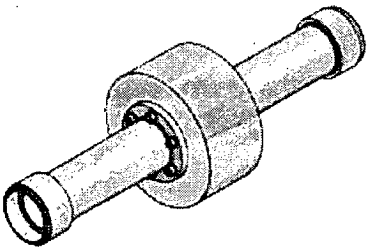
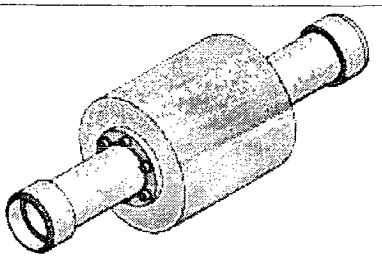


Illustration 1: Standard Attenuator Case

Given below in Table 10: Attenuator Configurations are the different types of attenuators that fit into the standard attenuator case (Drawing *1860A-01-018-00)* to form the different configuration types of the Model 1860 transport package.

Item	*Image*	*Description*
Model 1860 Configuration A Internal Attenuator		Model 1860A source drawer tube assembly, *Drawing Section 1860A-A1, Drawing 1860A-A1-019-00* the main attenuation is provided by the lead filled attenuator case.
Model 1860 Configuration B Internal Attenuator.		Model 1860B source drawer tube assembly, *Drawing Section 1860A-B1, Drawing 1860B-B1-010-00,* 150mm diameter, by 100mm wide tungsten attenuation.
Model 1860 Configuration C Internal Attenuator.		Model 1860C source drawer tube assembly, *Drawing Section 1860A-C1, Drawing 1860C-C1-010-00,* 200mm, diameter, by 100mm wide tungsten attenuation.
Model 1860 Configuration D Internal Attenuator.		Model 1860D source drawer tube assembly, *Drawing Section 1860A-D1, Drawing 1860D-D1-010-00,* 200mm diameter, by 210mm wide tungsten attenuation.

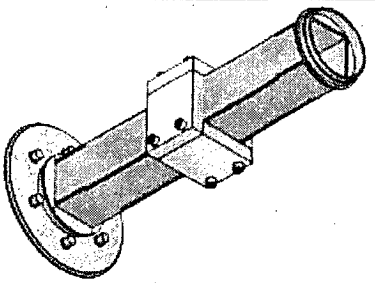
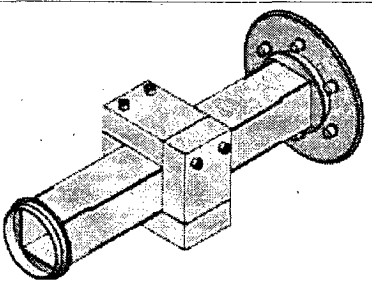
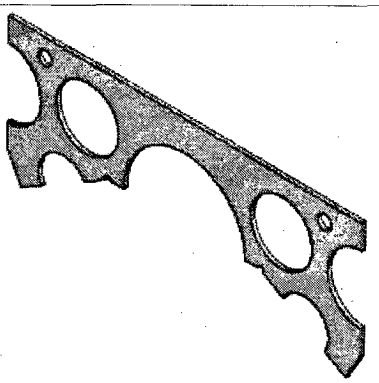
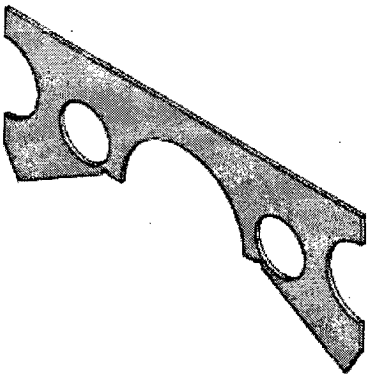
Item	*Image*	*Description*
Model 1860 Configuration E Internal Attenuator.		Model 1860E square source drawer assembly, *Drawing Section 1860E-A1, Drawing 1860E-E1-019-00, 25*mm Tungsten attenuator sides
Model 1860 Configuration F Internal Attenuator.		Model 1860F square source drawer assembly, *Drawing Section 1860F-A1, Drawing 1860F-F1-019-00,* 50mm Tungsten attenuator sides

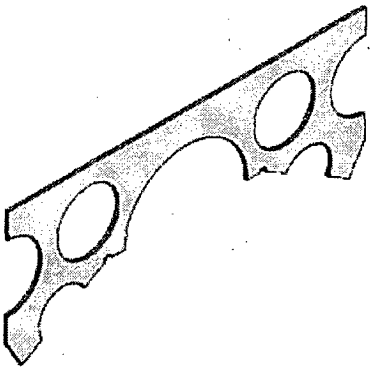
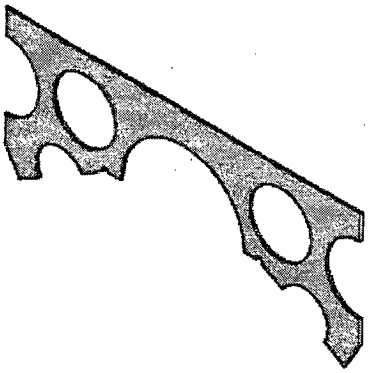
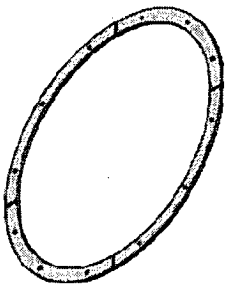
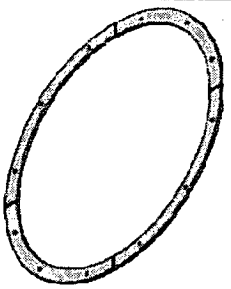
Table 10: Attenuator Configurations

Crumple Shield

A symmetrical crumple shield surrounds the attenuator case. Several permutations of the crumple shield were considered and the best fit between isotope carrying capacity, package size and overall weight proved to be a 460mm diameter case with 150mm support fins attached to the attenuator case, providing an overall weight of approximately 1000kg's.

Having created a smaller package the outer perimeter of the cask was redefined using a wire mesh attached to the tips of the crumple fins, this inherently increases the distance between the source and the point of measurement. Thus the transport index is lowered and the amount of attenuation provided by heavy elements is reduced. The crumple shield is constructed from three main building blocks, which are the crumple fins, the inner and outer support rings and the outer perimeter wire mesh. These main building blocks are shown below in Table 11: Crumple Shield Components. Note each crumple fin differs slightly depending upon its structural position around the attenuator. Additional information on the crumple shield design can be found in Crumple Shield on page 148 and images of the crumple shield impact test can be found in the *ANSTO 1860 Performance Evaluation Section page 14 to 16*

Item	*Image*	*Description*
Top Fin		Crumple shield top fin with lifting points to accommodate D-Shackles for hoisting. *Drawing Section 1860A-01, Drawing 1860A-01-171-03,* Constructed from 6mm 316 stainless steel
Lower Support Fin		Lower support fin constructed from 6mm 316 stainless steel to support the package weight in stationary position. *Drawing Section 1860A-01, Drawing 1860A-01-172-03*

Item	*Image*	*Description*
Side Support Fin		Side support fin constructed from 5mm 316 stainless steel. *Drawing Section 1860A-01, Drawing 1860A-01-173-03*
Side fin		Side fin. *Drawing Section 1860A-01, Drawing 1860A-01-174-03*
Inner Support Ring		Inner support ring, provides a lattice point to attach all crumple fins. *Drawing Section 1860A-01, Drawing 1860A-01-037-03*
Outer Support Ring		Outer support ring provides a lattice point to attached all crumple fins providing high strength and stability. *Drawing Section 1860A-01, Drawing 1860A-01-038-03*

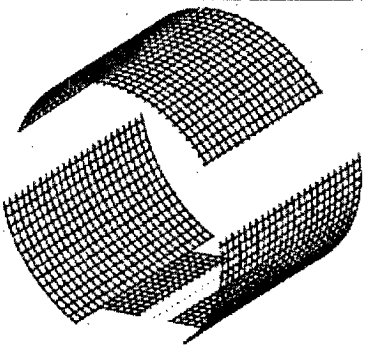
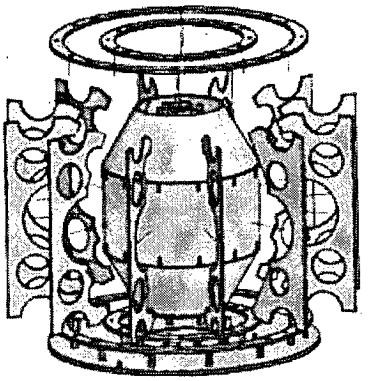
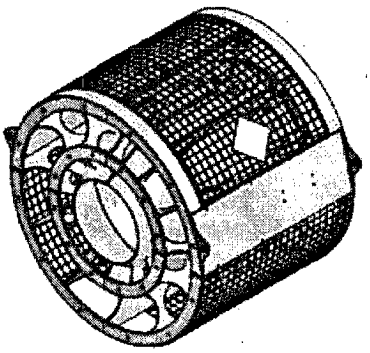
Item	*Image*	*Description*
Outer parameter wire mesh		The wire mesh defines the outer parameter of the package. *Drawing Section 1860A-01, Drawing 1860A-01-033-03*
Centre rings and fin assembly to a attenuator case		Assembly of crumple shield showing how attachment is made to the attenuator case. *Drawing Section 1860A-01, Drawing 1860A-01-032-03*
Centre rings, fins and mesh assembly, with inner attenuator case		*Drawing Section 1860A-01, Drawing 1860A-01-006-00*

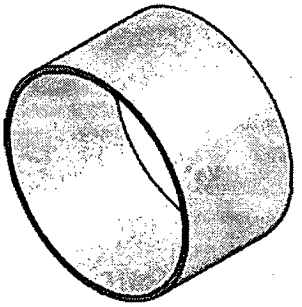
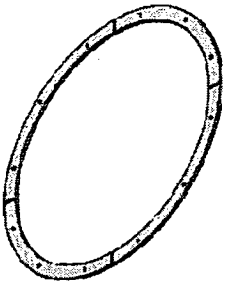
Table 11: Crumple Shield Components

End Shields

To protect the attenuator against impact damage on its ends the crumple zones are extended over and around the attenuator end points, further increasing the distance from the attenuator ends to the outer perimeter, thus reducing the field strength at the surface of the package, lowering the final transport index and the overall weight of the design.

The end shields are designed to be removable for access to the attenuator ends at the time of isotope loading and unloading. The end shields connect to the package via the inner and outer support rings, which are attached to the crumple fins as shown in *Drawing Section 1860A-01, Drawing 1860A-01-032-03.* The end shields incorporate access points for wipe testing at each end of the attenuator. The installation and removal procedure of the end shields is documented in on page additional information can be found in End Shields on page 148

The end shields remain constant for all package configurations, the common structural components are shown below in Table 12: End Shield Components

Item	*Image*	*Description*
End Shield Tube		End shield tube provides access point through crumple shields to the attenuator end. *Drawing Section 1860A-01. Drawing 1860A-01-191-03*
Inner Ring		Support for end shield fins and attachment to attenuator crumple shield. *Drawing Section 1860A-01. Drawing 1860A-01-067-03*

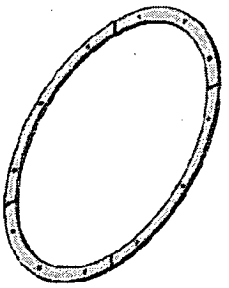
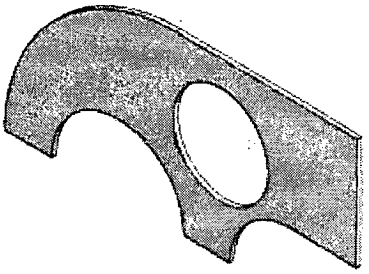
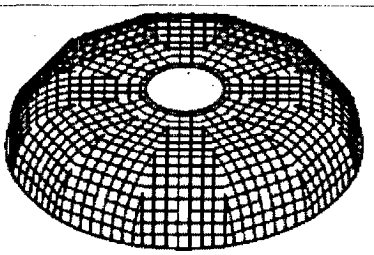
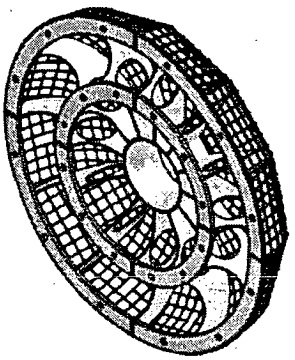
Item	*Image*	*Description*
Outer Ring		Support for end shield fins and attachment to attenuator crumple shield. *Drawing Section 1860A-01, Drawing 1860A-01-068-03*
End Fin		End fins connect to outer ring, inner ring and access tube. *Drawing section 1860A-01, Drawing 1860A-01-192-03*
End Mesh		End mesh to wrap around end fins to define the outer perimeter of the end shields. *Drawing Section 1860A-01, Drawing 1860A-01-064-03*
End Shield Assembly		End shield assembly, with fins, rings, access tube and mesh. *Drawing Section 1860A-01, Drawing 1860A-01-061-03*

Table 12: End Shield Components

Fork Lift Skid Design

The design of the fork lift skids is not central to the IAEA requirements for type B(U) packages. The fork lift skids are designed as a sturdy mounting base for the package. The skids are constructed from plastic material as the international rules on importation prohibit the import of timber into the USA and Australia without a special certificate. The components which make up the forklift skid with their associated drawing numbers are shown below in Table 13: Fork Lift Skid Components

The plastic skids are 100mm high to allow the tynes of a forklift enough vertical room to pass through the supports and allow the cask to be lifted under its centre of gravity. Additional information on the forklift skids can be found in Forklift Skids on page 149

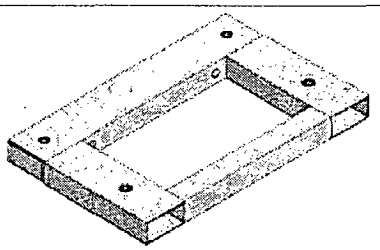
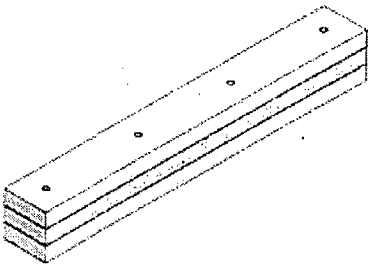
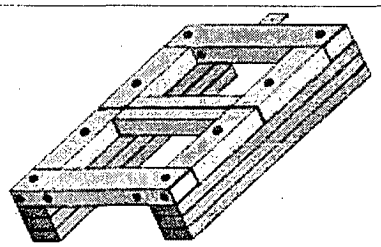
Item	*Image*	*Description*
Base support assembly		Base support assembly, *Drawing Section 1860A-01, Drawing 1860A-01-043-03*
Plastic skid assembly		Plastic skid assembly, *Drawing Section 1860A-01, Drawing 1860A-01-044-03*
Base assembly		Base assembly, *Drawing Section 1860A-01, Drawing 1860A-01-040-03*

Table 13: Fork Lift Skid Components

End Caps & Wipe Testing Ports

The design incorporates two end caps one on each side of the attenuator to secure the source drawer inside the attenuator. The end caps bolt to the attenuator ends and are security bolted and locked in place.

Each end cap incorporates a wipe testing port, such that the package source draw can be analysed for contamination before removal. The wipe test port has been designed to be large enough to conduct a wipe test with a filter paper or a large cotton bud.

Show below in Table 14: End Cap Components are the major components that make up the end cap.

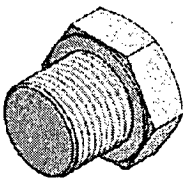
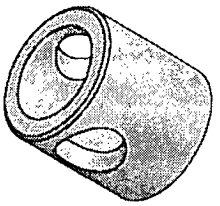
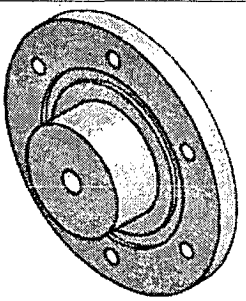
Item	*Image*	*Description*
End Cap Plug		Access to the wipe test port by the end cap plug. Drawing Section 1860A-01, Drawing 1860A-01-331-00
Locking Sleeve		Security feature to lock end caps to attenuator body. *Drawing Section 1860A-01, Drawing 1860A-01-120-00*
End Cap Assembly		End cap assembly, *Drawing Section 1860A-A1, Drawing 1860A-A1-109-00*

Table 14: End Cap Components

Shine Shields

It is possible that a narrow shine beam in the energy range of 30keV to 60keV can pass down the gap between the source drawer and drawer tube. To attenuate this beam, a shine shield is used. This shine shield is attached to the end cap as shown above in Table 14: End Cap Components.

The shine shield is larger in diameter than the drawer tube ensuring heavy metal shielding. The shine shield attenuates all low energy shine, 25mm of tungsten is used with configurations B, C and D and 20mm is used with the configurations E and F. See below for additional details and drawing references.

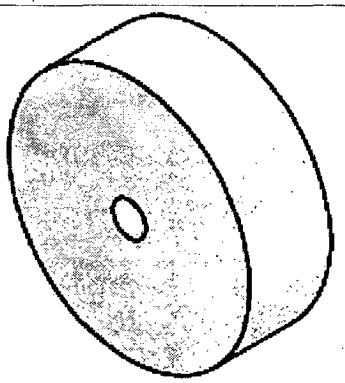
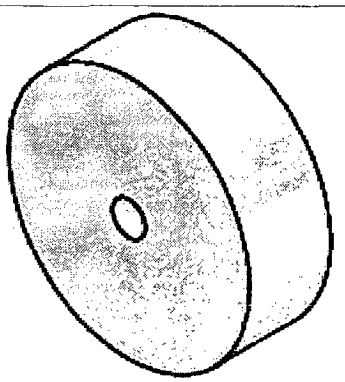
Item	*Image*	*Description*
End cap and shine shield for configuration B, C & D		Shine shield for this configuration used 25mm thick tungsten, refer to *Drawing Section 1860A-B1, Drawing 1860A-B1-108-00*
End cap and shine shield for configuration E & F		Shine shield for this configuration used 20mm thick tungsten, refer to *Drawing Section 1860A-E1, Drawing 1860A-E1-108-00*

Table 15: Shine Shields

Non Special Form Pressure Seal

The Model 1860 radiation transport cask is approved ***only for transportation of special form radioactive materials***. When special form capsules are used the specification of the capsule becomes part of the package design. High temperature seals have been incorporated to enable the type B(U) package to meet the pressure requirements of the enhanced water test of 2MPa.

Included in the design is a source drawer pressure seal if in the future A&DM wish to acquire certification for the transportation of non special form material, or under the circumstances of special consideration for non special form materials. Approval is required for the container used combined with the package enhanced pressure feature.

The design incorporates a metal seal which uses wafer technology to provide a sealing face to withstand a pressure greater than 2MPa. The metal seal is used opposed to a traditional rubber seal, such that in the event of a fire the high temperatures will not effect the sealing capability of the package. Additional information on the metal flex seal can be found in appendix *20*. The package will be transported with the metal seal in place during each shipment.

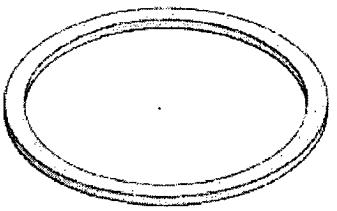
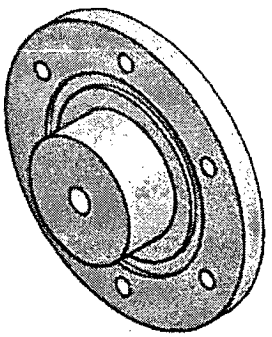
Item	*Image*	*Description*
Metal flex seal		The metal flex seal uses wafer technology, thus the seal can compress under to for a seal that can hold a pressure greater than 2MPa, refer to *Drawing Section 1860A-A1, drawing 1860A-A1-382-00*
End cap		The end cap is design with a grove to hold the metal flex seal, refer to *Drawing Section 1860A-A1, Drawing 1860A-A1-028-00*

Table 16: Pressure Sealing

Design Calculations Summary

Lifting Stress Analysis

The stresses at the lifting lugs and the welds on the top fin are analysed. Lifting the cask is done by a pair of certified D shackles and a 1 meter certified steel cable sling, refer to Lifting Stress On Top Support Fin. on page 83 . Results show that the shear strength of the lifting lugs is 9.5 times greater than that of the maximum load of the package, and the weld strength is approximately 30 times greater than the maximum load of the package.

Tie Down Points Stress Analysis

The stresses on the tie down points are analysed. The tie down points are design to meet the NRC 10CFR71.45 Standard. Refer to Tie Down Point Stress Analysis on page 85 for stress analysis calculations. A summary of the stress analysis calculations are as shown below.

Result	Description	Force % Vs Yield strength
1	Tie down point to meet requirement for horizontal force of 10g.	26%
2	Tie down point to meet requirement for vertical force of 2g.	8.2%
3	Tie down point to meet requirement for horizontal transverse force of 5g.	26.8%

Package Thermal Analysis

The model 1860A type B(U) package will radiate heat from the surface of its attenuator for a period of time after test 728(a). The temperature in the attenuator are everywhere decreasing, approaching initial steady state conditions.

The time taken from the package to reach an ambient temperature of 38°C in an environment void of solar additions is calculated to be 10.8554 hours. Where the time taken for the package to reach the ambient temperature of 38°C with the addition of solar energy input is calculated to be less than 19.3475 hours. See Thermal Analysis, Cooling of the Package, IAEA Clause 728(b) on page 97.

Top Fin Structural Analysis & Simulation

To drop a 500Kg plate onto the package from a height of 9 meters, the top fin will absorb the majority of the impact pressure, with a maximum pressure occurring at 971MPa. It is expected the fin will distort, bend and tare in some places. This distortion will depend on the angler direction of the impact force. In the best case, when the impact force is directly vertical on the top surface area of the fin, the deformation was simulated to be approximately 0.5mm. In the worst case where the impact force may be applied at an angle of 45 degrees to the top surface area of the fin, it is possible that 50mm of deformation could occur. See Impact Analysis IAEA Clause 727(c) on page 89

External Radiation Levels & Transport Index

The maximum loading for each configuration has been calculated to achieve a transport index of around 5. a summary of the results for each configuration type is as given below. The results show that each configuration can support its approved maxim loading, which is isotope specific.

Configuration A

Description	Activity (Ci)	Transport Index	Reference Equation
^{60}Co	1080	5.031	Refer to Configuration A, Equations for 60Co on page 102
^{137}Cs	27000	0.00423	Refer to Configuration A, Maximum Loading for 137Cs on page 105
^{226}Ra	1000	0.324	Refer to Configuration A, Maximum Loading for 226Ra on page 108
^{192}Ir	50000	0.00126	Refer to Configuration A, Maximum Loading for 192Ir on page 111

Configuration B

Description	Activity (Ci)	Transport Index	Reference Equation
^{60}Co	3100	3.987	Refer to Configuration A, Equations for 60Co on page 102 also see Configuration B, Maximum Side Loading for 60Co on page 118

^{137}Cs	27000	< 0.00423	Refer to Configuration B, Maximum Loading for 137Cs on page 116
^{226}Ra	1000	< 0.324	Refer to Configuration B, Maximum Loading for 226Ra on page 117
^{192}Ir	50000	< 0.00126	Refer to Configuration B, Maximum Loading for 192Ir on page 117

Configuration C

Description	Activity (Ci)	Transport Index	Reference Equation
^{60}Co	12160	5.670	Refer to Configuration C, Maximum Loading for 60Co on page 120
^{137}Cs	27000	< 0.00423	Refer to Configuration C, Maximum Loading for 137Cs on page 122
^{226}Ra	1000	< 0.324	Refer to Configuration C, Maximum Loading for 226Ra on page 123
^{192}Ir	50000	< 0.00126	Refer to Configuration C, Maximum Loading for 192Ir on page 123

Configuration D

Description	Activity (Ci)	Transport Index	Reference Equation
^{60}Co	15100	5.242	Refer to Configuration D, Maximum Loading for 60Co on page 124, also see Calculation 1, Field From End Source on page , also see Calculation 2, Field Strength from 60Co Pencil on page 130, also see Calculation 3, Maximum Loading Through End from 60Co Pencil on page 131

^{137}Cs	27000	< 0.00423	Refer to Configuration D, Maximum Loading for 137Cs on page 126
^{226}Ra	1000	< 0.324	Refer to Configuration D, Maximum Loading for 226Ra on page 127
^{192}Ir	50000	< 0.00126	Refer to Configuration D, Maximum Loading for 192Ir on page 127

Configuration E

Description	Activity (Ci)	Transport Index	Reference Equation
^{60}Co	1080	4.023	Refer to Configuration E, Maximum Loading for 60Co on page 134
^{137}Cs	27000	< 0.00423	Refer to Configuration E, Maximum Loading for 137Cs on page 136
^{226}Ra	1000	< 0.324	Refer to Configuration E, Maximum Loading for 226Ra on page 137
^{192}Ir	50000	< 0.00126	Refer to Configuration E, Maximum Loading for 192Ir on page 137

Configuration F

Description	Activity (Ci)	Transport Index	Reference Equation
^{60}Co	3100	5.414	Refer to Configuration F, Maximum Loading for 60Co on page 138
^{137}Cs	27000	< 0.00423	Refer to Configuration F, Maximum Loading for 137Cs on page 140
^{226}Ra	1000	< 0.324	Refer to Configuration F, Maximum Loading for 226Ra on page 141
^{192}Ir	50000	< 0.00126	Refer to Configuration F, Maximum Loading for 192Ir on page 141

Quality Assurance

The Analogue & Digital Measurements quality assurance system provides a solid basis for all facets of the development and production cycle for the Model 1860. In addition to the company QA system, QA policies were also developed specifically for the Model 1860 as it is a unique product. With a very specific development, testing and manufacture stages.

Design

Specific quality assurance procedures directly related to the design of the Model 1860 package have been constructed and are documented in the QAP – Design section on page 174. The QA procedures for the design of the package cover the following areas.

- Development cycle
- Design methodologies
- Responsibilities of the design engineers
- Regulatory authority compliance
- Organisational interfaces
- Performance inputs
- Outputs and design verification
- Control of design changes
- Technical drawing format and numbering standards
- Design flow control

Manufacture

Quality assurance procedures for the manufacture of the package have been specifically designed to provide a manufacturing process to produce a high quality product, fault free. These QA procedures are documented in the QAP – Manufacture section on page 187 and cover the following areas.

- Purchasing
- Material suppliers
- Subcontractors
- Product design
- Fabrication
- Material ordering and vendor parts
- Construction procedures

Testing

QA procedures for testing of the Model 1860 are documented in the QAP – Testing section on page 194 these testing procedures cover the area of design testing and third party design verification done by ANSTO. See the *ANSTO test report section* for the package evaluation.

Documentation

The documentation QP policies are covered in the Analogue & Digital Measurements QA system, additional information can be found in the QAP - Documentation section on page 195.

Product Usage

The correct use of the Model 1860 package is documented in the QAP – Use on page 196. Detailed usage procedures can be found in the Engineering Users Manual on page 234 which cover the following areas

- Tool box accessories
- Travel documents
- Pre shipment checks
- Receival checks
- Transport and package handling
- Source up loading
- Source down loading

Maintenance & Inspection

The correct maintenance and inspection procedures can be found in the QAP – Maintenance & inspection section on page 197. The Model 1860 has its own specific maintenance and inspection manual, see Maintenance And Inspection Manual on page 198 . This manual covers the following areas.

- General hazardous material warning to all users
- Pre transport inspection and maintenance
- Post transport inspection and maintenance
- End of mission inspections
- Tool box contents inspection
- Dispatch documentation inspection

Design Testing

Design Features for Incident Survival

To enable the cask to survive the criteria of the drop test as specified in the (*IAEA Regulations for the Safe Transport of Radioactive Materials page 99)* and in Drop Test # 2 Procedures on page 230 the case is fitted with fins designed to crumple and absorb the impact force of the drop.

In addition the fins are covered with a mesh to increase the heat dissipation characteristics of the cask to pass the thermal test as specified in the (*IAEA Regulations for the Safe Transport of Radioactive Materials page 100)* and in Thermal Test Procedure on page 232. This design feature also allows convection dissipation of the heat from isotope decay to ensure the outside of the cask does not rise above the air freight maximum temperature of 50°C as specified in regulation 617 (*IAEA Regulations for the Safe Transport of Radioactive Materials page 77)* and in Additional Requirements for Air Transport on page 217

To meet the requirements of the normal operating temperature range as stated in requirement 637 (*IAEA Regulations for the Safe Transport of Radioactive Materials page 81)* of -40°C to 55°C the case is constructed from 316 grade stainless steel which maintains it's integrity down to cryogenic temperatures.

The characteristics of 316 grade stainless steel while ensuring ease of decontamination to comply with regulation 609 (*IAEA Regulations for the Safe Transport of Radioactive Materials page 76)*, is corrosion resistance and inhibits the heat transfer from the case to the lead attenuator. The contact between the fins and attenuator is limited, this inhibits the heat flow at high differentials (fire) but has little delaying effect at low differentials (isotope decay heat dissipation).

While the parameters of special form radioactive material is taken as part of the containment, as stated in regulation 640 (*IAEA Regulations for the Safe Transport of Radioactive Materials page 81)* the 1860 has additional containment security with sealing in excess of 2MPa at 1000°C which meets the requirement of the enhanced water test as specified in regulation 730 (*IAEA Regulations for the Safe Transport of Radioactive Materials page 101).*

To ensure that the source drawer cannot be removed by unauthorised personnel, there is in addition to the end cover bolts, a cover to prevent removal of one of the bolts without removing the lock as specified in regulation 646 (*IAEA Regulations for the Safe Transport of Radioactive Materials page 82).*

Prototype Construction

Materials

The sheet materials were purchased through ABC laser cutting services as specified in the Subcontractors QA section on page 189.QA certificates were obtained, all parts were cut and QA checked against the drawings to ensure compliance to the Model 1860 QA procedure on Construction Procedures documented on page 192

The materials for the end plates and central tube were purchased from Sandvick and machined by C&I Engineering (see Subcontractors on page 189 and Material Suppliers on page 188). All parts were QA checked against the drawings to ensure conformity.

Fabrication

All sequences of fabrication were discussed and evaluated with Fineweld. At each stage of construction the dimensions were QA checked against the drawings and all welds tested for integrity. The central tube was not welded to the pour end plate to allow for movement of the tube during the application of heat to ensure that there was no distortion of the source drawer tube.

On completion of the construction of the body it was transported to Amac Alloys for loading with lead. The lead pour was carried out in a single operation and heat continued to be applied while the lead shrunk as it cooled, and additional lead was added.

The package was returned to Fineweld to seal the filling ports and the expansion fit on the centre tube. The outer mesh, placarding and the end crumple shields were fitted.

The centre of the package was line bored to ensure smooth operation of the drawer into and out of the cavity. Special tools were built to ensure no flex in the boring bar.

Destructive Testing

Demonstration of Compliance

Demonstration of compliance with the performance standards required in section VI of the "*IAEA Safety Standard series, Regulations for the Safe Transport of Radioactive Material*" are accomplished by the methods or combination of methods listed below inTable 17: Demonstration Methods.

Method	*Description of Method*
1	Performance of tests with specimens representing *LSA-III material*, or *special form radioactive material*, or *low dispersible radioactive material* or with prototypes or samples of the *packaging*, where the contents of the specimen or the *packaging* for the tests shall simulate as closely as practicable the expected range of *radioactive contents* and the specimen or *packaging* to be tested shall be prepared as presented for transport.
2	Reference to previous satisfactory demonstrations of a sufficiently similar nature.
3	Performance of tests with models of appropriate scale incorporating those features which are significant with respect to the item under investigation when engineering experience has shown results of such tests to be suitable for design purposes. When a scale model is used, the need for adjusting certain test parameters, diameter or compressive load, shall be taken into account.
4	Calculation, or reasoned argument, when the calculation procedures and parameters are generally agreed to be reliable or conservative.

Table 17: Demonstration Methods

After the specimen, has been subject to the physical tests, other appropriate methods of assessment are used to ensure that the requirements for performance and acceptance standards prescribed in section VI of the IAEA requirements are met, and covered to their full extent. Information of the selected tests and the justification type for each test can be found in Test Selections and Justification on page 214.

Destructive Tests.

The applicable destructive tests selected were formulated around the test methods for normal transport conditions and transport accident conditions, see Testing for Normal Transport Conditions on page 223 and in Testing for Transport Accident Conditions on page 224.

The resultant destructive tests to satisfy the requirement are shown below in Table 18: Applicable Destructive Tests, for further information on these test refer to Applicable Destructive Tests on page 226. Additional information on the destructive test program can be found in appendix 11.

IAEA reg.	*Description*	*Method*
722	1.2m drop onto flat surface. Package to be dropped onto its weakest point.	Physical test by ANSTO
727(a)	9:0m drop onto flat surface. Package temperature will be below -40°C.	Physical test by ANSTO
727(b)	1.2m drop onto vertical bar. Package temperature will be below -40°C.	Physical test by ANSTO
727(c)	500Kg plate to be dropped onto the top surface of the package	Calculation and reasoned argument
728(a)	Package will remain in 800°C environment for 30 minuets.	Physical test by ANSTO
728(b)	Heat rise test.	Calculation and reasoned argument
730	Water immerse test.	Calculation and reasoned argument

Table 18: Applicable Destructive Tests

Test Schedule

Refer to the section Test Schedule on page 227 for detailed information on the test dates and test locations. Testing was conducted and witnessed by the ANSTO mechanical engineering team.

Test Equipment

An array of test equipment was used in the destructive testing, some of this equipment required certification to various standards and IAEA regulations, a complete list of the equipment used can be found in the Equipment section on page 228. Also see appendix 12 for additional information on the package cooling system, to lower the package temperature to -40°C.

Drop Test Procedure (IAEA regulation 722)

In accordance with the IAEA regulation 722 the package must survive a 1.2metre drop onto a flat surface. The package must be droped in such a fashion that the package lands on its weakest point. Refer to Drop Test # 1 Procedure on page 230 for additional information and test procedures used.

Drop Test Procedure (IAEA regulation 727a)

In accordance with IAEA regulation 727(a) the package must withstand destructive testing, and the package must operate under the temperature range of -40°C to +40°C. For this reason the destructive test was done at a temperature of -40°C. To bring the package down below this temperature liquid nitrogen was used to chill the package. Refer to Drop Test # 2 Procedures on page 230 for additional information and testing procedures.

Drop Test Procedure (IAEA regulation 727b)

In accordance with IAEA regulation 727(b) the package must withstand destructive testing at a temperature of -40°C. Refer to Drop Test # 3 Procedure on page 232 for a list and description of the test procedures used.

Drop Test Calculation (IAEA regulation 727c)

In accordance with IAEA regulation 727(c) the package must withstand a crush test. This involves dropping a 500Kg plate from a distance of 9 meters onto the top surface of the package. To drop a 500Kg plate onto the package from a height of 9 meters, the top fin will absorb the majority of the impact pressure, with a maximum pressure occurring at 971MPa. It is expected the fin will distort, bend and tare in some places. This distortion will depend on the angler direction of the impact force. In the best case, when the impact force is directly vertical on the top surface area of the fin, the deformation was simulated to be approximately 0.5mm. In the worst case where the impact force may be applied at an angle of 45 degrees to the top surface area of the fin, it is possible that 50mm of deformation could occur. See Impact

Analysis IAEA Clause 727(c) on page 89

Thermal Test Procedure (IAEA regulation 728a)

In accordance with IAEA regulation 728(a) the package must be exposed to an average temperature of 800°C for a period of no less than 30 minutes. Refer to Thermal Test Procedure on page 232 for additional information and a list of procedures.

Thermal Test Calculation (IAEA regulation 728b)

In accordance with IAEA regulation 728(b) after the fire test of 728(a) the package temperature must decrease to ambient 38°C. The time taken from the package to reach an ambient temperature of 38°C in an environment void of solar additions is calculated to be 10.08 hours. Where the time taken for the package to reach the ambient temperature of 38°C with the addition of solar energy input is calculated to be less than 16.528 hours. See Thermal Analysis, Cooling of the Package, IAEA Clause 728(b) on page 97.

Official Destructive Test Report

The destructive testing was conducted by the ANSTO engineering team, the full test report is given in the *Type B(U) performance evaluation for the A&DM Model 1860 Prototype Cask*. This test report is attached as a section to this safety analysis.

Test Report Purpose

The purpose of the report is to document the performance testing and evaluation of the 1860 transport package, owned by *Analogue & Digital Measurements*. This document is intended to be used as supporting evidence in the submission to the competent authority for the certification of the A&DM 1860 series cask as a Type B(U) transport package.

Test Report Scope

This only covers the performance testing of the A&DM 1860 cask (i.e. transport package) for compliance to the ARPANSA regulations for Type B(U) packages. Note that for radioactive material transport packages the ARPANSA regulations, herein referred to as "the regulations", is for the most part a direct endorsement of the IAEA regulations. The report only addresses the most rigorous testing clauses from the regulations as found applicable to the package design. Note that the analysis of the package design specifications to the general design requirements of the regulations is not covered in this report.

Test Report Conclusions

From the limited testing conducted by ANSTO Engineering it was verified that the *Analogue & Digital Measurements* radioactive material transport package A&DM 1860 is compliant with the performance requirements of the Type B(U) regulations set out in the ARPANSA Code of Practice. In completing the evaluation of the A&DM 1860 prototype package in terms of performance, ANSTO engineering has several recommendations to offer; some of which are as shown below in Table 19: ANSTO Test Conclusions.

Item	*Conclusion*
1	It is recommended that the package be loaded with a source and a radiation survey be conducted on the surface of the attenuator to further verify that there was no damage sustained to the shield in the course of the performance testing.
2	It is recommended that the package design specifies an o-ring that is compatible with the environmental variations as set out in the regulations, i.e. -95kPa to 2000kPa; -40ºC to 70ºC; radiation.

Table 19: ANSTO Test Conclusions

Operational

This section refers to the general use of the Model 1860 type B(U) package. The following topics are covered in this section

- First Use Testing
- Normal Usage
- Maximum Contents
- Package Transportation

First Use Testing

As the attenuation data from a variety of sources is variable and there are manufacturing tolerances, the exact transport index cannot be calculated exactly. The design calculations could differ by ± 10% which in no way will present any danger, it will however slightly alter the transport index.

The maximum transport index this package will use is 10. However to be very conservative the design calculations for the maximum loading have been calculated around a transport index of 5. The allowable maximum will be determined at the time of first use.

The cask is approved for use up to a predetermined activity based on mathematical calculation. An engineer from A&DM is to be present on the inaugural shipment to obtain the maximum activity the cask can accommodate. This number is stored in the cask history file, each cask may have slightly different coefficients.

When the cask is first loaded, a survey at 1m is undertaken, the results are taken and recorded on the survey from as shown below in Illustration 2: Field Strength Survey. The point of highest reading is used to calculate the activity for a transport index of 10, the maximum load for the cask will be the lowest of the measured figure and that shown on the contents table. A supplied label is then engraved and riveted to the places provided on the placard plate. Additional information can be found in the Model 1860 users manual section First Use, Maximum Activity Determination on page 237.

Model 1860 Radiation Field Survey Form

Point	Field (µGy/h) Contact	Field (µGy/h) 1 meter
A1		
B1		
C1		
D		
E		
F		
A2		
B2		
C2		

CASK SERIAL NUMBER	
TECHNICIAN Name..... Position..... Company..... Signature.....	DATE / / ISOTOPE ACTIVITY Bq TRANSPORT INDEX

Illustration 2: Field Strength Survey

Conditions of Normal use

The 1860 transport cask is only available to enterprises that are licensed to handle large sources, and have radiation trained personnel with the knowledge, experience and the relevant licensing to competently carry out the task for which the cask will be used.

The package must be prepared for shipment in accordance with Dispatch Documentation Check List on page 79 and Dispatch Inspection Check List on page 78 these inspection check-lists for the protocol which ensures the following.

Item	*Description*
1	Users manual. This manual must accompany the cask during a UN2816 shipment. It sets out the strategy for the use of the 1860 for a variety of applications and is used as a guide for the safety procedure for a specific task which must be designed and managed by the user to suit the requirements of the task in hand and be accepted by the relevant regulator.
2	Emergency response plan. This manual must accompany the cask during a UN2816 shipment. It sets out the requirements to establish a safe zone around the cask in the event of an incident and is to be followed until the scene is taken over by the local regulators.
3	Details of the shipment and travel documents are to be forwarded to Analogue and Digital Measurements Pty Ltd or their representative for inclusion in the cask history file.

Table 20: Conditions for Normal Use

To enhance these prerequisites a guide to the correct usage of the 1860 cask, emergency procedures, shipping and receival, and quality assurance documents will accompany the cask in the tool box.

Maximum Contents

The following list sets out the maximum allowable load for each configuration.

Isotope	Max Loading (Ci)	Max Loading (TBq)	Physical Form	Special Form Certification	Package Configuration
^{137}Cs	27000	1000.00	Solid	Yes	A -> F
^{60}Co	1080	40.00	Solid	Yes	A
^{60}Co	3100	115.00	Solid	Yes	B
^{60}Co	12160	450.00	Solid	Yes	C
^{60}Co	15100	560.00	Solid	Yes	D
^{60}Co	1080	40.00	Solid	Yes	E
^{60}Co	3100	115.00	Solid	Yes	F
^{192}Ir	50000	1850.00	Solid	Yes	A -> F
^{226}Ra	1000	37.00	Solid	Yes	A -> F

General Transportation of the Package

Transportation (Forklift)

The Model 1860 radiation transport cask may be loaded on to or unloaded from a transport vehicle using a fork lift, with a rated lifting load greater than 1500kgs. Fork lift operations may also include general moving of the package around a working area. The correct operation procedures for transportation with a forklift can be found in Fork Lift Handling page 253

Transportation (Crane)

The Model 1860 Radiation Transport Cask may be loaded onto, or unloaded from a transport vehicle using a crane, with a rated lifting load greater than 1500kgs. The procedures for transportation with a crane can be found in Crane Handling on page 254. The package is supplied with a tool box that contains all necessary certified items such as shackles and lifting slings, a complete list of supplied tools can be found in Tool Box Accessory's on page 240

Transportation (Road)

During road transport the Model 1860 must be firmly secured to the transport fixture, such that the normal forces encountered during road transport do not allow the package to move in any direction from its initial placement. The package has four heavy duty tie down lugs, two located on each side of the package. Included within the tool box is a set of four tie down chains, each of which have a turn buckle to tension the chain and a D shackle to attach the chain to a tie down lug on the package, for additional information refer to Cask Tie Down (Road Transport) on page 255.

Transportation (Air)

During air transport the Model 1860 radiation transport cask must be firmly secured to the transport fixture. Usually the cask will be transported within a standard aircraft cargo container, for additional information refer to Cask Tie Down (Air Transport) on page 256.

Credible Accident Analysis.

Collision

Shown below in the following table are possible scenarios for a transport collision.

Transport Mode	Possible scenario
Air	Aircraft crash
Air	Package falls from aircraft in mid flight
Air	Package dislodges in cargo hold while aircraft is in turbulent air, and package collides with other cargo
Road	Truck collision with stationary object
Road	Truck collision with moving object (head on collision)
Road	Package transport on trailer, trailer detaches from vehicle and package collides with object
Road	Packages falls from transport vehicle during transport at high speed.
Rail	Package involved in high speed rail collision.
Marine	Package inside shipping container is dropped from height greater than 10 meters during loading / unloading from ship

A collision is a state where the cask has to absorb the energy due to the change of velocity either by coming to rest from a state of motion or a change from a position of rest to a state of motion.

It was demonstrated in the destructive testing (in accordance with TS-R-1 paragraph 727a) that the 9m drop did not damage the case. The only consequence was an increase of the package transport Index due to the distortion of the crumple shield (which it was designed to do), decreasing the distance from the source to the point of measurement. Refer to ARPANSA test evaluation for test results.

The crumple shield is designed to absorb the kinetic energy of impact protecting the case, attenuating materials, the source drawer and ultimately the capsule from damage. If the kinetic energy exceeds the total amount of energy required to flatten the crumple shield the remaining energy will be absorbed by the attenuator, thus distorting the case and extruding the lead attenuator.

If the drawer can be moved there would have been insufficient force to damage the

capsule and the drawer should be transferred to a second package and then taken to a hot cell for inspection of the capsule.

If the package is so badly damaged that the drawer cannot be withdrawn, the package would have to be used as the disposal container. As a matter of prudence, because the capsule cannot be inspected for damage, it is recommended that the test port be removed and epoxy resin be poured into the hole and the plug be reinstalled, this procedure would be repeated at both ends.

In the event of a collision exceeding 13.3m/s, it is expected that the package crumple shield would become distorted, for high speed collisions it is expected that the package crumple shield would be totally destroyed. This is however the main purpose of the crumple shield, it is designed to absorb the energy caused by the forces of deceleration during a collision, thus protecting the main attenuator. A total or partial loss of the crumple shield's will increase the transport index of the package by decreasing the distance from the outer surface of the package to the source itself.

It is estimated that there is virtually no chance of the internal radiation capsule losing material, i.e. becoming fragmented and dispersing particles outside the attenuator body, thus contaminating the surrounding area. This estimation is based on the premise that the capsule is secured inside the main attenuator body, within the source drawer, surrounded by dense layers of lead and tungsten.

The major problem that might occur in the event of a high speed collision is if the forces of deceleration and inertia are significant enough to extrude the lead. This lead extrusion may apply significant force to the inner drawer tube such that it collapses and distorts.

Fire

Shown below in the following table are possible scenarios for a fire.

Transport Mode	Possible scenario
Air	Aircraft crash producing high temperature fire produced by fuels
Air	Low temperature fire in cargo hold
Road	Road crash, high temperature fire produced by fuels.
Road	Low temperature fire in vehicle cargo transport tray
Rail	Low temperature fire in Rail cargo hold
Rail	High temperature fire inside enclosed area, ie. tunnel
Marine	Low temperature enclosed fire in shipping container,
Marine	High temperature fire, short term, produced on ship by marine fuels.

Due to the inexact science and the variability of a fire it is difficult to give an accurate evaluation of outcomes, for what could be called a typical fire. The Model 1860 type B(U) package has been proven to pass the heat, IAEA regulation 728, Results can be found in the ARPANSA package evaluation.

The rest of the assessment is conjecture based on results from reports from fire technologists, our in-house experience with melting lead to produce products and some guess work in conjunction with the scientific community. There are four main categories of fire definition, these are:

Definition	Description
1	Laminar Premixed
2	Laminar Diffusion
3	Turbulent Premixed
4	Turbulent Diffusion

The fire into which the Model 1860 package was destructively tested is classed as turbulent premixed, where the fuel and air are premixed in a fixed proportion to obtain optimum burning. An unwanted accidental fire is turbulent diffusion as the mixing of fuel and air is random and optimal burning is usually not achieved, thus resulting in lower temperatures. Many fire investigators have attempted to quantify fires, however due to the diverse parameters in play each fire is different and it's effects vary accordingly.

A broad range of investigators have arrived at a general consensus relating to the temperature of flames, these conclusions are:

Conclusion	Description
1	Temperature above the base in the solid flame region is almost constant throughout, at around 900°C.
2	In the intermittent flame region the temperature continuously drops until at the flame tip the temperature is about 320°C with the average being about 450°C
3	The fire plume drops to ambient temperature in a random way dependant on the intensity of the fire and ambient wind conditions.

Turbulent diffusion fire is broken into two types. Fires in the open areas and and fires in closed areas.

Area	Description
Open Space	A turbulent diffusion fire in an open space, the heat loss from the flame maintains the temperatures in the above table
Closed Space	A turbulent diffusion fire in an enclosed space where the heat dissipation is restricted, the solid flame temperature can rise over a long period of time to 1200°C. A common fire endurance test period is 4 hours and the temperature more commonly rises to within the range of 900-1000°C.

The amount of heat absorbed by the Model 1860 package can not be defined in absolute terms due to the variables of.

Variable	Description
1	The type of fuel.
2	The space in which the fire occurs.
3	Ambient air movement (wind conditions).
4	Draft induced by the intensity of the fire.
5	Methods used to extinguish the fire.

It has been demonstrated that the model 1860 package will survive a turbulent premixed fire in excess of 800°C for 30 minuets in accordance with TS-R-1 paragraph 728. As it takes more than an hour to melt 1000kg's of lead in the ideal conditions of a turbulent premixed furnace it is safe to conclude that; to melt the lead attenuation in the cask will take in excess of an hour at a constant temperature of 800°C or in excess of two hours in a diffused fire with an average flame temperature of 450°C. Within this two hour period attempts to extinguish the fire will have commenced, removing heat from the fire and if not lowering the temperature of the cask at least lowering the rate of accumulation of heat.

It is concluded that the Model 1860 package would not be compromised in the majority of fires. In the most intense fire, in an enclosed space, but it would be most unlikely that the Cask would be stored in an environment that could produce such a fire.

Perceived Hazards

Leaking Source

The most likely hazard would be a leaking source not detected at the point of loading, to down load this source without precaution could risk the contamination of a site with the direct danger to personnel and costs in safety and expense of a clean up.

The following features as shown below in Table 21: Hazard Design Features have been built into the cask to minimise the probability of contamination and give early warning of a problem.

Feature	*Description*
1	The source is placed in a cavity at the centre of the drawer (varies with drawer design). While this is not a hermetical seal it is of sufficient integrity to slow down the migration of a leaking isotope.
2	The distance from the source to the end caps is relatively long which will delay the migration of a leaking isotope.
3	The end covers designed to retain the source drawer are fitted with metal seals that achieve the sealing requirements of the enhanced water test and will survive 1000°C at a pressure of 2MPa.
4	To protect the technician from fully opening a containment system that is compromised, test ports are fitted (that will withstand the enhanced water test). The test plug is removed, the end of the drawer is wipe tested prior to removal of the end cover. If there is a positive wipe, remedial action can be taken before the situation is made worse.

Table 21: Hazard Design Features

Source Uploading and Downloading

Source transfers from radiation laboratory to radiation laboratory and the loading of a new source or the unloading of a depleted source will be undertaken in a facility which has a hot cell.

Therefore all unloading and loading will be undertaken using the protocols designed for the facility. The use of the 1860 cask will not create an increased risk.

Relevant procedures to be used as a guide to address the relevant work practices that have been created. The recommended procedures for source uploading and downloading are as shown below in Table 22: Source Upload and download procedures.

Procedure	*Description*	*Reference*
Source uploading in a hot cell	These procedures are provided as a guide for the uploading of a source from the Model 1860 transport cask inside a hot cell. They may be slightly modified to suit the specific variables at the time, however the general principles should remain the same. The procedures are not designed to replace the hot cell protocols but to form a guide to complete the work.	Refer to Source Up-Loading (Hot Cell) on page 259
Source downloading in a hot cell	These instructions are provided as a guide for downloading of a source from the Model 1860 radiation transport cask inside a hot cell. The instructions may be modified to suit the specific variables at the time, however the general principles should remain the same. These instructions are not designed to replace the hot cell protocol.	Refer to Source Down-Loading (Hot Cell) on page 262

Procedure	*Description*	*Reference*
Water Uploading	These instructions are provided as a guide for downloading a source from the Model 1860 radiation transport cask within a water bath. These instructions may be modified to suit the specific variables at the time, however, the general principles should remain the same. These instructions are not designed to replace the water bath protocol.	Refer to Water Bath Uploading on page 265
Water Bath Downloading	These instructions are provided as a guide for downloading a source from the Model 1860 radiation transport cask within a water bath. These instructions may be modified to suit the specific variables at the time, however, the general principles should remain the same. These instructions are not designed to replace the water bath protocol.	Refer to Water Bath Downloading on page 264

Table 22: Source Upload and download procedures

Field Transfers

The current method of field transfer of sources between a radiation treatment head and a transport cask requires the full alignment between the treatment head and the transport cask. This usually requires a gap of several centimetres to enable precise measurements to be made. To restrict the beam as the source transverses this gap a large quantity of sheet lead is used. Even with extreme care there is the risk of the source becoming jammed halfway, leaving the source at the point of minimum shielding.

To remove this weakness in the transfer, the end impact crumple shield is removed, alignment plates are bolted to machined faces on both the head and cask. The alignment plates are dowel pinned to each other to ensure perfect alignment. When the plates are bought together they are held in place with a series of bolts.

The source drawer has a handling bar that is screwed into the end through the test port on the off side. (The off side end plate is not removed to ensure even under the most obscure conditions the source cannot be removed through the off side) transfer will take 2 seconds, the drawer cannot become jammed, and the technician is protected by the mass of the cask and X-ray shine is absorbed by the gap shine shield in the off side end plate.

Procedures for uploading and downloading from a therapy head are as shown below in Table 23: Therapy Head, Upload and Download.

Procedure	*Description*	*Reference*
Therapy head transfer (Upload)	These instructions are provided as a guide for the uploading of a source from the Model 1860 to a therapy head. These instructions may be modified to suit the specific variables at the time, however, the general principles should remain the same.	Refer to Therapy Head Transfer (Upload) on page 267
Therapy head transfer (Download)	These instructions are provided as a guide for downloading a source from the Model 1860 radiation transport cask to a therapy head. These instructions may be modified to suit the specific variables at the time, however, the general principles should remain the same.	Refer to Therapy Head Transfer (Download) on page 268

Table 23: Therapy Head, Upload and Download

Transport Hazards

To ensure the safety of personnel, property and the environment, national and international transport regulations have been developed. These regulations and policies are implemented by regulatory authorities to control the transport of radioactive material. Measures required in these regulations are to ensure adequate containment, shielding and the prevention of hazardous situations in the event of a transport accident.

When a transport incident involving radioactive material occurs, although it may pose no radiation safety problem, emergency response actions are needed to ensure that a high level of radiation safety is maintained.

If a transport accident occurs that results in a release of radioactive material or loss of protective shielding, the consequences must be controlled by the correct emergency response actions. The type of emergency planning for responding to transport accidents involving radioactive material is similar to that required for responding to transport accidents involving other types of dangerous goods, such as flammables, explosives, poisonous gases, corrosives and toxic chemicals.

An emergency response plan has been developed for the Model 1860 radiation transport cask. This plan takes the following areas into consideration.

- The chain of communication at the time of an incident
- Transport incident, Drop
- Transport incident, Fire
- Transport incident, Theft
- Transport incident, Tamper

Communications

Emergency rules vary depending on the jurisdiction, in intent they are the same. A&DM recommend the following procedure, however this can be over-ridden by local regulations as required.

In the event of an accident during the transport of the Model 1860 radiation transport cask, a chain of communication between the responsible person involved during the incident and the emergency service personnel/regulatory authorities is essential. Contact details for all authorities through the transport route will be included in accompanying transport documentation, refer to Chain of Communications on page 159 for additional information.

Drop Incident

During normal transport conditions the radiation cask may sustain structural damage due to one or more of the following incidents as listed below in Table 24: Possible Causes for Structural Damage

Item	Incident
1	Drop onto flat ground less than 5 meters
2	Drop onto flat ground greater than 5 meters
3	Drop onto sharp spike
4	Drop onto sharp edge
5	Object dropped onto the radiation transport container

Table 24: Possible Causes for Structural Damage

All of the above incidents are treated with the same emergency response methodologies. The severity of an incident where the radiation transport container is dropped from a distance will not only depend on the height, angle and impact surface, but also numerous other variables that are specific to the incident environment, refer to Transport Incident (Drop) on page 162 for further information, including a complete list of procedure to handle this type of incident.

Fire Incident

During normal transport, an incident may occur where the radiation transport cask is subjected to extreme heat. All incidents are treated with the same emergency response methodologies. Such that the severity of an incident where the radiation transport container is subject to extreme temperatures for a period of time will depend on numerous variables. Variables that can not be measured at the time of an incident. Thus the emergency methodologies used in this section assume the worst case scenario.

A generic sequence of emergency procedural steps must be followed for all types of thermal incidents, where the worst case scenario is considered and the incident is handled with the upper most safety precautions to protect the emergency response personnel, the general public and the environment from the effects of radiation contamination, refer to Transport incident (Fire) on page 165 for further information including the procedures that should be taken in the event of a fire incident.

Theft Incident

A situation may occur when the radiation transport cask is deemed missing and the consignor or carrier no longer has control over the package. In this situation the local police must be called immediately. Refer to Transport incident (Theft) on page 168 for additional information.

Tamper Incident

At any time during the transport, if the locks are observed to be broken or damaged in any way. An immediate investigation is to be initiated to determine the following.

Item	*Description*
1	That the source is present
2	Where the incident occurred
3	When the incident occurred
4	How the incident occurred
5	Why the incident occurred
6	The responsible person at the time
7	If known, the responsible or suspect parties

Table 25: Tamper Incident

Inspection & Maintenance

Under normal usage the only damage to the cask will be minor wear and tear, a major incident that will cause damage to the integrity of the containment would be of catastrophic proportions and reportable to the relevant regulators and could require maintenance intervention from inspection by our engineers to replacement of the cask prior to the transport being continued.

Pre Transport Inspection

Before any nuclear radiation transport the A&DM Model 1860 must be inspected against the Model 1860 Dispatch Inspection Check List. This check list requires checking of the following items shown below. Also refer to Dispatch Inspection Check List on page 78 and Dispatch Documentation Check List on page 79 for additional pre transport inspection documentation.

Item	*Requirement*
1	All documents are current
2	End plates are in position and locking bolts are all in place and tightened to 30N/M. Wipe Test Ports are tightened to 40N/M
3	Both locks are in place and locked
4	End crumple shields are bolted in place and tightened to 50N/M
5	Destination plates are in place
6	Transport index measured and recorded in the history log
7	Transport index labels are in place and marked accordingly
8	Hold down ropes and turn-buckles are in the tool box (set of 4)
9	Handling bar (4 pieces is present in the tool box)
10	Transport documentation checked and signed off

Table 26: Pre Transport Inspection Check List

Dispatch Inspection Check List

DATE OF INSPECTION	CASK SERIAL NUMBER
SENDER INFORMATION **Address.**	**ISOTOPE**
	ISOTOPE ACTIVITY **Bq**
RECEIVER INFORMATION **Address.** **Contact Name.**	**AUTHORIZED PERSON** **Title.....** **First Name.....** **Surname.....** **Position.....** **Signature.....**

Before a Model 1860 Radiation Transport Cask can be dispatched on a mission, it first must adhere to a list of checks. These checks are designed to provide assurance that the cask configuration is stable, and that the required additional items are present and accounted for. Follow the inspection sequence as given below, and tick each box as you proceed. If for any reason an inspection point fails, the cask should not be dispatched and A&DM must be contacted immediately.

	ALL DOCUMENTS ARE CURRENT AND CORRECT
	END PLATES ARE IN POSITION, AND BOLTS TORQUED TO 30 Nm
	TEST PORT PLUGS AND COPPER WASHER'S IN PLACE AND TORQUED TO 40 Nm
	BOTH LOCKS ARE IN PLACE AND LOCKED
	END CRUMPLE SHIELDS, BOLTED IN PLACE AND TORQUED TO 50 Nm
	DESTINATION PLATES ARE IN PLACE
	TRANSPORT INDEX MEASURED AND RECORDED IN HISTORY LOG
	TRANSPORT INDEX LABELS IN PLACE AND MARKED ACCORDINGLY
	TOOL BOX CONTENTS ARE COMPLETE

Dispatch Documentation Check List

DATE OF INSPECTION	CASK SERIAL NUMBER
SENDER INFORMATION **Address.**	**ISOTOPE**
	ISOTOPE ACTIVITY **Bq**
RECEIVER INFORMATION **Address.** **Contact Name.**	**AUTHORIZED PERSON** **Title.....** **First Name.....** **Surname.....** **Position.....** **Signature.....**

A list of documentation that must accompany the Model 1860 Radiation Transport Cask during a transport of radioactive materials is given below. Place a tick next to each item if it exists. A copy of this document must be sent to A&DM prior to shipment.

	DANGEROUS GOODS DECLARATION
	EMERGENCY RESPONSE NUMBERS
	ROUTE MAP TO DISPATCH PORT AND RECEIVE PORT
	REGULATORS ACCEPTANCE OF THE IMPORT / EXPORT
	1860 COMPETENT AUTHORITY CERTIFICATION CERTIFICATE
	ISOTOPE SPECIAL FORM CERTIFICATE
	CAPSULE / CALIBRATION CERTIFICATE
	1860 FIELD SURVEY
	1860 WIPE TEST CERTIFICATE
	AUTHORITY TO TRANSPORT, SENDERS AND RECEIVERS REGULATOR
	EMERGENCY RESPONSE MANUAL
	MODEL 1860 USERS MANUAL
	DISPATCH INSPECTION CHECKLIST
	DISPATCH DOCUMENTATION CHECKLIST

Maintenance

The cask is to be pressure washed to remove any dirt, stickers or labels at the end of each round trip. After each shipment the cask is to be inspected for damage and minor imperfections to the outer mesh are an acceptable consequence or transport.

Any damage which opens the mesh to 50mm is considered to be unacceptable and requires repair prior to the next use. Photographs are to be forward to Analogue and Digital Measurements Pty Ltd for evaluation, recording and remedial action.

Any damage that impinges on the attenuator will require photographs to be forwarded to Analogue and Digital Measurements Pty Ltd for evaluation of the damage and a decision on remedial action, which would require the return to Analogue and Digital Measurements Pty Ltd nominated workshop for repair.

The cask is to be returned to Analogue and Digital Measurements Pty Ltd after 15 round trips or 3 years (which ever comes first) for detailed inspection and repair as required to maintain the Cask in as new condition.

Additional information on minor and major repairs can be found in Minor Repairs on page 210 and Major Repairs on page 211.

Detailed Design Calculations

Material Attenuation

Absolute information on attenuation coefficients for various materials from various sources are widely conflicting with respect to exact numbers.

After careful consideration we selected a graph produced by Amersham which provided conservative figures. The Amersham graph did not have data for Tungsten, actual test data was obtained from Sandvick for 90% Tungsten (10% Nickel / Iron binder) which has a density of 18, this was superimposed onto the Amersham graph. This data also is on the conservative as the design uses 97% tungsten which has a density of 18.5.

Verification of the graph data accuracy was obtained by cross referencing to spot data obtained from the following reference.

Reference	Engineering Compendium on Radiation Shielding
Publisher	Springer-Verlag Berlin Heidelberg New York 1968
Editor	R.G Jaeger
Sponsor	International Atomic Energy Agency

A list of detailed references to which the Amersham data is compared and verified against is as given below.

Reference	Description
Volume II, Chapter 9.1.1, Figure 9.1-, 9.1-2	Attenuation with lead and lead alloys. Exposure attenuation factor for broad beam gamma radiation for point source in lead
Volume II, Chapter 9.1.1, Table 9.1.1	Attenuation with lead and lead alloys. Equivalent thickness of various materials per unit of lead thickness
Volume II, Chapter 9.1.1, Table 9.1.2	Attenuation with lead and lead alloys. Comparison of gamma attenuation properties of various materials by weight and thickness
Volume II, Chapter 9.1.1, Table 9.1.4	Attenuation with lead and lead alloys. Radiation dose rate shield attenuation factors as a functions lead lead shield thickness
Volume II, Chapter 9.1.2, figure 9.1-19, 9.1-20	Attenuation with steel and steel alloys. Exposure attenuation factor for broad beam gamma radiation of a poi9nt source in steel
Volume II, Chapter 9.1.2, figure 9.1-22	Attenuation with steel and steel alloys. Radiation dose rate shield attenuation factor as a function of steel shield

	thickness
Volume II, Chapter 9.1.3, figure 9.1-38	Attenuation with Uranium. Radiation dose rate shield attenuation factors as a function of uranium shield thickness

As all attenuation data is on the side of conservatism the actual transport index at the time of first use will be considerably less than that allowed of 10.

Calculation Constants

Attenuating Material Data

Due to the conflicting attenuation information for various materials the more conservative data prepared by Amersham was selected and the absorption data for 97% tungsten obtained from Sandvik was superimposed.

Due to the inexact information on absorption coefficients we have made our selection of materials to give a calculated transport index of 5.

Calculations show that a beam of secondary radiation could beam out of the clearance between the drawer and drawer tube. This required the incorporation of a shine shield at each end of the drawer. The tungsten shine shield became part of the end cap. Refer to Appendix 2 for the attenuating material absorption curves

Air Kerma

The Air Kerma coefficients used in the calculations was selected (as stated by Amersham data) as the design Flux after considerable investigation and consultation with ARPANSA of the conflicting figures quoted in text books and publications.

Practical Limits

The limits of the various configurations of the cask was determined by the consideration of the activity of sources to be supplied plus those to be returned. The practical limits for Co 60 are 1000Ci, 3000Ci, 12000Ci for point sources and 15000Ci for pencils. The flux at 50mm from the outside of the cask was to be less than 500uGy and a transport index of around 5. The design aim was to achieve a balance between weight (cost of transport) and size. The best fit between the amount of lead and the cost of tungsten.

Lifting Stress On Top Support Fin.

The stresses at the lifting holes and the welds on the top fin are analysed. Lifting the cask is done by a pair of certified D shackles and a 1 meter certified steel cable sling. The following assumptions shown below in Table 27: Lifting Stress Assumptions are made.

Item	Assumption
1	The load on each lifting hole is 500Kgs thus the two lifting holes share the weight of the package.
2	The load on the welds on the top crumple fin is 1000Kgs, the whole weight of the package.
3	The reinforced eye supports are ignored for simplicity.

Table 27: Lifting Stress Assumptions

The calculations yield the following results as shown below in Table 28: Lifting Stress Results.

Result	Conclusion
1	The results show that each hole is able to sustain 4787Kgs well above the required load of 500kgs
2	The results show that the welds concerned are able to sustain 30113Kgs, well above the required 1000Kgs

Table 28: Lifting Stress Results

Calculation 1, Lifting Hole Strength

1000Kgs lifted by 2 holes
l = Maximum load on each hole
→ l = 500Kgs

y = 316 Stainless steel Tensile Yield
→ y = 413MPa

s = Max Shear Stress
→ s = 0.5 . y
→ s = 216MPa

A = Share Area
→ $A = 199mm \times 6mm \times 2mm = 228mm^2$

$$X = \text{Share Strength} = \frac{(A \times s)}{9.81\text{Kgs}}$$
$$\rightarrow X = \frac{(228 \times 216)}{(9.81)}$$
$$\rightarrow X = 4748\text{Kgs}$$

The shear strength is 9.5 times greater than the maximum load of the package, thus the lifting eye will sustain the load.

Calculation 2, Weld Strength

$$F = \text{Strength of Weld}$$
$$\rightarrow F = s \times (2tL)$$
$$\rightarrow F = s \times 2 \times b \times \cos(45) \times L$$

Where:

s = Maximum share stress = 206Mpa

t = Throat of weld = b.(cos(45))

b = Weld size = 3 mm

L = Effective length of welds

Substituting s and b

$$F = 206 \times 2 \times 3 \times 0.707 \times L$$

Share Area and Weld Length refer *Drawing Section 1860A-01, Drawing 1860A-01-171-03.*

Horizontal segments of weld = 178mm

Vertical segments of weld = 160mm

Total weld length = 338mm

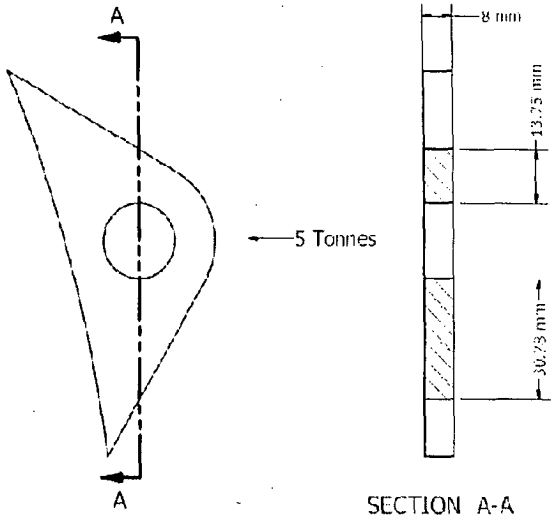
Substituting L

$$F = (206 \times 2 \times 3 \times 0.707) \times 338$$
$$F = 874 \times 338 \text{ Newtons } F = \frac{295142}{(9.81\text{Kgs})}$$
$$F = 30113\text{Kgs}$$

Tie Down Point Stress Analysis

File: C:\admwork\Model1860\Drawings\Inventor\1860A\Design_Calculation\1860A-01-181 strength.dw | Model / Component Rev: 1

Criteria to be inventigated:
Horizontal Force of 10 Tonnes on The Cask Tiedown Brackets.



Side View - Horizontal Force

Effectively, 10 Tonnes horizontal force will be bear by 2 tiedown brackets

Each bracket will experience 5.000 tonnes at its cross section normal to the direction of force

Cross Section Area normal to horizontal force
= 8 mm x (13.75 mm + 30.75 mm)
= 356.24 sq mm.

Stress as result of the force in MPa (Newton per mm square)
= Force in Newton / Area in mm normal to force
= 5,000 x 9.81 Newton / 356.24 sq mm
= 137.69 MPa

The material used (SS 316-483) has
Yield Strength = 210 Mpa
Tensile Strength = 540 Mpa
("Sandvik Stainless Steel and Specialty Alloy Stock Programme" page 9)

The stress on bracket is below its yield strength.
The force is 26% of material strength
(137.69 MPa / 540 Mpa x 100 per cent).

Conclusion:
Material strength exceeded test criteria.

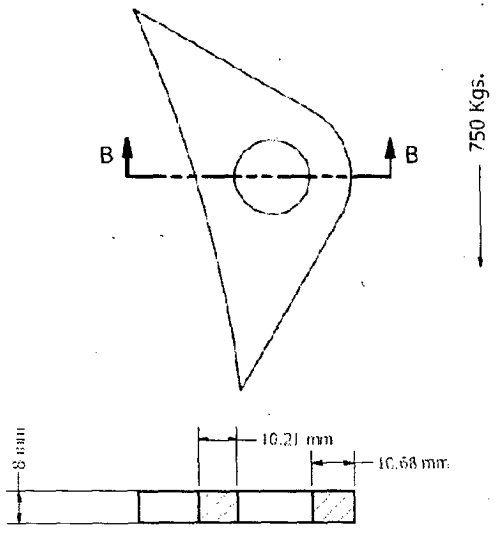
DRAWN richard	5/07/2007	Analogue & Digital Measurements P/L http://admeasure.com.au	
ENGINEERING CHECKED			
DRAWING QA CHECK L. GROGAN		Project / Model	1860A
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Number	1860A-01-181
MANUFACTURE QA		Component Description	Tiedown Bracket
		Drawing Description	Component Detail
		SIZE A3 / SCALE N.T.S / DWG NO 1860A-01-181 strength / SHEET 1 OF 1 / REV 1	

WARNING: This drawing MUST NOT be used for production unless it contains a GREEN STAMP

NOTE:

File: C:\admwork\Model\1860\Drawings\Inventor\1860A\Design_Calculations\1860A-01-181 Strength.idw | Model / Component Rev: 1

Criteria to be investigated:
Vertical Force of 3 Tonnes on The Cask Tiedown Bracket.



SECTION B-B

Effectively, 3 Tonnes Vertical force will be bear by 4 tiedown brackets

Each bracket will experience .75 tonnes at its cross section normal to the direction of force.

Cross Section Area normal to horizontal force
= 8 mm x (10.21 mm + 10.68 mm)
= 167.12 sq mm.

Stress as result of the force in MPa (Newton per mm square)
= Force in Newton / Area in mm normal to force
= 750 x 9.81 Newton / 167.12 sq mm
= 44.03 MPa

The material used (St. St. 403) has
Yield Strength = 210 Mpa
Tensile Strength = 540 Mpa
("Sanvik Stainless Steel and Speciality Alloy Stock Programme" page 9)

The stress on bracket is below its yield strength.
The force is 8.2% of material strength
(44.03 MPa / 540 Mpa x 100 per cent).

Conclusion:
Material strength exceeded test criteria.

DRAWN: P.Ward	5/07/2007
ENGINEERING CHECKED:	
DRAWING QA CHECK: L. GRUGAN	
TOLERANCE (UNLESS SPECIFIED):	0.2mm
MANUFACTURE QA:	

Analogue & Digital Measurements P/L
http://admcasure.com.au

Project / Model	**1860A**
Component Number	**1860A-01-181**
Component Description	Tiedown Bracket
Drawing Description	Component Detail

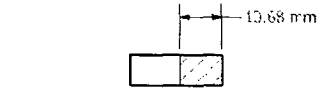
SIZE	SCALE	DWG NO	SHEET 2 OF 4	REV
A3	N.T.S	1860A-01-181 strength		1

WARNING: This drawing MUST NOT be used for production unless it contains a GREEN STAMP

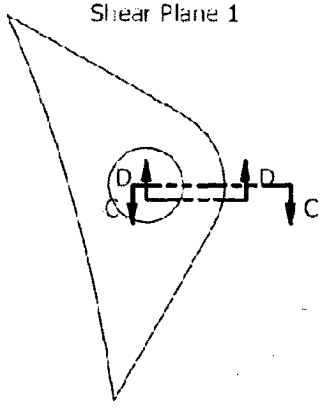
NOTE:

File C:\admwork\Model\1860\Drawings\Inventor\1860A\Design_Calculation\1860A-01-181 strength.idw | Model / Component Rev: 1

Criteria to be investigated:
Lateral Shear Force of 5 Tonnes on The Cask Tiedown Bracket.



SECTION C-C
Shear Plane 1



SECTION D-D
Shear Plane 2

Effectively, 5 Tonnes lateral force will be bea
by 2 tiedown brackets

Each bracket will experience 2.5 tonnes
at its shear plain parallel to the direction of force.
(Note there are 2 shear plains
The shear force is applied through a thickness,
say thickness on tie down rope)

Cross Section Areas parallel to shear force
= 8 mm x 10.68 mm x2
= 170.88 sq mm.
(For simplicity, the narrow cross section
assumed for both shear plains.)

Stress as result of the force in MPa (Newton per mm square)
= Force in Newton x Area in mm parallel to force

= 2500 x 9.81 Newton / 170.88 sq mm
= 143.52 MPa

The material used (St. St. 403) has
Yield Strength = 210 Mpa
Tensile Strength = 540 Mpa
("Sarvik Stainless Steel and Speciality Alloy Stock Programme"
page 9)

The stress on bracket is below its yield strength.
The force is 26.8% of material strength
(143.52 MPa / 540 Mpa x 100 per cent).

Conclusion:
Material strength exceeded test criteria.

DRAWN: richard	5/07/2007	**Analogue & Digital Measurements P/L** http://admeasure.com.au	
ENGINEERING CHECKED		Project / Model	1860A
DRAWING QA CHECK: L. GROGAN		Component Number	1860A-01-181
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Tiedown Bracket
MANUFACTURE QA		Drawing Description	Component Detail
		SIZE: A3 / SCALE: N.T.S / DWG NO: 1860A-01-181 strength SHEET 3 OF 4	REV: 1

WARNING: This drawing MUST NOT be used for production unless it contains a GREEN STAMP

NOTE:

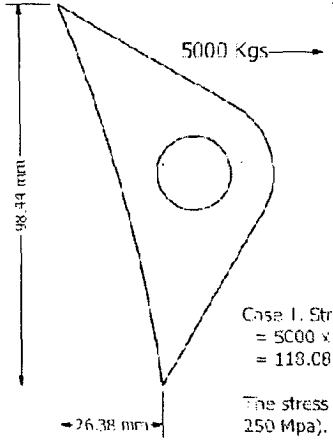
File: C:\admwork\Model 1860\Drawings\Inventor\1860A\Design Calculation\1860A-01-181 strength.idw | Model / Component Rev: 1

Criteria to be investigated:
Strength of Weld of Tiedown Bracket for:
1. 5000 Kgs Horizontal Force.
2. 750 Kgs Vertical Force.
3. 2500 Kgs Lateral Force

Strength of weld (Machine Design- Paul Black, page167)
Weld Shear Plain = Weld Length x Weld Throat Length

Throat Length of 3mm x 3mm weld = 3 Cos 45 ° = 2.12 mm

Vertical Throat Length = 98.44 mm
Horizontal Throat Length= 26.38



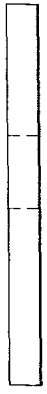
Case 1. Stress on weld
= 5000 x 9.81 N / 98.44 x 2.11 x 2 mm sq
= 118.08 MPa

The stress on weld is below its yield strength 250 Mpa).

750 Kgs

Case 2. Stress on weld
= 750 x 9.81 N / 26.38 x 2.11 x 2 mm sq
= 66.9 MPa

The stress on weld is below its yield strength 250 Mpa).



Case 3. Stress on weld
= 2500 x 9.81 N / 98.44 x 2.11 x 2 mm sq
= 59.04 MPa

The stress on weld is below its yield strength 250 Mpa).

Conclusion:
Weld strength exceeded test criteria.

DRAWN: richard	5/07/2007	
ENGINEERING CHECKED		
DRAWING QA CHECK: L. GROGAN		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	
MANUFACTURE QA		

Analogue & Digital Measurements P/L
http://admeasure.com.au

Project / Model	1860A
Component Number	1860A-01-181
Component Description	Tiedown Bracket
Drawing Description	Component Detail

SIZE	SCALE	DWG NO	SHEET 1 OF 1	REV
A3	N.T.S	1860A-01-181 strength		1

WARNING: This drawing MUST NOT be used for production unless it contains a SIGNED STAMP

NOTE:

Impact Analysis IAEA Clause 727(c)

Overview

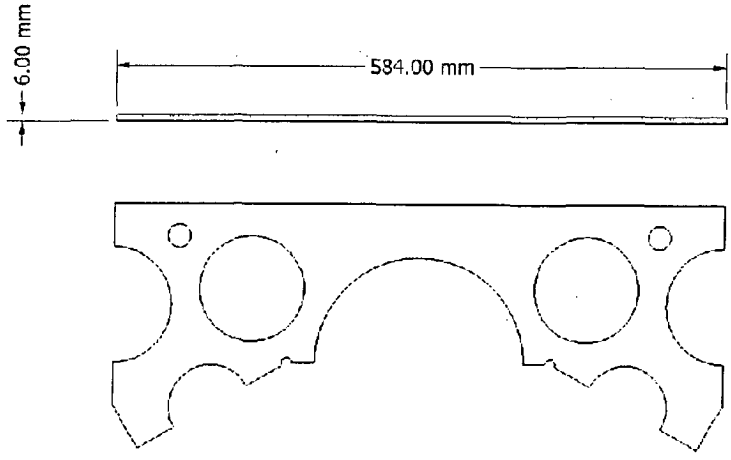
Clause 727(c) from the IAEA regulations for the Safe Transport of Radioactive Materials (TS-R-1), specifies the third drop test for the specimen. This drop test is not applicable through clause 656(b).(i). However for completeness a calculation to prove the integrity of the package after the dynamic crush test of 727(c) is as given below.

Clause 727(c) calls for a 500kg plate to be dropped onto the package from a height of 9 meters. In clause 727(a) the package was dropped from a height of 9 meters, and proved to pass the test, see ANSTO test report section 4.3.1. Considering that the package mass is approximately 1000kg's it is estimated that the damage to the package will be considerably less than the damage sustained in test 727(a).

It is difficult to estimate the exact damage that will be caused by test 727(c), we can however conclude it will be approximately 50% of the damage caused by 727(a). To analyse the top fin, a computer simulation will be conducted.

Energy absorbed by crumple fins

Consider a 500kg plate being dropped from a height of 9 meters, calculate the pressure on the top fin where the impact surface area is 3504mm2.



To do this we must calculate the force at impact and then convert this impact force to an impact pressure on the top surface area of the fin.

$$F = ma$$
$$F = m \times (\Delta v / \Delta t)$$

where m = Object Mass (500Kg's)

Δv = Change in velocity at impact

Δt = Change in time at impact

The Δv can be calculated by a standard velocity equation, and Δt can be estimated from slow motion footage taken from test 727(a). This footage will provide the best estimate to the time taken for the crumple fins to absorb the impact energy and slow the object down in the estimated time Δt. Calculate the velocity of the object after 9 meters of free fall.

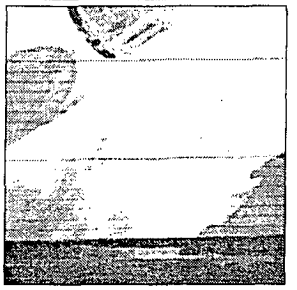
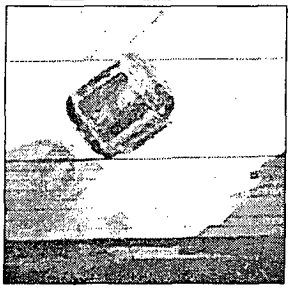
$$\frac{1}{2}mv^2 = mgh$$

$$v = \sqrt{2gh}$$

$$v = \sqrt{(2 \times 9.81 \times 9.0)}$$

$$v = 13.3 ms^{-1}$$

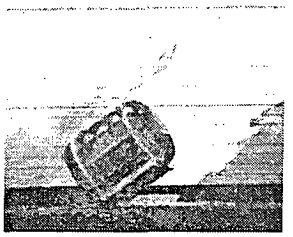
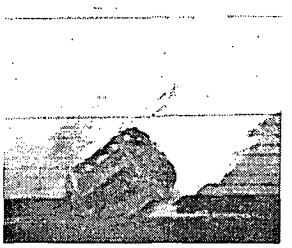
Determine Δt from the high speed footage for drop test 727(a). The footage does not have a time scale, It does however have a distance scale, and we know that the package is travelling at 13.3m/s. Thus the time taken to travel 1 meter is 75.18ms. Next we determine the time scale from the footage.

Time Stamp	Image
01:55	
02:12	

The time stamps from the footage show it take 17 seconds for the package to fall 1 meter, thus calculate the real time scale from the footage

$$17s \times y = 75.18ms$$
$$y = 4.42ms$$

Thus 1 second of footage is equal to 4.42ms real time. Now determine the time taken for the package to decelerate.

Time Stamp	Image
02:26	
02:30	

The from the high speed footage, it can be seen that it takes 4 seconds for the package to decelerate. Using the constant 'y' calculate above, determine the real time deceleration Δt.

$\Delta t = 4 \times y$
$\Delta t = 4 \times 4.42ms$
$\Delta t = 17.72ms$

Now calculate the impact force

$F = ma$
$F = m \times (\Delta v / \Delta t)$
$F = 500Kg \times 13.3ms^{-1} / 17.72ms$
$F = 375202N$

Convert this impact force to an impact pressure on the top fin

$$P = \frac{375202N}{3504mm^2}$$
$P = 107MPa$

Knowing the impact pressure on the top surface area of the fin. ANSYS is used to simulate the stress and deformation of the fin under the applied pressure of 107MPa.

Autodesk Inventor Professional Stress Analysis was used to simulate the behavior of a mechanical part under structural loading conditions. ANSYS technology generated the results presented here after.

The Relevance setting listed below controlled the fineness of the mesh used in this analysis. For reference, a setting of -100 produces a coarse mesh, fast solutions and results that may include significant uncertainty. A setting of +100 generates a fine mesh, longer solution times and the least uncertainty in results. Zero is the default Relevance setting. Bounding box dimensions represent lengths in the global X, Y and Z directions.

Bounding Box Dimensions	584. mm 231.9 mm 6. mm
Part Mass	2.657 kg
Part Volume	3.322e+ 005 mm³
Mesh Relevance Setting	0
Nodes	1817
Elements	198

Table 29: Part Statistics

The following material behavior assumptions apply to this analysis:

- Linear - stress is directly proportional to strain.
- Constant - all properties temperature-independent.
- Homogeneous - properties do not change throughout the volume of the part.
- Isotropic - material properties are identical in all directions.

Young's Modulus	1.93e+ 005 MPa
Poisson's Ratio	0.3
Mass Density	8.e-006 kg/mm³
Tensile Yield Strength	205. MPa
Tensile Ultimate Strength	515. MPa

Table 30: 316 Material Data

The following loads and constraints act on specific regions of the part. Regions were defined by selecting surfaces, cylinders, edges or vertices. Note: vector data corresponds to global X, Y and Z components.

Load and Constraint Definitions

Name	*Type*	*Magnitude*	*Vector*
Pressure 1	Surface Pressure	107. MPa	N/A
Fixed Constraint 1	Surface Fixed Constraint	0. mm	0. mm 0. mm 0. mm

Table 31: Load and Constraint Definitions

Constraint Reactions

Name	*Force*	*Vector*	*Moment*	*Moment Vector*
Constraint 1	3.749e+005 N	-4.948e-004 N 3.749e+005 N -3.798e-004 N	0.2947 N·mm	-1.589e-002 N·mm -4.231e-002 N·mm -0.2912 N·mm

Table 32: Constraint Reactions

The table below lists all structural results generated by the analysis. The following section provides figures showing each result contoured over the surface of the part.

Safety factor was calculated by using the maximum equivalent stress failure theory for ductile materials. The stress limit was specified by the tensile yield strength of the material.

Structural Results

Name	*Minimum*	*Maximum*
Equivalent Stress	1.176 MPa	971.1 MPa
Deformation	0. mm	0.4772 mm
Safety Factor	0.2111	N/A

Table 33: Structural Results

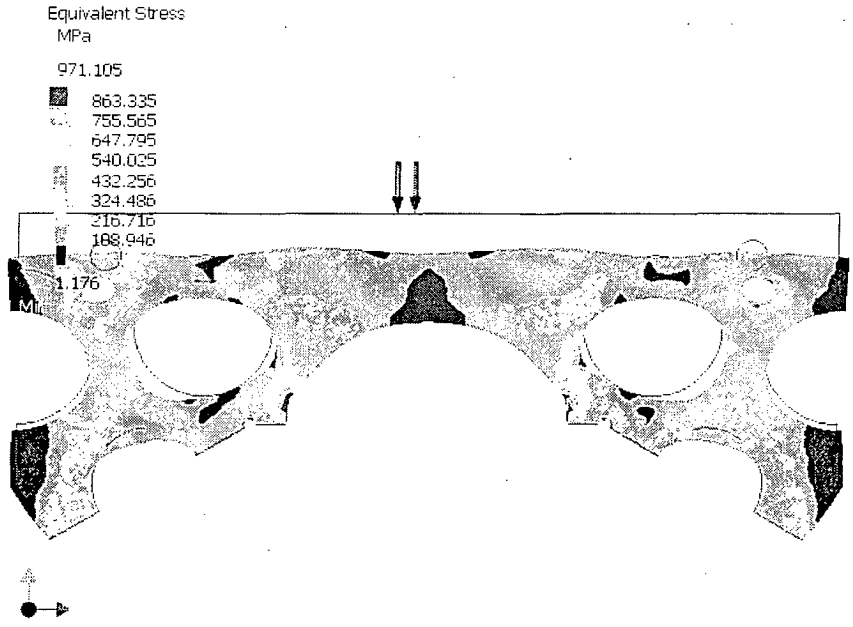


Illustration 3: Top Fin Equivalent Stress

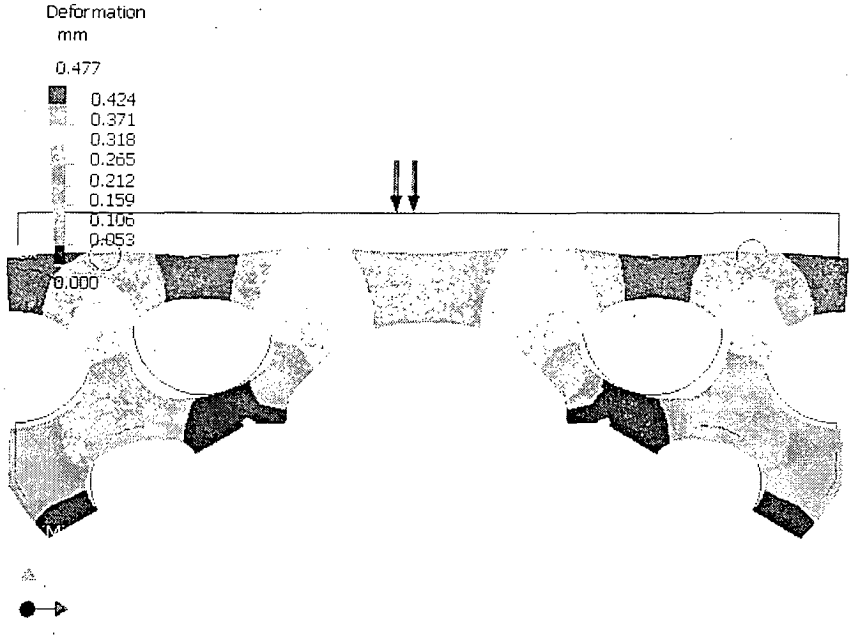


Illustration 4: Top Fin Deformation

Package Deformation

From the above simulation it is determined that the impact from the 500kg plate will deform the top fin. The deformation of the top fin will depend on the angler velocity of the impact force. In the worst case scenario, the 500Kg plate will compress the outer skin of the package and produce a flat spot between the two crumple fins either side of the top fin. From the package drawings (Illustration 5: Package Deformation, below) it can be seen that in the worst case, the deformation will be approximately 50mm. This will inherently increase the transport index of the package by decreasing the distance from the outer surface of the package to the attenuator core, thus increasing the dose rate at the surface. The increase in dose rate and transport index will be less than 10% as the distortion is only 50mm.

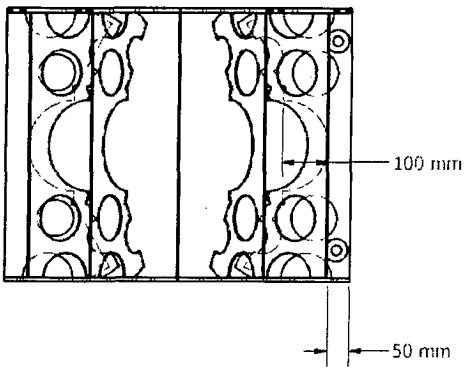


Illustration 5: Package Deformation

Conclusion

Thus to drop a 500Kg plate onto the package from a height of 9 meters, the top fin will absorb the majority of the impact pressure, with a maximum pressure occurring at 971MPa. It is expected the fin will distort, bend and tare in some places. This distortion will depend on the angler direction of the impact force. In the best case, when the impact force is directly vertical on the top surface area of the fin, the deformation was simulated to be approximately 0.5mm. In the worst case where the impact force may be applied at an angle of 45 degrees to the top surface area of the fin, it is possible that 50mm of deformation could occur.

Thermal Analysis, Cooling of the Package, IAEA Clause 728(b)

Calculation

IAEA Clause 728(b), requires that the package temperature drops after the fire test of 728(a). 728(b) specifies that the temperatures in the specimen are every where decreasing and are approaching initial steady state conditions. To prove that the temperatures in the package are everywhere decreasing, we will calculate the time taken for the package to be in equilibrium with an ambient temperature of 38°C. And also calculate the time taken for the package to be in equilibrium with ambient of 38°C, in direct sun light, with a solar energy input of 800W/m^2 given in table XI of TS-R-1. The properties of Lead used below are referenced from Appendix 3.

The following constants apply:

Constant	Description	Value
T1	Ambient temperature	38°C (311°K)
T3	Attenuator temperature with source loaded. See ANSTO report section 5.2	71.1°C (344.1°K)
m	Mass of the package	1000kg
A	Surface area of the package attenuator	1.32m^2
ε	Emissivity of Lead (Pb)	0.43
λ	Stefan-Boltzmann constant	56.7x10^{-9} W/m^2K^4
s	Solar energy	800 W/m^2
c	Specific heat capacity of lead	0.129kJ/Kg.K
h	Thermal Conductivity of lead	36W/m K
d	Average thermal conduction path, distance from attenuator skin to core, including distance from side to centre of core	0.5m

Table 34: Thermal Analysis Constants

The following assumptions apply:

Assumption	Description
1	The surface temperature of the attenuator is 800°C
2	Neglect the cooling fins attached to the attenuator
3	Solar energy addition of 800W/m^2 worst case scenario

Table 35: Thermal Analysis Assumptions

First Calculate the average temperature of the lead attenuator after 30 mins in the 800 °C environment.

The specific heat capacity of Lead is a measure of energy required to raise 1Kg of Lead by 1°K, where Δ1°C = Δ1°K. So now calculate the energy required to heat 1000Kg's of Lead by 1°C

$$c = 0.129 kJ/kg \times K$$

$$c = 129 J/kg \times K$$
$$c = 129 \times 1000 kg \times 1$$
$$c = 129000 J$$

Thus it will require 129,000 Joules of energy to raise 1000Kgs of Lead by 1°K. The thermal conductivity is a measure of how much thermal energy the Lead can conduct per meter for each °K

$$h = 36 W/m \times K$$

$$h = 36 \times 0.5 \times 1073$$

$$h = 19314 W$$
$$h = 19314 J/s$$

We know the time exposure is 30 mins or 1800 seconds, thus we can calculate the total energy conducted in 30 mins.

$$E = h \times t$$

$$E = 19314 \times 1800$$
$$E = 34765200 J$$

We know that from the specific heat capacity, it takes 129,000 J to raise the temperature of 1000Kgs of lead by °K, thus we calculate the temperature change of the attenuator mass

$$\Delta T = 34765200 \div 129000$$
$$\Delta T = 269.49\,^{\circ}C$$

Now Consider Stefan-Boltzmann's law of radiant heat.

$$Q = \varepsilon \lambda A (T2^4 - T1^4)$$

Now find Q, which is the energy (W) radiated from the surface of the package. First Determine the absolute temperature of the body in Kelvin (K), consider 0°C is 273°K

$$T2 = 269.5 + 273 = 542.5K$$
$$T1 = 38 + 273 = 311K$$

$$Q = \varepsilon \lambda A (T2^4 - T1^4)$$

$$Q = 0.43 \times 56.7 \times 10^{-9} \times 1.32 \times (542.5^4 - 311^4)$$

$$Q = 2406W$$
$$Q = 2.406kW$$

Now use the standard heat equation to determine the rate of radiant heat flow

$$Q = mc\Delta T$$

$$\Delta T = \frac{Q}{mc}$$
$$\Delta T = \frac{2.406}{(1000 \times 0.129)}$$
$$\Delta T = 0.01865\,^{\circ}C/s$$

now convert to °C/min

$$\Delta T = 0.0210 \times 60$$
$$\Delta T = 1.1191\,^{\circ}C/min$$

Assume surface temperature of 800°C loaded attenuator temperature of T3 (71.1°C), thus differential temp = 728.9°C

$$\frac{\left(\frac{728.9}{1.1191}\right)}{60} = 10.8554 \text{Hours}$$

Now assume the solar addition 800W/m^2 from Table XI, Solar insulation data, TS-R-1 page 84. For this calculation it is assumed worst case scenario, that the solar addition of 800W/m^2 is applied to the entire surface area of the attenuator.

$$Q = mc\Delta T$$

$$\Delta T = \frac{Q}{mc}$$

where $Q = 2.708 - (0.8 \times 1.32) = 1.35 \text{kW}$

$$\Delta T = \frac{1.35}{(1000 \times 0.129)}$$

$$\Delta T = 0.0104\,^{\circ}\text{C/s}$$

now convert to °C/min

$$\Delta T = 0.0104 \times 60$$

$$\Delta T = 0.6279\,^{\circ}\text{C/min}$$

Assume surface temperature of 800°C loaded attenuator temperature of T3 (71.1°C), thus differential temp = 728.9°C.

$$\frac{\left(\frac{728.9}{0.6279}\right)}{60} = 19.3475 \text{Hours}$$

Conclusion

From the above calculations it is concluded that the model 1860A type B(U) package will radiate heat from the surface of its attenuator for a period of time after test 728(a). The temperature in the attenuator are everywhere decreasing, approaching initial steady state conditions.

The time taken from the package to reach an ambient temperature of 38°C in an environment void of solar additions is calculated to be 10.8554 hours. Where the time taken for the package to reach the ambient temperature of 38°C with the addition of solar energy input is calculated to be less than 19.3475 hours.

Configuration A, Equations for ^{60}Co

Loading Calculations

The maximum isotope activity loading for the model 1860 configuration type A is concluded through the following equations.

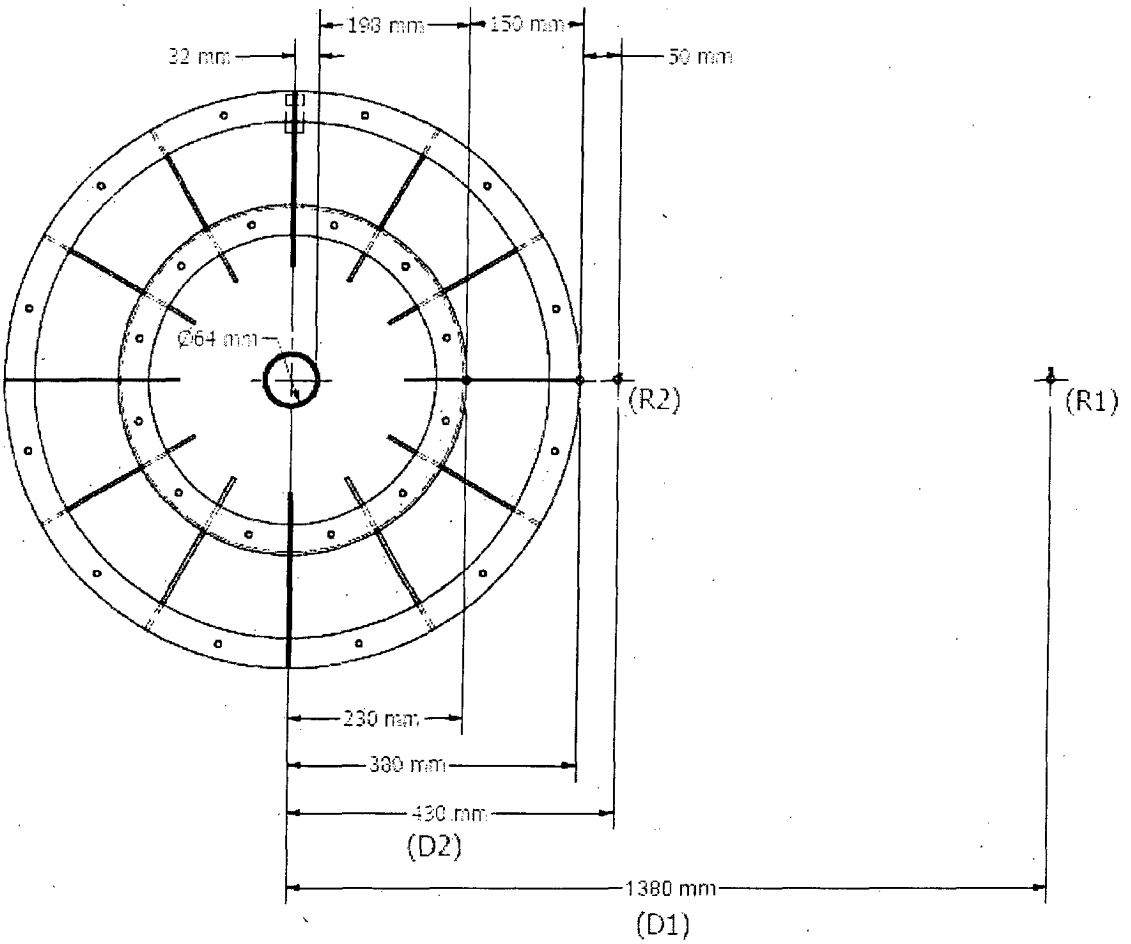


Illustration 6: Configuration A Calculation Layout

To determine the maximum activity loading the activity required to produce a field of 500µGry at 50mm from the outer surface of the package is calculated. Based on the Air Kerma constant of 11.1mGry/Ci/hr for ^{60}Co.

Calculation of the unshielded field at R2 based on the Air Kerma of 11.1mGry/Ci/hr at 1m from the source refer Illustration 6: Configuration A Calculation Layout as above

$$R2 = 11.1\left(\frac{1000}{D2}\right)^2$$

$$R2 = 11.1\left(\frac{1000}{430}\right)^2$$

$$R2 = 11.1 \times (2.326)^2$$

$$R2 = 11.1 \times 5.41$$

$$R2 = 60\text{mGry/Ci}$$

$$R2 = 6 \times 10^4 \mu\text{Gy/Ci/hr}$$

Thus at R2 the calculated dose rate is 60mGry/Ci/hr for the unshielded source. Next determine the dose rate with an applied shielding form 200mm of lead.

The attenuation for 200mm of lead from the Amersham graph produces the following constant 'A', where. See appendix 2 for attenuation curves.

$$A = 8 \times 10^{-6}$$

Now applying the transmission factor 'A' to the field at R2 yields the following result

$$\text{Dose} = R2 \times A$$

$$\text{Dose} = (6 \times 10^4).(8 \times 10^{-6})$$

$$\text{Dose} = 48 \times 10^{-2} \mu\text{Gry/Ci/hr}$$

Next calculate the maximum loading to produce a field of 500uGy at R2.

$$\text{Activity} = \frac{\text{Required Dose Rate}}{\text{Dose Rate Per Curie}}$$

$$\text{Activity} = \frac{500}{48 \times 10^{-2}}$$

$$\text{Activity} = 1041\text{ Ci}$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package, refer to Illustration 6: Configuration A Calculation Layout above.

$$R1 = \frac{(R2 \times D2^2)}{(D1^2)}$$

$$R1 = \frac{(500 \times 430^2)}{(1380^2)}$$

$$R1 = 48.545\mu\text{Gry/hr}$$

Now convert μGry/hr to mR/hr to calculate the transport index.

$$TI = \left(\frac{48.545}{10}\right)$$
$$TI = 4.85$$

Thus the loading of 1041Ci of ^{60}Co will produce a field strength of 500μGry at 50mm from the outer surface of the package. The calculated Transport index for this loading is 4.85.

Transport Index for Approved Loading of 1080Ci

From the Model 1860 Type B(U) package specifications, the maximum approved loading ^{60}Co for the type A configuration is 1080Ci. The resultant transport index is as calculated below.

$$TI = \left(\frac{\text{Max Approved Loading}}{\text{Calculated Loading}}\right) \times \text{Calculated Transport Index}$$
$$TI = \left(\frac{1080}{1041}\right) \times 4.85$$
$$TI = 5.031$$

Thus for a loading of 1080Ci of ^{60}Co the resultant transport index, taken at 1000mm from the outer surface of the package is calculated to be 5.031.

Configuration A, Maximum Loading for ^{137}Cs

Loading Calculations

From the calculations for the maximum loading of ^{60}Co in the type 'A' configuration it can be estimated that the maximum loading for ^{137}Cs would far exceed the physical space specifications of the attenuator. For this reason the following calculations are based around a maximum loading of 30,000 Ci of ^{137}Cs.

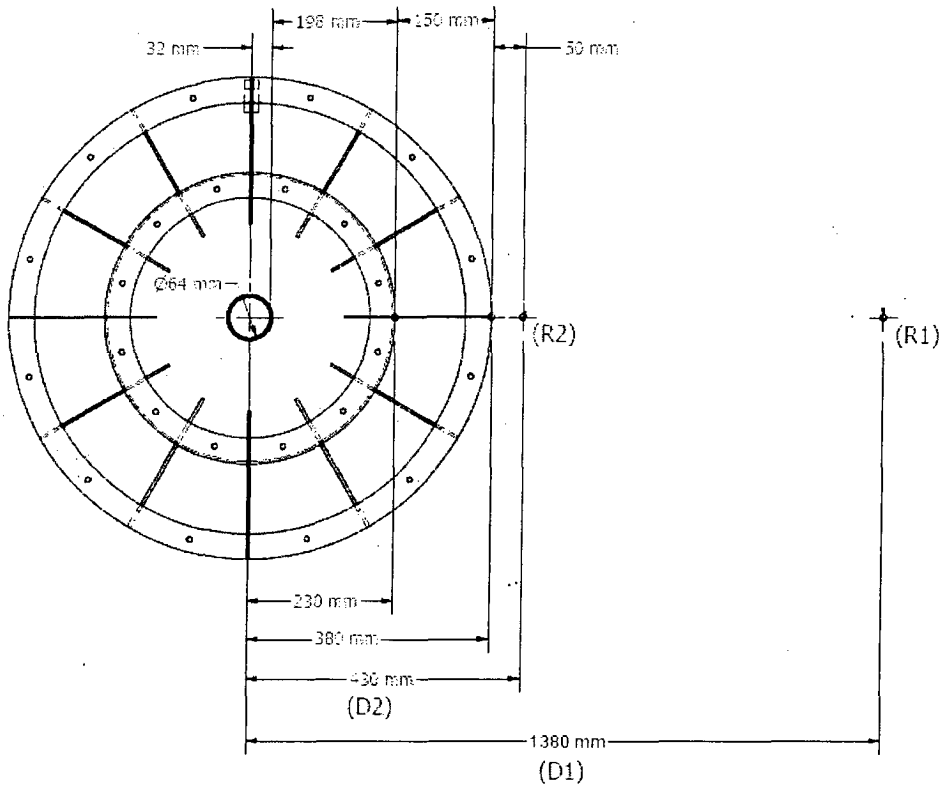


Illustration 7: Configuration A Calculation Layout for ^{137}Cs

All Calculations are based on the Air Kerma constant of 3300µGry/Ci/hr for ^{137}Cs.

Calculation of the unshielded field at R2 based on the Air Kerma of 3300µGry/Ci/hr at 1m from the source refer Illustration 7: Configuration A Calculation Layout for 137Cs as above

$$R2 = 3300\left(\frac{1000}{D2}\right)^2$$

$$R2 = 3300\left(\frac{1000}{430}\right)^2$$

$$R2 = 3300 \times (2.326)^2$$

$$R2 = 3300 \times 5.408$$

$$R2 = 1.784 \times 10^4 \mu Gy/Ci/hr$$

Thus at R2 the calculated dose rate is 1.784×10^4µGry/Ci/hr for the unshielded source. The calculated dose rate for a loading of 30,000 Ci of ^{137}Cs is.

$$Dose = (1.784 \times 10^4).(30{,}000)$$

$$Dose = 5.352 \times 10^8 \mu Gry/hr$$

Next determine the dose rate with an applied shielding form 200mm of lead. The transmission factor for 200mm of lead produces the following constant 'A'. See appendix 2 for attenuation curves.

$$A = 1.070 \times 10^{-9}$$

Now applying the attenuation constant 'A' to the field at R2 yields the following result

$$R2 = R2 \times A$$

$$R2 = (5.352 \times 10^8).(1.070 \times 10^{-9})$$

$$R2 = 0.572 \mu Gry/hr$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package, refer to Illustration 7: Configuration A Calculation Layout for 137Cs above.

$$R1 = R2 \times \left(\frac{D2}{D1}\right)^2$$

$$R1 = 0.572 \times \left(\frac{430}{1380}\right)^2$$

$$R1 = 0.047 \mu Gry/hr$$

Now convert μGry/hr to mR/hr to calculate the transport index.

$$TI = (\frac{0.047}{10})$$
$$TI = 0.0047$$

Thus for a loading of 30,000Ci of ^{137}Cs the field strength at 50mm from the surface of the package is calculated to be 0.572μGry/hr. The field strength at 1000mm from the surface of the package is calculated to be 0.055μGry/hr producing a transport index of 0.0047.

Transport Index for Approved Loading of 27000Ci

From the Model 1860 Type B(U) package specifications, the maximum approved loading ^{137}Cs for the type A configuration is 27000Ci. The resultant transport index is as calculated below.

$$TI = (\frac{\text{Max Approved Loading}}{\text{Calculated Loading}}) \times \text{Calculated Transport Index}$$
$$TI = (\frac{27000}{30000}) \times 0.0047$$
$$TI = 0.00423$$

Thus for a loading of 27000Ci of ^{137}Cs the resultant transport index, taken at 1000mm from the outer surface of the package is calculated to be 0.00423.

Configuration A, Maximum Loading for ^{226}Ra

Loading Calculations

The following calculations conclude the dose rate and transport index for a loading of 1000Ci of ^{226}Ra. 1000Ci of this isotope has been commercially considered as the maximum activity that would ever be transported in a single shipment. Typical transport scenario would be a loading of 250Ci of ^{226}Ra.

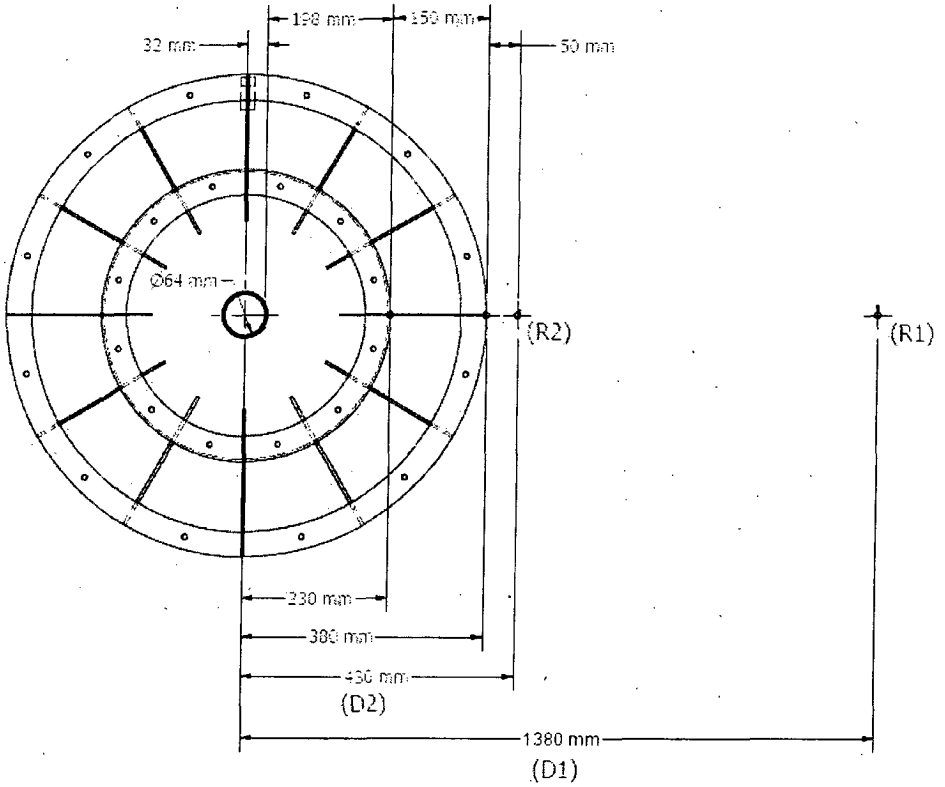


Illustration 8: Configuration A Calculation Layout for ^{226}Ra

All calculations are based on the Air Kerma constant of 8250µGry/Ci/hr for ^{226}Ra.

Calculation of the unshielded field at R2 based on the Air Kerma of 8250µGry/Ci/hr at R1 refer Illustration 8: Configuration A Calculation Layout for 226Ra as above

$$R2 = 8250\left(\frac{1000}{D2}\right)^2$$

$$R2 = 8250\left(\frac{1000}{430}\right)^2$$

$$R2 = 8250 \times (2.326)^2$$

$$R2 = 8220 \times 5.408$$

$$R2 = 4.462 \times 10^4\ \mu Gy/Ci/hr$$

Thus at R2 the calculated dose rate is 4.4616x10^{4}µGry/Ci/hr for the unshielded source. The calculated dose rate for a loading of 1000 Ci of ^{226}Ra at R2.

$$Dose = (4.462 \times 10^4).(1000)$$

$$Dose = 4.462 \times 10^7\ \mu Gry/hr$$

Next determine the dose rate with an applied shielding form 200mm of lead. The transmission factor for 200mm of lead produces the following constant 'A'. See appendix 2 for attenuation curves.

$$A = 7.500 \times 10^{-7}$$

Now applying the attenuation constant 'A' to the field at R2 yields the following result

$$R2 = R2 \times A$$

$$R2 = (4.462 \times 10^7).(7.500 \times 10^{-7})$$

$$R2 = 33.465 \times \mu Gry/hr$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package, refer to Illustration 8: Configuration A Calculation Layout for 226Ra above.

$$R1 = R2 \times \left(\frac{D2}{D1}\right)^2$$

$$R1 = 33.465 \times \left(\frac{430}{1380}\right)^2$$

$$R1 = 3.249 \mu Gry/hr$$

Now convert μGry/hr to mR/hr to calculate the transport index.

$$TI = (\frac{3.249}{10})$$
$$TI = 0.324$$

Thus for a loading of 1000Ci of ^{226}Ra the field strength at 50mm from the surface of the package is calculated to be 33.465μGry/hr. The field strength at 1000mm from the surface of the package is calculated to be 3.249μGry/hr producing a transport index of 0.324.

Transport Index for Approved Loading of 1000Ci

From the Model 1860 Type B(U) package specifications, the maximum approved loading ^{226}Ra for the type A configuration is 1000Ci. The resultant transport index is as calculated below.

$$TI = (\frac{\text{Max Approved Loading}}{\text{Calculated Loading}}) \times \text{Calculated Transport Index}$$
$$TI = (\frac{1000}{1000}) \times 0.324$$
$$TI = 0.324$$

Thus for a loading of 1000Ci of ^{226}Ra the resultant transport index, taken at 1000mm from the outer surface of the package is calculated to be 0.324.

Configuration A, Maximum Loading for ^{192}Ir

Loading Calculations

The following calculations conclude the dose rate and transport index for a loading of 50000Ci of ^{192}Ir. 50000Ci of this isotope has been commercially considered as the maximum activity that would ever be transported in a single shipment.

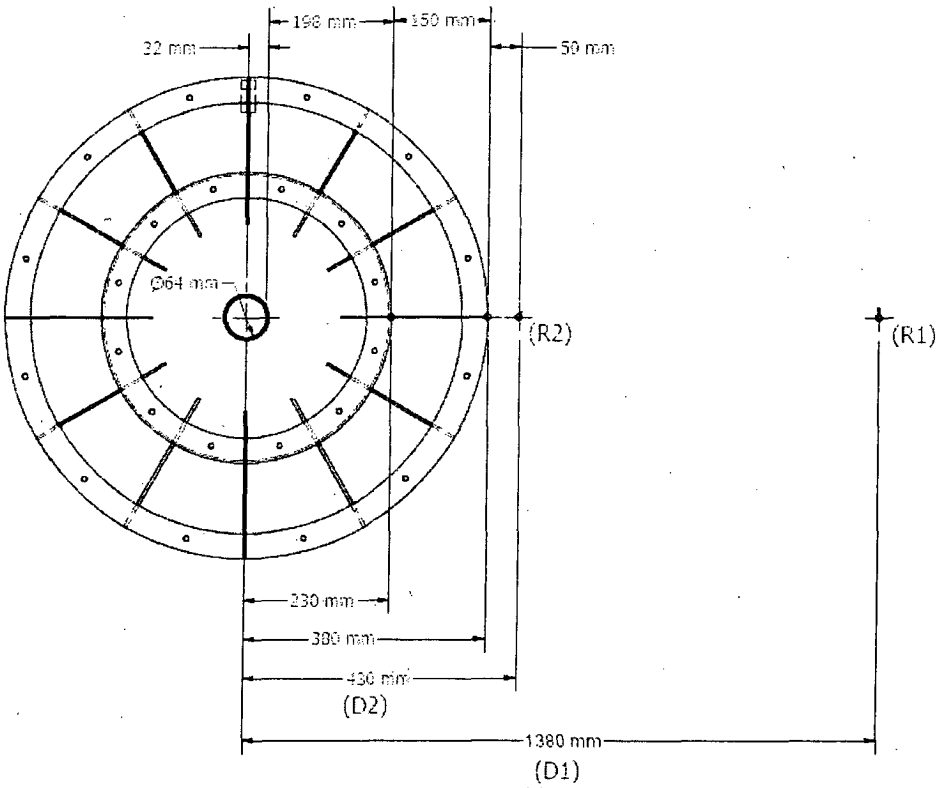


Illustration 9: Configuration A Calculation Layout for ^{192}Ir

All calculations are based on the Air Kerma constant of 4800Gry/Ci/hr for ^{192}Ir.

Calculation of the unshielded field at R2 based on the Air Kerma of 4800µGry/Ci/hr at R1 refer Illustration 9: Configuration A Calculation Layout for 192Ir as above

$$R2=4800\left(\frac{1000}{D2}\right)^2$$

$$R2=4800\left(\frac{1000}{430}\right)^2$$

$$R2=4800\times(2.326)^2$$

$$R2=4800\times5.408$$

$$R2=2.5958\times10^4\,\mu Gy/Ci/hr$$

Thus at R2 the calculated dose rate is 2.5958x10^{4}µGry/Ci/hr for the unshielded source. The calculated dose rate for a loading of 50000 Ci of ^{192}Ir at R2.

$$Dose=(2.5958\times10^4).(50000)$$

$$Dose=1.2979\times10^9\,\mu Gry/hr$$

Next determine the dose rate with an applied shielding form 200mm of lead. The transmission factor for 200mm of lead produces the following constant 'A'. See appendix 2 for attenuation curves.

$$A=1.0\times10^{-10}$$

Now applying the attenuation constant 'A' to the field at R2 yields the following result

$$R2=R2\times A$$

$$R2=(1.2979\times10^9).(1.0\times10^{-10})$$

$$R2=0.12979\,\mu Gry/hr$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package, refer to Illustration 9: Configuration A Calculation Layout for 192Ir above.

$$R1=R2\times\left(\frac{D2}{D1}\right)^2$$

$$R1=0.12979\times\left(\frac{430}{1380}\right)^2$$

$$R1=0.0126\,\mu Gry/hr$$

Now convert μGry/hr to mR/hr to calculate the transport index.

$$TI = (\frac{0.0126}{10})$$
$$TI = 0.00126$$

Thus for a loading of 50000Ci of ^{192}Ir the field strength at 50mm from the surface of the package is calculated to be 0.12979μGry/hr. The field strength at 1000mm from the surface of the package is calculated to be 0.0126μGry/hr producing a transport index of 0.00126

Transport Index for Approved Loading of 50000Ci

For a loading of 50000Ci of ^{192}Ir the resultant transport index, taken at 1000mm from the outer surface of the package is calculated to be 0.00126

Configuration B, Maximum Loading for ^{60}Co

Loading Calculations

The following calculations determine the dose rate and transport index for ^{60}Co.

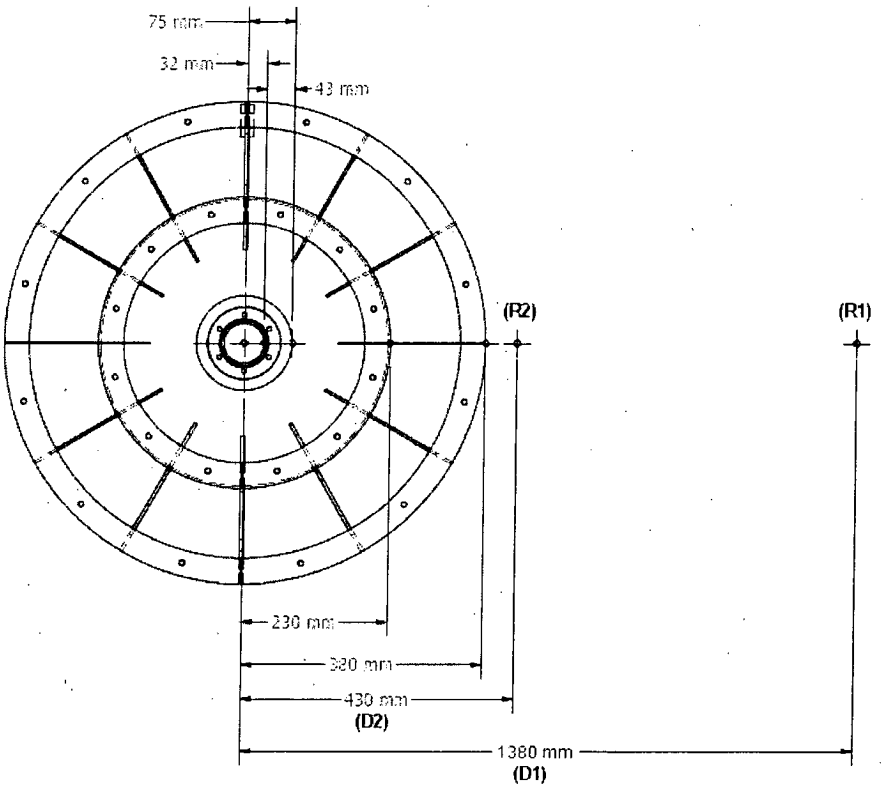


Illustration 10: Configuration B Calculation layout for ^{60}Co

The maximum activity loading required to produce a field of 500μGry at 50mm from the outer surface of the package is calculated in the equation below.

Calculation of the unshielded field at R2 based on the Air Kerma of 11.1mGry/Ci/hr at R1 refer Illustration 10: Configuration B Calculation layout for 60Co as above

$$R2 = 11.1\left(\frac{1000}{D2}\right)^2$$

$$R2 = 11.1\left(\frac{1000}{430}\right)^2$$

$$R2 = 11.1 \times (2.326)^2$$

$$R2 = 11.1 \times 5.41$$

$$R2 = 60\text{mGry/Ci}$$

$$R2 = 6 \times 10^{4}\,\mu\text{Gy/Ci/hr}$$

Thus at R2 the calculated dose rate is 60mGry/Ci/hr for the unshielded source.

Configuration B has 155mm of lead and 43mm of tungsten shielding. The transmission factor for 155mm of lead and 43mm of tungsten produces the following constant 'A'. See appendix 2 for attenuation curves.

$$A = \text{Lead Transmission Factor} \times \text{Tungsten Tranmission Factor}$$

$$A = \left(1.2 \times 10^{-4}\right).\left(1.8 \times 10^{-2}\right)$$

$$A = 2.16 \times 10^{-6}$$

Now applying the transmission factor 'A' to the field at R2 yields the following result

$$\text{Dose} = R2 \times A$$

$$\text{Dose} = (6 \times 10^{4}).(2.16 \times 10^{-6})$$

$$\text{Dose} = 1.296 \times 10^{-1}$$

$$\text{Dose} = 0.1296\,\mu\text{Gry/Ci/hr}$$

Next calculate the maximum loading to produce a field of 500uGy at R2.

$$\text{Activity} = \frac{\text{Required Dose Rate}}{\text{Dose Rate Per Curie}}$$

$$\text{Activity} = \frac{500}{0.1296} = 3858.0246$$

$$\text{Activity} = 3858\,\text{Ci}$$

Thus the maximum loading of 3858Ci of ^{60}Co will produce a field strength of 500µGry at 50mm from the outer surface of the package. The calculated Transport index for this loading is the same as in Configuration A at 4.85.

Transport Index for Approved Loading of 3100Ci

From the Model 1860 Type B(U) package specifications, the maximum approved loading ^{60}Co for the type B configuration is 3100Ci. The resultant transport index is as calculated below.

$$TI = \left(\frac{\text{Max Approved Loading}}{\text{Calculated Loading}}\right) \times \text{Calculated Transport Index}$$

$$TI = \left(\frac{3100}{3858}\right) \times 4.85$$

$$TI = 3.987$$

Thus for a loading of 3100Ci of ^{60}Co the resultant transport index, taken at 1000mm from the outer surface of the package is calculated to be 3.987.

Configuration B, Maximum Loading for ^{137}Cs

Loading Calculations

The configuration B attenuator is composed of lead and tungsten and will have a much smaller transmission factor compared to configuration A, therefore the transport index for 30,000 Ci of ^{137}Cs will be lower than the value given in Configuration A, Maximum Loading for 137Cs on page 105.

Transport Index for Approved Loading of 27000Ci

The configuration type B package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 27000Ci of ^{137}Cs will be lower than the value calculated in Transport Index for Approved Loading of 27000Ci on page 107.

Configuration B, Maximum Loading for ^{226}Ra

Loading Calculations

The configuration B attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 1,000 Ci of ^{226}Ra will be lower than the value given in Configuration A, Maximum Loading for 226Ra on page 108.

Transport Index for Approved Loading of 1000Ci

The configuration type B package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 1000Ci of ^{226}Ra will be lower than the value calculated in Transport Index for Approved Loading of 1000Ci on page 110.

Configuration B, Maximum Loading for ^{192}Ir

Loading Calculations

The configuration B attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 50000Ci of ^{192}Ir will be lower than the value given in Configuration A, Maximum Loading for 192Ir on page 111.

Transport Index for Approved Loading of 50000Ci

The configuration type B package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 50000Ci of ^{192}Ir will be lower than the value calculated in Transport Index for Approved Loading of 50000Ci on page 113.

Configuration B, Maximum Side Loading for ^{60}Co

Loading Calculations

The configuration B transport cask contains a cylindrical tungsten shield around the source. However the region 30° from the centreline does not contain any tungsten shielding resulting in a higher transmission factor.

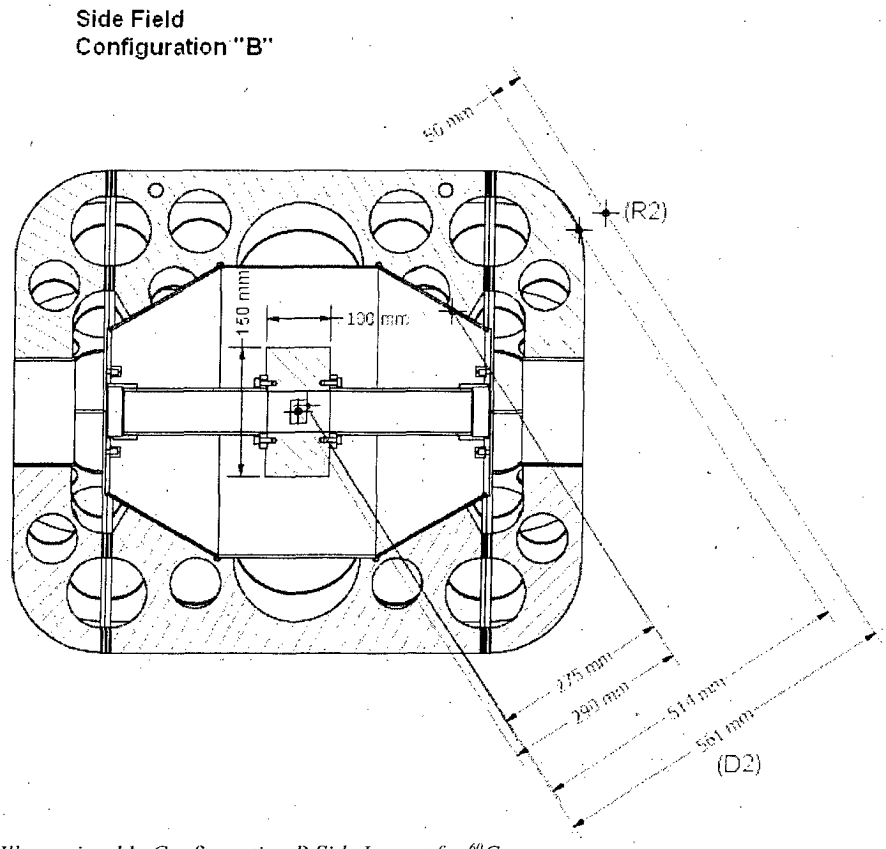


Illustration 11: Configuration B Side Layout for ^{60}Co

All Calculations are based on the Air Kerma constant of 11.1mGry/Ci/hr for ^{60}Co.

Calculation of the unshielded field at R2 based on the Air Kerma of 11.1mGry/Ci/hr at 1m from the source refer Illustration 11: Configuration B Side Layout for 60Co as above

$$R2 = 11.1\left(\frac{1000}{D2}\right)^2$$

$$R2 = 11.1\left(\frac{1000}{561}\right)^2$$

$$R2 = 11.1\times(1.783)^2$$

$$R2 = 11.1\times 3.177$$

$$R2 = 35.270\text{mGry/Ci}$$

$$R2 = 35.270\times 10^3\,\mu\text{Gy/Ci/hr}$$

Thus at R2 the calculated dose rate is 35.270x10^{3}µGry/Ci/hr for the unshielded source. The calculated dose rate for a loading of 3,100 Ci of ^{60}Co is.

$$\text{Dose} = (35.270\times 10^3).(3{,}100)$$

$$\text{Dose} = 10.933\times 10^7\,\mu\text{Gry/hr}$$

Next determine the dose rate with an applied shielding form 260mm of lead. The transmission factor for 260mm of lead produces the following constant 'A'. See appendix 2 for attenuation curves.

$$A = 3\times 10^{-7}$$

Now applying the attenuation constant 'A' to the field at R2 yields the following result

$$R2 = R2\times A$$

$$R2 = (10.933\times 10^7).(3\times 10^{-7})$$

$$R2 = 32.800\mu\text{Gry/hr}$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package, refer to Illustration 11: Configuration B Side Layout for 60Co above.

$$R1 = R2\times\left(\frac{D2}{D2+950}\right)^2$$

$$R1 = 32.800\times\left(\frac{561}{1511}\right)^2$$

$$R1 = 32.800\times(0.3713)^2$$

$$R1 = 4.521\mu\text{Gry/hr}$$

Now convert µGry/hr to mR/hr to calculate the transport index.

$$TI = \left(\frac{4.521}{10}\right)$$

$$TI = 0.452$$

Thus for a loading of 3,100Ci of ^{60}Co the field strength at 50mm from the surface of the package is calculated to be 32.800µGry/hr. The field strength at 1000mm from the surface of the package is calculated to be 4.521µGry/hr producing a transport index of 0.452.

Configuration C, Maximum Loading for ^{60}Co

Loading Calculations

The following calculations determine the dose rate and transport index for ^{60}Co.

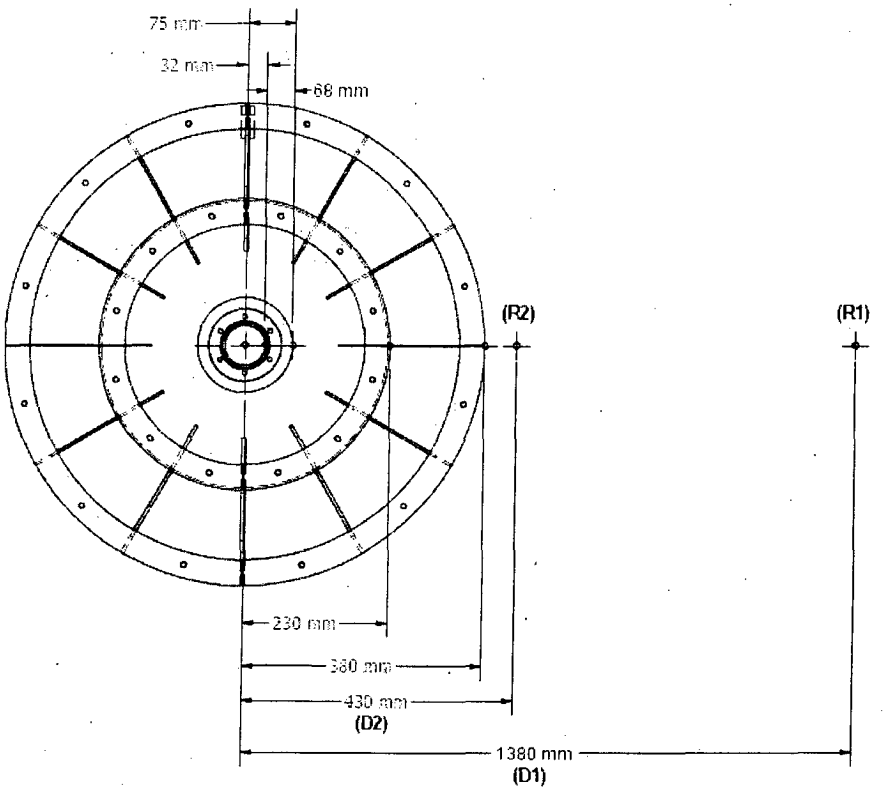


Illustration 12: Configuration C Calculation layout for ^{60}Co

The maximum activity loading required to produce a field of 500µGry at 50mm from the outer surface of the package is calculated in the equation below.

Calculation of the unshielded field at R2 based on the Air Kerma of 11.1mGry/Ci/hr at R1 refer Illustration 12: Configuration C Calculation layout for 60Co as above

$$R2 = 11.1\left(\frac{1000}{D2}\right)^2$$

$$R2 = 11.1\left(\frac{1000}{430}\right)^2$$

$$R2 = 11.1 \times (2.326)^2$$

$$R2 = 11.1 \times 5.41$$

$$R2 = 60\text{mGry/Ci}$$

$$R2 = 6 \times 10^4\ \mu\text{Gy/Ci/hr}$$

Thus at R2 the calculated dose rate is 60mGry/Ci/hr for the unshielded source.

Configuration C has 130mm of lead and 68mm of tungsten shielding. The transmission factor for 130mm of lead and 68mm of tungsten produces the following constant 'A'. See appendix 2 for attenuation curves.

$$A = \text{Lead Transmission Factor} \times \text{Tungsten Tranmission Factor}$$
$$A = (5.7\times10^{-4}).(1.4\times10^{-3})$$
$$A = 7.98\times10^{-7}$$

Now applying the transmission factor 'A' to the field at R2 yields the following result

$$\text{Dose} = R2\times A$$
$$\text{Dose} = (6\times10^{4}).(7.98\times10^{-7})$$
$$\text{Dose} = 47.88\times10^{-3}$$
$$\text{Dose} = 0.04788\,\mu\text{Gry/Ci/hr}$$

Next calculate the maximum loading to produce a field of 575uGy at R2.

$$\text{Activity} = \frac{\text{Required Dose Rate}}{\text{Dose Rate Per Curie}}$$
$$\text{Activity} = \frac{575}{0.04788} = 12009.1896$$
$$\text{Activity} = 12009\,\text{Ci}$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package, refer to Illustration 11: Configuration B Side Layout for 60Co above.

$$R1 = R2\times\left(\frac{D2}{D2+950}\right)^2$$
$$R1 = 575\times\left(\frac{430}{1380}\right)^2$$
$$R1 = 575\times(0.3115)^2$$
$$R1 = 55.8\mu\text{Gry/hr}$$

Now convert µGry/hr to mR/hr to calculate the transport index.

$$TI = \left(\frac{55.8}{10}\right)$$
$$TI = 5.6$$

Thus the maximum loading of 12000Ci of ^{60}Co will produce a field strength of 575µGry at 50mm from the outer surface of the package. The calculated Transport index for this loading is 5.6.

Transport Index for Approved Loading of 12160Ci

From the Model 1860 Type B(U) package specifications, the maximum approved loading ^{60}Co for the type C configuration is 12160Ci. The resultant transport index is as calculated below.

$$TI = \left(\frac{\text{Max Approved Loading}}{\text{Calculated Loading}}\right) \times \text{Calculated Transport Index}$$

$$TI = \left(\frac{12160}{12000}\right) \times 5.6$$

$$TI = 5.670$$

Thus for a loading of 12160Ci of ^{60}Co the resultant transport index, taken at 1000mm from the outer surface of the package is calculated to be 5.670

Configuration C, Maximum Loading for ^{137}Cs

Loading Calculations

The configuration C attenuator is composed of lead and tungsten and will have a much smaller transmission factor compared to configuration A, therefore the transport index for 30,000 Ci of ^{137}Cs will be lower than the value given in Configuration A, Maximum Loading for 137Cs on page 105.

Transport Index for Approved Loading of 27000Ci

The configuration type C package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 27000Ci of ^{137}Cs will be lower than the value calculated in Transport Index for Approved Loading of 27000Ci on page 107.

Configuration C, Maximum Loading for ^{226}Ra

Loading Calculations

The configuration C attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 1,000 Ci of ^{226}Ra will be lower than the value given in Configuration A, Maximum Loading for 226Ra on page 108.

Transport Index for Approved Loading of 1000Ci

The configuration type C package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 1000Ci of ^{226}Ra will be lower than the value calculated in Transport Index for Approved Loading of 1000Ci on page 110.

Configuration C, Maximum Loading for ^{192}Ir

Loading Calculations

The configuration C attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 50000Ci of ^{192}Ir will be lower than the value given in Configuration A, Maximum Loading for 192Ir on page 111.

Transport Index for Approved Loading of 50000Ci

The configuration type C package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 50000Ci of ^{192}Ir will be lower than the value calculated in Transport Index for Approved Loading of 50000Ci on page 113.

Configuration C, Maximum Side Loading for ^{60}Co

Loading Calculations

The configuration C transport cask contains a cylindrical tungsten shield the same width as in configuration B but a larger diameter. Therefore the maximum side loading calculations will be the same as in Configuration B, Maximum Side Loading for 60Co on page 118.

Configuration D, Maximum Loading for ^{60}Co

Loading Calculations

The model 1860 in the type D configuration is designed to house three 5000Ci ^{60}Co sources

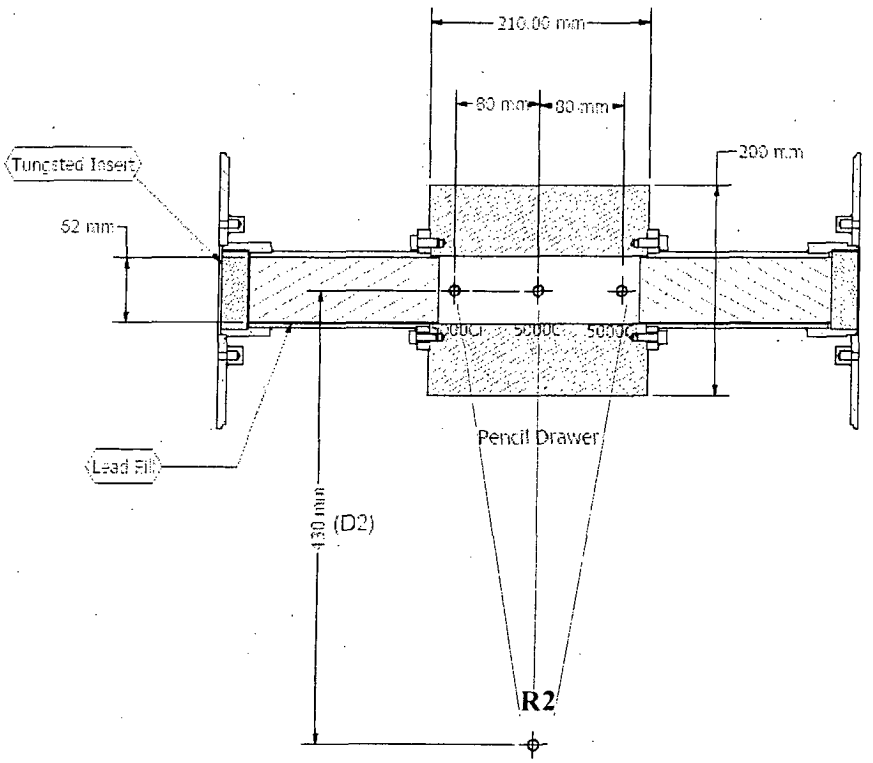


Illustration 13: Configuration D Calculation Layout for ^{60}Co

All calculations are based on the Air Kerma constant of 11.1mGry/Ci/hr. Calculation of the unshielded field at 50mm from the package surface based on the Air Kerma of 11.1mGry/Ci/hr.

$$R2 = 11.1\left(\frac{1000}{D2}\right)^2$$

$$R2 = 11.1 \times (2.326)^2$$

$$R2 = 11.1 \times 5.41$$

$$R2 = 60\text{mGry/Ci}$$

$$R2 = 6 \times 10^4\ \mu\text{Gy/Ci/hr}$$

Thus at 50mm from the package surface the calculated dose rate is 60mGry/Ci/hr for the unshielded source.

The attenuation transmission factor for the two end sources is a product of the attenuation properties for both the lead and tungsten components. From the Amersham graph the transmission coefficient 'T' for tungsten (69mm) and the transmission coefficient 'L' for lead (132 mm) are as given below. See appendix 2 for attenuation curves.

$$T = 1.100 \times 10^{-3}$$
$$L = 4.500 \times 10^{-4}$$

Thus the final transmission factor is 'A' where:

$$A = T \times L$$
$$A = (1.100 \times 10^{-3}) \times (4.500 \times 10^{-4})$$
$$A = 4.950 \times 10^{-7}$$

Therefore at R2, 50mm from the surface of the package the dose rate will be 'X' for the two end sources

$$D2 = (6 \times 10^{4}) \times (4.950 \times 10^{-7})$$
$$D2 = 0.0297 \mu Gy/Ci/hr$$

$$X = 2 \times (D2 \times 5000Ci)$$
$$X = 2 \times (148.5)$$
$$X = 297 \mu Gry/hr$$

Next the dose at R2 50mm from the package surface will be "Y' where the transmission factor for this calculation is 0.0479 as the attenuation is reduced as the beam path is directly vertical for the centre source.

$$Y = 0.0479 \times 5000$$
$$Y = 239.5 \mu Gry/hr$$

The total dose rate at 50mm from the package surface is a summation for X and Y

$$TotalDose = 239.5 + 297$$
$$TotalDose = 536.5 \mu Gry/hr$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package using the dose rate at 50mm from the package surface for all three sources

$$R1 = R2 \times \left(\frac{D2}{D2+950} \right)^2$$
$$R1 = 536.5 \times \left(\frac{430}{1380} \right)^2$$
$$R1 = 52.089 \mu Gry/hr$$

Now convert µGry/hr to mR/hr to calculate the transport index.

$$TI = (\frac{52.089}{10})$$
$$TI = 5.208$$

Thus for a loading of 15,000Ci of ^{60}Co the field strength at 50mm from the surface of the package is calculated to be 536.5µGry/hr. The field strength at 1000mm from the surface of the package is calculated to be 52.089µGry/hr, producing a transport index of 5.208

Transport Index for Approved Loading of 15100Ci

From the Model 1860 Type B(U) package specifications, the maximum approved loading ^{60}Co for the type D configuration is 15100Ci. The resultant transport index is as calculated below.

$$TI = (\frac{\text{Max Approved Loading}}{\text{Calculated Loading}}) \times \text{Calculated Transport Index}$$
$$TI = (\frac{15100}{15000}) \times 5.208$$
$$TI = 5.242$$

Thus for a loading of 15100Ci of ^{60}Co the resultant transport index, taken at 1000mm from the outer surface of the package is calculated to be 5.242

Configuration D, Maximum Loading for ^{137}Cs

Loading Calculations

The configuration D attenuator is composed of lead and tungsten and will have a much smaller transmission factor compared to configuration A, therefore the transport index for 30,000 Ci of ^{137}Cs will be lower than the value given in Configuration A, Maximum Loading for 137Cs on page 105.

Transport Index for Approved Loading of 27000Ci

The configuration type D package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 27000Ci of ^{137}Cs will be lower than the value calculated in Transport Index for Approved Loading of 27000Ci on page 107.

Configuration D, Maximum Loading for ^{226}Ra

Loading Calculations

The configuration D attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 1,000 Ci of ^{226}Ra will be lower than the value given in Configuration A, Maximum Loading for 226Ra on page 108.

Transport Index for Approved Loading of 1000Ci

The configuration type D package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 1000Ci of ^{226}Ra will be lower than the value calculated in Transport Index for Approved Loading of 1000Ci on page 110.

Configuration D, Maximum Loading for ^{192}Ir

Loading Calculations

The configuration D attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 50000Ci of ^{192}Ir will be lower than the value given in Configuration A, Maximum Loading for 192Ir on page 111.

Transport Index for Approved Loading of 50000Ci

The configuration type D package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 50000Ci of ^{192}Ir will be lower than the value calculated in Transport Index for Approved Loading of 50000Ci on page 113.

Calculation 1, Field From End Source

To calculate the maximum field strength at a distance of 50mm from the side of the package. A point which is in alignment to the end source beam, which just misses the tungsten attenuator is analysed.

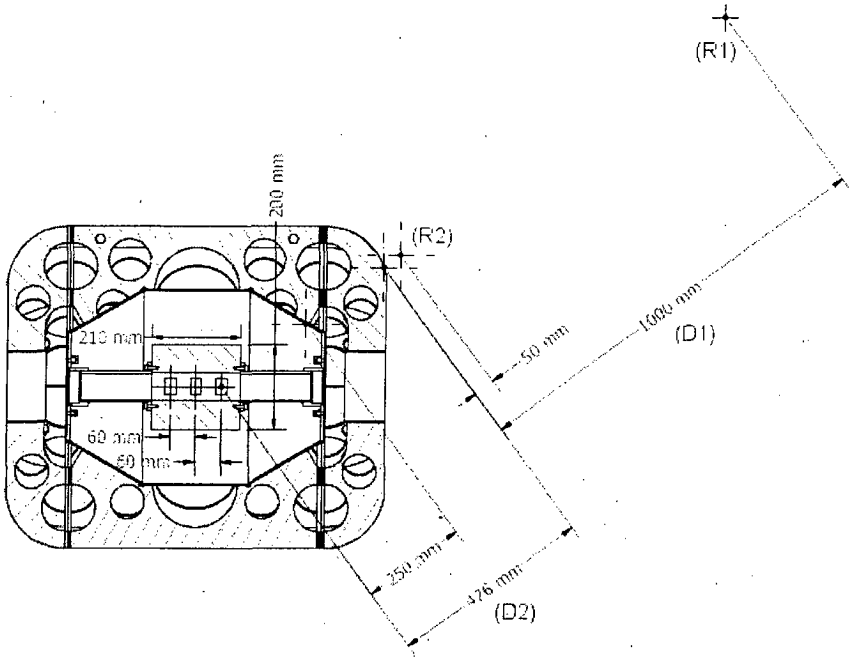


Illustration 14: Configuration D Calculation Side Layout for ^{60}Co

The distance from the centre of the end source to the outside of the attenuator case is 250mm. The distance from the surface of the end capsule to the outside of the attenuator case is 235mm.

Using the Air Kerma constant of 11.1mGry/Ci/hr calculate the dose rate at R2 50mm from the package surface for an unshielded source.

$$R2 = 11.1\left(\frac{1000}{D2+50}\right)^2$$

$$R2 = 11.1\left(\frac{1000}{526}\right)^2$$

$$R2 = 11.1 \times (1.901)^2$$

$$R2 = 11.1 \times 3.614$$

$$R2 = 40.120 \text{mGry/Ci}$$

$$R2 = 40.120 \times 10^3 \mu\text{Gy/Ci/hr}$$

Thus the dose rate at 50mm from the surface package for an unshielded ^{60}Co source of 5000Ci is:

$$\text{Dose} = (40.120 \times 10^{3}).(5000)$$
$$\text{Dose} = 20.060 \times 10^{7}\ \mu\text{Gry/hr}$$

The transmission factor A for 235mm of lead is $1x10^{-6}$ (See appendix 2 for attenuation curves.). Applying this factor, the attenuated dose rate at 50mm from the outer surface of the package at point R2 is determined by

$$R2 = \text{Dose} \times A$$
$$R2 = (20.060 \times 10^{7}).(1 \times 10^{-6})$$
$$R2 = 200.596\mu\text{Gy}$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package using the dose rate at 50mm from the package surface for all three sources

$$R1 = R2 \times \left(\frac{D2}{D2+950}\right)^{2}$$
$$R1 = 200.596 \times \left(\frac{526}{1476}\right)^{2}$$
$$R1 = 25.475\mu\text{Gry/hr}$$

Now convert μGry/hr to mR/hr to calculate the transport index.

$$TI = \left(\frac{25.475}{10}\right)$$
$$TI = 2.547$$

Calculation 2, Field Strength from ^{60}Co Pencil

Using construction detail from a Nordian Model 2200 pencil it is seen that the pencil is constructed from seven 6.3mm x 25.4mm individual capsules of 300Ci each.

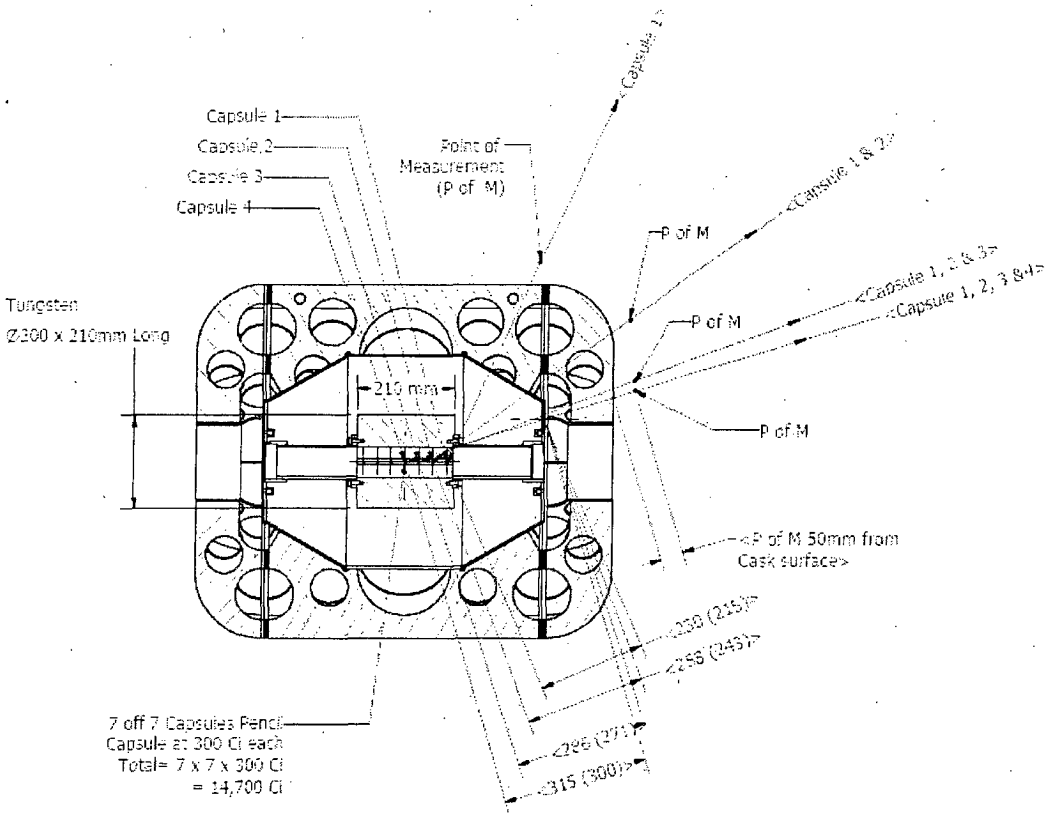


Illustration 15: Configuration D Calculation 7 Capsule Pencil Layout for ^{60}Co

Using the same method to calculate the dose rate as in Configuration D, Maximum Loading for 60Co on page 124, the following data is tabulated. Where capsules 5 6 and 7 have been omitted as their field strength contribution is negligible.

Capsule	Lead Path	Transmission	Distance to Point of Measurement	Distance to 1 meter	µGry/Ci/hr at Point of measurement
1	215mm	3.5×10^{-6}	455mm	1400mm	53617
2	240mm	8.0×10^{-7}	480mm	1420mm	48177
3	270mm	1.0×10^{-7}	505mm	1450mm	43525
4	300mm	2.0×10^{-8}	530mm	1480mm	39116

Table 36: Side Field Strength Results for 7 Capsule Pencil

Calculation 3, Maximum Loading Through End from ^{60}Co Pencil

Using the same Nordian Model 2200 pencil the following equations calculate the maximum loading through the shaft of the cask.

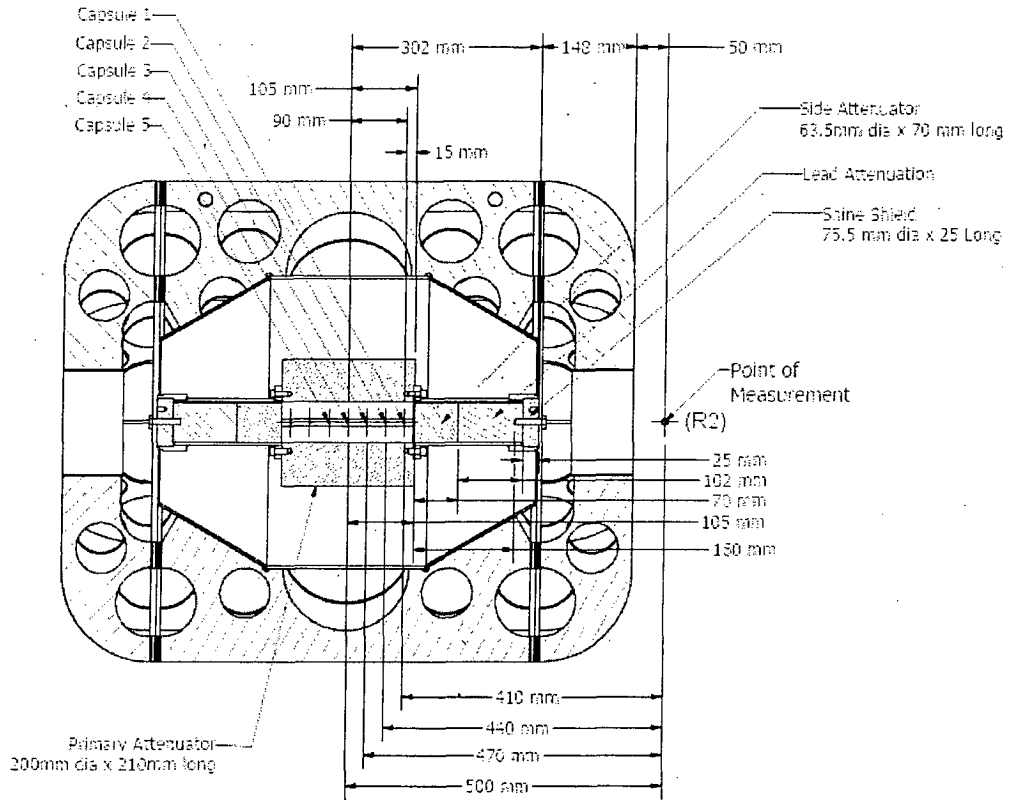


Illustration 16: Configuration D Calculation 7 Capsule Pencil Side Layout for ^{60}Co

Using the Air Kerma constant of 11.1mGry/Ci/hr calculate the dose rate at R2 50mm from the package surface for each of the seven unshielded capsules in seven pencils is given in .

Capsule	*Equation*	*Field Strength*
1	$R2=11.1\left(\frac{1000}{410}\right)^2$	66032μGry/Ci/hr
2	$R2=11.1\left(\frac{1000}{440}\right)^2$	57335μGry/Ci/hr
3	$R2=11.1\left(\frac{1000}{470}\right)^2$	50249μGry/Ci/hr
4	$R2=11.1\left(\frac{1000}{500}\right)^2$	44400μGry/Ci/hr
5	$R2=11.1\left(\frac{1000}{530}\right)^2$	39516μGry/Ci/hr
6	$R2=11.1\left(\frac{1000}{560}\right)^2$	35395μGry/Ci/hr
7	$R2=11.1\left(\frac{1000}{590}\right)^2$	31887μGry/Ci/hr

Table 37: Max Loading Through End At 50 mm From Surface with 7 Capsule Pencil

Adding the dose rate for each capsule the dose rate for the seven unshielded pencils at 50 mm from the surface of the cask is 324,814μGry/Ci/hr each.

Assuming that the spaces between the capsules and the capsules themselves don't provide any attenuation the attenuation material is 95mm of tungsten and 90mm of lead. Using the transmission coefficient from the Amersham graph produces the total transmission coefficient 'A'. See appendix 2 for attenuation curves.

$$A=5.6\times10^{-7}$$

The maximum loading for each pencil to result in a 500μGry/hr dose rate at 50mm from the surface of the cask can now be calculated.

$$R2=\frac{500}{(3.2481\times10^{5})\times(5.6\times10^{-7})}$$
$$R2=2749\text{Ci}$$

Therefore the maximum loading for each capsule is

$$\text{Capsule} = \frac{2749}{7}$$

$$\text{Capsule} = 393\text{Ci}$$

Thus for a dose rate of 500μGry/hr at 50mm from the surface of the cask each of the seven capsule in the seven pencils can be loaded with 393Ci of ^{60}Co therefore a total of 19242Ci of ^{60}Co can be transported in seven pencils. However this loading must be reduced to 15,100Ci as this is the maximum activity the configuration type D package is approved for.

Configuration E, Maximum Loading for ^{60}Co

Loading Calculations

Configuration E holds the source capsule within a 25mm thick 3 inch square draw of tungsten.

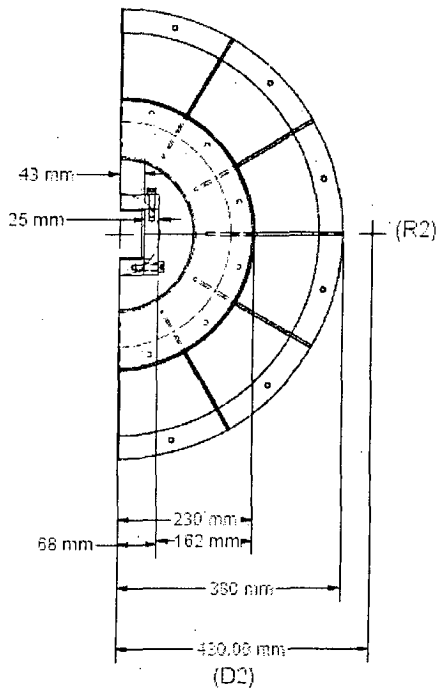


Illustration 17: Configuration E Calculation Layout for ^{60}Co

To determine the maximum activity loading the activity required to produce a field of 500µGry at 50mm from the outer surface of the package is calculated. Based on the Air Kerma constant of 11.1mGry/Ci/hr for ^{60}Co.

Calculation of the unshielded field at R2 based on the Air Kerma of 11.1mGry/Ci/hr at 1m from the source refer Illustration 17: Configuration E Calculation Layout for 60Co as above

$$R2 = 11.1\left(\frac{1000}{D2}\right)^2$$

$$R2 = 11.1\left(\frac{1000}{430}\right)^2$$

$$R2 = 11.1 \times (2.326)^2$$

$$R2 = 11.1 \times 5.41$$

$$R2 = 60\text{mGry/Ci}$$

$$R2 = 6 \times 10^4 \mu\text{Gy/Ci/hr}$$

Thus at R2 the calculated dose rate is 60mGry/Ci/hr for the unshielded source. Next determine the dose rate considering the attenuation material.

The attenuation for 25mm of tungsten and 162mm of lead from the Amersham graph produces the following constant 'A'. See appendix 2 for attenuation curves.

$$A = \text{Tungsten} \times \text{Lead}$$
$$A = (8\times10^{-2})\times(8\times10^{-5})$$
$$A = 6.4\times10^{-6}$$

Now applying the transmission factor 'A' to the field at R2 yields the following result

$$\text{Dose} = R2 \times A$$
$$\text{Dose} = (6\times10^{4}).(6.4\times10^{-6})$$
$$\text{Dose} = 384\times10^{-3}\,\mu\text{Gry/Ci/hr}$$

Next calculate the maximum loading to produce a field of 500uGy at R2.

$$\text{Activity} = \frac{\text{Required Dose Rate}}{\text{Dose Rate Per Curie}}$$
$$\text{Activity} = \frac{500}{384\times10^{-3}}$$
$$\text{Activity} = 1302\,\text{Ci}$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package, refer to Illustration 17: Configuration E Calculation Layout for 60Co above.

$$R1 = R2\left(\frac{D2}{D2+950}\right)^2$$
$$R1 = 500\left(\frac{430}{1380}\right)^2$$
$$R1 = 48.545\,\mu\text{Gry/hr}$$

Now convert µGry/hr to mR/hr to calculate the transport index.

$$TI = \left(\frac{48.545}{10}\right)$$
$$TI = 4.85$$

Thus the maximum loading of 1302Ci of ^{60}Co will produce a field strength of 500µGry at 50mm from the outer surface of the package. The calculated Transport index for this loading is 4.85.

Transport Index for Approved Loading of 1080Ci

From the Model 1860 Type B(U) package specifications, the maximum approved loading ^{60}Co for the type E configuration is 1080Ci. The resultant transport index is as calculated below.

$$TI = \left(\frac{\text{Max Approved Loading}}{\text{Calculated Loading}}\right) \times \text{Calculated Transport Index}$$

$$TI = \left(\frac{1080}{1302}\right) \times 4.85$$

$$TI = 4.023$$

Thus for a loading of 1080Ci of ^{60}Co the resultant transport index, taken at 1000mm from the outer surface of the package is calculated to be 4.023

Configuration E, Maximum Loading for ^{137}Cs

Loading Calculations

The configuration E attenuator is composed of lead and tungsten and will have a much smaller transmission factor compared to configuration A, therefore the transport index for 30,000 Ci of ^{137}Cs will be lower than the value given in Configuration A, Maximum Loading for 137Cs on page 105.

Transport Index for Approved Loading of 27000Ci

The configuration type E package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 27000Ci of ^{137}Cs will be lower than the value calculated in Transport Index for Approved Loading of 27000Ci on page 107.

Configuration E, Maximum Loading for ^{226}Ra

Loading Calculations

The configuration E attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 1,000 Ci of ^{226}Ra will be lower than the value given in Configuration A, Maximum Loading for 226Ra on page 108.

Transport Index for Approved Loading of 1000Ci

The configuration type E package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 1000Ci of ^{226}Ra will be lower than the value calculated in Transport Index for Approved Loading of 1000Ci on page 110.

Configuration E, Maximum Loading for ^{192}Ir

Loading Calculations

The configuration E attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 50000Ci of ^{192}Ir will be lower than the value given in Configuration A, Maximum Loading for 192Ir on page 111.

Transport Index for Approved Loading of 50000Ci

The configuration type E package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 50000Ci of ^{192}Ir will be lower than the value calculated in Transport Index for Approved Loading of 50000Ci on page 113.

Configuration F, Maximum Loading for ^{60}Co

Loading Calculations

Configuration F holds the source capsule within a 50mm thick 3 inch square draw of tungsten.

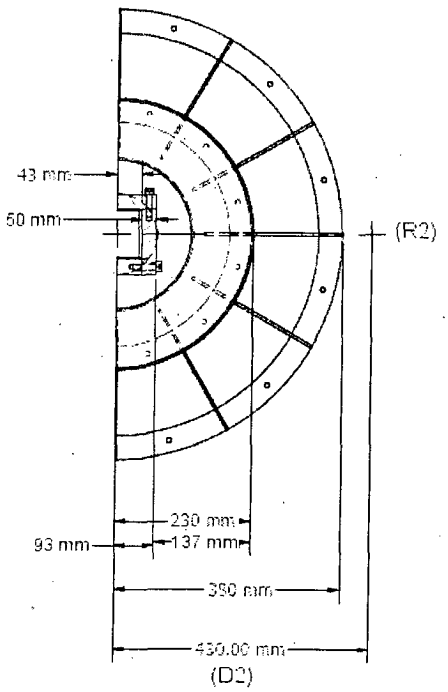


Illustration 18: Configuration F Calculation Layout for ^{60}Co

To determine the maximum activity loading the activity required to produce a field of 500µGry at 50mm from the outer surface of the package is calculated. Based on the Air Kerma constant of 11.1mGry/Ci/hr for ^{60}Co.

Calculation of the unshielded field at R2 based on the Air Kerma of 11.1mGry/Ci/hr at 1m from the source refer Illustration 18: Configuration F Calculation Layout for 60Co as above

$$R2 = 11.1\left(\frac{1000}{D2}\right)^2$$

$$R2 = 11.1\left(\frac{1000}{430}\right)^2$$

$$R2 = 11.1 \times (2.326)^2$$

$$R2 = 11.1 \times 5.41$$

$$R2 = 60\text{mGry/Ci}$$

$$R2 = 6 \times 10^4\ \mu\text{Gy/Ci/hr}$$

Thus at R2 the calculated dose rate is 60mGry/Ci/hr for the unshielded source. Next determine the dose rate considering the attenuation material.

The attenuation for 50mm of tungsten and 137mm of lead from the Amersham graph produces the following constant 'A'. See appendix 2 for attenuation curves.

$$A = \text{Tungsten} \times \text{Lead}$$
$$A = (1 \times 10^{-2}) \times (3 \times 10^{-4})$$
$$A = 3 \times 10^{-6}$$

Now applying the transmission factor 'A' to the field at R2 yields the following result

$$\text{Dose} = R2 \times A$$
$$\text{Dose} = (6 \times 10^{4}).(3 \times 10^{-6})$$
$$\text{Dose} = 18 \times 10^{-2}\ \mu\text{Gry/Ci/hr}$$

Next calculate the maximum loading to produce a field of 500uGy at R2.

$$\text{Activity} = \frac{\text{Required Dose Rate}}{\text{Dose Rate Per Curie}}$$
$$\text{Activity} = \frac{500}{18 \times 10^{-2}}$$
$$\text{Activity} = 2777\,\text{Ci}$$

Now calculate the estimated transport index at 1 meter from the outer surface of the package, refer to Illustration 18: Configuration F Calculation Layout for 60Co above.

$$R1 = R2\left(\frac{D2}{D2 + 950}\right)^2$$
$$R1 = 500\left(\frac{430}{1380}\right)^2$$
$$R1 = 48.545\,\mu\text{Gry/hr}$$

Now convert µGry/hr to mR/hr to calculate the transport index.

$$TI = \left(\frac{48.545}{10}\right)$$
$$TI = 4.85$$

Thus the maximum loading of 2777Ci of ^{60}Co will produce a field strength of 500µGry at 50mm from the outer surface of the package. The calculated Transport index for this loading is 4.85.

Transport Index for Approved Loading of 3100Ci

From the Model 1860 Type B(U) package specifications, the maximum approved loading ^{60}Co for the type F configuration is 3100Ci. The resultant transport index is as calculated below.

$$TI = \left(\frac{\text{Max Approved Loading}}{\text{Calculated Loading}}\right) \times \text{Calculated Transport Index}$$

$$TI = \left(\frac{3100}{2777}\right) \times 4.85$$

$$TI = 5.414$$

Thus for a loading of 3100Ci of ^{60}Co the resultant transport index, taken at 1000mm from the outer surface of the package is calculated to be 5.414

Configuration F, Maximum Loading for ^{137}Cs

Loading Calculations

The configuration F attenuator is composed of lead and tungsten and will have a much smaller transmission factor compared to configuration A, therefore the transport index for 30,000 Ci of ^{137}Cs will be lower than the value given in Configuration A, Maximum Loading for 137Cs on page 105.

Transport Index for Approved Loading of 27000Ci

The configuration type F package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 27000Ci of ^{137}Cs will be lower than the value calculated in Transport Index for Approved Loading of 27000Ci on page 107.

Configuration F, Maximum Loading for ^{226}Ra

Loading Calculations

The configuration F attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 1,000 Ci of ^{226}Ra will be lower than the value given in Configuration A, Maximum Loading for 226Ra on page 108.

Transport Index for Approved Loading of 1000Ci

The configuration type F package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 1000Ci of ^{226}Ra will be lower than the value calculated in Transport Index for Approved Loading of 1000Ci on page 110.

Configuration F, Maximum Loading for ^{192}Ir

Loading Calculations

The configuration F attenuator has a smaller transmission factor compared to configuration A, therefore the transport index for 50000Ci of ^{192}Ir will be lower than the value given in Configuration A, Maximum Loading for 192Ir on page 111.

Transport Index for Approved Loading of 50000Ci

The configuration type F package is composed of a lead and tungsten attenuator, opposed to the configuration type A which uses only a lead attenuator. Thus the additional of the tungsten will provide additional attenuation and a much smaller transmission factor. Therefore the transport index for the approved loading for 50000Ci of ^{192}Ir will be lower than the value calculated in Transport Index for Approved Loading of 50000Ci on page 113.

Detailed Design

Reason For Design (Local)

An order was taken for the supply of a Radiation Therapy System at a research centre which was to contain 10,000 Ci of ^{60}Co.

The head of the unit was approved as a type B(U) transport cask in it's own right, however the laboratory that was to manufacture the capsule had a time problem with approval for it's Capsule Special Form Certification. It became evident that the Competent Authority Documentation for the therapy head was about to expire and would not be reissued as the head would not comply with the 1996 Transport Code (amended 2003).

Reason For Design (International)

An international search for a compliant Type B(U) Transport Container revealed a world wide problem. The search revealed hundreds of marooned sources in their current location due to the fact that there is no compliant transport cask in which to ship them to a repository or recycle laboratory. A problem of transport with the reloading of existing equipment with new sources and the disposal of the old, coupled with the supply of new equipment containing radioactive materials also presented itself.

Ongoing discussion with A&DM associates around the world indicated a need for a Radiation Transport Cask that could transport up to 12000 Ci ^{60}Co point sources and up to 15000 Ci ^{60}Co in pencil form.

Further research showed that Australia has a limited number of applications and by itself does not justify the expenditure of developing the Radiation Transport Cask and associated equipment. However, our American affiliate is currently using a US -WC6 Type B Transport Cask for work in the USA and Mexico, this constitutes six therapy head reloads per year. It was estimated that the A&DM Transport Cask, giving them B(U) capability would enable them to complete up to 30 reloads per year with the current resources.

A&DM understand that there is a growing concern that orphan sources may fall into the hands of terrorist organisations, thus there is an urgent need to provide a safe method of transport which currently cannot be carried out due to lack of suitable equipment. The understanding is that the A&DM design will be adaptable to many of these issues and the extensive engineering experience accompanying the design will enhance the ability to create a solution for other configurations.

Design Solution

It was decided that if A&DM could design a unit with the following features (shown below in Table 38: Tailored Features) tailored to the Type B(U) requirements, the company would be able to solve the immediate radioactive source transport problems, and then address the greater issues.

Feature	*Description*
1.	Meet all the requirements for type B(U) package design.
2.	Be suitable for transport by air (this requirement dictates a low surface temperature rise at maximum source activity).
3.	Minimum weight/size for the maximum activity to obtain the lowest transport costs possible.
4.	The design must be so designed, that the physical structure is capable of easy decontamination cleaning.
5.	Be able to accommodate various internal configurations.
6.	The design must be capable of handling point sources up to 12000 Ci ^{60}Co which is the maximum size source for therapy head reloads.
7.	The design must be capable of handling pencil sources up to 15000 Ci ^{60}Co
8.	The design must be capable of using square or round source drawers
9.	The design must be capable of being constructed with variations to the internal attenuating material to minimize the cost of manufacture for a cask with less than the design maximum capability.
10.	The design must be capable of being constructed with variations to the internal attenuating material to minimize the transport index for special circumstances.
11.	The design must be capable of being mated to existing equipment to enable easy transfer of sources/source drawers.
12.	In the event of damage to the cask it must be easily repaired to enable a shipment to continue.
13.	Tie-down points for road or container use must be positioned so that damage cannot occur to the cask during normal use and be simple enough to not require lengthy explanation of use.
14.	For air transport the cask has to have the additional tie down provision to use webbing straps

Feature	*Description*
15.	The cask must have provision to be lifted using a crane i.e. lift points for connection of shackles.
16.	The cask must be capable of being handled with a fork lift.
17.	Labelling procedures must be relatively easy to use but difficult to deface.
18.	Labelling must be such that it cannot be lost during disaster extremes.
19.	Provision must be made to affix to either side a name plate with isotope description, this name plate to have the same qualities as the placarding.
20.	Protective devices at the ends must be removable.
21.	Any tools, tie down or special equipment must be carried on board.
22.	End access plates must be tamper proof.
23.	Access at each end to enable internal wipe testing.
24.	Submersible to an excess of 2500 Kpa

Table 38: Tailored Features

With such a product A&DM accesses immediate work valued in excess of $1,000,000 per year, which would be available, enabling the following transports:

- Supply of systems
- Supply of new radioactive sources
- Disposal of depleted radioactive sources

The hire of the cask to others would be worth in excess of $250,000 per year without the add ons of provision of our engineers. This along with our supply problem justifies the risk.

Design Investigation

Specifications

Initial code requirement investigations were under taken using section 10 of the IATA Dangerous Goods Documentation, refer to Appendix 1. While this document is very difficult to follow it was a guide to produce design criteria shown below in Table 39: Design Criteria.

Parameter	*Description*
1.	The operational temperature range must exceed -40deg C to 70deg C (10.5.3.10)
2.	The cask must withstand conditions of normal transport (10 . 6.3.4) with no loss of shielding to increase the radiation level by 20%
3.	The package must protect the radiation source against accident conditions of transport. When dropped 9 M onto a hard stand (we took this to mean at less than -40deg) (10.6.3.6.1.1)
4.	The package must protect the radiation source against accident conditions of transport. The attenuation of radiation must not be compromised by a 1M Drop onto a 150mm Dia X200mm long bar (10.6.3.6.1.2)
5.	The package must protect the radiation source against accident conditions of transport. Survival of the package in a fire in excess of 800Deg C for 1/2 Hour (10.6..3.6.2.2)
6.	As we would predominantly be moving the package by air we would be required to meet the temperature rise criteria of "when loaded with the maximum activity of isotope and held in an environment of 38deg C for a week the outside of the package must not exceed 50deg C " (10.6.2.2)
7.	The package must be able to be submerged to 50 feet of water (150 kpa) (10.6.3.6.3.1)
8.	Field at 1M from the surface must not exceed 10mSv/Hr with the maximum Activity (10.6.2.2.4)

Table 39: Design Criteria

Construction Materials.

After considerable discussion and advice from Mr. Noel Herbert, Material Consultant ASSDA (Australian Stainless Steel Development Association) it was decided that we would construct our cask entirely from 316 stainless steel. (AUSTENITIC Stainless Steel) for the following reasons shown below in Table 40: Material Selection Decisions

Item	*Description*
1.	316 stainless steel will not go brittle at cryogenic temperatures. (Refer Section 3.5 Appendix 05)
2.	Years of diverse applications provide a wealth of evidence to it's durability
3.	316 stainless steel is extremely resistant to corrosion (Refer 3.1 of Appendix 05)
4.	Stainless steel has a relatively low thermal conductivity which will slow the diffusion of heat into the core.
5.	316 stainless steel is readily available in tube, pipe, rod, bar, sheet, plate and mesh.
6.	316 stainless steel can be welded using common methods (rod tig-mig) and is high on the list of relative material ability (refer to section 4 Appendix 05)
7.	316 stainless steel is available from a variety of mills with Quality Assurance certification to its composition.
8.	316 stainless steel bolts with Q.A. traceability are readily available.

Table 40: Material Selection Decisions

Stage One Decisions

Size and Weight

Weight became one of our prime design parameters as the cost of air freight of Class 7 materials is from US$7 to US$20/kg depending upon imponderables known only to the freight companies.

For this reason we discarded the concept of building a very strong and rigid package that could withstand the forces of the 9M drop and opted for the more elegant approach of controlling the deceleration using crumple zones that would collapse on impact.

Calculations

Due to the conflicting attenuation information for various materials we selected the more conservative data prepared by AMERSHAM and superimposed absorption data for 97% tungsten obtained from SANDVIK (Appendix 02).

Worksheets are attached as Appendix 03.

Due to the inexact information on absorption coefficients we have made our selection of materials to give a transport index of 5.

Attenuating Material

The initial calculation indicated that the use of lead as the attenuating material alone would result in a larger heavier package than we were hoping for. As the cask is predominantly to be moved by air freight weight and therefore size became the predominant parameter.

Depleted uranium would enable us to make a smaller attenuator, the difficulties of casting and machining preclude it's use as the preferred shield. While we will seek approval to use depleted uranium it will only be employed if a special criteria arises that will require the additional shielding.

97% tungsten became our material of choice. Due to the problems of carrying out a density quality assurance our supplier can only issue an Assay Certificate (Appendix 04) not a certificate of compliance that material is free from voids. We believe this is not an issue as any problems with the material will show up during construction, and the cask must be certified for it's capacity at it's first use, this assay will identify any deficiencies.

Radiation Attenuation

There are several styles of internals for different load configurations and capacities. Only lead will be used as the attenuating material for transporting Co60 sources less than 1000Ci and Cs137 up to 60000Ci.

For Co60 sources up to the design capacity of 12000Ci for Point and 15000 for pencils the primary attenuation is tungsten.

The size of the tungsten attenuator can be adjusted for future units to accommodate actual variations measured after the first unit has been loaded and surveyed. It is proposed that we limit the cask to 250 watts. Approximately 15,000 Ci Co60.

Crumple Shield

Having created a larger package at the tips of the crumple fins, we redefined the outer perimeter of the cask using a wire mesh. Increasing the distance between the source and the point of measurement of the "Transport Index" lowered the amount of attenuation to be provided by the heavy elements.

Several permutations were considered and the best fit between carrying capacity and weight was 460mm dia with 150mm fins, and calculated out to 1000Kg, approximately half the weight of our original estimate using a traditional design.

End Shields

To protect the attenuator on it's ends, the crumple zone has to extend over the ends, however, this creates a problem during loading and unloading and therefore they must be removable. This enables access to the ends of the attenuator for preparation of the drawer for transit and transfer. The fins are connected together via a central pipe creating a strong end for protection of the access flanges and creates an access point to the caps for wipe testing.

Heat Transfer

316 stainless steel with it's poor thermal conductivity would help to inhibit the transfer of heat to the lead core, the addition of the fins would effectively increase the surface area to a heat source. To limit heat transfer to the core at high temperature differential the area of contact between fin and attenuator body is kept to minimum, by the design of the fins and the cutaways for the crumple points.

A secondary effect of the fin is to conduct heat away from the core to limit the temperature rise of the body caused by the decay of the isotope. Limiting the line of contact between the fins and the attenuator body at low temperature differentials does not cause a problem of heat build up at the attenuator.

Rigidity

To create the required strength to support it's own weight the three bottom fins that connect to the base were increased in thickness, as was the top fin, to allow for the lifting points, all fins were tied together with heavy end rings to create an interlocking matrix. While the outer mesh will assist in making the matrix more rigid it has not entered into our considerations as calculation to it's effect is extremely complex and changes little.

Lifting Points

Two 1 tonne shackles are fitted through reinforced holes at the ends of the top central fin and close to the end rings so that weight is transferred into the rings.

Forklift Skids

The design of the fork lift skids is not central to the design survivability of the cask. Our design shows these to be 100mm hardwood, however as the international rules on timber are under review due to quarantine issues these skids for production will be manufactured from a plastic material.

Tie-Down Points

Two tie down points at each end in the top quarter will be used to restrain the cask in transit. Four wire ropes with turn buckles are provided. An additional band covers the top of the end rings to facilitate the use of webbing straps which can be used if appropriate attachment points cannot be found for the restraint ropes

Placarding

To ensure that critical information cannot get lost during transport, accident, maintenance or repair the serial number will be deeply engraved into the body. This will ensure that all information can be tracked regardless of the extent of damage to the cask.

On each side of the cask a data plate area has been created where at one end invariable information related to the cask will be deeply engraved e.g. manufacturer, address, model number, serial number, competent authority number and weight.

For the normal transport information relating to the specific use a bolt on stainless steel plate will be fixed to the other end of the data plate area. This plate will have deeply engraved the senders name and address, the receivers name and address, plus the UN number for the shipment, the trefoil will be engraved on as appropriate.

On the reverse side will be deeply engraved the return senders name and address, the receivers name and address plus the UN number for the shipment, the trefoil will be engraved on as appropriate.

This plate will be supplied for each shipment and ensures that the labelling is controlled from our office and cannot be defaced or lost even in a disaster event.

The label is attached using 4 screws with the appropriate side showing (See Appendix 17)

Above the data plate area on both sides is a plate onto which the stick on transport index label will be attached. Also provided will be two engraved labels showing the contents of the cask and they are screwed one on each side of the cask.

Initial Drawings

Drawing Numbers 32030 through 32050 are attached as Appendix 06, these are the initial drawings of the package.

Decision to build the prototype

We were satisfied that the cask would survive the testing as described in the IATA dangerous goods manual and there would be sufficient application to warrant the expenditure. The procedure and sequence of construction is documented and attached as Appendix 07.

Suppliers

A list of approved material suppliers can be found in the model 1860 Quality Assurance Programe

Construction

- The sheet materials were purchased through ABC Laser Cutting Services, all parts were checked against the drawings.
- The end plates and central tube were machined by C&I Engineering.
- All parts were taken to Fineweld Stainless Steel for fabrication.
- All sequences of construction were discussed and evaluated prior to being carried out.
- On completion of the body it was transported to Amac Alloys for loading with lead. Note: The lead pour must be carried out in a single operation and continue while the lead shrinks as it cools (Appendix 15).
- It was returned to Fineweld to seal the filling ports and the expansion fit on the centre tube. The outer mesh and the end crumple shields were fitted.
- Special tools were built to ensure no flex in the boring bar while the centre of the cask was line bored to ensure smooth operation of the drawer into and out of the cavity. The unit was glass beaded to give a clean finish.

Regulators

Victorian Dept. of Human Services (Radiation Section) were listed as a Competent Authority. They were to oversee the design procedures, test program, review the results and assist us with obtaining the accreditation and consequently the B(U) certification.

Test Laboratory

Victoria University Dept. of Civil Engineering were to carry out the testing of the packaging, they are the premier packaging test laboratory in Victoria and have all the facilities and expertise to do the testing that is required except for the hard stand necessary for the drop tests.

After considerable discussion and finally agreement in principle on the test program, Analogue and Digital Measurements undertook to build the hard stand at their site to enable them to do all the testing.

IATA Test Requirements

Section 10 of the IATA Dangerous Goods Regulations were broken down and analysed to:

a) ensure we had covered all the must have features.

b) develop our test program.

To ensure that there would be no issues on acceptance of the testing and test results, a clear agreement on the exact meaning of the procedures and tests required was to be documented and agreed to prior to carrying out any test.

We presented Victoria University with an extract of the test program from the IATA Dangerous Goods Manual (Appendix 01).

Due to the way this document is written a clear unambiguous program could not be agreed on with Victoria University, we therefore looked for a better document.

Change of the Design Code

Victorian Dept. of Human Services (Radiation Section) were listed as a Competent Authority. They were to oversee the design procedures, test program, review the results and assist us with obtaining the accreditation and consequently the B(U) certification.

Victoria University Dept. of Civil Engineering carry out testing of packaging, they have all the facilities and expertise to do the testing that is required except for the hard stand necessary for the drop tests.

After considerable discussion and finally agreement in principle on the test program, Analogue and Digital Measurements undertook to build the hard stand at their site to enable them to do all the testing.

To ensure that there would be no issues on acceptance of the testing and testing results, a clear agreement on the exact meaning of the procedures and tests required was to be documented and agreed to prior to carrying out any test.

We presented Victoria University with an extract of the test program from the IATA Dangerous Goods Manual. Due to the manner in which the book is written it became questionable on weather our interpretation would be considered correct.

As we could not agree on the exact test procedures we decided to search out further information.

IAEA TS-R-1

We located the IAEA document Regulations for the safe transport of radioactive materials TS-R-1 (Amended 2003)

While our understanding of the design requirements for the cask and the test program were almost exact, the test procedures were much easier to understand.

IAEA TS-R-1 General Requirements

Section 6 sets out the basic design criteria for the package, exerts (Appendix 08) covering paragraphs 606 to 662 were considered and discussed with the Victorian regulators. It was agreed that all the design features were either not applicable or had been covered in our design. Refer to our letter to Dept. of Human Services (Appendix 10).

IAEA Test Requirements

The test requirements as set out in TS-R-1 Section 7 were reviewed and a clearly defined document of the appropriate tests required to meet the Type B(U) test program was developed (Appendix 09).

This document was presented to Victoria University and Victorian Dept. of Human Services (Radiation Section) and agreement was reached on the proposed test program.

A document titled Destructive test procedures for the model 1860 type B(U) transport cask was created (Appendix 11).

Decision to Test

When we were ready to carry out the test program the appropriate personnel at Victoria University were unavailable for 6 months. This was an unacceptable delay so we looked to alternatives.

We negotiated a test program with ANSTO using our destructive test procedure document., considerable discussion on how to achieve the required conditions of test took place.

The code does not specifically say the 9M drop test must be at less than -40deg C It was our decision to lower the temperature for both type (B) drops.

Considerable discussion took place on the method of carrying out the drop test at below -40deg C, the ANSTO's method to lower the temperature was to use dry ice as they had used in the past for smaller packages. We were uncomfortable with this procedure as we wished to video the drops for future evaluation and we believed the core would not

get to a low enough temperature and the mesh would quickly rise above -40deg C. We insisted on the more expensive use of liquid nitrogen.

Our proposition was to build a box with a stainless steel tray at the bottom, sit the cask in the box and poor liquid nitrogen over the cask. When the core reached -80deg C take the unit to 9M and drop it (Appendix 12).

As ANSTO did not have an oven large enough to take the cask I obtained the resources of a heat treatment plant. To protect the plant from a lead leakage the cask was to sit in the tray used for the liquid nitrogen.

ANSTO modified the program to suit their better understanding of the test requirements. Their proposal is attached as (Appendix 13).

The main deviation to the test program was to not carry out the heat rise test and show it's suitability by calculation because of the obvious heat dissipation capability of the fins and mesh construction. We had manufactured a heater to simulate the maximum source of 250W and will at some time in the future confirm ANSTO's predictions.

Testing

An order was placed on ANSTO to carry out the required test. This was carried out on the 7th and 8th of September 05.

Test Results

ANSTO's report is attached as a separate document titled:

TYPE B(U) PACKAGE

PERFORMANCEEVALUATION OF

THE A&DM 1860 PROTOTYPE CASK

Photographs of the drop testing and oven test are attached as Appendix 16.

For interest a video is available which shows the damage occurring in slow motion.

Radiation Management

A&DM's Radiation Management Manual is designed to meet the requirements of our activities both within our workshop and at remote sights. Analogue and Digital Measurements P/L Radiation Management Program Manual is a separate document and is to be read in conjunction with this document.

Engineering Training Manual

Loading, unloading, tie down Procedures, special transport requirements, incident reporting and accident management are covered in the documentation that is to accompany the cask and can be found in the Model 1860 Users Manual.

IAEA TS-R-1 Quality Assurance

We were developing a Q.A. program specifically for the manufacture and usage of the casks, it became obvious that our documentation control, ordering and inspection protocols were inadequate to meet the program requirements of TS-R-1. Thus a company QA program was constructed

A&DM Q.A. Program

Our Quality Assurance has been completely re-evaluated and now complies with industry best practice. All documents are controlled using a software re-visioning system. This procedure ensures there is one master file. Drawings, instructions, procedures and traceable records are all the latest issue and are issued fresh with every order.

Variations

Any variation to a document requested by manufacturing after issue must be verified with engineering to ensure any variation will not impact on the cask design. If agreed to, the change will be made, all documents recalled and a new set issued.

Sequential QA

At the completion of each part, the subcontractor's QA officer will check the part against the drawing and signs the drawing as checked. If the part is to go to a second subcontractor A&DM are advised the parts are ready and passed QA. The part will then be delivered to the second subcontractor.

If a part is to be married to others to form a sub assembly the QA officer must ensure he has the signed-off drawings of all the parts. On completion of the sub assembly the QA officer must sign off the sub assembly drawing.

This procedure is continued until the assembly must go to another plant for the construction to continue, all quality assured drawings must accompany the assembly.

At completion of construction when the cask arrives at A&DM's workshop it will have all the quality assured drawings that make up the cask. A&DM's QA officer checks the radiation cask for correctness of detail and accepts the cask into our inventory as a completed cask. The QA officer must check the drawings into the history file of that cask.

Review

A&DM's QA officer must check the drawings to ensure that the procedures have been followed and look for any notes or comments provided by any of the individuals in the construction process. Any notes must be followed up to address any implications on the integrity of the manufacturing process. All suggestions to improving the system must be investigated.

At the completion of a job all procedures will be discussed to evaluate if any

improvements can be made without changing the design.

This procedure has been designed to ensure that there are no drawings left around, so that there is no chance of producing a part to an incorrect drawing or instruction.

Analogue and Digital Measurements P/L Q.A. Program Manual is a separate document and is to be read in conjunction with this document.

Emergency Response Plan

Introduction

Background

The use of radioactive material is an important part of modern life and technology. Radioactive material is used extensively in medicine, industry, agriculture, research consumer products and electrical power generation. Millions of packages containing radioactive material are consigned for transport each year throughout the world. The quantities of these materials in shipments vary on a scale from very small to very large.

To ensure the safety of personnel, property and the environment, national and international transport regulations have been developed These regulations and policies are implemented by regulatory authorities to control the transport of radioactive material. Measures required in these regulations are to ensure adequate containment, shielding and the prevention of hazardous situations in the event of a transport accident.

Radioactive materials are transported by road, rail, sea and air, each mode of transport is governed by its own specific rules and regulations. According to the IAEA, to date there has not been a reported transport accident involving radioactive materials that have resulted in serious radiological consequences, however despite the extensive application of these stringent safety controls, transport accidents involving radioactive materials have occurred and will continue to occur.

Despite this excellent safety record, plans must be developed to ensure that an adequate emergency response capability is available when transport incidents do occur, with responsibilities defined and actions ready to be taken.

When a transport incident involving radioactive material occurs, although it may pose no radiation safety problem, emergency response actions are needed to ensure that a high level of radiation safety is maintained.

If a transport accident occurs that results in a release of radioactive material or loss of protective shielding, the consequences must be controlled by the correct emergency response actions. The type of emergency planning for responding to transport accidents involving radioactive material is similar to that required for responding to transport accidents involving other types of dangerous goods, such as flammables, explosives, poisonous gases, corrosives and toxic chemicals.

Objective

The objective of this emergency response plan is to provide guidance to the regulators, consignors, carriers and emergency response authorities. The Analogue & Digital Measurements emergency response plan is for an incident involving the Model1860 radiation transport cask and is established to provide guidelines for dealing effectively and safely with the potential risk to operator, public and the environment in a radioactive contamination situation.

This emergency response plan is formulated so that an operator or consignor can effectively determine the severity of a potential exposure, resulting from a transport or work related accident.

A&DM recognises that emergency response plans may vary from state to state, but the fundamental rescue and containment methodologies used will remain consistent. Each responsible authority constructs it's own radiation emergency response plan and best decides how to apply the guidelines set out in the *'IAEA Safety Standards Series, Planning and Preparing for Emergency Response to Transport Accidents Involving Radioactive Material".*

A&DM has constructed this emergency response plan around the IAEA recommendations and guidelines. This emergency response plan is not intended to provide step by step instructions on all facets of an emergency response scenario, but rather to provide quick, accurate and relevant information needed to handle the immediate situation involving the A&DM Model 1860 before emergency services arrive. And to provide the emergency response services with information of the type, severity and potential hazards associated with the incident and provide some direction or action pathway on how to respond to the situation and how to best control any radiological hazards.

A&DM require that the emergency response plan be carried with the package at all times. The emergency response plan will be consulted first, in the event of an accident or emergency.

A&DM requires that this emergency response plan be studied by the consignor, contractor or transport company prior to shipment. A&DM also requires that this emergency response plan be used as the first means of determining the severity of damage to the radiation transport cask, and the first means of developing a systematic approach to deal with any potential hazards.

Responsibilities of Consignors and Carriers

The primary responsibility for ensuring preparedness for a given shipment of radioactive material rests with the consignor. The consignor will insure that before undertaking the transport of radioactive material, the carrier or carriers responsible for transporting the material through its pathway are fully aware of the procedures to be followed in the event of a transport accident.

Although the primary responsibility for safe shipping is with the consignor, the carrier also has responsibilities both for the safety during transport and for the proper reaction sequence during the event of an accident. Both the carrier and the consignor must be prepared to respond to an accident and provide the appropriate technical assistance and aid in the development of response methodologies with the emergency services. The carrier has basic training in emergency response procedures for dangerous materials, these procedures are to be used to control the incident before the specifics of this emergency response plan are implemented.

The consignor will ensure that adequate arrangements are available to deal effectively with transport accidents involving radioactive material. These arrangements will include being prepared to provide information about the shipment, knowing how to deal with such an accident and providing emergency and or technical assistance to an accident site when requested or required.

The consignor will make available to the carrier the appropriate emergency instructions and other information concerning the emergency responses. The carrier will ensure that proper emergency instructions are carried on board the transport medium. All efforts will be made by the carrier company to ensure that emergency information will be available to the first on scene emergency response services in the event that the carrier personnel are incapacitated.

Chain of Communications

Emergency rules vary from jurisdiction to jurisdiction, in intent they are the same. A&DM recommend the following procedure, however this can be over-ridden by local regulations as required.

In the event of an accident during the transport of the A&DM Model1860 radiation transport cask, a chain of communication between the responsible person involved during the incident and the emergency service personnel/regulatory authorities is essential. Contact details for all authorities through the transport route will be included in accompanying transport documentation.

Shown below in Illustration 19: Chain Of Communication is a structured flow chart of the communication stream where the typical flow of information is conveyed between the different entities.

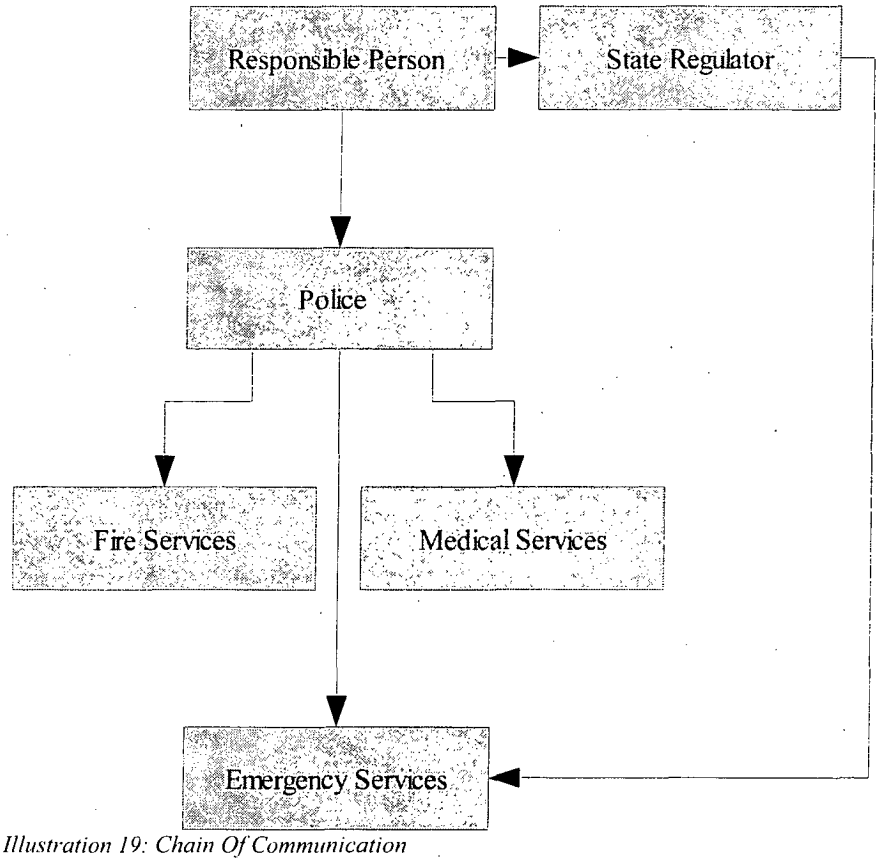


Illustration 19: Chain Of Communication

In the event of an incident the local police must be contacted and notified of the severity of the situation, this will allow them to initiate their appropriate emergency procedure. The regulatory authority must then be contacted and given the appropriate information, the regulatory authority will then provide instructions while emergency services are on the way to the site.

The following procedures should be followed during an emergency.

1. During an emergency the responsible person must remain calm and speak clearly such that all information is received correctly and can thus be filtered down to the relevant personnel.

2. Contact the local police and advise them of the situation. Provide accurate details on the type and severity of the incident. The responsible person must advise what services he or she believes are necessary to resolve the situation.

Item	*Description*
1.	Fire Services
2.	Medical Services
3.	Emergency Services

Table 41: Emergency Services

The responsible person must also provide the following information to the local police.

Item	*Description*
1.	Location of the incident
2.	Landmarks
3.	Other hazards
4.	Time of the incident
5.	Package type
6.	Package cargo isotope
7.	Package cargo activity
8.	Additional requested information

Table 42: Information for Emergency Services

3. Contact the state regulatory authority and advise them that an incident has occurred. Provide the regulatory authority with the following information.

Item	*Description*
1.	Location of the incident
2.	Time of the incident
3.	Package type
4.	Package cargo isotope
5.	Package cargo activity
6.	Additional requested information

Table 43: Information for State Regulatory Authority

The regulatory authorities are specialized in handling incidents involving radioactive materials. The responsible person should pay particular attention to any recommendations and dose limit methodologies they recommend to enforce, before professional emergency response services arrive.

Transport Incident (Drop)

During normal transport conditions the radiation cask may sustain structural damage due to one or more of the following incidents.

Item	*Incident*
1.	Drop onto flat ground less than 5 meters
2.	Drop onto flat ground greater than 5 meters
3.	Drop onto sharp spike
4.	Drop onto sharp edge
5.	Object dropped onto the radiation transport container

Table 44: Possible Causes for Structural Damage

All of the above incidents are treated with the same emergency response methodologies. The severity of an incident where the radiation transport container is dropped from a distance will not only depend on the height, angle and impact surface, but also numerous other variables that are specific to the incident environment. Such variables can not be measured until the time of an incident.

A generic sequence of emergency procedural steps must be followed for all types of drop incidents, where the worst case scenario is considered and the incident is handled with the uppermost safety precautions to protect the emergency response personal, the general public and the environment from the effects of radiation contamination.

The responsible person, at the time of the incident, for example, the escorting engineer (if present), truck driver, fork lift driver, site supervisor or company manager must execute the following steps:

1. Contact the police emergency number, as detailed in the transport documents. The police should be informed of the location of the incident, its severity and suggest additional emergency services that are required.

2. Contact the state regulatory authority and notify them of the incident giving location, severity, details of the cargo type, its activity and a contact phone number.

3. The responsible person must control the incident site until emergency services arrive. Traffic may be stopped or detoured until the situation is controlled by emergency services. Onlookers must be kept well clear of the exclusion zone, however the details of anyone that does enter the exclusion zone, for whatever reason, must be recorded and passed onto emergency services when they arrive.

4. An exclusion zone of 5 meters minimum is to be formed around the package, to exclude all but emergency services from the incident site.

5. Should the package pose an immediate physical danger to personnel, the package must be stabilised by whatever means possible. If the package poses no immediate physical danger then it must be left where it lays.

6. Analogue & Digital Measurements must be contacted to provide advice as necessary.

While emergency service personnel such as local police and the state regulators are trained to handle emergencies involving radioactive material. The Model1860 radiation transport cask is unique , thus emergency response personnel will not have immediate knowledge of the package. These procedures should be conducted by an individual with knowledge of radiation.

1. Using a radiation survey meter, take a reading at the perimeter of the exclusion zone. Slowly walk towards the package, carefully watching the meter. If the transport index at 1 meter from the surface of any indentation exceeds 10μSv then it is possible that the cask has been compromised.

   If the dose limits are low, and the dose at 1 meter from the package surface does not exceed the transport index it is most likely the package is completely intact.

2. Inspect the cask for visual damage to the central attenuator. Wipe test around the end caps and any indentation that has occurred to the central attenuator. If any radiation above background is measured on the wipe it is assumed there is leakage, and must be reconfirmed by the regulators.

3. If an indentation has occurred to the outer mesh which is greater than 50mm the transport index must be adjusted accordingly.

4. If the wipe test results and the measured transport index are within specifications it is safe to continue with the shipment, however approval from the state regulatory authority must be sought. Analogue & Digital Measurements must be informed of the decision.

5. If the cask is compromised by either high radiation level (damaged crumple shield) or initial wipe test a full in-depth assessment using appropriate instrumentation must be made. If the investigation confirms a leakage, the cask is to be wrapped in plastic film to prevent migration of contaminants and moved to the closest safe storage site to enable time to prepare the most expedient rescue plan.

   After detailed investigation and discussion with the regulatory authorities a decision will be made to carry out a field transfer to a new cask (Cask to Cask Transfer on page 269)or move the cask to a hot-cell. The flow chart shown below in Illustration 20: Drop Incident, Emergency Flow Chart provides a graphical flow chart approach to a drop incident.

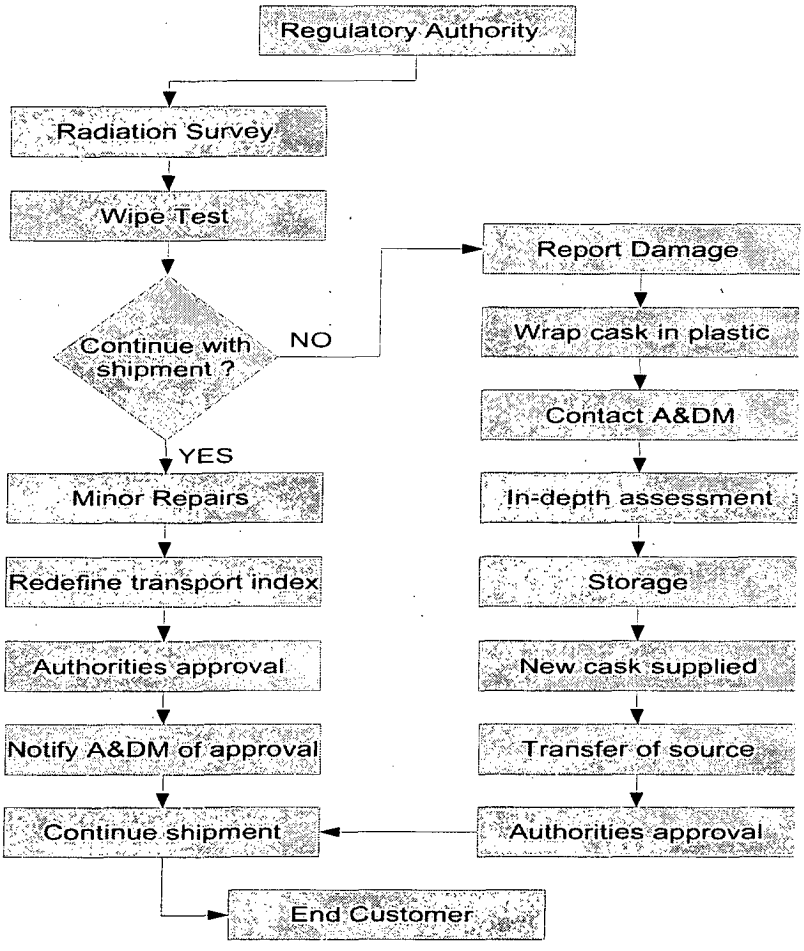


Illustration 20: Drop Incident, Emergency Flow Chart

Transport incident (Fire)

During normal transport, an incident may occur where the radiation transport cask is subjected to extreme heat. All incidents are treated with the same emergency response methodologies. Such that the severity of an incident where the radiation transport container is subject to extreme temperatures for a period of time will depend on numerous variables. Variables that can not be measured at the time of an incident. Thus the emergency methodologies used in this section assume the worst case scenario.

A generic sequence of emergency procedural steps must be followed for all types of thermal incidents, where the worst case scenario is considered and the incident is handled with the upper most safety precautions to protect the emergency response personnel, the general public and the environment from the effects of radiation contamination.

The responsible person, at the time of the incident, for example, the escorting engineer (if present), truck driver, fork lift driver, site supervisor or company manager must execute the following steps:

1. Contact the emergency services, as detailed in the transport documents. The police should be informed of the location of the incident, its severity and suggest additional emergency services that are required.

2. Contact the state regulatory authority and notify them of the incident giving location, severity, details of the cargo type, its activity and a contact phone number.

3. An exclusion zone of 5 meters minimum is to be formed around the package, to exclude all but emergency services from the incident site.

4. The responsible person must control the incident site until emergency services arrive. Traffic may be stopped or detoured until the situation is controlled by emergency services. Onlookers must be kept well clear of the exclusion zone, however, the details of anyone that does enter the exclusion zone, for whatever reason, must be recorded and passed onto emergency services when they arrive.

5. On the arrival of the fire service, water must be sprayed onto the cask while they fight the seat of the fire.

6. On extinguishing the fire, the package, should it impose an immediate physical danger to personnel, must be stabilised by whatever means possible. If the package poses no immediate physical danger then it must be left where it sits.

7. Analogue & Digital Measurements must be contacted to provide advice as necessary.

While emergency service personnel such as local police and the state regulators are trained to handle emergencies involving radioactive material. The Model1860 radiation transport cask is unique, thus, emergency response personnel will not have immediate knowledge of the package. These procedures should be conducted by an individual with knowledge of radiation.

8. When the fire is extinguished, the surrounding environment around the cask must be stabilised to avoid additional flare-ups.

9. Using a radiation survey meter, take a reading at the perimeter of the exclusion zone. Slowly walk towards the package, carefully watching the meter. If the transport index at 1 meter from the surface of the cask exceeds 10μSv then it is possible that the cask has been compromised. If the dose limits are low, and the dose at 1 meter from the package surface does not exceed the transport index, it is most likely that the package is completely intact.

10. The radiation transport cask must be left to cool until it can be safely handled.

11. Inspect the cask for visual damage to the central attenuator, look for cracks or expanded points, look for the presence of lead leakage around the attenuator and on the ground (If the unit was involved in a physical incident in combination with the fire, follow the emergency procedures in the *"transport incident (drop)"* section of this manual).

12. Wipe test around the end caps and any suspect points around the attenuator. If any radiation above background is measured on the wipe it is assumed there is leakage, and must be reconfirmed by the regulators.

13. If the wipe test results and the measured transport index are within specification the cask must be left to cool for a period of 24 hours prior to continuing with the shipment. Approval from the state regulatory authority must be sought and Analogue & Digital Measurements must also be informed of the decision.

14. If the cask is compromised by either high radiation level or initial wipe test, a full in-depth assessment using appropriate instrumentation must be made. If the investigation confirms a leakage the cask is to be wrapped in plastic film to prevent migration of contaminants and moved to the closest safe storage site to enable time to prepare the most expedient rescue plan.

15. After detailed investigation and discussion with the regulatory authorities the decision to carry out a field transfer to a new cask or move the cask to a hot-cell will be made.

The flow chart shown below in Illustration 21: Fire Incident, Emergency Flow Chart provides a graphical flow chart approach to a drop incident.

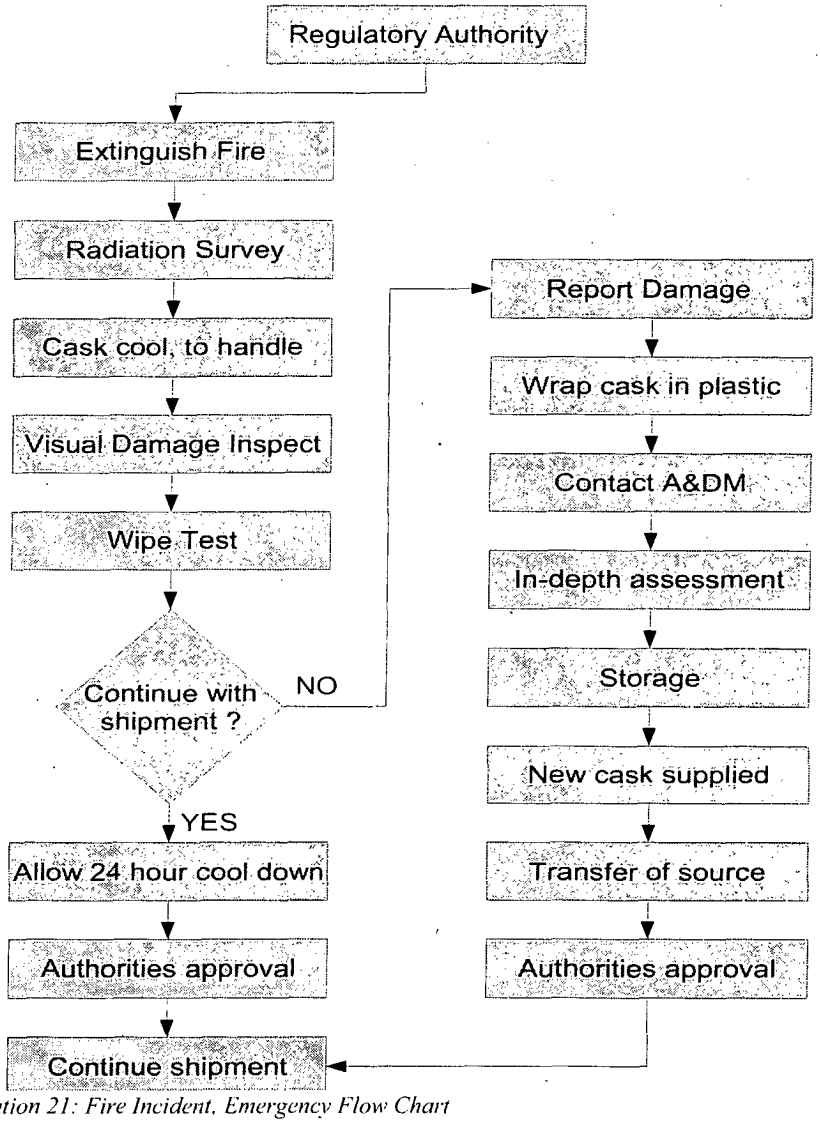


Illustration 21: Fire Incident, Emergency Flow Chart

Transport incident (Theft)

A situation may occur when the radiation transport cask is deemed missing and the consignor or carrier no longer has control over the package. In this situation the local police must be called immediately, followed by the state nuclear regulatory authority. The following items of information must be conveyed to the authorities.

- Last known location of the source.
- Last time of control.
- Current location of responsible person.
- Time of discovery.
- A physical description of the cask.
- Contents of the cask (isotope).
- Activity of the isotope.
- Transport index.
- Observed inconsistencies or suspected parties.

Where a GPS or a GSM tracking device is attached to the radiation transport cask, all necessary instructions, data, numbers and passwords will be handed over to the competent authority.

The immediate environment surrounding the missing cask must not be disturbed. The responsible person is to construct an exclusion zone around the environment where the cask was last seen. The responsible person must detain any persons entering the exclusion zone, and must try to detain any person fleeing the scene before emergency services arrive.

Analogue & Digital measurements must be notified of the situation.

Transport incident (Tamper)

At any time during the transport, if the locks are observed to be broken or damaged in any way, or the package is suspected of having been tampered with. The following procedures must be conducted. refer to Illustration 20: Drop Incident, Emergency Flow Chart on page 164 for a detailed operation flow.

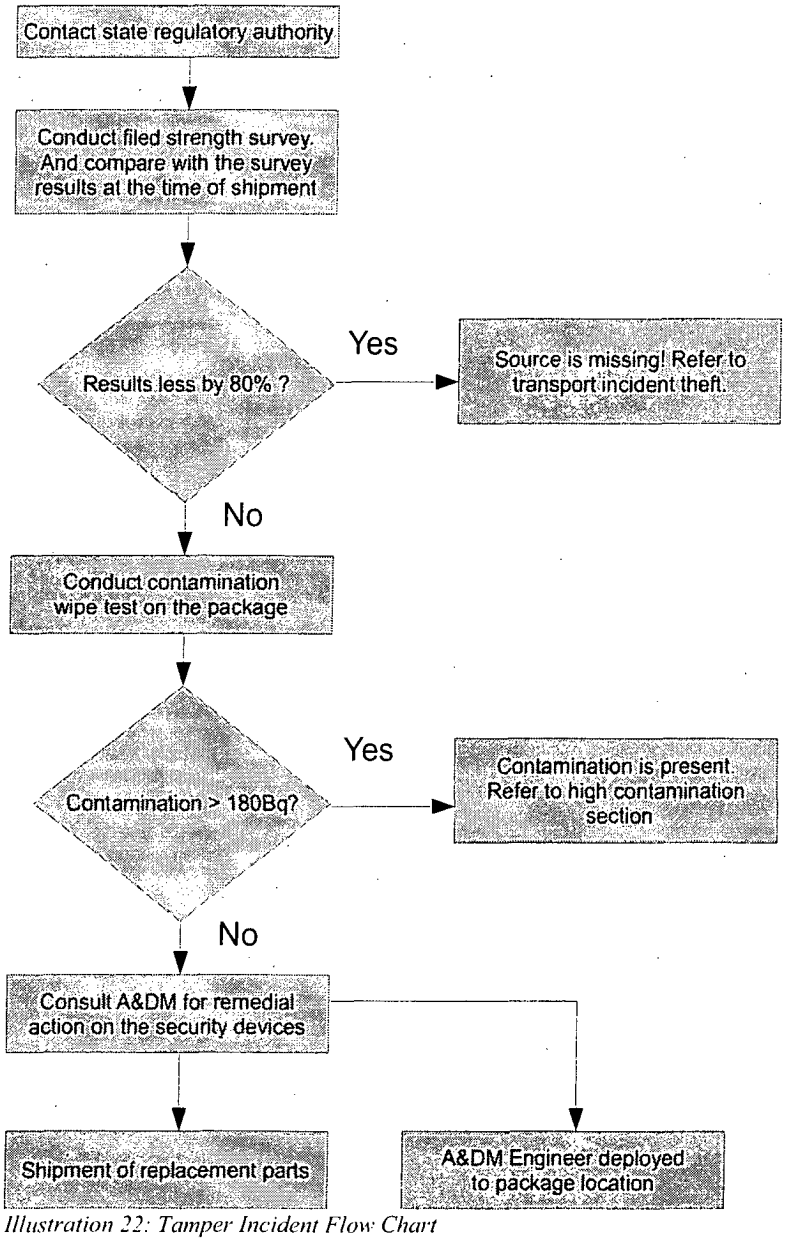


Illustration 22: Tamper Incident Flow Chart

1. The immediate environment surrounding the cask must not be disturbed. The responsible person is to construct a 5 meter exclusion zone around the package. The responsible person must detain any persons entering the exclusion zone and must try to detain any person fleeing the scene before emergency services arrive.
2. The state nuclear regulatory authority should be contacted immediately. The regulatory authority will advise on the situation. The following steps must be conducted by either the responsible person or a representative from the state regulatory authority to determine the severity of the situation.
3. Conduct a radiation field strength survey around the cask, refer to Radiation Field Survey & Transport Index on page 238 for correct procedure. Compare the field strength survey with the one conducted at the time of shipment.
4. If the field strength survey results are considerably less (> 80%) than those taken at the time of shipment it is possible that this source is missing. Refer to Transport incident (Theft) on page 168 for detailed procedures.
5. If the field strength from the survey is roughly the same as the results taken at the time of shipment, it is safe to assume that the source is present within the attenuator.
6. A contamination wipe test must be conducted at the wipe test ports on each end cap of the attenuator. Refer to Wipe Testing on page 242.
7. If the wipe test results show contamination > 180 Bq refer to Transport Incident (High Contamination) on page 171 for procedural steps.
8. If the wipe test results show no contamination, the source is secure and still intact.
9. For repair of the package security devices, A&DM must be consulted. A&DM will advise the type of remedial action to repair the security devices, this will either be the shipment of new parts to the package location, or the deployment of an A&DM engineer to site, to solve the issue.

Transport Incident (High Contamination)

General handling details of the package are the responsibility of the source carrier. And as part of the safe work practices the shipper is required to present the local regulatory authority the detailed work plan and the transport route see Travel Documents on page 241. While it is not possible to predict all situations the following is to be used as a guide in the event of removable contamination being found (> 180 Bq).

In the event of removable contamination being measured during a wipe test the following procedures must be followed.

1. Make sure all wipe test ports are installed and tensioned to 20N/M, this will ensure the package is correctly sealed, and will prevent the migration of removable contamination from the inside of the attenuator to the outside of the package.
2. Construct a 5 meter exclusion zone around the package, control the parameter, thus not allowing any persons to enter the exclusion zone.
3. The local regulatory authority are to be advised of the problem. The regulatory authority will send a specialist to the package location to assess the problem
4. The supplier of the special form source is to be advised of the problem.
5. Analogue & Digital Measurements are to advised of the problem.
6. The local regulatory authority are to carry out a second wipe test using different equipment than that used for the first, to verify the problem.
7. the local regulatory authority are to manage the decontamination of the package regardless of the level of measurable contamination in accordance with their own internal policies and procedures.
8. Once decontaminated, the package and source are to be returned to the capsule fabrication laboratory under a special transportation arrangement. The contaminated capsule is the responsibility of the capsule fabrication laboratory.
9. Once the capsule is removed from the package in the fabrication laboratory, the model 1860 must be decontaminated using the fabrication laboratory decontamination procedures, this is usually achieved with hot high pressure water.
10. After decontamination the package must be verified clean prior to being placed back into service.

Quality Assurance Programme

Introduction

The quality assurance requirements have been met in accordance with the best practices documented in ISO/AS9001:2000.

Document Requirements

The following table shown below in Table 45: Documentation Requirements highlights the requirements for this section.

Item	*Requirement*
1.	Quality assurance programs based on international, national or other standards acceptable to the competent authority shall be established and implemented for: 1. Design 2. Manufacture 3. Testing 4. Documentation 5. Use 6. Maintenance 7. Inspection These standards will be addressed in accordance with ISO9001:2000.
2.	Certification that the design specification has been fully implemented shall be available to the competent authority.
3.	The manufacturer, consignor or user shall be prepared to provide facilities for competent authority inspection during manufacture and use and to demonstrate to any cognizant competent authority that: 1. The manufacturing methods and materials used are in accordance with the approved design specifications. 2. All packagings are periodically inspected and, as necessary, repaired and maintained in good condition so that they continue to comply with all relevant requirements and specifications, even after repeated use. Where competent authority approval is required, such approval shall take into account and be contingent upon the adequacy of the quality assurance programme.

Table 45: Documentation Requirements

Structure Composition

Analogue & Digital Measurements Pty. Ltd, hereafter referred to as A&DM has an evolving quality assurance program in place, which is based on the best practices documented in ISO/AS9001:2000. While A&DM does not have official 9001 certification, it works very hard to ensure it's systems comply closely with the applicable Australian standards.

A revision of A&DM's Quality Assurance Program hereafter referred to as the QAP is targeted directly at the Model1860 Radiation Transport Cask. The QAP addresses the following areas, shown below in Table 46: QA Programme - Target Areas

Area	*Description*
1. Design	Ensuring that all design work is carried out in a controlled manner, using proven tools and methodologies by competent engineers. The control over the design and development stages, review, verification and validation to be handled by competent engineers
2. Manufacture	Absolute manufacturing steps and instruction documentation to be developed by competent engineers. Ensuring that all design information is conveyed to the parties responsible for manufacturing, and that each party ensure adherence to the manufacturing requirements.
3. Testing	Ensuring that the design and any subsequent designs are tested in accordance with the competent authorities regulations.
4. Documentation	Ensuring that all documentation related to the Model 1860 Radiation Transport Cask is written and maintained to a set of standards.
5. Use	Ensuring the use of the Model 1860 Radiation Transport Cask is within its design specifications. Also, to ensure the intent and the use of the cask is conducted in a safe fashion.
6. Maintenance	Ensuring that each cask is regularly maintained and serviced in accordance with developed methodologies.
7. Inspection	Ensuring each cask is inspected for specifics prior to and after any use.

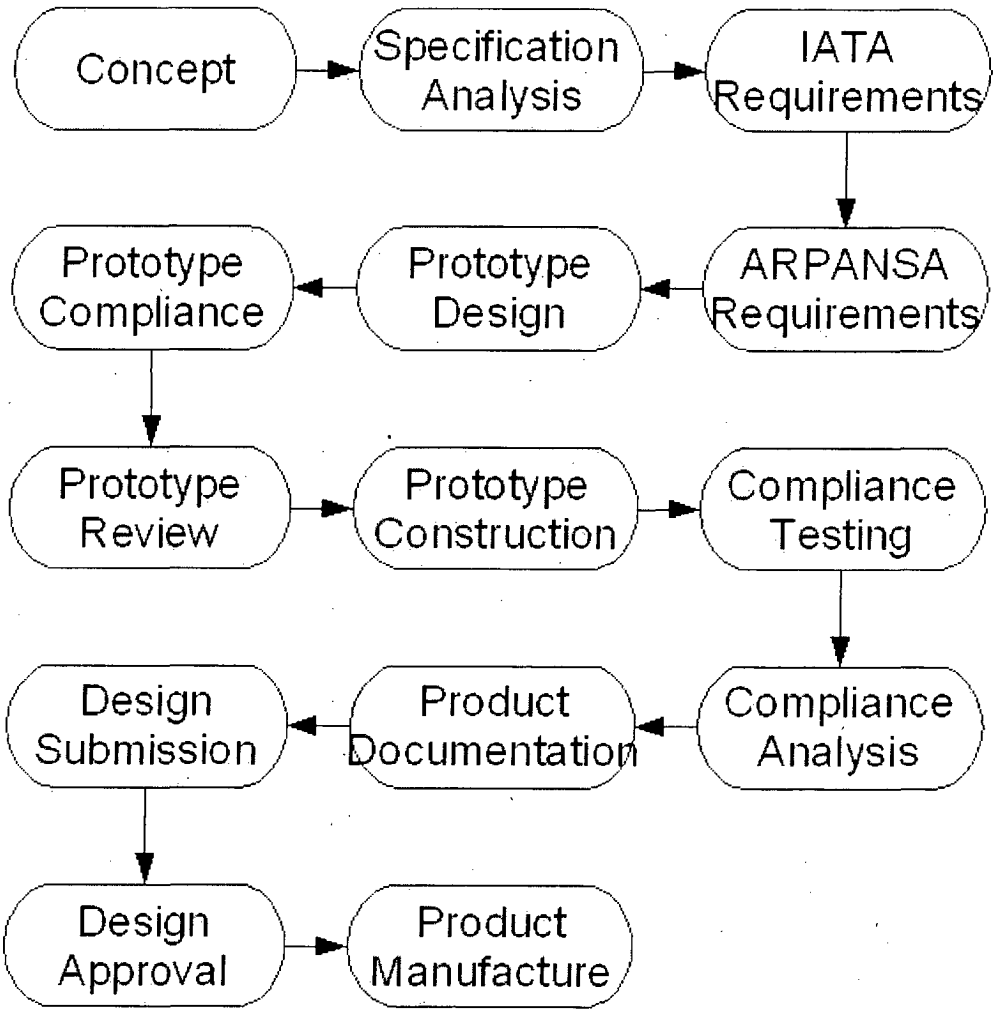
Table 46: QA Programme - Target Areas

QAP – Design

This section covers the quality assurance program relevant to the design of the Model1860 Radiation Transport Cask.

Development Cycle

The development cycle for the Model1860 radiation transport cask will closely follow the steps shown below in Drawing 1: Development Cycle.



Drawing 1: Development Cycle

The development cycle is a sequential set of design steps from the conception of the design on to the design approval and finally finishing at the end product. Should additional steps be required, they will be added and documented in the detailed design document of this literature series.

The *Model 1860 Detailed Design* document is created for the purpose of documenting the design process, Typically the detailed design document will consist of the following sections.

- Main driving source for the design / product
- Design Investigation, Specifications and Materials
- State One Decisions
- Design Solution
- Initial Drawings
- Suppliers
- Construction
- Prototype
- Regulatory Requirements
- Testing
- Test Results

Design Methodologies

The design of the Model 1860 Radiation transport cask will comply with the requirements and best practices given in the *Analogue & Digital Measurements Quality Systems, Master Quality Manual*

All Design will be carried out by competent engineers in a controlled manner using proven tools. The design and progress of the project will be constantly reviewed by management for accuracy, correct use of tools / software and up to date project / document control.

Responsibilities of the Engineers

The responsibilities associated with the multiple stages of design are assigned to different company members, each having proven specific skills to satisfactory complete the allocated design stage to a high professional level. However, the ultimate responsibility for the entire project lays with the A&DM Managing Director. The company employees to complete this project and their positions are as shown below in Table 47: Company Employee Positions.

Name	*Position*
Ted Parrot	Managing Director.
Kieren Grogan	Nuclear Systems Engineer, RSO
Richard Teh	Mechanical Engineer, QA Officer
Lachlan Grogan	R&D Managing Engineer, QA Manager

Table 47: Company Employee Positions

Each employment position takes specific responsibilities during the design on the cask. These responsibilities are chosen to match the strong points held by each position, these are as shown below in Table 48: Position Responsibilities.

Position	*Responsibility*
Managing Director	1. Financial allocation 2. Initial design conception 3. Prototype design 4. Design approval 5. Documentation approval
Nuclear Systems Engineer	1. Design consulting 2. Design review 3. Design compliance 4. Design documentation
Mechanical Engineer	1. Concept consulting 2. Prototype design 3. Prototype review 4. Final design 5. Manufacture procedures
R&D managing engineer	1. Mechanical & structural consulting 2. Quality assurance 3. Design review 4. Design simulation

Table 48: Position Responsibilities

Regulatory Authority Compliance

The hazardous nature of the material to be transported within the cask requires compliance with both national and international regulatory authorities. These regulatory authorities govern the safe use of and transport of radioactive materials. To have the design approved design regulations/parameters and safe working regulations must be adopted from the authorities. The main authority requirements subject to the design of the cask are as shown below in Table 49: Regulatory Authorities.

Authority	*Description*
ARPANSA	Australian Radiation Protection And Nuclear Safety Agency
IATA	International Aviation Transport Agency
IAEA	International Atomic Energy Agency
CASSA	Civil Aviation S S A
AMSA	Australian Maritime Safety Authority

Table 49: Regulatory Authorities

Organisational Interfaces

It is vital that all people and organizations concerned in both the manufacture and transport aspects of the package have a clear understanding of their own interfacing responsibilities and limits of operation and control and also those of others.

Such an understanding can be achieved by a simple definition of responsibilities, this is given in the *A&DM – Quality Systems, Master Quality Manual*. Where internal interfaces occur, the organization should clearly identify them within its management system, possibly in the documentation/procedures for a particular activity. Where external interfaces occur, they should be identified and agreed upon and care should be taken to ensure that responsibilities have been clearly defined in appropriate documents such as purchase orders, specifications and contracts.

Performance inputs

The performance inputs into the design are divided into two sections, the functional performance and the regulatory performance.

The Model1860 requires the following functional performance as shown below in Table 50: Function Performance.

Item	*Description*
1.	Have capacity to carry 15,000 Ci of ^{60}Co.
2.	Able to accept therapy head source drawers.
3.	Be light weight for low cost transport.
4.	Able to withstand type B(U) destructive testing.
5.	Confirmed with type B(U) regulations.

Table 50: Function Performance

The regulatory performance input requires design compatibility to the following regulatory authority requirements as shown below in Table 51: Regulatory Performance

Regulator	*Requirements*
IAEA	Transport of Radioactive Materials
ARPANSA	Transport of Radioactive Materials
IATA, CASA	Dangerous Goods Regulations

Table 51: Regulatory Performance

Outputs (Design Regulation Compliance)

The IAEA design requirements stand as the template for ARPANSA and IATA design requirements. The prototype design meets the 57 IAEA design requirements. These requirements can be found in General Requirements for all packages section of the Test Procedures document of this document set.

Verification

The completed prototype transport cask was checked against the original drawings to ensure they were in specification by A&DM. Agreements have been made with all parties involved in manufacturing the transport cask that all parts are checked at incoming inspection so that it can be ensured that every part used in the transport cask is in specification.

A series of mechanical tests were conducted on the transport cask by a 3rd party to ensure that it can comply with the appropriate standards.

Radiation attenuation testing has not yet been conducted due to the inability to transport appropriate sources to our factory. Theoretical calculations have been conducted and are attached in the ANSTO report and practical measurements will be forwarded on for each variant when those sources are stored in the transport cask.

Control Of Changes

Within the design and development process, each part needed to produce the transport cask has a set of drawings associated with it. All drawings and assemblies have a unique drawing number and revision number, therefore allowing tracking of the design to occur. All drawings are administrated by a secure storage and revision software package called Microsoft Visual Source Safe. Source Safe implants labels into each file of the design, therefore allowing knowledge of the revision of all the parts inside a particular finished design. This will therefore allow more effective servicing and replacement of superficial parts if there is a need.

Source Safe also implements an up to date information functionality. Where if an engineer wishes to work on a file he must first check it out of the Source Safe data bases, such that no other engineer can work on the file at the same time. This provides only one copy of the file on the Source Safe data base, and thus the users of the file can be 100% confident that the file in use is the most latest version of that particular file.

With the Manufacturing Release (MR) completed and the design declared complete and handed over to manufacturing, it is now mandatory to issue an Engineering Change Notice (ECN) for any changes into the manufacturing process. This includes details such as a change of supplier of a manufactured part or if a particular part needed to be modified. A list of ECN's are linked in with the project and labelled appropriately using Source Safe to tie them to the revision of the product. Refer to the A&DM Quality Manual for more information about the ECN process.

Any change which influences the out cask construction or integrity will require a new submission to ARPANSA for changes to the certificate of approval. More details on the control of changes can be found in the *A&DM – Quality Systems, Master quality Manual*

Technical Drawings

Mark Number

Is the Model version of the Competent Authority Approval.

The prototype unit did not have a Mark number. At the issuing of the first Competent Authority Certificate the Mark Number "A" will be added to the Model Number. If the unit has to be resubmitted to ARPANSA for revalidation, on approval the Mark Number will progress to "B" etc.

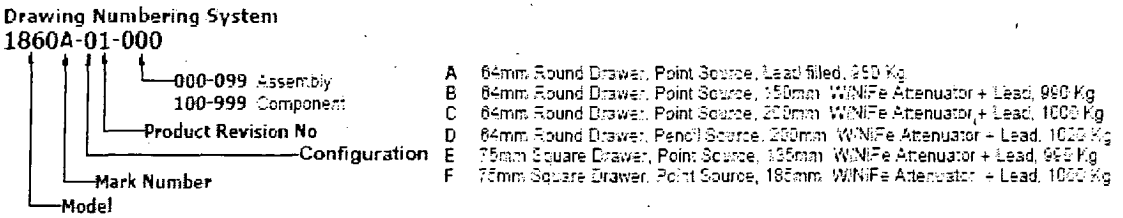
Approved for Manufacture

Any drawing issued for manufacture must:

1. have both Drawing Revision "Approved" and Product "Approved" initialled
2. carried a **stamped in Green** "APPROVED for MANUFACTURE until DD/MM/YY."

Drawing Numbering System

A system of assigning a number to a drawing that reflects its origin.



Drawing Number

A drawing number is a make up of a number derived from "the Drawing Numbering System" plus "an extension number".

When instructions or other information are added to it, instead of assign a new drawing number, "an extension number" is added.

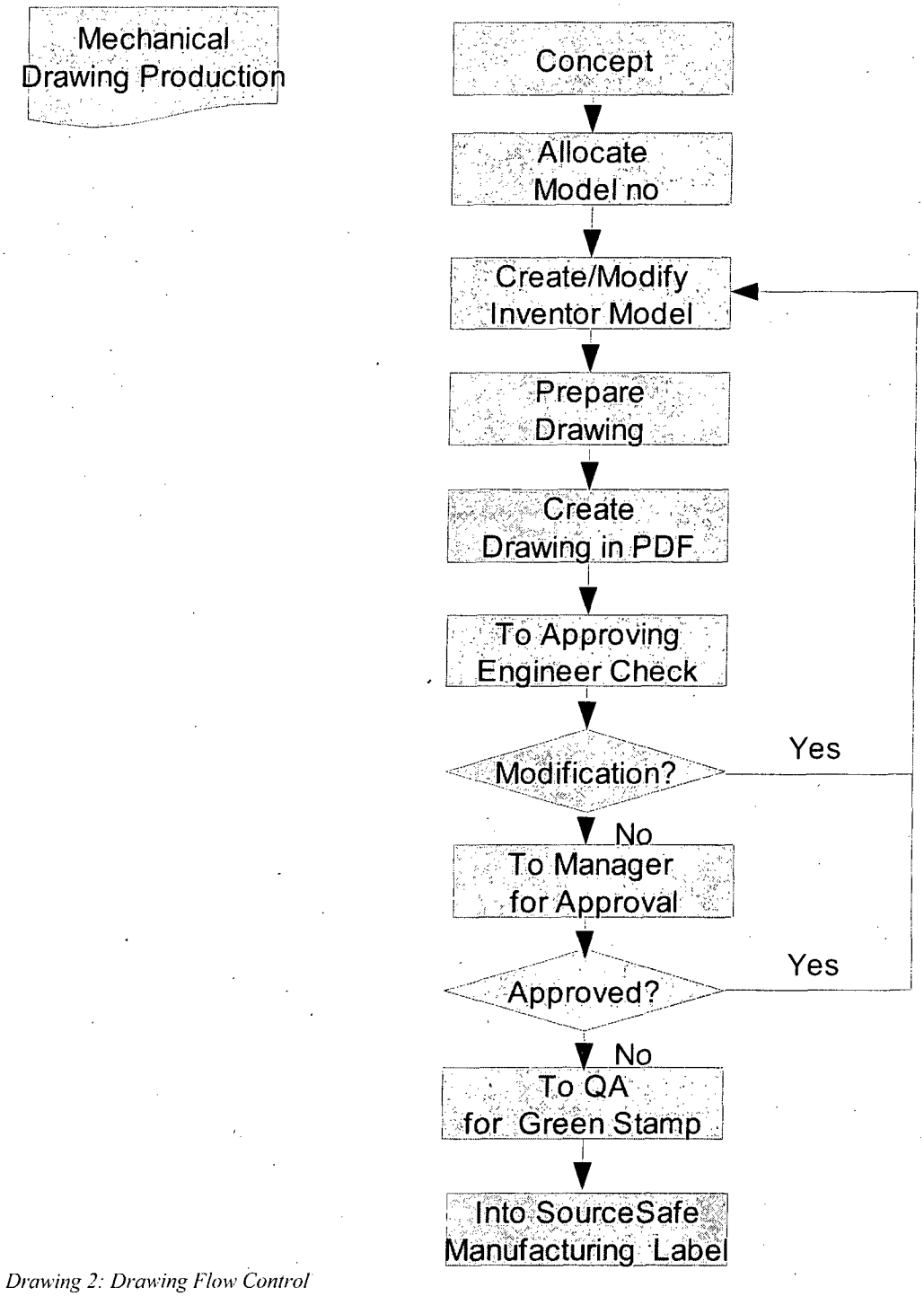
This allows drawing to convey addition information but keeping the reference to the component or assembly intact.

For example extension

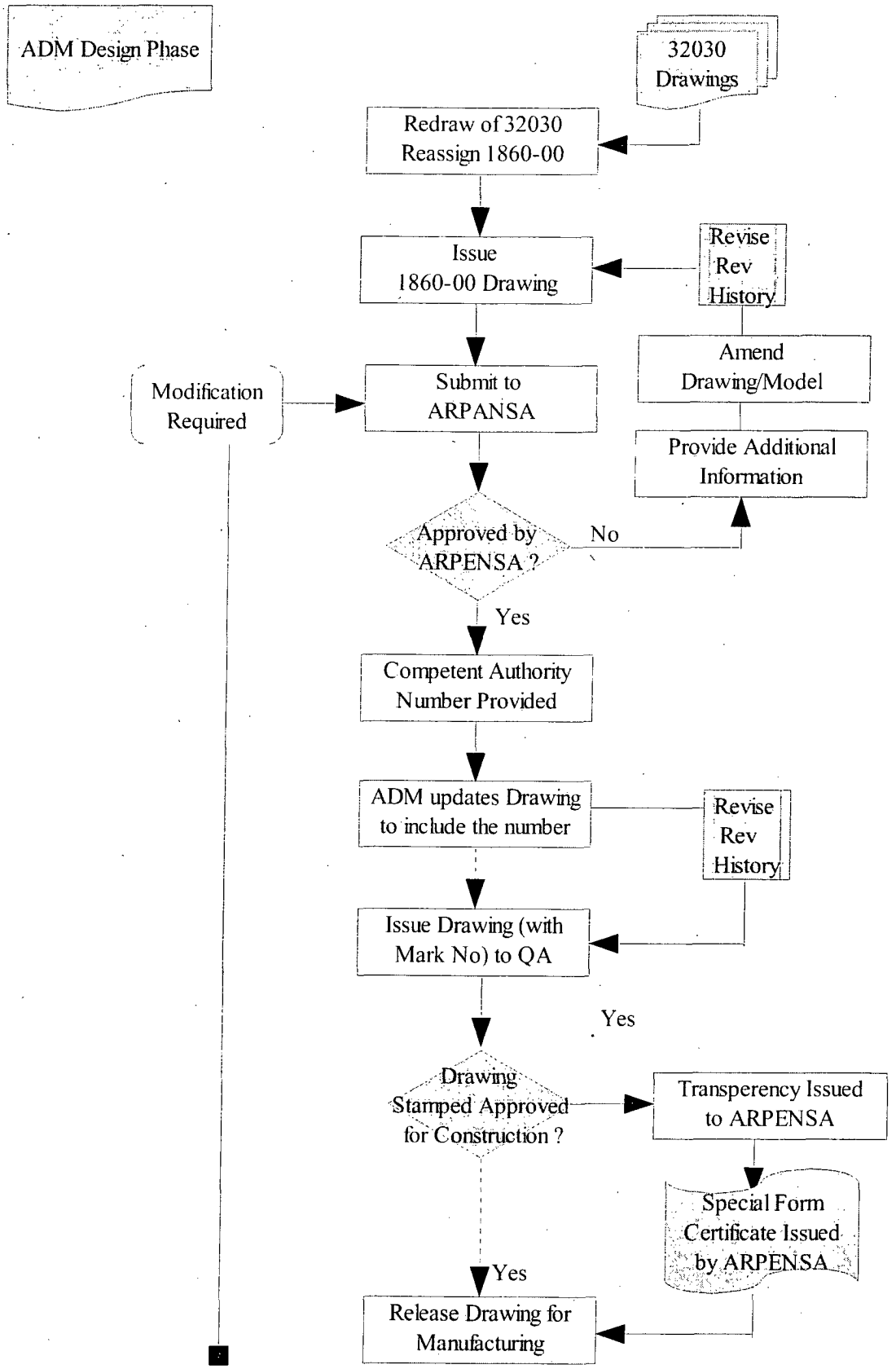
-03	assembly instructions added
-02	application options added.
-01	another variation of views
-05	installation instructions added

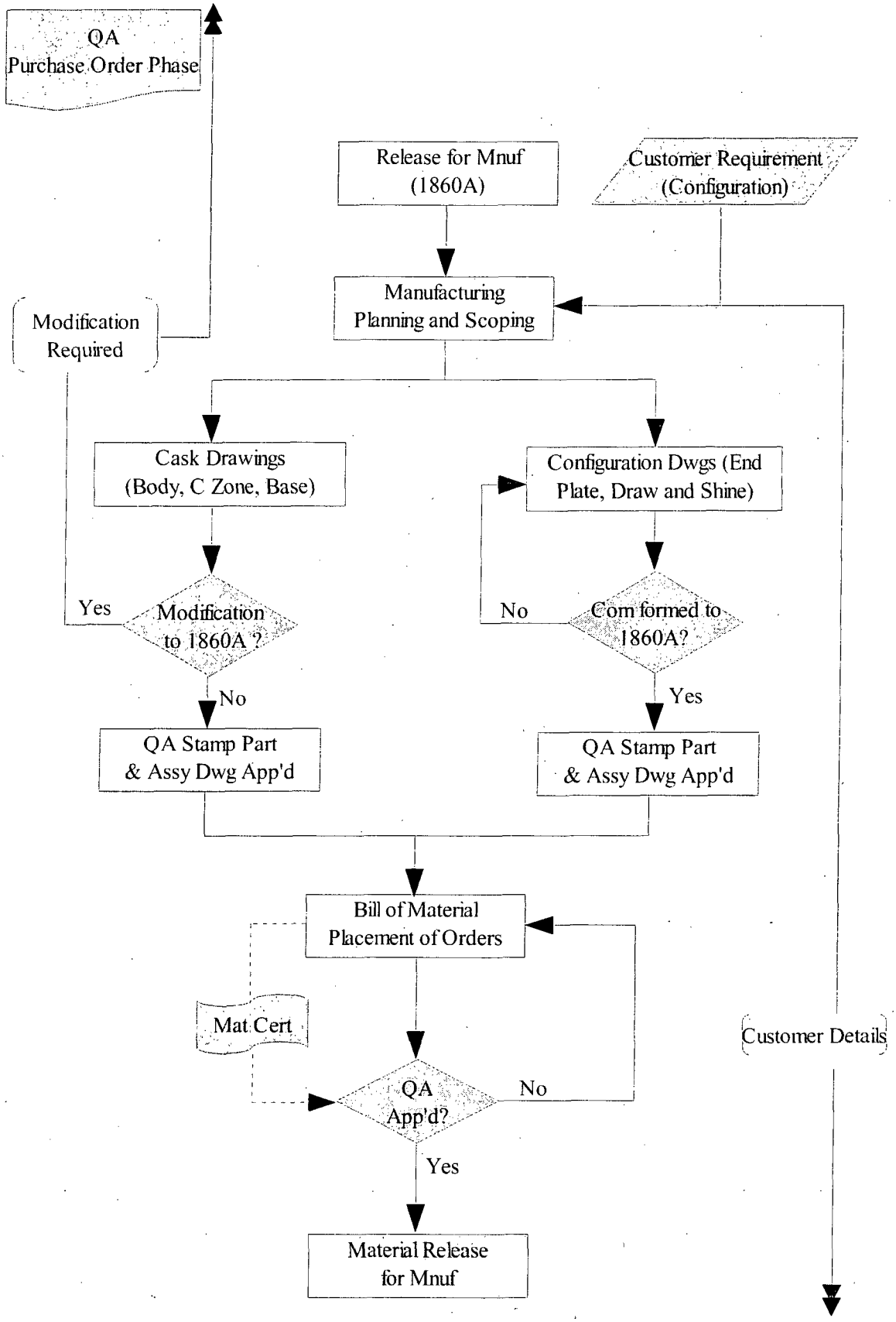
Design Flow Control

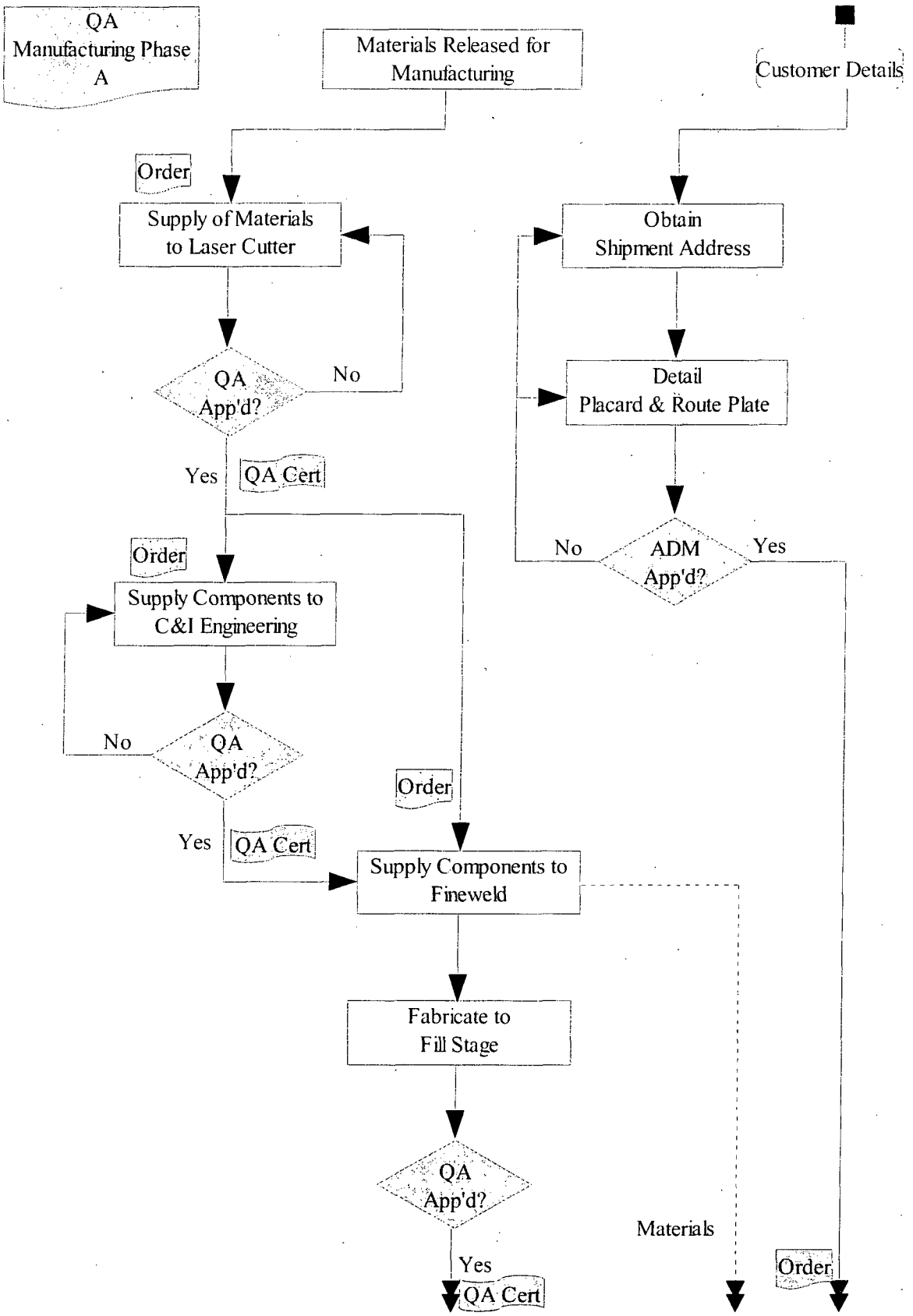
The Steps involved in creating a mechanical drawing, through to drawing number allocation and final approval is as shown below in Drawing 2: Drawing Flow Control.

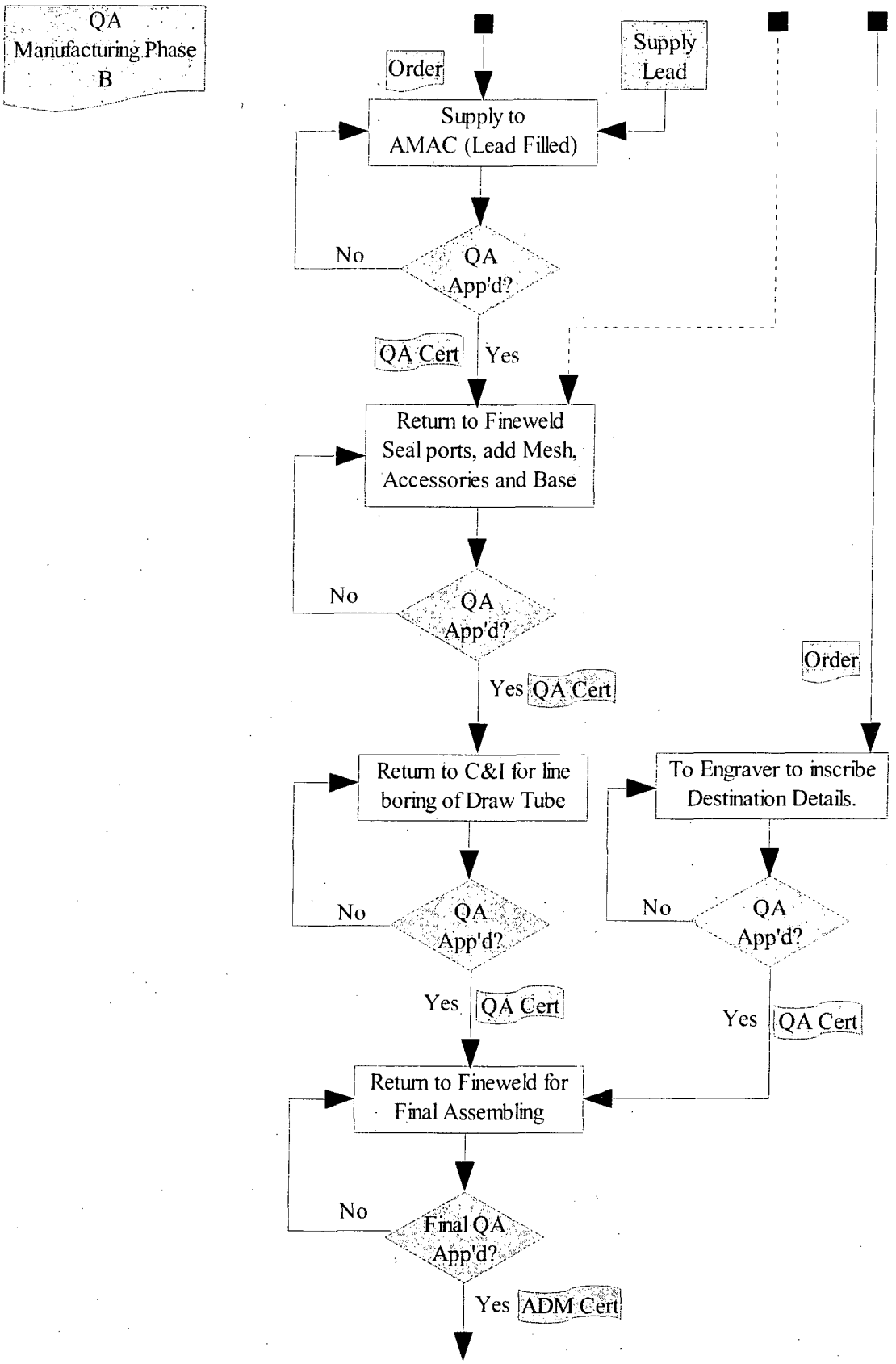


Drawing 2: Drawing Flow Control


ADM Design Phase
32030 Drawings
Redraw of 32030 Reassign 1860-00
Issue 1860-00 Drawing
Revise Rev History
Amend Drawing/Model
Modification Required
Submit to ARPANSA
Provide Additional Information
Approved by ARPENSA ?
No
Yes
Competent Authority Number Provided
ADM updates Drawing to include the number
Revise Rev History
Issue Drawing (with Mark No) to QA
Yes
Drawing Stamped Approved for Construction ?
Transperency Issued to ARPENSA
Special Form Certificate Issued by ARPENSA
Yes
Release Drawing for Manufacturing


QA
Purchase Order Phase
Release for Mnuf
(1860A)
Customer Requirement
(Configuration)
Manufacturing
Planning and Scoping
Modification
Required
Cask Drawings
(Body, C Zone, Base)
Configuration Dwgs (End
Plate, Draw and Shine)
Yes
Modification
to 1860A ?
No
Com formed to
1860A?
No
Yes
QA Stamp Part
& Assy Dwg App'd
QA Stamp Part
& Assy Dwg App'd
Bill of Material
Placement of Orders
Mat Cert
Customer Details
QA
App'd?
No
Yes
Material Release
for Mnuf


QA
Manufacturing Phase
A
Materials Released for
Manufacturing
Customer Details
Order
Supply of Materials
to Laser Cutter
Obtain
Shipment Address
QA
App'd?
No
Detail
Placard & Route Plate
Yes
QA Cert
No
ADM
App'd?
Yes
Order
Supply Components to
C&I Engineering
No
QA
App'd?
Order
Yes
QA Cert
Supply Components to
Fineweld
Fabricate to
Fill Stage
QA
App'd?
Materials
Yes
QA Cert
Order


QA
Manufacturing Phase
B
Order
Supply
Lead
Supply to
AMAC (Lead Filled)
No
QA
App'd?
QA Cert
Yes
Return to Fineweld
Seal ports, add Mesh,
Accessories and Base
No
QA
App'd?
Yes
QA Cert
Order
Return to C&I for line
boring of Draw Tube
To Engraver to inscribe
Destination Details.
No
QA
App'd?
Yes
QA Cert
No
QA
App'd?
Yes
QA Cert
Return to Fineweld for
Final Assembling
No
Final QA
App'd?
Yes
ADM Cert

QAP – Manufacture

Purchasing

A&DM prepares a schedule of materials to be purchased, as well as subcontracted, for each job prior to initiation of work on the contract. Purchase orders, which are issued include a complete description of the item to be purchased as well as any qualifications which must be met and any certifications which are required.

All pertinent drawings and manufacturing procedures are included as part of the purchase orders. A&DM purchase orders also require that all suppliers or subcontractors notify A&DM and obtain approval before any changes in design, materials or dimensions are undertaken.

Direct Shipping

In cases where a shipment is made from the supplier directly to the customer, all instructions regarding shipment are included.

Qualified Vendors

A&DM maintains a list of vendors for which qualified vendors are selected based on past performance as evaluated by A&DM in surveys and audits performed by the various departments of A&DM.

Subcontractors

In the case of subcontracts for manufacturing, A&DM performs vendor surveys and evaluation prior to approving subcontracts. When the subcontractor provides the materials, these vendors are required to establish quality assurance procedures and records for raw materials received with material certification, if required, including performance of fabricated parts purchased.

A Material Safety Data sheet (MSD) may also be required where applicable. In cases where materials of a radiological nature are subcontracted, A&DM requires that these vendors submit information for permanent record relative to the quality of these products. (i.e. leak test information on sealed sources, etc.).

Material Suppliers

Material Suppliers can vary due to availability of materials in stock. A&DM Have two suppliers of fasteners in stainless steel and three suppliers of stainless steel sheet tube and bar.

Tungsten

Company Name	*Company Address*
China Tungsten	Xiamen Fujian China.

Table 52: Tungsten Suppliers

Fasteners

Company Name	*Company Address*
Keables Pty Ltd	185 A'Beckett St. Melbourne 3000 Victoria
Austain Fasteners Pty Ltd	26 Sinclair Road, Dandenong 3175 Victoria

Table 53: Fastener Suppliers

Stainless Steel

Company Name	*Company Address*
Fagersta Steels Pty Ltd	95-97 Levanswell Road, Moorabbin 3189 Victoria.
Sandvik Australia Pty Ltd	South Gippsland H'Way, Dandenong 3175 Victoria.
Midway Metals Pty Ltd	33 Tatterson Road, Dandenong 3175 Victoria.

Table 54: Stainless Steel Suppliers

Subcontractors

Subcontractors can vary for a multitude of reasons, A&DM have a group of masters in their field that are used for their workmanship and reliability.

Laser Cutting

Company Name	*Company Address*
Ultimate Laser Pty Ltd	36 – 40 Micro Circuit Dandenong 3175 Victoria
ABC Laser Cutting Pty Ltd	28 Aster Ave Carrum Downs 3201 Victoria

Table 55: Laser Cutting Subcontractors

Machining

Company Name	*Company Address*
C & I Precision Engineering	9 Cumberland Drive Seaford 3198 Victoria

Table 56: Machining Subcontractors

Sheet Fabrication

Company Name	*Company Address*
Fineweld Stainless Steel	17 Tova Drive Carrum Downs 3201 Victoria

Table 57: Sheet Fabrication Subcontractors

Lead Pouring

Company Name	*Company Address*
Amac Alloys	38 Research Drive Croyden South Victoria

Table 58: Lead Pouring Subcontractors

Product Design

The product will be constructed from design drawings that are certified and approved by the relevant regulatory authorities and A&DM Design Engineers. When a design is certified by the regulatory authority A&DM may make modifications to the design, namely different source draw configurations, but will however, require approval by the regulatory authority before fabrication and use of the package can commence.

Fabrication

Quality Assurance of fabrication for each component and it's associated workmanship standard during manufacture is necessary to produce a high level of quality to assure that:

1. The Transport Cask meets national and international requirements.
2. The Transport Cask meets company manufacture requirements.
3. At the end of the manufacture program A&DM end up with a successful working product that requires no alteration.

The manufacture process inherently involves multiple sequential steps, where the working step requires completion before the proceeding step can occur. Quality assurance during manufacture will therefore become a procedural sequence, where the evolution/construction of the cask requires QA for each section to assure a chain reaction of multiple faults do not occur.

In the manufacturing section of the detailed design document the quality assurance portion for each section immediately follows it's fabrication procedures.

Procedure for Ordering Materials and Vendor Parts

Engineering

1. Check stock of parts and materials.
2. Obtain from marketing the number and configuration of the units to be built.
3. Assign serial numbers.
4. Prepare a cutting out line to determine the amount of raw materials to be purchased.
5. Prepare a list of the vendor parts required.
6. Pass the item lists to purchasing.

Purchasing

1. Using the engineering list of materials, obtain a quotation from the preferred suppliers.
2. Consult with Engineering on,
   a. The use of excess materials.
   b. Number of parts to be cut from raw materials.
   c. Number of Vendor parts to be ordered.
3. Prepare the orders have them checked by engineering.
4. Orders are to be signed by authorised officer.

Receipt of Materials

1. Make a physical check of size and quantity of materials received against that ordered.
2. Mark all materials with the appropriate order number.
3. If a tolerance has been specified outside the class specification take measurements to confirm the correct tolerance has been supplied.
4. Check material Q.A. documents have been received. Enter Q.A. documents into history file of the serial number of the item under construction and the purchase order file.

Construction Procedures

Ordering Of Component Parts

1. Determine the specific parts and number or parts to be supplied.
   a. Provide drawings of the parts to be manufactured to the supplier of the parts or service.
   b. Discuss with the manufacturing unit the requirements and detail of each part.
   c. Obtain a quotation for the parts to be ordered.
2. Prepare a purchase order listing the parts by description, part number and quantity.
3. Advise the manufacturing unit of the numbers identifying the raw materials.
4. Send Q.A checked drawings for the parts nominated on the order to the manufacturing unit.
5. Despatch the Q.A checked raw materials to the Manufacturing Unit
   a. On receipt, the manufacturing unit is to ensure they have received the correct materials.
   b. On receipt, the manufacturing unit is to ensure they have received sufficient materials to produce the ordered components.
   c. The manufacturing unit is to confirm they have received the correct material and quantity.

Manufacturing Of Component Parts

1. Parts are to be produced as per the drawings, from the material supplied.
2. Any material left over is to be returned to A&DM with the order number legible
3. All Parts produced are to be checked against the nominated Q.A control dimensions
4. When all parts to a particular drawing are complete and Q.A checked the Q.A and date box on the appropriate drawing is to be filled in and the drawing returned to A&DM.
5. On advice from the manufacturing unit that the parts are complete and Q.A checked, A&DM's engineers will.
   a. Ensure Q.A boxes on all drawings are completed.
   b. Carry out spot checks to ensure compliance.
   c. Transfer the components to the next point of manufacture.
6. Mark up the master Q.A document confirming parts compliance with specifications.

Assemblies

1. Engineering to prepare a configuration specific construction manual with an assigned serial number.
2. Prepare a purchase order for the construction of the assemblies.
3. Construction manual is to be issued with the purchase order.
4. Component parts are to be delivered to the manufacturing unit.
5. Component parts are to be checked against the part Q.A drawing to confirm compliance.
6. If no issues are raised, it is assumed the assembly can be manufactured from the component part.
7. At the completion of each assembly the Q.A dimensions are to be checked for conformity to the drawing and the Q.A box Signed off and dated.
8. The sequence continues to the end of the deliverables.
9. On advice from the manufacturing unit that the parts are complete and Q.A checked, A&DM's engineers will.
    a. Carry out spot checks to ensure compliance.
    b. Ensure Q.A boxes on all drawings are completed and mark up the master Q.A. document confirming compliance.
10. Transfer the components to the next point of manufacture.
11. Take the Construction Manual to the next point of manufacture.
12. Repeat this sequence until final assembly is complete.

QAP – Testing

Design Testing

For the package to be compliant to the regulatory authority design standards significant testing must be done to prove compliance. The *"Test Procedures"* section of this submission details the test selection and test method used to prove compliance. The results of the destructive testing can be found in the destructive testing results section.

Prior to the destructive testing the prototype cask must first prove compliance with the IAEA / ARPANSA type B(U) structural design requirements in clause 606 to 664 in the IAEA regulations. The prototype package to be tested should be proportional to the package intended for production.

The results of all testing done to the prototype Transport Cask has been recorded or referenced by the '*Model1860 Quality Assurance Verification: Transport Cask*' . As can be seen from this report all mandatory requirements were met.

As stated within the Quality Assurance document 3rd party mechanical stability testing, including drop testing and temperature testing, have been conducted and verified by ANSTO against the requirements for a type B(U) transport cask.

Theoretical calculations on radiation attenuation, impact resistance and internal stress points have also been conducted throughout the design. These calculations and results can be found within the appendices of the approval submission documentation.

QAP - Documentation

Documentation Standards

It is necessary to have significant standards to to produce and manage a document. Any Documents used in; or related to, a final product must follow these documentation standards which include specifics such as.

- Structure Requirements
- Document Headings
- Captions
- Cross References
- Equations
- Document Templates
- Indexes and Tables
- Images

The *A&DM – Quality Systems, Quality Master Manual* section on *Document Control*, *Control of Records* and *Document standards* outlines the company policies and standards with respect to this topic.

QAP – Use

Requirements Before Use

It is a prerequisite before using the cask, that the responsible person have prior training with radiation, this must include the items shown

1. General radiation awareness training
2. General radiation familiarization training
3. Radiation safety training
4. Accident avoidance training
5. Emergency response training
6. Job specific training

User Manual Documentation

The Model 1860 Radiation Transport Cask is provided with a detailed users manual. This manual provides the steps required to complete the most common of tasks that are required during both transport and general use.

Item	*Description*
Transport	
1.	First use
2.	Tool box accessories
3.	Travel documents
4.	Pre-Shipment and receival checks
5.	End of mission checks
6.	Fork-Lift handling
7.	Crane handling
8.	Package tie down methods
General Use	
1.	Hot-cell upload
2.	Hot_cell download
3.	Water bath upload
4.	Water bath download
5.	Therapy head download
6.	Therapy head upload

QAP – Maintenance & inspection

Maintenance and Inspection of the Model 1860 Radiation Transport Cask must be carried out in accordance with the *Model 1860 Maintenance and Inspection Manual.*

Inspection checks are to be made both before the package is sent and after the package arrives. Maintenance is to be carried out if required, this is determined after the appropriate inspection is made.

Maintenance And Inspection Manual

Introduction

This document provides a detailed step by step approach to inspecting and maintaining the A&DM model 1860 Radiation Transport Cask. It is a prerequisite before using the cask, that the responsible person have prior training with radiation and the specifics of the application, the cask is being used for. These requirements are typically a collection of some or all of the items shown below in Table 59: Training Requirements.

Item	*Description*
1.	General radiation awareness training
2.	General radiation familiarization training
3.	Radiation safety training
4.	Accident avoidance training
5.	Emergency response training
6.	Job specific training

Table 59: Training Requirements

This maintenance and inspection manual provides a concise list of the steps required to correctly maintain and inspect the A&DM model 1860 Radiation Transport Cask. However should a task be required that is not documented in this manual, A&DM should be contacted to provide consultation with respect to the required task. This Maintenance and inspection manual contains the following sections, as shown below in Table 60: Document Sections.

Item	*Description*
1.	Radiation Transport Cask Documentation Check List
2.	Shipping Check List
3.	Pre Transport Check List - Unloaded (UN2908)
4.	Post Transport Check List - Unloaded (UN2908)
5.	Pre Transport Check List - Loaded (UN2916)
6.	Post Transport Check List - Loaded (UN2916)
7.	Pre Transport Check List - Return Unloaded
8.	End of Mission Inspection
9.	Confirm Tool Box Content Inspection
10.	Minor Repairs
11.	Major Repairs

Table 60: Document Sections

General Warning

Analogue and Digital Measurements provides a general warning to all peoples directly involved with the use of the Model 1860 Radiation Transport Cask. During transport of radioactive materials the package will display the general radioactive materials warning sign as shown below in Illustration 23: Radioactive Materials Warning.

Illustration 23: Radioactive Materials Warning

The transport index of the package will also be displayed by one of the following LSA signs shown below in Illustration 24: Radioactive Material LSA 2 and Illustration 25: Radioactive Material LSA 3

Illustration 24: Radioactive Material LSA 2

Illustration 25: Radioactive Material LSA 3

All personnel working around or directly working with the radiation transport cask are advised of the potential hazards and risks involved. Should the contents of the cask be exposed outside the attenuator serious bodily damage can occur. Extreme caution should be practice at all times when working with the cask. If an incident does occur, all peoples involved should distance and shield themselves from the source to minimize the damaging effects of ionizing radiation.

Inspection and Maintenance

Pre Transport

Before any nuclear radiation transport the A&DM Model 1860 must be inspected against the Model 1860 Dispatch Inspection Check List. This check list requires checking of the following items as shown below in Table 61: 1860 Check-list Items.

Item	*Requirement*
1.	All documents are current
2.	End plates are in position and locking bolts are all in place and tightened to 30N/M. Wipe Test Ports are tightened to 40N/M
3.	Both locks are in place and locked
4.	End crumple shields are bolted in place and tightened to 50N/M
5.	Destination plates are in place
6.	Transport index measured and recorded in the history log
7.	Transport index labels are in place and marked accordingly
8.	Hold down ropes and turn-buckles are in the tool box (set of 4)
9.	Handling bar (4 pieces is present in the tool box)
10.	Transport documentation checked and signed off

Table 61: 1860 Check-list Items

Pre Transport Check List - Unloaded (UN2908)

Item	*Requirement*
1.	Ensure that the cask serial number is the one assigned to the Mission.
2.	Ensure that the end plates are in place and the 6 X M8 socket set screws are in place and tightened to 20 N/M. (new metal seal is not necessary)
3.	Ensure test port plug is in place and tightened to 20 N/M (new copper washer is not necessary)
4.	Install locks on each end, check that they are locked.
5.	Ensure that the 48 X M10 socket set screws holding the end crumple shields are in place and tightened to 50 N/M
6.	Check the skid bolts are in place and tightened to 30 N/M
7.	Remove the destination placards and arrange them with the correct Sender/Receiver label for the next leg of the Mission toward the outside and bolt in place with the 4 X M6 socket set screws, tighten to 20 N/M
8.	Ensure all radiation signs have been removed.
9.	Check that the contents of the tool box is correct to the content list, advise A&DM of any missing parts.
10.	Check document list is compete and fill out check list.
11.	Forward a complete set of documents and check lists to 1860@nuclearstuff.com.au

Table 62: Pre Transport Check List – Unloaded

Post Transport Check List – Unloaded (UN2908)

Item	*Requirement*
1.	Ensure that the cask serial number is the one assigned to the mission.
2.	Check locks on each end are in place and locked.
3.	Inspect the cask all over, noting any transport damage. All evidence of rough treatment is to be photographed and forwarded to 1860@nuclearstuff.com.au An assessment of the damage will be made and remedial action taken where necessary.
4.	Major damage will require the cask to be taken out of service and returned to A&DM. Appropriate placarding and instruction will be forwarded.
5.	Wipe test the drawer cavity. In excess of 180 Bq of removable contamination is considered to be compromised and will require decontamination.
6.	Install the end cap using the 6 X M8 socket set screws and tightened to a torque of 20 N/M.
7.	Install the test port plugs and tightened to 20 N/M.
8.	Check that the contents of the tool box is correct according to the content list, advise A&DM of any missing parts.

Table 63: Post Transport Check List – Unloaded

Pre Transport Check List - Loaded (UN2916)

Item	*Requirement*
1.	Ensure that the cask serial number is the one to be returned.
2.	Load the source as per the documented loading work plan.
3.	Install the end plates using a new metal seal from the tool box install the 6 X M8 socket set screws and tightened to a torque of 20N/M.
4.	Wipe test the ends of drawer through the test port to confirm a contamination free shipment.
5.	Install the test port plugs using new copper washers from the tool box and tightened to 20 N/M.
6.	Dispose of old copper washers and metal seals.
7.	Fix engraved contents labels (one each side) using 4 X M4 socket set screws.
8.	Install locks on each end, check that they are locked.
9.	If the end crumple shields were removed to facilitate the downloading of the source, replace them and ensure that the 48 X M10 socket set screws are in place and tightened to 50 N/M
10.	Check the skid bolts are in place and tightened to 30 N/M
11.	Remove the destination placards and arrange them with the correct sender/receiver label (for the next leg of the mission) toward the outside and bolt in place with the 4 X M6 socket set screws, tighten to 20N/M
12.	Confirm label has correct UN number of UN2916
13.	Ensure old radiation signs have been removed.
14.	Survey the cask to obtain the transport index.
15.	Affix the appropriate yellow label and fill in the details.
16.	Check that the contents of the tool box is correct according to the content list, advise A&DM of any missing parts.
17.	Complete the dangerous goods declaration.
18.	Check document list is compete and fill out the check list. Place a copy of all documents into the tool box.
19.	Forward a complete set of documents and check lists to 1860@nuclearstuff.com.au

Table 64: Pre Transport Check List – Loaded

Post Transport Check List – Loaded (UN2916)

Item	*Requirement*
1.	Ensure that the cask serial number is the one assigned to the mission.
2.	Confirm the contents are as specified.
3.	Check locks on each end are in place and locked.
4.	Remove the test port plugs and wipe test the ends of drawer through the test port to confirm the shipment is contamination free.
5.	Inspect the cask all over, noting any transport damage. All evidence of rough treatment is to be photographed and forwarded to 1860@nuclearstuff.com.au An assessment of the damage will be made and remedial action taken where necessary.
6.	Major damage will require the cask to be taken out of service and returned A&DM. Appropriate placarding and instruction will be forwarded:
7.	If the source removal procedure requires close coupling, remove the end crumple shields.
8.	Remove the end cap on the machined end.
9.	Attach a handling rod to the drawer through the test port on the other end.
10.	Wipe test the drawer cavity. In excess of 180 Bq of removable contamination is considered to be compromised and will require decontamination.
11.	Down load the Source as per the documented loading work plan. wipe test the drawer cavity. In excess of 180 Bq of removable contamination is considered to be compromised and will require decontamination.
12.	Remove engraved contents labels (one each side) held on using 4 X M4 socket set screws.
13.	Install the end cap using a new metal seal from the tool box install the 6 X M8 socket set screws and tightened to 20N/M.
14.	Remove transport index labels.
15.	If the end crumple shields were removed to facilitate the downloading of the Source, replace them and ensure that the 48 X M10 socket set screws are in place.

Item	*Requirement*
16.	Install the test port plugs and tightened to 20 N/M.
17.	Check that the contents of the tool box is correct according to the content list, advise A&DM of any missing parts.

Table 65: Post Transport Check List – Loaded

End of Mission Inspection

Item	*Requirement*
1.	On receipt of the cask ensure that the serial number is the one assigned to the mission.
2.	A wipe test must be carried out at both ends of the cask. (a) Remove test port plug (b) With a long cotton bud moistened with wipe test fluid, wipe around the inside of the wipe test port and the end of the drawer (c) Less than 180 Bq of removable material constitutes a safe source, any test in excess of 180 Bq will require further investigation. (d) In the event of removable contamination being found the situation is to be reported to the local regulators. (e) A protocol will be developed to remove the contamination. (f) A&DM are to be notified and all details as they occur are to be entered into the history log.
3.	Remove the end crumple shields taking note of the condition of the M10 threads on both inner and outer end rings as the bolts are removed. Any sign of compromise will require major repair investigation as described in Major Repairs below.
4.	M8 treads on the end plates are to be checked (any sign of compromise will require a major repair investigation as described in Major Repairs below).
5.	Inspect the mesh for damage.
6.	Inspect the placard plates. If damaged they are to be replaced.
7.	Inspect the crumple fins for distortion and damage. If damaged they are to be repaired.
8.	Inspect the welds around the attenuator circumference (any sign of compromise will require a major repair investigation as described in Major Repairs below).
9.	The base is to be inspected for distortion, any dimension out of tolerance by 1mm is to be corrected.
10.	Welds between the fins and end rings are to be inspected. for cracks (any sign of compromise will require a major repair investigation as described in Major Repairs below).
11.	All parts are to be washed down using a high pressure water jet.

Table 66: End of Mission Inspection

Tool Box Content Inspection

The items supplied as accessories are provided to assist all who come in contact with the 1860 cask. as shown below in Table 67: Provided Items is a complete list of items the tool box should have. If during an inspection an item should be missing, the item should be replaced with item serial numbers stored in the cask history file.

Item	*Description*
1.	Turn buckle with wire rope attached x 4
2.	Shackle
3.	Shackle
4.	Webbing sling
5.	Webbing tie down sling
6.	Webbing ties down sling
7.	3/8-16 x 500mm handling bar
8.	M10 x 500mm handling bar
9.	500mm handling bar extension
10.	500mm handling bar extension
11.	500mm handling bar extension
12.	Travel documents & users manual

Table 67: Provided Items

Shown below in Table 68: Spares is a list of spare parts for the transport cask. If an item is missing it should be replaced with a new approved item, and a record of this, stored in the cask history file.

Item	*Description*	*Quantity*
1.	Metal seal	4
2.	Copper washer	4
3.	M8 x 25mm set screw	4
4.	M10 x 20mm set screw	10

Table 68: Spares

The cask can not be despatched for a mission without a full compliment of accessories. A&DM are to be advised immediately of any shortfall, and replacements will be provided.

Dispatch Documentation Check-list

DATE OF INSPECTION	CASK SERIAL NUMBER
SENDER INFORMATION **Address.**	**ISOTOPE**
	ISOTOPE ACTIVITY **Bq**
RECEIVER INFORMATION **Address.** **Contact Name.**	**AUTHORIZED PERSON** **Title**..... **First Name**..... **Surname**..... **Position**..... **Signature**.....

A list of documentation that must accompany the model 1860 radiation transport cask during a transport of radioactive materials is given below. Place a tick next to each item if it exists. A copy of this document must be sent to A&DM prior to shipment.

	DANGEROUS GOODS DECLARATION
	EMERGENCY RESPONSE NUMBERS
	ROUTE MAP TO DISPATCH PORT AND RECEIVE PORT
	REGULATORS ACCEPTANCE OF THE IMPORT / EXPORT
	1860 COMPETENT AUTHORITY CERTIFICATION CERTIFICATE
	ISOTOPE SPECIAL FORM CERTIFICATE
	CAPSULE / CALIBRATION CERTIFICATE
	1860 FIELD SURVEY
	1860 WIPE TEST CRTIFICATE
	AUTHORITY TO TRANSPORT, SENDERS AND RECEIVERS REGULATOR
	EMERGENCY RESPONSE PROCEDURES
	1860 USERS MANUAL
	DISPATCH INSPECTION CHECKLIST
	DISPATCH DOCUMENTATION CHECKLIST

Dispatch Inspection Check-list

DATE OF INSPECTION	CASK SERIAL NUMBER
SENDER INFORMATION **Address.**	**ISOTOPE**
	ISOTOPE ACTIVITY **Bq**
RECEIVER INFORMATION **Address.** **Contact Name.**	**AUTHORIZED PERSON** **Title.....** **First Name.....** **Surname.....** **Position.....** **Signature.....**

Before a model 1860 Radiation Transport Cask can be dispatched on a mission, it first must adhere to a list of checks. These checks are designed to provide assurance that the cask configuration is stable, and that the required additional items are present and accounted for. Follow the inspection sequence as given below, and tick each box as you proceed. If for any reason an inspection point fails, the cask should not be dispatched and A&DM must be contacted immediately.

	ALL DOCUMENTS ARE CURRENT AND CORRECT
	END PLATES ARE IN POSITION, AND BOLTS TORQUED TO 30 Nm
	TEST PORT PLUGS AND COPPER WASHER'S IN PLACE AND TORQUED TO 40 Nm
	BOTH LOCKS ARE IN PLACE AND LOCKED
	END CRUMPLE SHIELDS, BOLTED IN PLACE AND TORQUED TO 50 Nm
	DESTINATION PLATES ARE IN PLACE
	TRANSPORT INDEX MEASURED AND RECORDED IN HISTORY LOG
	TRANSPORT INDEX LABELS IN PLACE AND MARKED ACCORDINGLY
	TOOL BOX CONTENTS ARE COMPLETE

Post Transport

Minor Repairs

A minor repair is any work that requires only cosmetic repairs to the cask caused by transient transport mishandling, or poor technician skills, which will not have any effect on the integrity of the cask; that is damage to any of the components listed above in Table 63: Post Transport Check List – Unloaded.

Item	*Components*
1.	The threads holding the end shields
2.	The threads holding the end plates in place
3.	Placarding plate
4.	The attenuator mesh
5.	End shields
6.	Base or skids

Table 69: Minor Repairs

Damage to the end shields is considered minor and repair is almost limited to the straightening of the mesh if there is no distortion to the end rings or the fins, in which case they will be replaced.

Repairs will invariably compromise the cosmetics of the cask so to achieve an even matt finish the cask is to be glass bead grit blasted.

After grit blasting the lettering on the placard plate will have to be filled with black oil based enamel paint.

Photographs of the damage and the subsequent step by step repairs are to be forwarded to A&DM at 1860@nuclearstuff.com.au for inclusion in the history file.

Major Repairs

A major repair is any repair that requires more than cosmetic repairs to the cask replacement of the mesh or end crumple shields.

Major repairs will be carried out at A&DM's Seaford Plant or Foss Therapy Services Plant Santa Lomus California by A&DM's technicians.

Prior to shipment to the repair plant the Cask must show a negative Wipe Test.

The repair procedure is described above in Table 62: Pre Transport Check List – Unloaded.

Item	*Procedure*
1.	Remove the end crumple shields.
2.	Remove the fork lift skids.
3.	Inspect the mesh for damage, any sections that cannot be simply straightened are to be cut off.
4.	Placard plates if damaged are to be cut off.
5.	Crumple fins if damaged are to be cut off.
6.	Welds around the attenuator circumference are to be inspected for cracks, any cracks are to be ground out and re welded.
7.	Base is to be inspected for distortion, any dimension out of tolerance by 1mm is to be corrected.
8.	Welds between the fins and end rings are to be inspected for cracks, any cracks are to be ground out and re welded.
9.	All M10 threads on both inner and outer end rings are to be checked, tight threads are to be tapped out, damaged threads are to be filled, re drilled and re tapped.
10.	M8 threads on the end plates are to be checked, tight threads are to be re tapped, loose or damaged threads are to be repaired using Helicoils.
11.	Check end crumple shields.
12.	Repair or replace as necessary.
13.	A catalogue of required parts is ordered, manufactured and forwarded to the repair plant along with the fin assembly jig.
14.	All areas where parts have been removed are to be ground back to base metal.
15.	The cask is to be positioned onto the fin assembly jig
16.	New parts are to be tacked into place.

Item	*Procedure*
17.	Welds are to be completed following the sequence set out in Drg No 1860-00-xxx
18.	Install placard plates.
19.	Install attenuator mesh.
20.	Check that the drawer tube is straight and dimensionally correct.
21.	Line bore if necessary.
22.	Recheck all critical dimensions and sign off a Q.A. Complete Sheet.
23.	To achieve an even matt finish the cask is to be glass bead grit blasted.
24.	Record in the history file the Q.A. details of the parts used.

Table 70: Major Repair Procedure

Photographs of the damage and the subsequent repairs are to be forwarded to A&DM at 1860@nuclearstuff.com.au for inclusion in the history file.

Test Procedures

Introduction

This section on test procedures demonstrates A&DM's compliance to not only the test procedures, but also the performance standards as documented elsewhere in this library of documents. The test procedures are developed to test the integrity of the Model 1860 radiation transport cask, these were also designed to meet the testing requirements set by the IAEA. For demonstration of the containment systems ability to withstand accident conditions during transport.

Demonstration of Compliance

Demonstration of compliance with the performance standards required in section VI of the "*IAEA Safety Standard series, Regulations for the Safe Transport of Radioactive Material*" are accomplished by the methods or combination of methods listed below in Table 71: Demonstration Methods.

Method	*Description of Method*
a.	Performance of tests with specimens representing LSA-III material, or special form radioactive material, or low dispersible radioactive material or with prototypes or samples of the packaging, where the contents of the specimen or the packaging for the tests shall simulate as closely as practicable the expected range of radioactive contents and the specimen or packaging to be tested shall be prepared as presented for transport.
b.	Reference to previous satisfactory demonstrations of a sufficiently similar nature.
c.	Performance of tests with models of appropriate scale incorporating those features which are significant with respect to the item under investigation when engineering experience has shown results of such tests to be suitable for design purposes. When a scale model is used, the need for adjusting certain test parameters, such as penetrator, diameter or compressive load, shall be taken into account.
d.	Calculation, or reasoned argument, when the calculation procedures and parameters are generally agreed to be reliable or conservative.

Table 71: Demonstration Methods

After the specimen, has been subject to the physical tests, other appropriate methods of assessment shall be used to ensure that the requirements for performance and acceptance standards prescribed in section VI of the IAEA requirements are met, and

covered to their full extent.

Test Selections and Justification

The performance of Model1860 radiation transport cask will be evaluated against the requirements of the type B(U) transport package regulations set by the IAEA. The tests to prove compliance with the regulations will consist of selecting the most rigorous tests in each section.

On completion of the most rigorous tests, it can be concluded by reasoned argument that if the package can survive the most destructive tests it will pass all other clauses.

The tests to be conducted on the prototype package are a combination of the most highly destructive tests selected to specifically cover the requirements for type B(U) package certification. For type B(U) certification, it is required that the prototype pass two sets of tests as shown below in Table 72: Type B(U) test sets.

Test	*Description*
1.	Test to demonstrate ability to withstand normal transport conditions, this is Type A.
2.	Test to demonstrate ability to withstand accident conditions of transport, this is Type B(U).

Table 72: Type B(U) test sets

The tests to demonstrate compliance with the IAEA regulations for type B(U) packages are a combination of:

1. General requirements for all packages.
2. Additional requirements for air transport.
3. Requirements for type A packages.
4. Requirements for type B(U) packages.
5. Tests for type A packages.
6. Test for type B(U) packages.

A&DM deems it necessary to comply with and provide proof of compliance with all regulations from design to testing, to manufacture. Before any testing can commence, compliance with the design regulations must be well established. These design regulations are itemized with the associated compliance methods.

General Requirements for all Packages

To demonstrate compliance with the general requirements for all packages before testing, the design parameters referred to from paragraph 606 to 616 of the IAEA regulations are explored and shown below in Table 73: General Package Requirements.

Clause	*Response*	*Compliance Method*
606, 607, 608	The weight of Model 1860 in its various configurations is between 950Kg and 1100 Kg. Model 1860 has been designed with the following handling feature. 1. Crane Attachment points.: the top vertical fin is fitted with two points reinforced to accept 19mm shackles. 2. Forklift Skids: the base of the cask is constructed from 316 stainless steel, to which is bolted 100 x 100mm replaceable hardwood timber skids. 3. Tie Downs: there are four tie down points positioned on the attenuator crumple shield rim. Included in the standard shipping equipment, certified steel wire ropes and turn-buckles are provided. In addition, the outer mesh and crumple fins present significant strength to accommodate tie downs positioned over the top of the cask, if required.	Structural design implementation.
609	The design of the cask is such that there are no protruding features from the outer parameter defined by the mesh, apart from the lifting and tie-down points. The cask construction is of stainless steel and therefore will be immune to aggressive decontamination procedures. The source draw cavity can be accessed without removing the end crumple shields for ease of wipe testing prior to shipping or upon receipt at its destination.	Structural design implementation
610	The outer parameter of the cask is defined by a covering of stainless steel mesh. The core attenuator is cylindrical. There is no area that can collect water.	Structural design implementation

Clause	*Response*	*Compliance Method*
611	At the time of transport, labelling will be attached to two vertical plates mounted on the sides of the cask. There is no provision for additional features to be added to the cask at the time of transport.	Structural design implementation
612	The only access to the radiation containment chamber is through the ends of the attenuator core which are bolted on using six 8mm bolts with split washers. Covering this end plate is a security fixture that allows for locking of each end plate.	Structural design implementation
613	The cask is constructed entirely from 316 stainless steel and is unaffected by intense radiation fields or sustained high temperatures.	Material selection
614	Not applicable. The cask incorporates no valves within the design.	Not applicable, see clause 614 response
615	The inner core attenuator is welded to contain the molten lead during manufacture and to withstand the pressures encountered during thermal testing. The end plates are constructed to withstand a pressure greater than 150kPa.	Structural design implementation
616	The cask is designed to take a drawer that will accommodate the container that holds the radioactive material. This is predominately radioactive material that has special form encapsulation, such as pencils and capsules.	Structural design implementation

Table 73: General Package Requirements

Additional Requirements for Air Transport

The additional design requirements for the package, required for safe transport by air are explored, and shown below in Table 74: Requirements for Air Transport.

Clause	*Response*	*Compliance Method*
617	The cask is to be tested that the outer mesh surface area of the cask will not exceed 50°C in a 38°C environment.	Calculation
618	The cask is constructed from 316 stainless steel which will not fracture or stress.	Physical test
619	The package containing radioactive material to be transported by air will be able to withstand a maximum normal operating pressure greater than 95kPa. This will be proved by calculation and reasoned argument with respect the the metalflex gasket structural specifications.	Calculation

Table 74: Requirements for Air Transport

Requirements for Type A Packages

The design requirements for type A packages are explored and listed below in Table 75: Requirements for Type A packages.

Clause	*Clause Response*	*Compliance Method*
634	The smallest overall dimension of the package is greater than 10cm.	Structural design implementation
635	Security feature.	Structural design implementation
636	All attachment points are constructed from 316 stainless steel. The attachment points are considered as part of the package and are thus tested during the type B(U) drop test.	Reasoned Argument, see clause 636 response
637	The design of the package takes into account the temperature range from -40°C to + 800°C thus, this clause is met through type B(U) testing.	Reasoned argument, see clause 637 response
638	Design and manufacturing is in accordance with A&DM Quality Assurance systems.	Covered through A&DM QA Systems
639	Security feature.	Structural design implementation
640	Not considered as part of containment system	Reasoned Argument, see clause 640 response
641	Not applicable the containment system does not form a separate unit of the package	Reasoned Argument
642	Not applicable, 1860 package is for transportation of solids only.	Reasoned Argument
643	The containment of the radioactive materials will remain present under a reduction of ambient pressure to 60 kPa due to the metalflex gasket properties	Reasoned Argument, see clause 643 response

Clause	*Clause Response*	*Compliance Method*
645	Not applicable. The radiation shield has no removable components.	Reasoned Argument, see clause 645 response
646	The package is tested to withstand the type B(U) testing procedures. These tests are more destructive than those stated in paragraphs 719 – 724.	Reasoned Argument, see clause 646 response
647	Not applicable. The package is not designed for liquid radioactive material.	Reasoned Argument, see clause 647 response
648	Not applicable. The package is not designed for liquid radioactive material.	Reasoned Argument, see clause 648 response
649	Not applicable. The package is not designed for the transport radioactive gases.	Reasoned Argument, see clause 649 response

Table 75: Requirements for Type A packages

Requirements for Type B(U) Packages

The design requirements for type B(u) packages are explored and listed below in Table 76: Requirements Type B(U) Package

Clause	*Response*	*Compliance Method*
651	Unit is constructed from 316 stainless steel and is not affected by moisture, corrosion, thermal expansion, etc.	Reasoned Argument, see clause 651 response
652	The temperature on the outside of the package will not exceed 50°C in a 38°C ambient environment. The structural properties of the cooling fins and the definition of the outside of the package by the wire mesh will not allow this. Heat transfer calculations will provide a scientific response.	Calculation
653	Noted, ambient tempreature is assumed to be 38 degrees Celsius	Noted
654	Noted. Solar insolation conditions in table XI are assumed in calculations	Noted
655	Not required. Package does not contain additional thermal protection, outside its structural design	Noted
656	Self imposed leakage limit after testing was zero.	Bubble Test conducted by ANSTO Labs
657	Designed to withstand the enhanced water immersion test specified in paragraph 730. The points at which water can enter the containment system are through the two end caps, encapsulating the source draw. The end caps are sealed to the attenuator body by two metalflex gaskets which are able to withstand pressures in the Mpa region.	Calculation & reasoned argument, see clause 657 response
658	Not applicable. 1860 type B(U) package transports solids only	Reasoned Argument, see clause 658 response

Clause	*Response*	*Compliance Method*
659	Not applicable, the package does not contain a pressure relief system.	Reasoned Argument, see clause 659 response
660	The package is to be subject to the pressures imposed during type B(U) testing.	Reasoned Argument, see clause 660 response
661	Not applicable, the package is not pressurized.	Reasoned Argument, see clause 661 response
662	Designed to meet clause 617. That is a maximum ambient temp of 50.	Reasoned Argument, see clause 662 response
663	Noted. Inherent design implementation	Noted
664	Package is constructed from 316 stainless steel.	Reasoned Argument, see clause 664 response

Table 76: Requirements Type B(U) Package

Preparation of Package Before Testing

Before any type of regulation compliance testing, the package must be inspected in accordance with IAEA regulations. The purpose of the inspection is to identify and record any faults or damage to the package, particular attention being given to the following areas:

1. Divergence from the specified design documentation.
2. Defects present from the package manufacture.
3. Corrosion or deterioration.
4. Distortion of package features.

Any faults with the package, or damage to the package must be properly documented before any form of testing can commence, this is to ensure accurate test results are recorded and accurate test conclusions are obtained.

The containment system of the package is clearly specified prior to any form of testing. And the external features of the specimen are clearly identified so that reference may be made to any part of the package both during and after destructive testing.

Testing for Normal Transport Conditions

The tests required to prove compliance with the physical conditions of normal transport are as shown below in Table 77: Tests For Normal Transport Conditions.

Clause	*Comments*	*Test Method*
720	Clause 719 states for a water spray test. The test is not valid.	Not applicable, reasoned argument
721	Clause 719 states for a water spray test. The test is not valid.	Not applicable, reasoned argument
722(a)	Package to be dropped onto a flat surface, with the specifications described in 717 from height of 1.2 meters.	Physical destructive test
722(b)	Not applicable. Package is not of fibre wood construction, and mass is not less than 50kg.	Not applicable, see clause 722(b) comments
722(c)	Not applicable. Package is not of fibre wood construction, and mass is not less than 100kg.	Not applicable, see clause 722(c) comments
723(a) 723(b)	Not applicable. The shape of the package prevents stacking of objects. The cask outer shell is cylindrical. If an object were stacked onto the cask it would tend to roll off.	Not applicable, see clause 723(a) & 723(b) comments
724(a) 724(b)	Dropping 3.2cm diameter bar of 6 kg mass will not penetrate the outer mesh of the transport cask, let alone touch the attenuator core. Test 727(a) will however be conducted.	Not applicable by reasoned argument, see clause 724(a) & 724(b) comments
725(a) 725(b)	The transport cask is not designed for liquids and/or gases.	Not applicable, see clause 725(a) & 725(b) comments

Table 77: Tests For Normal Transport Conditions

Testing for Transport Accident Conditions

The tests to prove compliance with the physical conditions during transport accidents are as shown below in Table 78: Test For Transport Accident Conditions.

Clause	*Comments*	*Test Method*
727(a)	Drop Test from 9 meters onto hard surface. The package will be at a temperature of -40°C and will be dropped on the target from a point to suffer the maximum damage. Low temperature drop is to meet the requirements of 637.	Physical destructive test
727(b)	Drop test from 1.2 meters onto a defined shaped spike. Package to be dropped so as to suffer the maximum damage. Package will be at -40°C to prove structural strength, and to comply with 637.	Physical destructive test
727(c)	The mass of the package is greater than 500kg, thus test 727(a) will produce more damage than 727(c). By clause 656(b)(i), test 727(c) is void as the model 1860 package has a mass greater than 500kg's in its lightest configuration. Structural calculation and simulation is performed on the top fin for completeness.	reasoned argument, and calculation see clause 727(c) comments
728(a)	Package will be exposed to 800°C for a period no less than 30 minuets. Following this the package will be inspected and weighed.	Physical destructive test
728(b)	After 728(a) the temperatures in the package must, everywhere be decreasing and approaching steady state conditions.	Reasoned argument, A&DM calculation
729	Standard water immersion test not needed as enhanced water immersion test follows, and is more destructive.	Not applicable by reasoned argument, see clause 729 comments

Clause	*Comments*	*Test Method*
730	Enhanced water immersion test, to test the package for a pressure of at least 2 Mpa. The package will be compromised on the failure of the metalflex gasket at each end cap. Due to the metalflex gasket high pressure rating, it is by reasoned argument this test will not be conducted on the basis of the metalflex gasket technical specifications. Also the package is for transport of special form materials only.	Not applicable by reasoned argument, see clause 730 comments

Table 78: Test For Transport Accident Conditions

Applicable Destructive Tests

A tabulation of the destructive tests required to collaborate both the structural & mechanical design, the safety design methodologies and the brute physical toughness of the package to withstand the demanding conditions during normal transport and during transport accidents are as shown below in Table 79: Applicable Destructive Tests.

IAEA reg.	*Description*	*Method*
722	1.2m drop onto flat surface. Package to be dropped onto its weakest point.	Physical test by ANSTO
727(a)	9.0m drop onto flat surface. Package temperature will be below -40°C.	Physical test by ANSTO
727(b)	1.2m drop onto vertical bar. Package temperature will be below -40°C.	Physical test by ANSTO
727(c)	Impact force from 500Kg plat dropped from 9m, See Impact Analysis IAEA Clause 727(c) on page 89	A&DM Calculation
728(a)	Package will remain in 800°C environment for 30 minuets.	Physical test by ANSTO
728(b)	Radiant heat thermal analysis. See Thermal Analysis, Cooling of the Package, IAEA Clause 728(b) on page 97	A&DM Calculation
728	Heat rise test.	Calculation by ANSTO
730	Water immerse test.	Calculation and reasoned argument by ANSTO

Table 79: Applicable Destructive Tests

Destructive Testing Procedure

Purpose

The purpose of these testing procedures is to document the steps required to complete destructive tests on the nominated type B(U) package.

Scope

The following test procedure covers the drop tests and thermal tests for performance testing in compliance to the IAEA type B(U) regulations and the Australia national ARPANSA regulations.

Test Schedule

The testing to be conducted and witnessed by ANSTO mechanical engineering will follow the schedule shown below in Table 80: Test Schedule. In addition to these tests ANSTO will also provide evidence in the form of either calculation or reasoned argument for the heat rise test (IAEA clause 728) and the water immersion test (IAEA clause 730).

Test	*Date*	*Test*	*Comments*
1.	07/09/2005	Drop test, IAEA clause 722	Testing will be done on-site at ANSTO
2.	07/09/2005	Drop test, IAEA clause 727(a)	Testing will be done on-site at ANSTO
3.	07/09/2005	Drop test IAEA clause 727(b)	Testing will be done on-site at ANSTO
4.	08/09/2005	Thermal test, IAEA clause 728	Testing will be done at LSW group, Yennora

Table 80: Test Schedule

Equipment

To complete the required tests the following equipment will be used, this list is as shown below in Table 81: Equipment list.

Item	*Description*	*Comments*
1.	Drop test target	Drop test target to meet requirement specifications as per IAEA clause 717
2.	Crane	Crane to be used for lifting of the package.
3.	Quick release mechanism	Used for releasing the package from a height onto a target.
4.	20 litre drum of sand	To confirm the vector alignment of the package with the centre of the target platform prior to test.
5.	Lifting equipment	All lifting equipment to be certified and tested prior to use.
6.	Load cell + readout	A calibrated load cell device is required to accurately measure the package mass.
7.	Vertical bar as per specified in 727(b)	Vertical bar, 20cm long positioned on the drop target surface
8.	Temperature measurement system	Temperature measurement system to be calibrated and certified
9.	Liquid nitrogen	To be used to lower the Temperature of the package below -40°C
10.	High speed camera	Used to record the package impact with the target
11.	Furnace	Raised to 800°C for thermal testing
12.	Microshield software	Used for calculation of field strengths around the package
13.	Dummy test capsule	Provided by International Isotopes, constructed to be of the same size, weight and construction.

Table 81: Equipment list

Equipment Set up

The equipment will be placed as shown below in Illustration 26: Equipment Setup. A&DM recognizes that slight modifications to this equipment set up may be required at the time of testing.

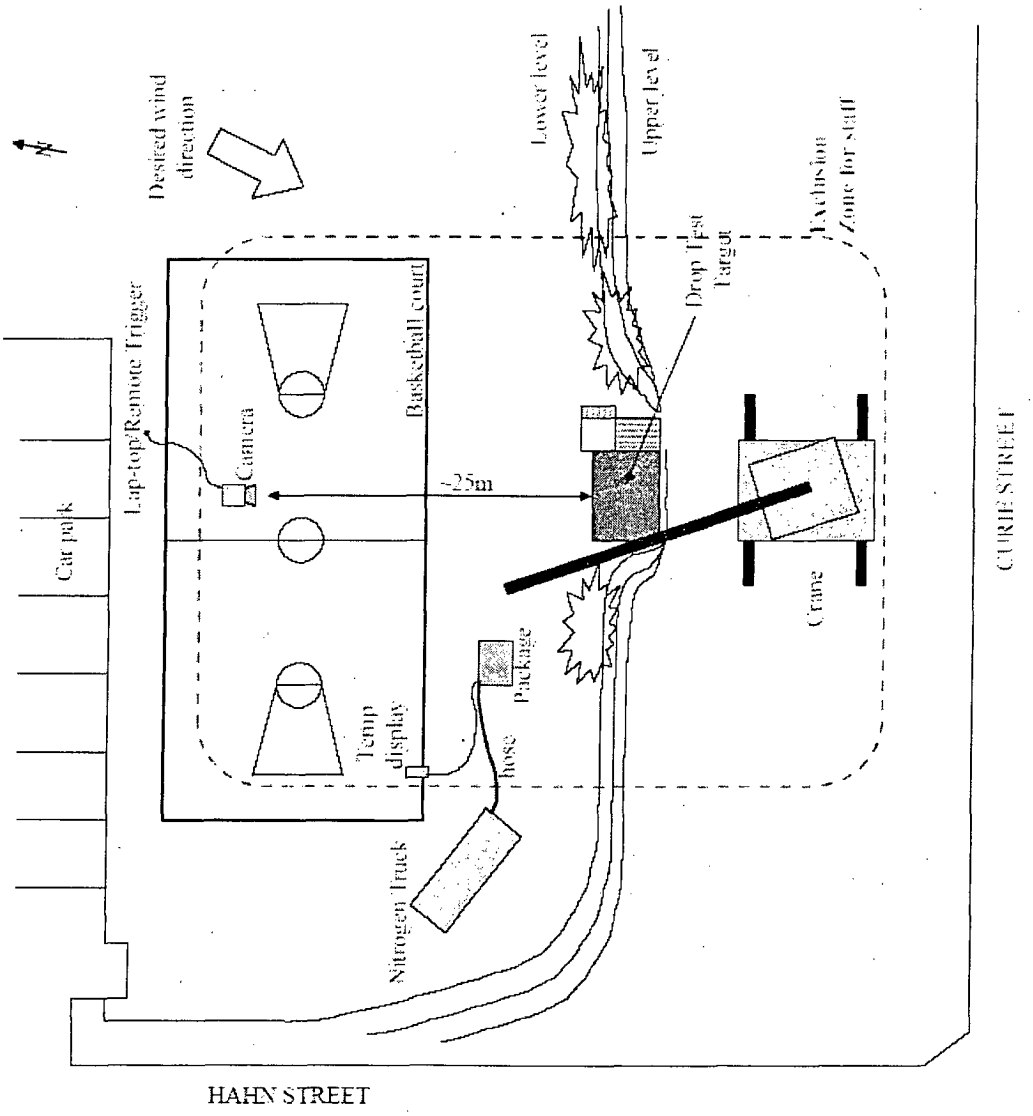


Illustration 26: Equipment Setup

Following the equipment set up, the dummy test capsule will be loaded into the source drawer. This capsule will remain in the source drawer until such time that the testing is complete. A bubble test will be conducted on the test capsule to ensure its integrity in compliance with IAEA regulations.

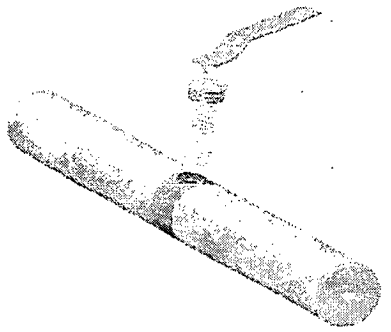


Illustration 27: Capsule Loading

Drop Test # 1 Procedure

Following the set-up of equipment, the following procedure will be followed:

1. A dry run will first be conducted, by dropping a dummy package to verify the alignment vector with the target.

2. The package net weight will be taken, by connecting the load cell to the crane hook and to the designated package lifting points. The package will be lifted just clear of the test target and it's mass will be recorded. The package will then be lowered and the load cell removed from the lifting assembly.

3. The quick release mechanism will be connected between the crane hook and the package lifting equipment. The lifting sling will be connected to only one of the lifting lugs on the package. This will allow the package to hang at an angle of approximately 45 degrees from the horizontal and allow for the desired impact point to be hit, and thus cause the most amount of damage.

4. The package will be hoisted to a height of 1.2 meters above the surface of the target. The package will be dropped onto the target and it's impact recorded by high speed camera. The deflections/indentation and markings sustained to the package will also be recorded.

Drop Test # 2 Procedures

In accordance with IAEA regulations 727(a) the package must withstand destructive testing at a temperature of -40°C. To bring the package down below this temperature liquid nitrogen will be used to chill the package.

1. The package is hoisted into a specially designed wooden box with a stainless steel catchment tray for chilling of the package. Two thermocouples are attached to the package, one on the inner attenuator, and one on the outer fins. This is as shown above in Illustration 27: Capsule Loading.

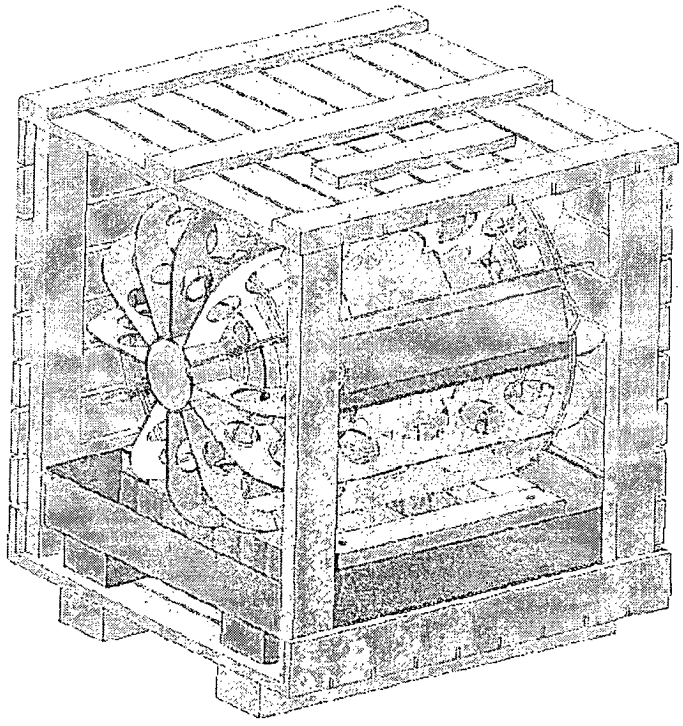


Illustration 28: Chilling Box

2. Liquid nitrogen is sprayed over the package in a symmetrical fashion to achieve even chilling on all surfaces. The package thermal temperature will be taken to -80°C, this will allow enough heating such that the package remains below -40°C for drop test # 2 and drop test # 3.

3. The package is to be lifted out of the chilling box and aligned with the center of the drop target. It is lowered to the ground and the quick release mechanism is inserted between the package sling and the crane lifting block. The package is to be hoisted from one of it's side lifting points, such that it is positioned at an angle so that when it hits the ground the maximum amount of damage can occur.

4. The package is to be hoisted to a height of 9 meters, where the distance is measured from the bottom of the package to the top surface of the drop target.

5. The package will be dropped onto the target and its impact recorded by high speed camera, the thermal temperature, deflections/indentation and markings sustained to the package will be recorded for future analysis.

Drop Test # 3 Procedure

In accordance with IAEA regulations 727(b) the package must withstand destructive testing at a temperature of -40°C.

1. Post drop test # 2 the package temperature should be below -40°C, however this should be verified before drop test # 3 commences.

2. The quick release mechanism is inserted between the lifting sling and the crane lifting block. The package lifting sling is attached to two of the side lifting points, thus the package will be suspended, and when dropped impact will occur on the side of the package.

3. A vertical bar of 150mm diameter by 200mm long (in accordance with IAEA specifications) will be placed at the centre impact point of the drop target.

4. The package will be hoisted 1.2 meters above the drop target, this is the distance between the lower most point of the package and the upper most point of the drop target.

5. The package will be dropped onto the target and it's impact recorded by high speed camera. The deflections/indentation and markings sustained to the package will be recorded for future analysis.

Thermal Test Procedure

In accordance with IAEA clause 728(a) the package must be exposed to an average temperature of 800°C for a period no less than 30 minuets. To achieve this the following procedural steps will be followed.

1. A furnace capable of sustaining an average temperature of 800°C, and large enough to house the package will be brought up to a stable temperature before the testing starts.

2. A thermocouple will be fitted to one of the packages outer fins and inner attenuator core to record the temperatures during testing.

3. The package will be placed into the furnace and allowed to heat.

4. The temperature of the package will be constantly monitored and recorded every 5 minute period.

5. The temperature of the furnace will be constantly monitored and recorded every 5 minute period.

6. The package will be removed from the furnace after 30 minutes and visually inspected for lead leakage and structural deformation, all results and observations must be recorded. The package will be allowed to cool for a period of 6 hours.

7. The package will be weighed with the same calibrated load cell used in drop test # 1, step 2. The package weight will be recorded.

Engineering Users Manual

Introduction

This document provides a detailed step by step approach to using the A&DM Model 1860 Radiation Transport Cask. It is a prerequisite before using the cask, that the responsible person have prior training with radiation, this must include the items shown below in Table 82: Training requirements

Item	*Description*
1.	General radiation awareness training
2.	General radiation familiarization training
3.	Radiation safety training
4.	Accident avoidance training
5.	Emergency response training
6.	Job specific training

Table 82: Training requirements

Sections

This training manual provides the steps required to complete the most common of tasks that are required during both transport and general use. However, should a task be required that is not documented in this manual Analogue & Digital Measurements should be contacted with a request made for detailed procedural steps with respect to the specific task. This training manual contains the following sections shown below in Table 83: Training Sections

Item	*Description*
Transport	
1.	First use
2.	Tool box accessories
3.	Travel documents
4.	Pre-Shipment and receival checks
5.	End of mission checks
6.	Fork-Lift handling
7.	Crane handling
8.	Package tie down methods
General Use	
1.	Hot-cell upload
2.	Hot_cell download
3.	Water bath upload
4.	Water bath download
5.	Therapy head download
6.	Therapy head upload

Table 83: Training Sections

General Warning

Analogue and Digital Measurements provides a general warning to all peoples directly involved with the use of the Model 1860 Radiation Transport Cask. During transport of radioactive materials the package will display one of the following LSA signs shown below in Illustration 29: Radioactive Material LSA 2 and Illustration 30: Radioactive Material LSA 3

Illustration 29: Radioactive Material LSA 2

Illustration 30: Radioactive Material LSA 3

All personnel working around or directly working with the radiation transport cask are advised of the potential hazards and risks involved. Should the contents of the cask be exposed outside the attenuator serious bodily damage can occur. Extreme caution should be practised at all times when working with the cask. If an incident does occur, all peoples involved should distance and shield themselves from the source to minimize the damaging effects of ionizing radiation. Following this the model 1860 Emergency Response Plan should be activated.

First Use, Maximum Activity Determination

The cask is approved for use up to a predetermined activity based on mathematical calculation. An engineer from A&DM is to be present on the inaugural shipment to obtain the maximum activity the cask can accommodate.

a) When a cask is first loaded it is to be surveyed to generate a 1 meter field density map using the known activity of the capsule.

b) Using the highest measured field strength value. calculate the total source activity to obtain a maximum transport index of 10.

c) If the calculated activity value exceeds the approval value the maximum activity will be the approval value.

d) If the calculated activity value is less than the approval value the maximum activity will be that calculated from the measured value.

e) The activity selected as the maximum allowable and the date is to be engraved on a label supplied for the cask .

f) The label is to be riveted to the cask placard.

g) The cask field strength survey, the calculations and a digital photograph of the placard is to be forwarded to A&DM for entry into the cask history file.

h) A copy of the proof of maximum activity is to be forwarded to ARPANSA.

If the first use is a pick-up of a source of uncertain activity the maximum activity survey is to be carried our using the best available estimate of the source activity from the data available and adding a safety factor of an additional 20% source activity. A temporary maximum activity label is to be fitted.

As soon as the source can reliably be measured. The calculation is to be repeated and affix a permanent label to the cask, follow steps f, g, & h above.

Radiation Field Survey & Transport Index

Before any shipment of radioactive material, the model 1860 type B(U) package must undergo a radiation field strength survey to determine the field strength at contact and one meter from the outer surface of the package. The filed strength survey enables the user to produce a standard map of the radiation field emitted from the package with an isotope loaded inside. The standard survey can be used to verify the integrity of the main attenuator, and also to determine the transport index for the shipment.

Conducting the Field Survey.

The Radiation field strength survey is conducted using the standard Model 1860 Radiation Filed Survey Form. This form is supplied standard with the required documentation during each transport see Travel Documents on page 241. The survey is conducted by measuring the field at contact and at a distance of one meter from the surface of the package the appropriate fields on the standard survey form are then completed. A copy of this form can be seen in Standard Radiation Field Survey Form on page 239

Calculating the Transport Index

To calculate the transport index for the shipment the maximum field strength at a distance of one meter from the outer surface of the package is taken. This field strength in the units of µGy/hr, this is then divided by a factor of 10. The maximum field strength is determined from the field strength survey.

The image shown on the right is an example of a field strength survey conducted on the package, at the designated points, in contact and 1 meter from the outer surface of the package. The highest field strength is measured to be 52µGy/hr at point F, one meter from the surface of the package. Thus to calculate the transport index TI.

TI = (Max Field Strength @ 1 meter) / 10
TI = 52 / 10
TI = 5.2

From the above example it can been seen that the transport index for this shipment is calculated to be 5.2

Point	Field (µGy) Contact	Field (µGy) 1 meter
A1	500	48
B1	480	32
C1	600	51
D	310	28
E	470	31
F	610	52
A2	380	23
B2	520	42
C2	530	44

Standard Radiation Field Survey Form

Model 1860 Radiation Field Survey Form

Point	Field (μGy)	Field (μGy)
	Contact	1 meter
A1		
B1		
C1		
D		
E		
F		
A2		
B2		
C2		

CASK SERIAL NUMBER	
TECHNICIAN Name..... Position..... Company..... Signature.....	DATE / / ISOTOPE ACTIVITY Bq TRANSPORT INDEX

Tool Box Accessory's

The items supplied as accessories are provided to assist all who come in contact with the 1860 cask. Ensure the next link in the transport chain is not at a disadvantage by your negligence. Thus please ensure that any aid be returned to the tool box after use. The contents of the tool box are as shown above in Table 67: Provided Items.

Item	*Description*	*Serial Number*
1.	Turn buckle with wire rope attached x 4	
2.	Shackle	
3.	Shackle	
4.	Webbing sling	
5.	Webbing tie down sling	
6.	Webbing ties down sling	
7.	3/8-16 x 500mm handling bar	
8.	M10 x 500mm handling bar	
9.	500mm handling bar extension	
10.	500mm handling bar extension	
11.	500mm handling bar extension	
12.	Travel documents & users manual	

Table 84: Provided Items

New metal seals are provided for each mission, however additional spares have been included to cover the event of damage or loss during loading. Do not remove spares unless required. A list of spares is as shown above in Table 68: Spares.

Item	*Description*	*Quantity*
1.	Metal seal	4
2.	Copper washer	4
3.	M8 x 25mm set screw	4
4.	M10 x 20mm set screw	10
5.	Test port plug	1

Table 85: Spares

The cask can not be despatched for a mission without a full compliment of accessories. A&DM are to be advised immediately of any shortfall, and replacements will be provided.

Travel Documents

Before a shipment the following list of documents as shown below in Table 86: Travel Documents are required to be completed.

The most important document to be carried with the package at all times is the Model 1860 Emergency Response Manual. The Emergency Response Manual details what to do in the event of a specific type of accident. It is a requirement in accordance with the IAEA TS-R-1 paragraph 308 & 309 that an emergency plan be formulated and used as the first reference in the event of an accident.

Item	*Description*
1.	Model 1860 Emergency Response Manual
2.	Model 1860 Users Manual
3.	Dangerous goods declaration
4.	Route map & Work Plan
5.	Regulators acceptance of the route map
6.	1860 competent authority certification
7.	Isotope special form certificate
8.	Capsule / Calibration Certificate
9.	1860 cask field strength survey
10.	Accessory list
11.	Despatch inspection QA certificate (check-list)
12.	Despatch documentation QA certificate (check-list)

Table 86: Travel Documents

Wipe Testing

The design of the package includes a source drawer wipe test port on each attenuator end cap. The wipe test port has been designed such that a wipe test can be performed quickly and easily without removing the attenuator end cap. A wipe test is conducted to search for removable contamination, this is a specialized test that requires the use of a highly sensitive counting chamber. Wipe testing is performed at the time of loading by the laboratory personal, or in an emergency situation by the carrier or state regulatory authority.

The wipe test is conducted through the wipe test port located on each end of the attenuator body. The wipe test port is part of the end cap, and provides access to the inner source drawer without removing the anti tamper devices and the end cap its self, see Illustration 33: Fork Lift Picking Points below.

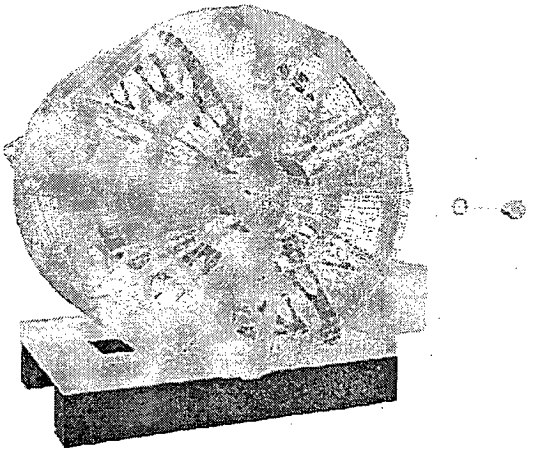


Illustration 31: Wipe Test Port Location

A close up of the wipe test port is shown below. To conduct a wipe test, the port plug is removed, the wipe test conducted, and the port immediately re-installed and tensioned to 20N/M. For no reason should the test port be left open, unless testing for removable contamination.

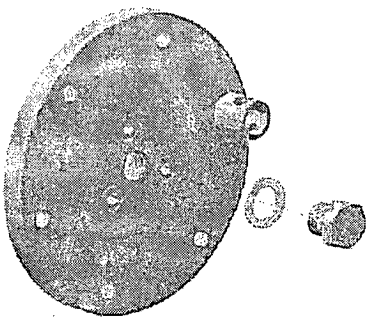


Illustration 32: Wipe Test Port Close Up

Pre-shipment Checks, Outbound Empty (UN2908)

Before shipment of an empty outbound Model1860 cask the following checks as shown below in Table 87: Outbound Empty, Checks must be made.

Item	*Check*
1.	Ensure that the cask serial number is the one assigned to the Mission.
2.	Ensure that the end plates are in place and the 6 x M8 socket set screws are in place and tightened to a torque of 20N/M. (new metal seal is not necessary).
3.	Ensure Test Port Plug is in place and tightened to a a torque of 20 N/M (new copper washer is not necessary).
4.	Install locks on each end, check that they are locked.
5.	Ensure that the 48 X M10 socket set screws holding the end crumple shields are in place and tightened to 50 N/M.
6.	Check the skid bolts are in place and tightened to 30 N/M
7.	Remove the destination placards and arrange them with the correct sender/receiver label for the next leg of the mission toward the outside, and bolt in place with the 4 X M6 socket set screws, tighten to 20N/M.
8.	Ensure all radiation signs have been removed.
9.	Check that the contents of the tool box is correct to the content list, advise A&DM of any missing parts.
10.	Check document list is compete and fill out check list.
11.	Forward a complete set of documents and check lists to 1860@nuclearaustralia.com.au

Table 87: Outbound Empty, Checks

Pre-Shipment Checks, Return Empty (UN2908)

Before shipment of an empty Model1860 cask to be returned to A&DM, the following checks as shown below in Table 88: Return Empty, Checks must be made.

Item	*Check*
1.	Ensure that the cask serial number is the one scheduled for return.
2.	un-install any drawer accessories that were used to transport the previous movement.
3.	Wipe Test the inside of the Drawer Tube both ends. (This is verification of the download checks of the previous movement).
4.	Ensure that the end plates are in place and the 6 x M8 socket set screws are in place and tightened to a torque of 20 N/M. (new metal seal is not required).
5.	Ensure test port plug is in place and tightened to a a torque of 20 N/M (new copper washer is not necessary).
6.	Install locks on each end, check that they are locked.
7.	Ensure that the 48 x M10 socket set screws holding the end crumple shields are in place and tightened to 50 N/M.
8.	Check the skid bolts are in place and tightened to 30 N/M.
9.	Remove the destination placards and arrange them with the correct sender / receiver label (for the next leg of the mission) toward the outside and bolt in place with the 4 x M6 socket set screws, tighten to 20N/M.
10.	Ensure all radiation signs have been removed.
11.	Check that the contents of the tool box is correct to the content list, advise A&DM of any missing parts.
12.	Check document list is compete and fill out the check list.
13.	Forward a complete set of documents and check lists to 1860@nuclearaustralia.com.au.

Table 88: Return Empty, Checks

Receival Checks, Empty (UN2908)

On receival of a Model1860 transport cask which is empty of any radioactive materials the following items given below in Table 89: Receival Checks, Empty must be followed.

Item	*Check*
1.	Ensure that the cask serial number is the one assigned to the mission.
2.	Check locks on each end are in place and locked.
3.	Inspect the cask all over, noting any transport damage. All evidence of rough treatment is to be photographed and forwarded to 1860@nuclearaustralia.com.au. An assessment of the damage will be made and remedial action taken where necessary. Major Damage will require the cask to be taken out of service and returned A&DM. Appropriate placarding and instruction will be forwarded.
4.	Wipe test the drawer cavity. (In excess of 180 Bq of removable contamination is considered to be compromised and will require decontamination)
5.	Install the end cap using the 6 x M8 socket set screws and tightened to a torque of 20N/M.
6.	Install the test port plugs and tightened to a a torque of 20 N/M.
7.	Check that the contents of the tool box are correct to the content list. advise A&DM of any missing parts.

Table 89: Receival Checks, Empty

Pre-Shipment Checks, Outbound Loaded (UN2916)

Before any shipment of radioactive materials can occur, the following checks, shown below in Table 90: Outbound Loaded, Checks must be made.

Item	*Check*
1.	Ensure that the Cask serial number is the one to be returned.
2.	Load the Source as per the Documented Loading Work Plan.
3.	Install the End Plates using a new metal seal from the Tool Box install the 6 X M8 socket set screws and tightened to a torque of 20N/M.
4.	Wipe Test the ends of Drawer through the Test Port to confirm a contamination free shipment.
5.	Install the Test Port Plugs using new copper washers from the Tool Box and tightened to a a torque of 20 N/M.
6.	Dispose of old Copper Washers and metal seal.
7.	Fix Engraved contents labels (one each side) using 4 X M4 Socket Set Screws.
8.	Install locks on each end, check that they are locked.
9.	If the End Crumple Shields were removed to facilitate the downloading of the Source, replace them and ensure that the 48 X M10 Socket Set Screws are in place and tightened to 50 N/M
10.	Check the Skid Bolts are in place and tightened to 30 N/M
11.	Remove the destination placards and arrange them with the correct Sender/Receiver label (for the next leg of the Mission) toward the outside and bolt in place with the 4 X M6 socket set screws, tighten to 20N/M
12.	Confirm label has correct UN number UN2916
13.	Ensure old Radiation Signs have been removed.
14.	Survey the Cask to obtain the Transport Index. See Radiation Field Survey & Transport Index on page 238

Item	*Check*
15.	Affix the appropriate Yellow label and fill in the details
16.	Check that the contents of the Tool Box is correct to the content list, advise A&DM of any missing parts.
17.	Complete the Dangerous goods Declaration.
18.	Check Document list is compete and fill out the Check list. Place a copy of all documents into the tool box.
19.	Forward a complete set of documents and check lists to 1860@nuclearaustralia.com.au

Table 90: Outbound Loaded, Checks

Receival Checks, Loaded (UN2916)

On reception of a Model1860 loaded with radioactive material the following checks, as shown below in Table 91: Receival Checks, Loaded must be made.

Item	*Check*
1.	Ensure that the Cask serial number is the one assigned to the Mission.
2.	Confirm the contents are as specified
3.	Check locks on each end are in place and locked.
4.	Remove the Test Port Plugs and Wipe Test the ends of Drawer through the Test Port to confirm the shipment is contamination free.
5.	Inspect the cask all over, noting any transport damage. All evidence of rough treatment is to be photographed and forwarded to 1860@nuclearaustralia.com.au An assessment of the damage will be made and remedial action taken where necessary. Major Damage will require the Cask to be taken out of service and returned A&DM. Appropriate placarding and instruction will be forwarded.
6.	If the source removal procedure requires close coupling. remove the End Crumple Shields.
7.	Remove the End Cap on the machined end.
8.	Attach a Handling Rod to the Drawer through the Test Port on the other end.
9.	Down load the Source as per the Documented Loading Work Plan.
10.	Wipe Test the Drawer Cavity. (In excess of 180 Bq of removable contamination is considered to be compromised and will require decontamination.)
11.	Remove engraved contents labels (one each side) held on using 4 X M4 Socket Set Screws.
12.	Install the End Cap using a new metal seal from the Tool Box install the 6 X M8 socket set screws and tightened to a torque of 20N/M.

Item	*Check*
13.	Remove transport index Labels.
14.	If the End Crumple Shields were removed to facilitate the downloading of the Source, replace them and ensure that the 48 X M10 Socket Set Screws are in place.
15.	Install the Test Port Plugs and tightened to a a torque of 20 N/M.
16.	Check that the contents of the Tool Box is correct to the content list, advise A&DM of any missing parts.

Table 91: Receival Checks, Loaded

End of Mission Inspection

The end of mission is defined as the point where the transport cask as finished its designated job and is returned to its point of origin, or its next point of use, in an empty state. At the end of each mission the transport cask must be inspected to assure that it is in good working order for its next mission. This inspection guide is as given below.

Item	*Requirement*
1.	On receipt of the cask ensure that the serial number is the one assigned to the mission.
2.	A wipe test must be carried out at both ends of the cask. (a) Remove test port plug (b) With a long cotton bud moistened with wipe test fluid, wipe around the inside of the wipe test port and the end of the drawer (c) Less than 180 Bq of removable material constitutes a safe source, any test in excess of 180 Bq will require further investigation. (d) In the event of removable contamination being found the situation is to be reported to the local regulators. (e) A protocol will be developed to remove the contamination. (f) A&DM are to be notified and all details as they occur are to be entered into the history log.
3.	Remove the end crumple shields taking note of the condition of the M10 threads on both inner and outer end rings as the bolts are removed. Any sign of compromise will require major repair investigation, A&DM should be notified and consulted immediately.
4.	M8 treads on the end plates are to be checked (any sign of compromise will require a major repair and investigation, A&DM should be notified and consulted immediately
5.	Inspect the mesh for damage.

Item	*Requirement*
6.	Inspect the placard plates. If damaged they are to be replaced.
7.	Inspect the crumple fins for distortion and damage. If damaged they are to be repaired.
8.	Inspect the welds around the attenuator circumference (any sign of compromise will require a major repair.
9.	The base is to be inspected for distortion, any dimension out of tolerance by 1mm is to be corrected.
10.	Welds between the fins and end rings are to be inspected. for cracks any sign of compromise will require a major repair
11.	All parts are to be washed down using a high pressure water jet.

Table 92: End of Mission Inspection

Transport

Stacking

The Model 1860 is not designed for high density stacking, the external shape of the package prohibits the stacking of other materials on top of the package. Under no circumstances should any object be stacked on top of the Model 1860 package.

The Model 1860 package may be stacked on top of other packages. The foundation that the package is stacked upon must be able to withstand the mass of the package, and any other external forces that may be applied during any mode transportation.

The outer surface of the Model 1860 package prohibits the stacking of other products / materials on top of the package. If any products / materials are stacked on top of the Model 1860 package, there is a high possibility that these products / materials will fall, as the Model 1860 does not provide a secure and stable stacking foundation.

If the Model 1860 is transported in a shipping crate or container. The stacking properties of the shipping crate or container will supersede the above restrictions. Update of the stacking requirements should be forward to the transport company prior to the advise of the current situation.

Fork Lift Handling

The A&DM Model 1860 Radiation Transport cask may be loaded on to or unloaded from a transport vehicle using a fork lift, with a rated lifting load greater than 1500kgs. Fork lift operations may also include general moving of the package around a working area. The following general fork lift procedures should be used:

1. Lift the package from the designated picking points as shown below in Illustration 33: Fork Lift Picking Points making sure that the fork lift picks are fully extended through the base of the package.

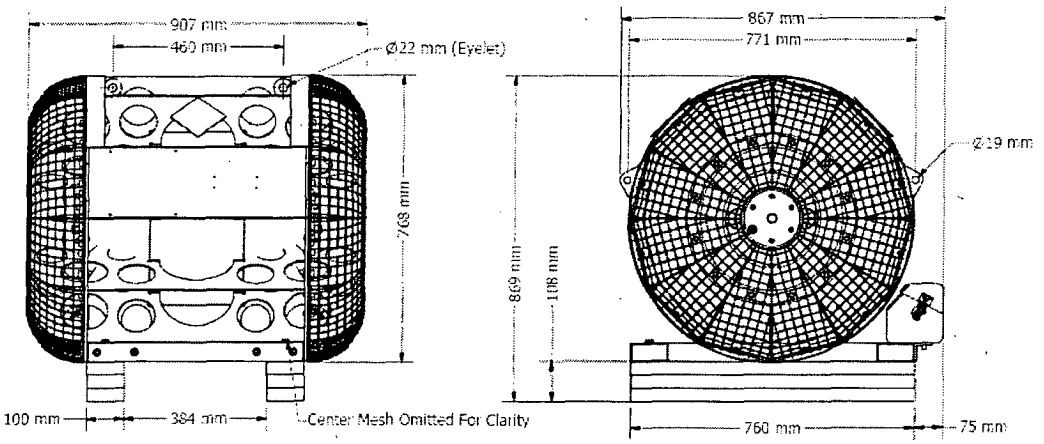


Illustration 33: Fork Lift Picking Points

2. Lower the package close to the ground for transport from point A to point B to minimize potential damage if the cask is dropped.

3. Place the package down at the desired point, make sure the surface is suitable for the package mass and ensure that the package is stable and level upon final positioning.

Should the package be dropped from any height during transport the emergency response plan must be immediately consulted for further required action.

Crane Handling

The A&DM Model1860 Radiation Transport cask may be loaded onto or unloaded from a transport vehicle using a crane, with a rated lifting load greater than 1500kgs. The following procedures should be used when lifting the package with a crane.

1. Attach the lifting sling to the package via the two D-shackles. Confirm that the lifting sling and the D-shackle serial numbers match those displayed in the package documentation. Both the lifting sling and D-shackles are approved and certified to support the weight of the package. For safety reasons it is not suitable to use non-approved lifting equipment. Shown below in Illustration 34: Lifting sling is the correct configuration for attachment, where the D-shackles connect the sling to the package and the crane lifting hook is placed at the top of the sling to lift the package.

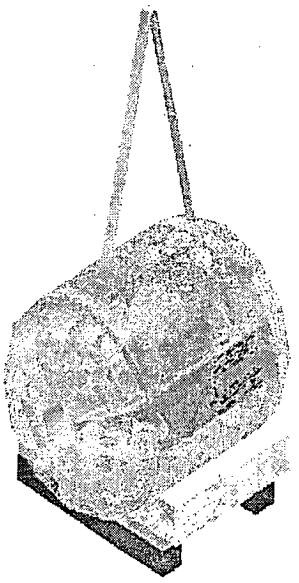


Illustration 34: Lifting sling

2. Lower the package to the desired position, first making sure that the position surface is structurally stable and suitably level to support the package.

Cask Tie Down (Road Transport)

During road transport the Model 1860 Radiation Transport Cask must be firmly secured to the transport fixture, such that the normal forces encountered during road transport do not allow the package to move in any direction from its initial placement

The package has four heavy duty tie down lugs, two located on each side of the package. Included within the tool box is a set of four tie down chains, each of which have a turn buckle to tension the chain and a D shackle to attach the chain to a tie down lug on the package.

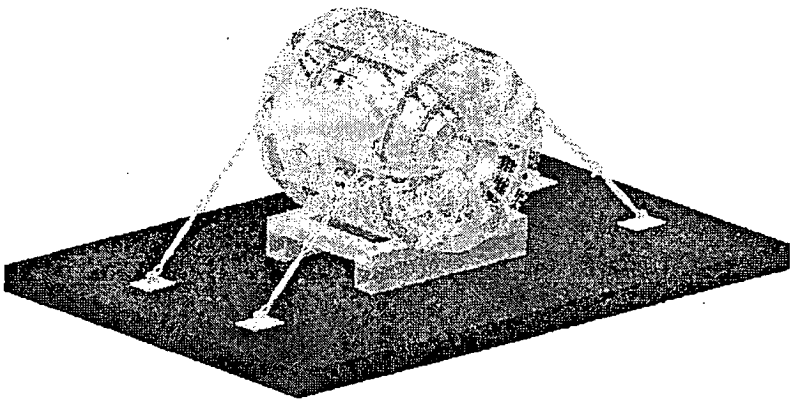
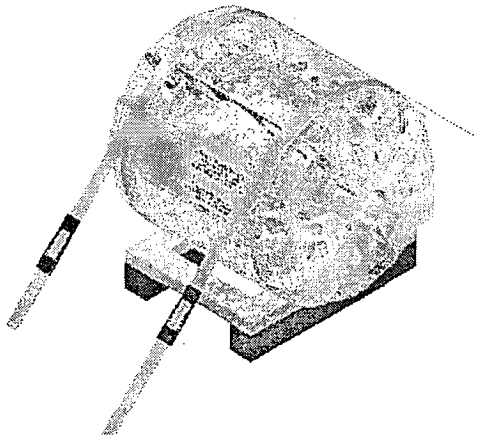


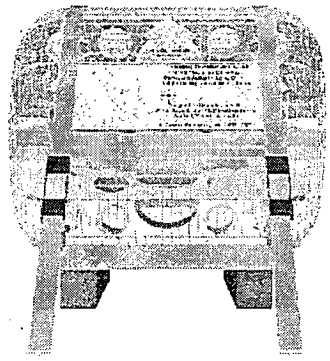
Illustration 35: Road Transport Tie Down

The attachment points to the transport vehicle may vary, It is recommended that package be firmly secured, with the tie down chains extending from the package at an angle of about 45 degrees as shown above in Illustration 35: Road Transport Tie Down. It is recommended that the tie downs be fixed to claw hooks by looping the chain through the hook and then tensioning with the turn buckle. If however claw hooks are not available use an alternative method to secure the package making sure the select points are strong enough to support the package and the forces of transport.

Cask Tie Down (Air Transport)

During air transport the Model 1860 Radiation Transport Cask must be firmly secured to the transport fixture. Usually the cask will be transported within a standard aircraft cargo container.





Use the provided tie down straps around the transport container to secure the package to the cargo container in accordance with transportation company procedures and policies.

Operator Skills

Overview

This section outlines the required operator skill level and staffing requirements for the uploading and downloading of a source into and out of the model 1860 type B(U) package. These requirements only comply to operators of the package, in the case where the package is sent to be loaded at the isotope laboratory, internal company procedures and protocols will override these requirements. In other words the operator that loads the package at the laboratory, is employed by the laboratory and thus conforms to any prerequisite skills and experience deemed by the laboratory necessary to hold the position of employment.

Staffing Level

Procedure	Staff Occupation	Number of operators
Transfer of source from 1860 package	Engineer	1
Set up and alignment of the package	Engineer	2
Movement of heavy equipment	Labourer	1

The transfer of a source into and out of the model 1860 package is performed by one engineer, It is recommended that no other personal be in the vicinity during a source transfer. This is in accordance with the ALARA principle, as only one person is required to transfer the source.

During the setup and alignment it is considered wise to have a second person that is licensed and understands the objectives of the job. This second person will ensure that each stage of the job is checked, over seen and confirmed thus to minimize any chance of a critical error occurring.

When bringing the cask and equipment together it will be necessary to use personnel that are not radiation trained, to move the heavy items into place. These personnel must be instructed on their specific tasks, and instructed by one of the engineers.

Prerequisite Experience

Personnel that will carry out the transfer must meet the following requirements

Prerequisite Experience Criteria A Trained by Analogue & Digital Measurements in the correct use of the model 1860 type B(U) package and

Requirement	Description
1	Licensed to carry out work with radioactive isotopes
2	Monitored with both film badge and personal electronic dosimeter

Prerequisite Experience Criteria B Approved by the responsible regulatory authority but must have the following credentials

Requirement	Description
1	Engineering degree with mechanical and electronic background or 10 year relevant experience.
2	Minimum 3 years experience in working with sources greater than 10TBq
3	Minimum 3 years experience with transportation of radioactive materials
4	Practical experience and working knowledge of the equipment the source is to be installed into or removed from
5	Licensed to carry out work with radioactive isotopes
6	Monitored with both film badge and personal electronic dosimeter
7	Reviewed the model 1860 manuals and procedures with the regulatory authority

Source Up-Loading (Hot Cell)

> The Model 1860 source drawer is not designed for high internal pressures. The source drawer should not be pressurized by any means, under any circumstances

The following instructions are provided as a guide for the uploading of a source from the A&DM Radiation Transport Container inside a hot cell. The following instructions may be slightly modified to suit the specific variables at the time, however the general principles should remain the same. These instructions are not designed to replace the hot cell protocols but to form a guide and check list for the cask.

1. The source to be up-loaded is required to have an approved leak test certificate prior to loading into the source drawer.

2. Prepare the transport cask to accept the source drawer. The cask should be clean and inspected for damage.

3. Ensure the six threads that secure each of the end caps to the cask are free of internal damage. Ensure each bolt and thread can be easily installed by hand.

4. Remove the crumple shell protecting the machined end of the cask by removing the 24 M10 bolts with the use of a 8mm socket head key as shown below in Illustration 36: Removal Of End Crumple Shell.

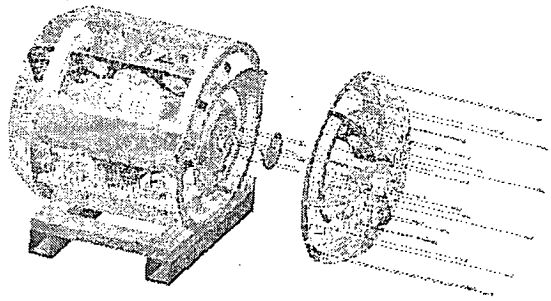


Illustration 36: Removal Of End Crumple Shell

5. Ensure the draw end cap is secured to the non-machined end of the cask. A metal seal is placed in a machined groove on the underside of the end cap. The end cap is then attached to the cask via the six bolts, each tensioned to 60Nm. At the centre of the end cap is a plug and copper washer this should be tensioned to 20Nm. Shown below in Illustration 37: The End Cap is an exploded image of the end cap with the metal seal. Please note the metal seal and copper plug washer must be replaced on each upload.

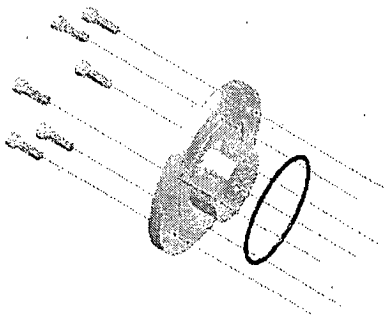


Illustration 37: The End Cap

6. Inspect the machined end of the attenuator, and insure that is is free from foreign materials, inspect the end cap and metal seal interface to make sure that both surfaces are clean and that the metal seal sits snugly in place. Inspect the source drawer, make sure it is clean and free from abrasions and spurs.

7. Move the cask end cap and source drawer into the hot cell.

8. Insert the source capsule into the source drawer as per the drawer/equipment manufacturer instructions.

9. Screw the 3/8 inch handling rod into the end of the transport drawer, and slowly push the drawer into the transport cask as shown below.

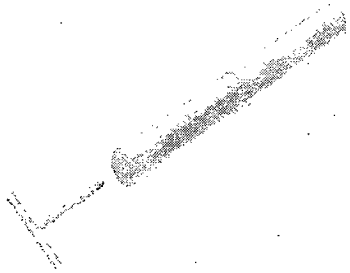


Illustration 38: Transport Drawer

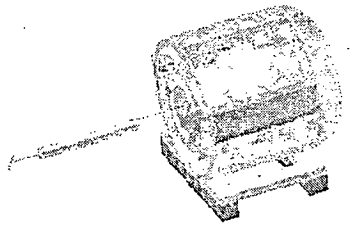


Illustration 39: Insert Drawer

10. Position the end cap, with metal seal in place into it's mounting position and fasten with 2 bolts opposite and tighten finger tight.

11. Remove the transport cask from the hot cell and install the remaining bolts into the end cap and tension to 20Nm.

12. Wipe test around both end caps and plug entry points to ensure no contamination is present.

13. Install the end cap plugs with new copper washers and tighten to 40Nm

14. Install end crumple shield, fasten in place with the 24 M10 bolts, tension to 40Nm.

15. Insert the tamper proof locking mechanism over each end cap. Lock in place with combinational lock.

16. Survey the cask and prepare transport index labelling and the transport declaration.

17. Ensure both destination and return label plates are correct to order instruction and fit into place.

Source Down-Loading (Hot Cell)

The following instructions are provided as a guide for downloading of a source from the A&DM Radiation Transport Container inside a hot cell. The following instructions may be modified to suit the specific variables at the time, however the general principles should remain the same. These instructions are not designed to replace the hot cell protocol but to form a guide and check list for the cask.

1. Survey the cask and compare the results with the transport index. If there is a major difference then investigate the reasons.

2. Remove the tamper proof locking mechanisms from each of the end caps. If the tamper proof mechanisms appear to have been tampered with consult the emergency response manual.

3. Remove the plugs in each of the end caps, and with a cotton bud wipe test the ends of the drawer for removable contamination.

4. Completely remove four of the bolts from the end cap on the machined end of the cask. The remaining two bolts should be de-tensioned so that they can be easily removed in the hot cell

5. Remove the two end crumple shields

6. Prepare the necessary transfer tools and storage position or storage container for the source to be downloaded.

7. Insert the transport cask into the hot cell.

8. Remove the two remaining bolts in the end cap and remove the end cap entirely from the transport cask.

9. Using a threaded handling bar, insert it into the source drawer at least ten turns and test that the source drawer moves easily.

10. Slowly remove the source drawer from the transport cask. Withdraw the source drawer making sure the drawer end comes clear of the cask and ensure that the drawer is not damaged in any way.

11. Wipe test around the capsule cavity for removable contamination and if clear

store the source drawer and remove the transport cask from the hot-cell.

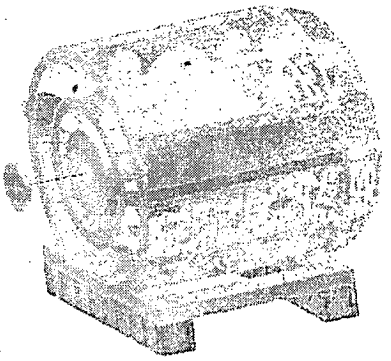


Illustration 40: Removal of the end cap

12. Take the cask to a designated cleaning site and clean the cask with a high pressure water jet, removing all labels and dirt.

13. Inspect the cask for any structural damage and test the integrity of all bolt threads around the end caps. Any damage found is to be digitally photographed and transmitted to A&DM engineering department for assessment.
    1. If all is in order and the cask is to be reused immediately, transport the unit back to the loading area.
    2. If the cask will not be reused in the immediate future, the end caps and crumple zone must be replaced and the unit stored until required.
    3. If the cask is to be used at a different site all bolts, the crumple zone and end caps must be replaced and all bolts torque to specification. The cask should be re-labelled and dispatched with the correct documentation.

Water Bath Downloading

The following instructions are provided as a guide for downloading a source from the A&DM Radiation Transport Container within a water bath. The following instructions may be modified to suit the specific variables at the time, however, the general principles should remain the same. These instructions are not designed to replace the water bath protocol but to form a guide and check list for the cask.

Item	*Task*
1	It is recommended that both end crumple shields be removed to make the unit smaller and easier to manipulate.
2	Remove test port plugs on both ends of the unit.
3	Wipe test the ends of the drawer to ensure no leakage has occurred during transport. It is important to wipe test before moving the cask into the water bath to avoid possible bath contamination
4	Remove five of the six end plate bolts from the machined end of the cask and loosen the sixth bolt, such that it is finger tight
5	Install the short handling bar through the test plug port in the end cap.
6	Place the cask over the water bath.
7	Remove the last end plate bolt.
8	Slide the end plate over the handling bar away from the attenuator.
9	Lower the cask into the water bath.
10	Withdraw the source drawer from the transport cask.
11	Remove the sources as per water bath protocol.

Water Bath Uploading

The Model 1860 source drawer is not designed for high internal pressures. The source drawer should not be pressurized by any means, under any circumstances

The following instructions are provided as a guide for downloading a source from the A&DM Radiation Transport Container within a water bath. The following instructions may be modified to suit the specific variables at the time, however, the general principles should remain the same. These instructions are not designed to replace the hot-cell protocol but to form a guide and check list for the cask.

Item	*Task*
1.	Prepare the drawer with the source or sources to be transported.
2.	Install the small handling bar into the end of the drawer.
3.	It is recommended that both end crumple shields be removed to make the unit smaller and easier to manipulate.
4.	Remove one end plate.
5.	Remove test port plug from the end plate
6.	Place attenuator into water bath.
7.	Install the drawer into the cask.
8.	Raise the cask.
9.	Slide the end plate over the handling bar.
10.	Install one of the end plate bolts loosely.
11.	Remove the cask from the Water Bath.
12.	Lower the cask to the ground with a 25mm timber under the fork skid opposite to the end with the loose end plate.
13.	Allow the water to drain completely.
14.	Install the remaining 5 bolts into the end plate.
15.	Torque all end plate bolts to 20 N/M.
16.	Remove the handling bar.

Item	*Task*
17.	Wipe test through the wipe test ports at each end plate.
18.	Replace and torque the test plug ports to 30N/M.
19.	Replace both end crumple shields.
20.	Install the locks.

Therapy Head Transfer (Upload)

The Model 1860 source drawer is not designed for high internal pressures. The source drawer should not be pressurized by any means, under any circumstances

The following instructions are provided as a guide for uploading of a source from the A&DM Radiation Transport Container to a therapy head. The following instructions may be modified to suit the specific variables at the time, however, the general principles should remain the same.

Item	*Task*
1.	Remove both end crumple shields from the attenuator. This will allow for easier movement, alignment and manipulation.
2.	The end of the cask opposite the filling ports is machined square to the drawer.
3.	Remove the end plate from this end.
4.	Attach the cask adapter plate to the cask, torque bolts to 30 N/M.
5.	Attach the head adapter plate to the head, torque bolts to 30 N/M.
6.	Bring the two adapter plates together and bolt them. Note: the bolts must be screwed in finger tight, do not force alignment.
7.	When fully aligned tighten the adapter plate bolts to 20 N/M.
8.	Remove the test plug port from the other end.
9.	Install a handling rod into the drawer.
10.	Push the drawer from the cask into the therapy head.
11.	Attach the drawer to the control mechanism of the head.
12.	Remove the handling rod.
13.	Separate the cask and head.
14.	Complete the assembly of the head.

Therapy Head Transfer (Download)

The following instructions are provided as a guide for downloading a source from the A&DM Radiation Transport Container to a therapy head. The following instructions may be modified to suit the specific variables at the time, however, the general principles should remain the same.

Item	*Task*
1.	Remove both end crumple shields from the attenuator. This will allow for easier movement, alignment and manipulation.
2.	The end of the cask opposite the filling ports is machined square to the drawer.
3.	Remove the end plate from this end.
4.	Attach the cask adapter plate to the cask, torque bolts to 30 N/M.
5.	Attach the head adapter plate to the head, torque bolts to 30 N/M.
6.	Bring the two adapter plates together and bolt them. Note: the bolts must be screwed in finger tight, do not force alignment.
7.	When fully aligned tighten the adapter plate bolts to 20 N/M.
8.	Remove the test plug port from the other end.
9.	Insert the full length handling rod through the test plug port into the therapy head and screw into the source drawer.
10.	Disconnect the source drawer from the therapy head detent pin such that the drawer is free to move within the therapy head source drawer chamber.
11.	Slowly pull drawer from the therapy head into the cask.
12.	Remove the handling rod.
13.	Separate the cask and head.
14.	Attach the remaining end plate, such that the source drawer is secure inside the attenuator.
15.	Wipe test through the wipe test ports on each end cap to check for removable contamination.
16.	Install the end port plugs and tension to 30N/M.
17.	Install the end crumple shields and prepare the cask for transport

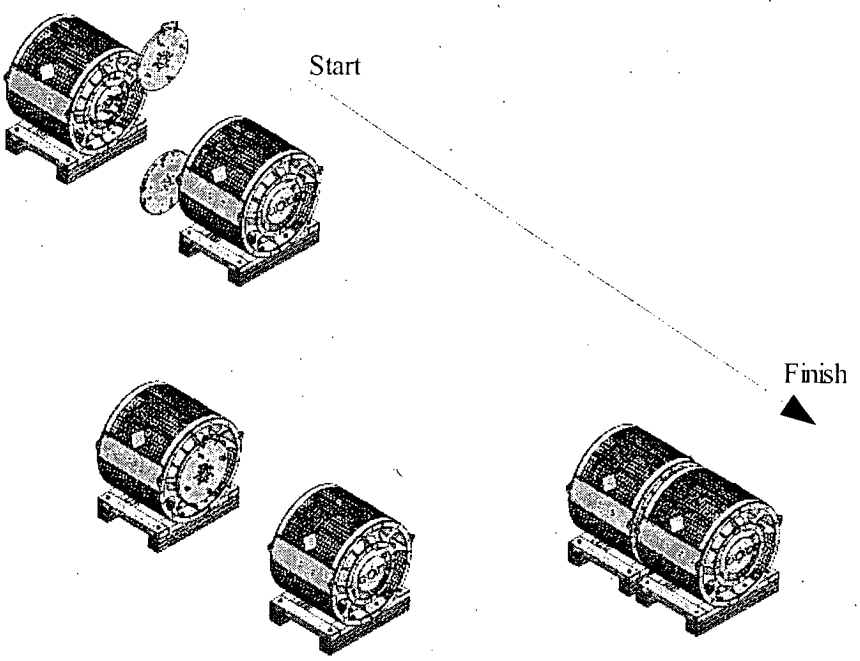
Cask to Cask Transfer

A cask to cask source transfer is a rare event, the procedure may be used in a situation where a source transfer is critical. A cask to cask transfer is only performed by an A&DM Engineer, with the use of special factory design alignment and position tools. If a cask to cask transfer is require A&DM must be contacted immediately.

The Model 1860 source drawer is not designed for high internal pressures. The source drawer should not be pressurized by any means, under any circumstances

The following instructions are provided as a guide for transferring a source from one model 1860 type B(U) package to another model 1860 type B(U) package. A cask to cask transfer will most likely occur in a laboratory or emergency situation where the source transfer is critical. For example if an incident occurs during transport such that the package is damaged and the transport cannot continue, a field transfer for the source into a new package might be necessary. Shown below in the following image is the a pictorial representation of the cask to tack transfer procedure.

The general procedure for a cask to cask transfer is as shown below. The ends of each cask are removed and the A&DM cask adaptor plates are fitted to each cask. The casks are then aligned, on all three axis, using the alignment plat pins. Finally the two casks are brought together, aligned on all axis, such that the source drawer can freely slide from one cask to the other.


Start
Finish

To successfully complete a cask to cask transfer some special tools are required. These tools are not a standard tool box accessory that travels with the package, instead they are tools that are supplied by the A&DM engineers who execute the cask to cask transfer. A complete list of tools required to complete the cask to cask transfer are as given above in Table 83: Training Sections. These are special application tools designed for specific functionality and are not available for general use without the support and supervision of an A&DM engineer.

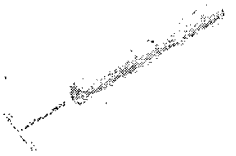
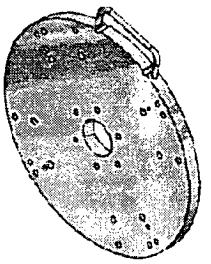
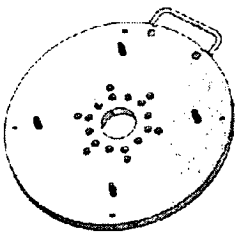
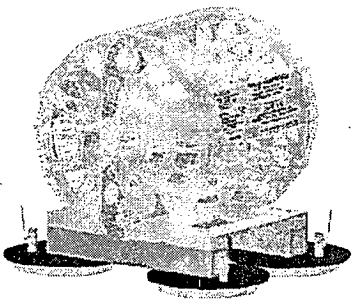
Item	Description	Image
1	M10 500mm handling rod & three 50mm handling bar, standard tool box components, see Tool Box Accessory's on page 240.	
2	Drawer Transfer Adapter (Female). Refer to drawing section *Special Tools*, drawing number *1864-01-009-00*. This female adaptor is bolted to the machined face of the cask, pins on the male adaptor plat insert into the alignment holes, thus aligning the source drawer.	
3	Drawer Transfer Adapter (Male). Refer to drawing section, *Special Tools*, drawing number *1864-01-007-03*. The male adaptor plate pins insert into the female adaptor plate holes thus aligning the source drawers on all axis.	
4	Pneumatic skate package slider and support system. This is a unique tool A&DM has developed for specific handling applications to mate 2 packages together. The skate provides a frictionless surface allowing the packages to freely slide together, reducing any loading forces on the adaptor plates.	

Table 93: Special Tools

given above in Table 82: Training requirements is a list steps used to successfully transfer a source from one model 1860 package to another. These steps are used only by a trained A&DM engineer, and may be modified at the time to suite specific environmental and unforeseen variables.

Item	*Task*
1.	Remove both end crumple shields from the attenuator of each cask. This will allow for easier movement, alignment and manipulation.
2.	The end of the cask opposite the filling ports is machined square to the drawer.
3.	Remove the end plate from this end on each cask
4.	Attach an adapter plate to each cask, torque bolts to 30 N/M.
5.	Bring the two adapter plates together and bolt them. Note: the bolts must be screwed in finger tight, do not force alignment.
6.	When fully aligned tighten the adapter plate bolts to 20 N/M.
7.	Remove the remaining end plate from the empty cask
8.	Insert the full length handling rod through the source drawer of the empty cask, into the source drawer for the loaded cask and screw into place
9.	Slowly pull source drawer from cask to cask
10.	Remove the handling rod.
11.	Separate the cask and head.
12.	Attach the remaining end plates, such that the source drawer is secure inside the newly loaded cask
13.	Wipe test through the wipe test ports on each end cap to check for removable contamination.
14.	Install the end port plugs and tension to 30N/M.
15.	Install the end crumple shields and prepare the cask for transport

Table 94: Cask to Cask Transfer Procedures

Illustration Index

Illustration 1: Standard Attenuator Case.....35

Illustration 2: Field Strength Survey....62
Illustration 3: Top Fin Equivalent Stress....96
Illustration 4: Top Fin Deformation....96
Illustration 5: Package Deformation....97
Illustration 6: Configuration A Calculation Layout....103
Illustration 7: Configuration A Calculation Layout for 137Cs....106
Illustration 8: Configuration A Calculation Layout for 226Ra....109
Illustration 9: Configuration A Calculation Layout for 192Ir....112
Illustration 10: Configuration B Calculation layout for 60Co....115
Illustration 11: Configuration B Side Layout for 60Co....119
Illustration 12: Configuration C Calculation layout for 60Co....121
Illustration 13: Configuration D Calculation Layout for 60Co....125
Illustration 14: Configuration D Calculation Side Layout for 60Co....129
Illustration 15: Configuration D Calculation 7 Capsule Pencil Layout for 60Co....131
Illustration 16: Configuration D Calculation 7 Capsule Pencil Side Layout for 60Co
....132
Illustration 17: Configuration E Calculation Layout for 60Co....135
Illustration 18: Configuration F Calculation Layout for 60Co....139
Illustration 19: Chain Of Communication....160
Illustration 20: Drop Incident, Emergency Flow Chart....165
Illustration 21: Fire Incident, Emergency Flow Chart....168
Illustration 22: Tamper Incident Flow Chart....170
Illustration 23: Radioactive Materials Warning....201
Illustration 24: Radioactive Material LSA 2....201
Illustration 25: Radioactive Material LSA 3....201
Illustration 26: Equipment Setup....231
Illustration 27: Capsule Loading....232
Illustration 28: Chilling Box....233
Illustration 29: Radioactive Material LSA 2....238
Illustration 30: Radioactive Material LSA 3....238
Illustration 31: Wipe Test Port Location....244
Illustration 32: Wipe Test Port Close Up....244
Illustration 33: Fork Lift Picking Points....254
Illustration 34: Lifting sling....255
Illustration 35: Road Transport Tie Down....256
Illustration 36: Removal Of End Crumple Shell....260
Illustration 37: The End Cap....261
Illustration 38: Transport Drawer....261
Illustration 39: Insert Drawer....261
Illustration 40: Removal of the end cap....264

Index of Tables

Table 1: IAEA General Design Requirements....25

Table 2: IAEA General Design Requirements for Air Transport....26
Table 3: IAEA General Design Requirements for Type A Packages....28
Table 4: IAEA General Design Requirements for Type B(U) Packages....29
Table 5: Commercial Design Requirements....29
Table 6: Design Parameters....31
Table 7: 316 Stainless Steel Characteristics....32
Table 8: Configuration Weights....33
Table 9: Package Dimensions....34
Table 10: Attenuator Configurations....37
Table 11: Crumple Shield Components....40
Table 12: End Shield Components....42
Table 13: Fork Lift Skid Components....43
Table 14: End Cap Components....44
Table 15: Shine Shields....45
Table 16: Pressure Sealing....46
Table 17: Demonstration Methods....56
Table 18: Applicable Destructive Tests....57
Table 19: ANSTO Test Conclusions....60
Table 20: Conditions for Normal Use....63
Table 21: Hazard Design Features....71
Table 22: Source Upload and download procedures....73
Table 23: Therapy Head, Upload and Download....74
Table 24: Possible Causes for Structural Damage....76
Table 25: Tamper Incident....77
Table 26: Pre Transport Inspection Check List....78
Table 27: Lifting Stress Assumptions....84
Table 28: Lifting Stress Results....84
Table 29: Part Statistics....94
Table 30: 316 Material Data....94
Table 31: Load and Constraint Definitions....95
Table 32: Constraint Reactions....95
Table 33: Structural Results....95
Table 34: Thermal Analysis Constants....98
Table 35: Thermal Analysis Assumptions....99
Table 36: Side Field Strength Results for 7 Capsule Pencil....131
Table 37: Max Loading Through End At 50 mm From Surface with 7 Capsule Pencil....133
Table 38: Tailored Features....145
Table 39: Design Criteria....146
Table 40: Material Selection Decisions....147
Table 41: Emergency Services....161
Table 42: Information for Emergency Services....161
Table 43: Information for State Regulatory Authority....162
Table 44: Possible Causes for Structural Damage....163

Table 45: Documentation Requirements....173
Table 46: QA Programme - Target Areas....174
Table 47: Company Employee Positions....177
Table 48: Position Responsibilities....177
Table 49: Regulatory Authorities....178
Table 50: Function Performance....179
Table 51: Regulatory Performance....179
Table 52: Tungsten Suppliers....190
Table 53: Fastener Suppliers....190
Table 54: Stainless Steel Suppliers....190
Table 55: Laser Cutting Subcontractors....191
Table 56: Machining Subcontractors....191
Table 57: Sheet Fabrication Subcontractors....191
Table 58: Lead Pouring Subcontractors....191
Table 59: Training Requirements....200
Table 60: Document Sections....200
Table 61: 1860 Check-list Items....202
Table 62: Pre Transport Check List - Unloaded....203
Table 63: Post Transport Check List - Unloaded....204
Table 64: Pre Transport Check List - Loaded....205
Table 65: Post Transport Check List - Loaded....207
Table 66: End of Mission Inspection....208
Table 67: Provided Items....209
Table 68: Spares....209
Table 69: Minor Repairs....212
Table 70: Major Repair Procedure....214
Table 71: Demonstration Methods....215
Table 72: Type B(U) test sets....216
Table 73: General Package Requirements....218
Table 74: Requirements for Air Transport....219
Table 75: Requirements for Type A packages....221
Table 76: Requirements Type B(U) Package....223
Table 77: Tests For Normal Transport Conditions....225
Table 78: Test For Transport Accident Conditions....227
Table 79: Applicable Destructive Tests....228
Table 80: Test Schedule....229
Table 81: Equipment list....230
Table 82: Training requirements....236
Table 83: Training Sections....237
Table 84: Provided Items....242
Table 85: Spares....242
Table 86: Travel Documents....243
Table 87: Outbound Empty, Checks....245
Table 88: Return Empty, Checks....246

Table 89: Receival Checks, Empty....247
Table 90: Outbound Loaded, Checks....249
Table 91: Receival Checks, Loaded....251
Table 92: End of Mission Inspection....253
Table 93: Special Tools....271
Table 94: Cask to Cask Transfer Procedures....272

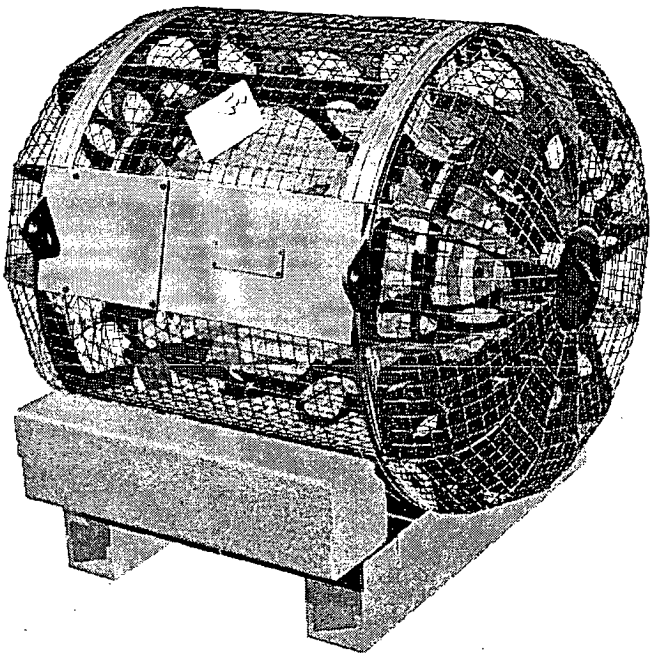
Analogue & Digital Measurements P/L
ABN: 57 005 531 484

http://admeasure.com.au
sales@admeasure.com.au

27 Cumberland Drive
Seaford, 3198
Victoria Australia

Ph: 03 8770 6500
Fax: 03 8770 6590

MODEL 1860 TYPE B(U) PACKAGE DOCUMENTATION APPENDICES



Document Identifier:

AppendixMaster.odm

Location:

C:\admwork\Model1860\Documents\Library\Appendix\

Contributors:

Kieren Grogan, Analogue & Digital Measurements (Kieren@eqss.com.au)

Revision History

Revision History for this document. This section only notes major contributions by the editors. Further information may be found in VSS.

Revision	*Author*	*Notes*
1.0	KRG	Initial Construction
1.1	KRG	Revision
1.2	KRG	Final Edit & QA

Documentation Conventions

The list below highlights important documentation conventions.

Text presented in this manner is intended to provide the user with some general information. The user should ensure information presented in this manner is clearly understood.

Text presented in this manner provides the user with information to assist in completion of the current procedure being explained.

Text presented in this manner indicates that further actions are required by the user.

Text presented in this manner indicates that a failure to follow directions could result in damage to equipment, loss of information, bodily harm, or loss of life.

Table of Contents

Appendix 01 7
IAEA Dangerous Goods Extract 7
Appendix 02 11
Absorption Curves 11
Appendix 03 44
Properties of Lead (Pb) 44
Appendix 04 47
Assay Certificate 47
Appendix 05 49
Stainless Steel Manual Sections 3 & 4 49
Appendix 06 55
Original Drawings 55
Appendix 07 64
Sequence of Construction 64
Appendix 08 71
IAEA Regulations, Section 6 Extract 71
Appendix 09 77
IAEA Regulations, Section 7 Extract 77
Appendix 10 83
Letter to DHS 83
Appendix 11 87
Destructive Test Programme 87
Appendix 12 91
Liquid Nitrogen Test Box And Tray 91
Appendix 13 93
ANSTO Test Schedule 93
Appendix 14 96
International Isotopes Special Form Certificate 96
Appendix 15 99
Photographs of Lead Pour 99
Appendix 16 101
Photographs Of Drop and Heat Tests 101
Appendix 17 103
Placard Drawings 103
Appendix 18 111
Dispatch Inspection Check List 111
Appendix 19 113
Dispatch Documentation Check List 113
Appendix 20 115
Metal Seal Information 115

Appendix 21 123
Radiation Field Survey Form 123

Appendix 01

IAEA Dangerous Goods Extract

Design Parameters

10.5.3.10 Temperature of accessible surfaces must not exceed 50C at an ambient of 38C will maximum energy output.

10.5.3.10. The temperature of the accessible surfaces of packages must not exceed 50°C at an ambient temperato of 38°C with no account taken for insolation.

10.6.2.2.15 Ambient Temperature Range -40C to +38C
a package shall be designed for an ambient temperature range from -40°C to +38°C.

10.5.3.12 Internal Pressure up to 95 KPA. (14 PSI)
Packages containing radioactive material must be capable of withstanding without leakage, an internal pressure that produces a pressure differential of not less than 95kPa.

10.5.2.1 Activity The Heat Generated by the radiation must be considered (ref 10.5.3.10)
testing will be with 200W - about 15,000BTU/hr
i.e. activity, of the radioactive material is very large, is that the heat generated by the radiation may be significant, in which case heat dissipation is considered

The temperature of the accessible surfaces of packages must not exceed 50°C at an ambient temperature 38C with no account taken for insolation.

10.6.2.1.1.2 Outside of the package must have a system of Seal which is not readily breakable to show evidence of tampering.
outside of every package must incorporate a feature, such as a seal, which is not readily breakable and which, while intact, will be evidence that the package has not been opened.

10.6.2.1.1.5 When subjected to the tests in 10.6.3.4 Normal Transport Conditions
If the package were subjected to the tests specified in 10.6.3.4 there must be no
(a) loss of shielding integrity which would result in more than a 20% increase in the radiation level at any external surface of the package; and
(b) loss or dispersal of the radioactive contents.

Overhead 1

a. Water Spray Test 10.6.3.4.2
The specimen must be subjected to a water spray test that simulates exposure to rainfall of approximately 50 mm per hour for at least one hour.

b. Free Drop Test 10.6.3.4.3
The specimen must drop onto the target so as to suffer maximum damage in respect of the safety features to be tested.

(a) The height of drop measured from the lowest point of the package to the upper surface of the target must be not less than the distance specified in Table 10.6.13 for the applicable weight. The target must be as defined in 10.6.3.3.

c. Stacking Test 10.6.3.4.4 5X WX

10.6.3.4.4 **Stacking Test**

The specimen must be subjected, for a period of 24 hours to a compressive load equal to the greater of the following
the equivalent of five times the weight of the actual package; or
the equivalent of 13 kPa (0.13 bar or 2 lbf/in²) multiplied by the vertically projected area of the package.the load must be applied uniformly to two opposite sides of the specimen, one of which must be the base on which the package would normally rest.

d. Penetration Test 10.6.3.4.5 6KgBar 32mmd

10.5.3.4.5 **Penetration Test**

The specimen must be placed on a rigid, flat, horizontal _ surface which will not move significantly while the t being carried out. A bar of 32 mm (1.25 in) diameter hemispherical end and a weight of 6 kg (13 lb) m dropped and directed to fall, with its longitudinal axis vertical onto the centre of the weakest part of the package, so that if it penetrates sufficiently far, it will hit the containment system. The bar must not be significantly deformed. test performance. The height of drop of the bar mo from its lower end to the intended point of impact upper surface of the specimen must be 1 m (40 in

10.6.2.6 No Loss of shielding to increase Radiation Level by 20% or Loss or dispersal of contents.
Ability to Withstand Accident Conditions during transport

10.6.2.2.4 Field at 1M from the Surface must not exceed 10MSV/Hr with the Max Contents
Accumulated loss must be less than A2 in one week

10.6.2.2.4 A package must be so designed that if it was subjected to

(a) The tests specified in 10.6.3.c it would restrict the lost it radioactive contents to not more than A2, perb) the tests specified in 10.6.3.5,10.6.3.4--' 2 Drop'10.6.3.6:2 and 10.6.3.6.3.1 and the test in either 10.6.3. Drop Test 3 when the package has a weight less equal to 500 kg, an overall density not greater 1,000 kg/m based on the external dimensions, and active contents greater than 1,000 A_2 not as special radioactive materia', or 10.6.3.6. 1.1 Drop 1 for all packages it would retain sufficient shielding to ensure radiation level at 1 m from the surface of the package would not exceed 10 mSv/h with the maximum contents for which the package is designed to contain; restrict the accumulated loss of radioactive contents period of one week to not more than 10 A_2 for <ypton-85 and not more than A_2 for all other radionuclides.

10.6.2.2 Requirements for Type B Packages

10.6.2.2.1 Type B(U) Packages. Type B(U) packages must meet the requirements of 10.5.3, 10.5.2.1 1 (except for 10.6.2.1.1.6(b)), 10.6.2.1.2, and in addition to the requirements specified in 10.6.2.2.2 to 10.6.2.2.13.

10.6.2.2.2 A package must be so designed that, under the ambient conditions specified below, the heat generated within the package by the radioactive contents will not, under normal conditions of transport, as demonstrated by the tests in 10.6.3.4, adversely affect the package in such a way that it would fail to meet the applicable requirements for containment and shielding if left unattended for a period of one week. Particular attention must be paid to the effects of heat which may:

(c) in combination with moisture, accelerate corrosion. For the purposes of 10.6.2.2.2, the ambient temperature must be taken as 38°C and the solar insolation conditions must be assumed to be as given by Table 10.6.A.

10.6.2.2.2 Internal Heat not to effect the package in anyway when left unattended for a period of 1 week
ie a. not effect the capsule
b. not effect the shielding
c. in combination with moisture not accelerate corrosion
Note- Ambient temperature to be taken as 38C.
test must be carried out in an oven for 1 week at 38C with design Heat

Type B Package insolation Criteria (10.6.2.2.2)

Form and location of surface	Insolation for 12 hours per day W/ m]
Flat surfaces transported horizontally: base	none
other surfaces	800
Flat surfaces NOT transported horizontally: each surface	
Curved surfaces:	400

Alternatively, a sine function may be used adopting an absorption coefficient and neglecting the effects of possible reflection from neighbouring objects.

10.6.2.2.3 Drop Test

10.6.2.2.3 A package which includes thermal protection for the purpose of satisfying the requirements of the thermal test specified in 10.6.3.6.2 must be so designed that such protection will remain effective if the packaging is subjected to the tests specified in 10.6.3.4 10.6.3.1.1 Drop Test 1 and 10.6.3.6.1.2 Drop Test 2 or 10.6.3.6.1.2 Drop Test 2 and 10.6.3.6.1.3 Drop Test 3 as appropriate. Any such protection on the exterior of the package must not be rendered ineffective by conditions commonly encountered in normal handling or transport, or in accidents, and which are not simulated in the tests referred to above e.g. by ripping, cutting, skidding abrasion or other rough handling.

10.6.3.6.1.1 Drop Test 1 – 10.6.3.6.1.2 Drop Test 2
(Drop 30M) (Penetration 1M)

Demonstration of compliance with the performance standards required in this subsection may be accompany of the following methods or by a combination peformance of tests with specimens representing material or Special Form radioactive material, or Dispersable radioactive material or with prototypes or of the packaging, provided that the contents of the or the packaging for the tests simulate as closely as practicable

alt 10.6.3.6.1.1 Drop Test 2 – 10.6.3.6.1.3 Drop Test 3
(Penetration Test) (500Kg Slab onto to Target)
Not Applicable refer 10.6.2.2.4.6

10.6.2.2.11 Does not require screens to be subjected to tests for Surface Temp rise.

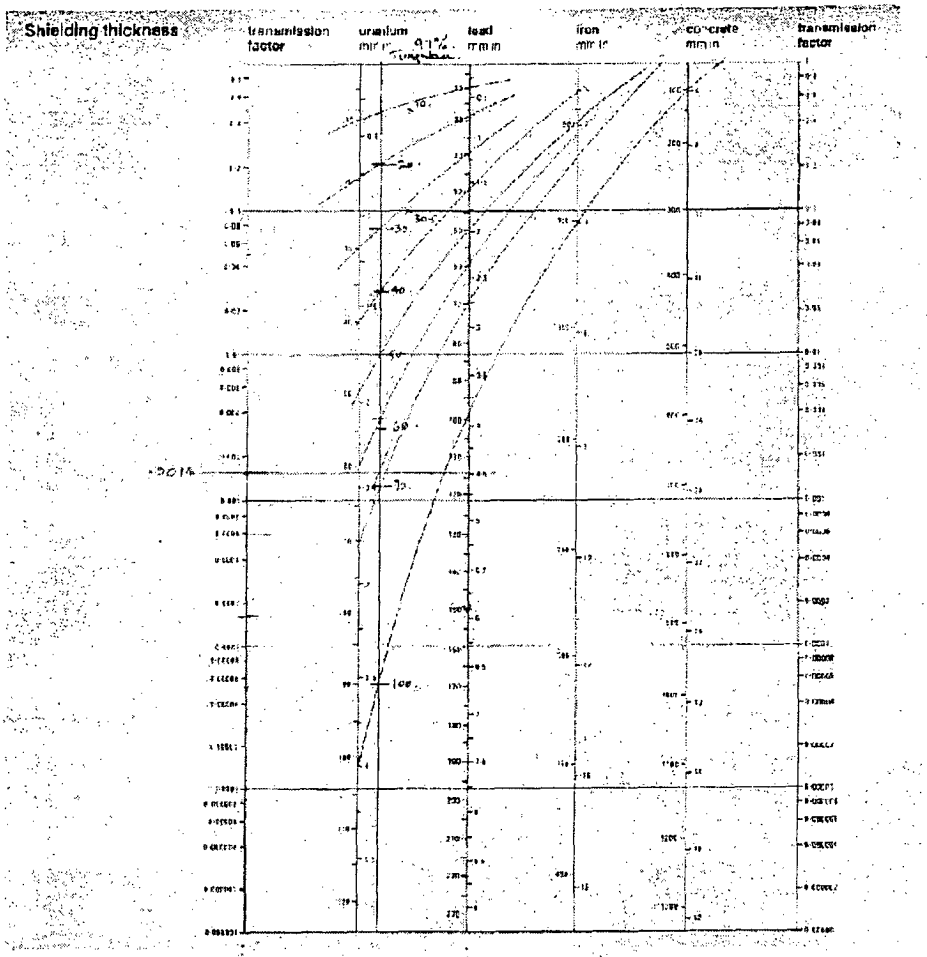
10.6.3.1.2 Assessment of Results

Appendix 02

Absorption Curves

Cobalt-60

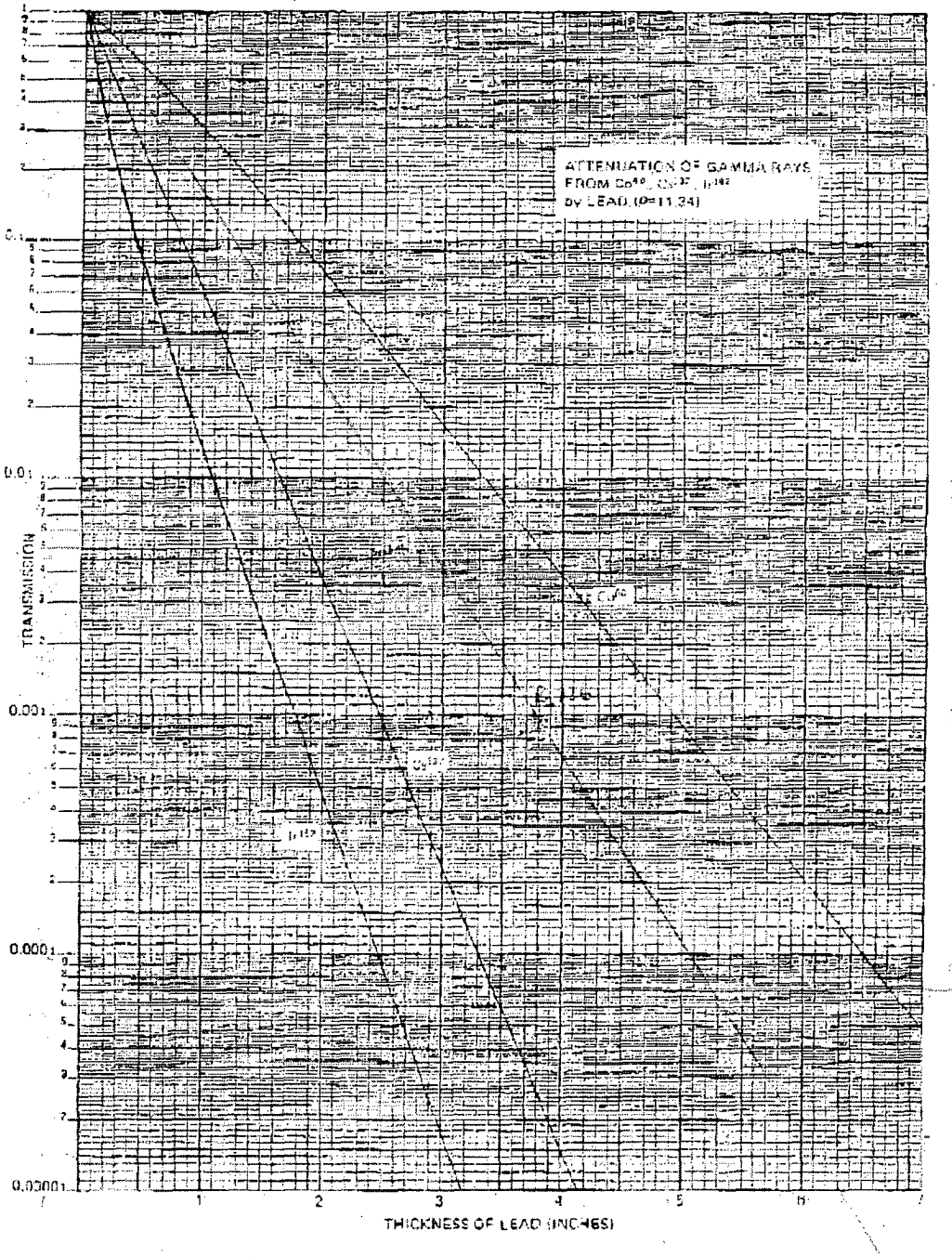
Shielding data

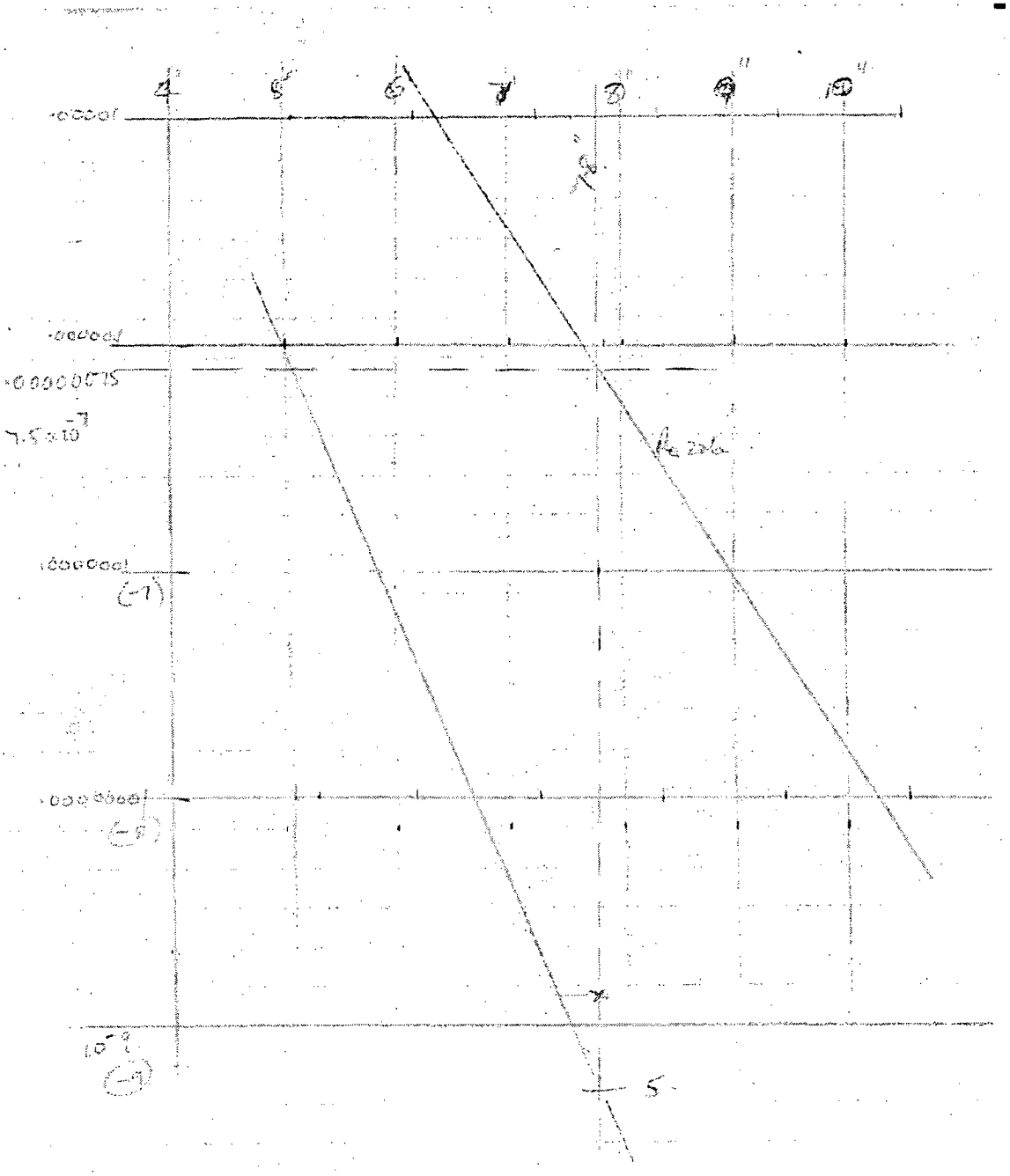


Radioactive decay

The activity at the time of use may be calculated by multiplying the activity at date of measurement by the appropriate factor from the table below:

months from date of measurement	0	2	4	6	8
0	1·000	0·978	0·957	0·936	0·916
10	0·896	0·877	0·858	0·839	0·821
20	0·803	0·786	0·769	0·752	0·736
30	0·720	0·705	0·689	0·674	0·659
40	0·645	0·631	0·617	0·604	0·591
50	0·578	0·566	0·553	0·541	0·530


ATTENUATION OF GAMMA RAYS
FROM
by LEAD (ρ=11.34)
TRANSMISSION
THICKNESS OF LEAD (INCHES)



Absolute information on attenuation coefficients for various materials from various sources are widely conflicting with respect to exact numbers.

After careful consideration we selected a graph produced by Amersham which provided conservative figures. The Amersham graph did not have data for Tungsten, actual test data was obtained from Sandvick for 90% Tungsten (10% Nickel / Iron binder) which has a density of 18, this was superimposed onto the Amersham graph. This data also is on the conservative as the design uses 97% tungsten which has a density of 18.5.

Verification of the graph data accuracy was obtained by cross referencing to spot data obtained from the following reference.

Reference	Engineering Compendium on Radiation Shielding
Publisher	Springer-Verlag Berlin Heidelberg New York 1968
Editor	R.G Jaeger
Sponsor	International Atomic Energy Agency

A list of detailed references to which the Amersham data is compared and varified against is as given below.

Reference	Description
Volume II, Chapter 9.1.1, Figure 9.1-, 9.1-2	Attenuation with lead and lead alloys. Exposure attenuation factor for broad beam gamma radiation for point source in lead
Volume II, Chapter 9.1.1, Table 9.1.1	Attenuation with lead and lead alloys. Equivalent thickness of various materials per unit of lead thickness
Volume II, Chapter 9.1.1, Table 9.1.2	Attenuation with lead and lead alloys. Comparison of gamma attenuation properties of various materials by weight and thickness
Volume II, Chapter 9.1.1, Table 9.1.4	Attenuation with lead and lead alloys. Radiation dose rate shield attenuation factors as a functions lead lead shield thickness
Volume II, Chapter 9.1.2, figure 9.1-19, 9.1-20	Attenuation with steel and steel alloys. Exposure attenuation factor for broad beam gamma radiation of a poi9nt source in steel
Volume II, Chapter 9.1.2, figure 9.1-22	Attenuation with steel and steel alloys. Radiation dose rate shield attenuation factor as a function of steel shield thickness
Volume II, Chapter 9.1.3, figure 9.1-38	Attenuation with Uranium. Radiation dose rate shield attenuation factors as a function of uranium shield thickness

As all attenuation data is on the side of conservatism the actual transport index at the time of first use will be considerably less than that allowed of 10.

Chapter 9

SHIELDING MATERIALS

9.1. MATERIALS AGAINST GAMMA RAYS

9.1.1. LEAD AND LEAD ALLOYS

by E. E. HAMER and A. E. MCARTHY

9.1.1.1. INTRODUCTION

Pure lead is a soft, structurally weak, low melting point (327.4 °C) material with a density of 11.34 g/cm³; it is an excellent attenuator of gamma radiation. Normally, alloying reduces the density and therefore its shielding effectiveness, but the structural properties are significantly improved. Lead is attractive as a shielding material against gamma radiation because of its low cost-to-density ratio, the variety of forms available, and the numerous fabrication methods that can be used.

9.1.1.2. OCCURRENCE AND EXTRACTION

The earth's crust is calculated to be about 0.0016% lead. The only ore of commercial importance is galena (PbS), which is usually found associated with iron, zinc, and silver minerals. Secondary lead is presently recovered in tonnage that is about equivalent to primary lead production. Lead has a high salvage value because of its good resistance to corrosion and the comparative ease with which it may be recovered from scrap materials by smelting and refining processes [1].

9.1.1.3. PROPERTIES

A. Nuclear Properties

Tables 9.1.–1 and –2 compares thicknesses and weights of lead and five other materials for equivalent gamma-ray shielding.

Table 4.1.–3 (Vol. I, p. 175) lists values of the gamma ray mass-attenuation coefficient μ/ρ [cm²/g]; Table 4.1.–9 (Vol. I, p. 183) lists values of the mass energy-transfer coefficient μ_{tr}/ρ, and the mass energy-absorption coefficient, μ_{en}/ρ.

Figures 9.1.–1 and –2 and Table 9.1.–3 show the exposure-attenuation factors for broad-beam gamma radiation of a point isotropic source in lead for various energies of incident gamma radiation as a function of the lead thickness [3].

The exposure-attenuation factor K can be used to obtain the gamma radiation dose rate I from a point isotropic source through a specified thickness of shielding r in accordance with the equation

$$K = I/I_0 = B\,e^{-\mu r},$$

where

I_0 gamma ray dose rate for an unshielded point isotropic source at the specified distance,

B Taylor buildup factor for the material thickness being considered and the photon energy of the radiation source,

μ attenuation coefficient of the shield material for the source radiation [cm⁻¹],

Figures 9.1.–3 through –16 show the shield (exposure)-attenuation factor, s_t, for the radiation dose rate as a function of the lead shield thickness for a large number of radioisotopes and certain isotope combinations [4]. Included are curves (Fig. 9.1.–18) for mixed fission products (MFP-)

Table 9.1.–1. Equivalent thicknesses of various materials per unit lead thickness, for 5 and 10 mean free paths of lead, for several gamma-ray energies [2][a]

Energy [MeV]	Iron		Water		Concrete	
	$(\mu t)_{Pb} = 5$	$(\mu t)_{Pb} = 10$	$(\mu t)_{Pb} = 5$	$(\mu t)_{Pb} = 10$	$(\mu t)_{Pb} = 5$	$(\mu t)_{Pb} = 10$
0.10	21.0	—	—	—	—	—
0.5	3.9	3.6	32.8	27.8	—	—
1.0	2.2	2.1	16.0	14.3	7.2	6.6
2.0	1.8	1.7	12.5	11.6	5.6	5.4
3.0	1.8	1.8	13.3	12.5	5.9	5.7
4.0	1.9	1.9	15.0	14.2	6.7	6.4
5.0	2.1	2.0	17.1	15.9	7.5	7.2
6.0	2.3	2.1	19.3	17.9	8.5	8.0
7.0	2.4	2.3	21.6	19.9	9.4	8.8
8.0	2.5	2.3	23.8	21.9	10.0	9.4

[a] Differences in equivalent thicknesses over 5 and 10 mean free paths is attributable to differences in buildup-factor ratios for 5 and 10 mean free paths. Multiply any given lead thickness by the values given in the table to obtain the equivalent thickness of iron, water, and concrete.

[1] Engineering Compendium, Vol. II

Table 9.1.–2. Comparison of gamma attenuation properties of various materials by thickness and weight [1].

Buildup of lower energy radiation not taken into account.
(1 lb/sq. ft = 4.882 kg/m²; 1 lb/cu. ft = 16.02 kg/m³)

1. Relative thickness

Material	Density [lbs/cu. ft]	Shield thickness [ft]			
		0.2 MeV	0.5 MeV	1.0 MeV	3.0 MeV
Concrete	144	2.5	4.1	5.4	9.1
Heavy concrete	288	1.13	2.05	2.7	4.55
Iron	450	0.7	1.26	1.75	2.91
Lead	707	0.071	0.44	0.95	1.63
Tungsten	1200	0.054	0.38	0.68	0.985
Uranium	1170	0.036	0.22	0.52	0.91

Slabs of these thicknesses will attenuate radiation by 10^{10}, i. e., for a spherical source 1 foot in radius, radiation 10 feet from center of source is attenuated by 10^{10}.

2. Effect of geometry on weight

Material	Shield weight in pounds							
	0.2 MeV		0.5 MeV		1.0 MeV		3.0 MeV	
	A	B	A	B	A	B	A	B
Concrete	360	22 500	590	79 200	780	157 500	1310	619 000
Heavy concrete	325	10 150	590	32 900	780	59 900	1310	205 000
Iron	315	7 370	568	19 900	780	37 600	1310	111 000
Lead	50	68	310	5 880	670	19 000	1150	50 900
Tungsten	65	814	360	6 010	720	15 540	1180	34 200
Uranium	45	76	255	3 990	605	12 290	1070	29 200

Column A gives lbs/sq. ft of slab perpendicular to radiation; Column B gives total weight of spherical shield. Thickness as above.

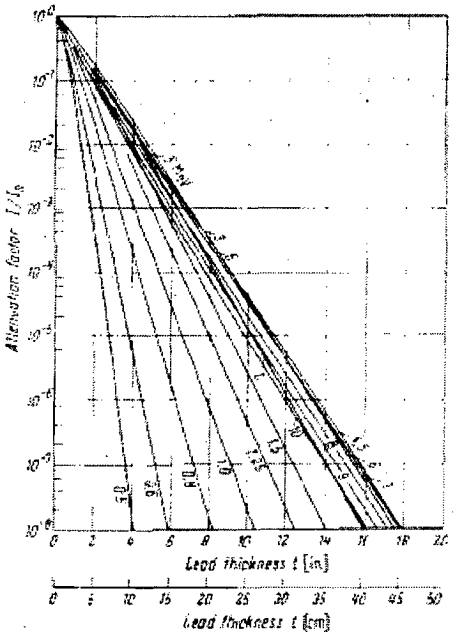


Fig. 9.1.–1. Exposure attenuation factors I/I_0 for broad-beam gamma radiation of a point isotropic source in lead ($\varrho = 11340$ kg/m³) in dependence on the energy of incident gamma radiation, E_γ [3].

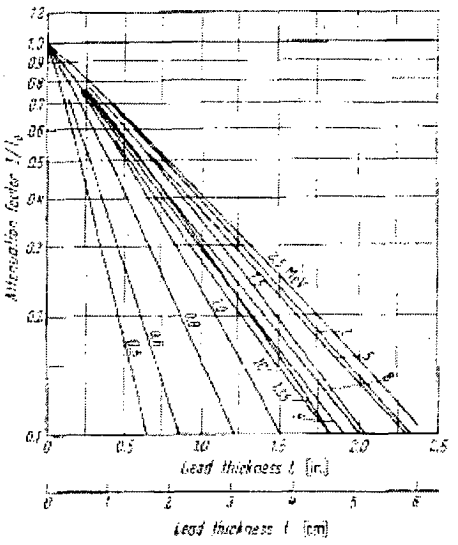


Fig. 9.1.–2. Exposure attenuation factors I/I_0 for broad-beam gamma radiation of a point isotropic source in lead ($\varrho = 11340$ kg/m³) in dependence on the energy of incident gamma radiation, E_γ [3].

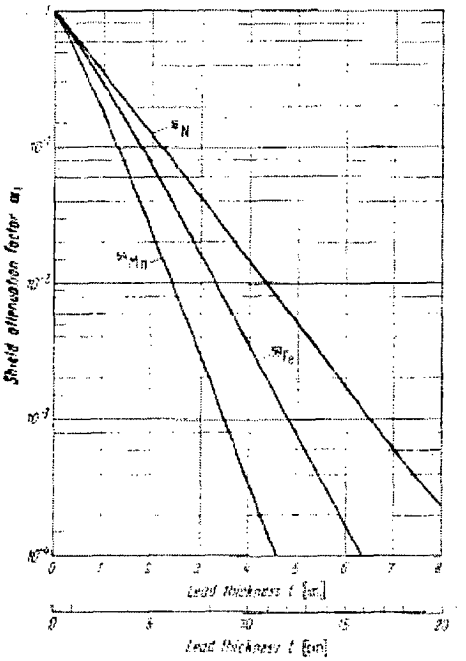


Fig. 9.1.–3. Radiation dose rate shield attenuation factor for ^{16}N, ^{56}Mn and ^{59}Fe as a function of lead shield thickness [4].

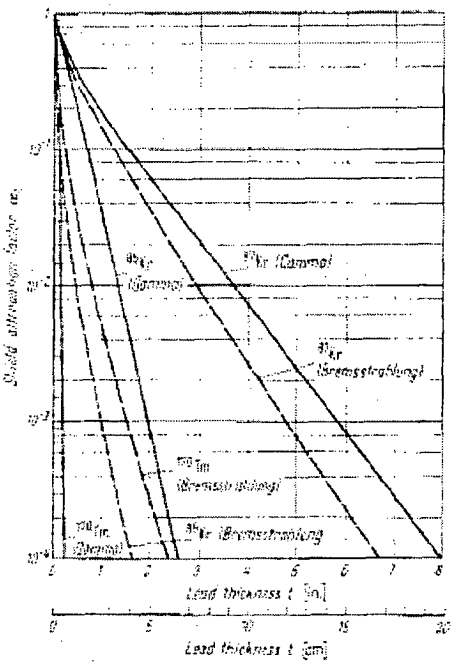


Fig. 9.1.–5. Radiation dose rate shield attenuation factor for ^{85}Kr, ^{85}Kr and ^{170}Tm as a function of lead shield thickness [4].

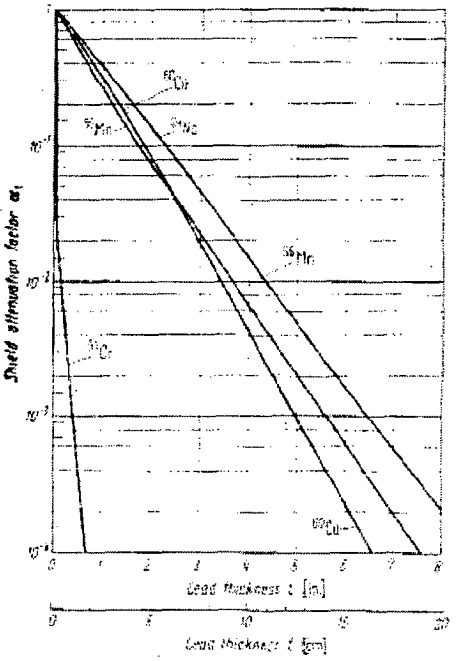


Fig. 9.1.–4. Radiation dose rate shield attenuation factor for ^{24}Na, ^{51}Cr, ^{56}Mn and ^{64}Cu as a function of lead shield thickness [4].

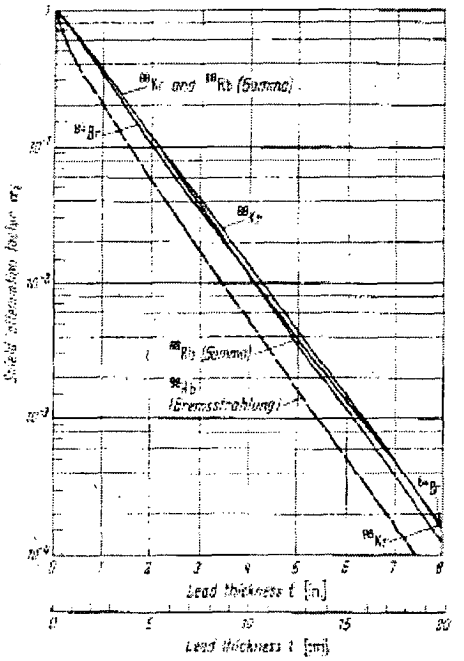


Fig. 9.1.–6. Radiation dose rate shield attenuation factor for ^{88}Br, ^{85}Kr and ^{88}Rb as a function of lead shield thickness [4].
Note: The curve for ^{85}Kr–^{88}Rb (gamma) falls between the individual curves for ^{85}Kr and ^{88}Rb (gamma). In the interest of clarity, the curve for the combined isotopes is not shown.

Table 9.1-3. Exposure attenuation factors I/I_0 for broad beam gamma radiation of a point isotropic source in *lead* [$\varrho = 11\,340$ kg/m³] in dependence on the energy of incident gamma radiation E_0 [3]

Note: Attenuation factor .3480 09- read: $0.3480 \cdot 10^{-9}$

r [cm]	E_0 [MeV] 0.5	0.6	0.8	1.0	1.25	1.5	2.0	2.5	3.0	3.5	4.0	4.5
0.1	.8820 00	.9105 00	.9303 00	.9316 00	.9496 00	.9633 00	.9666 00	.9676 00	.9669 00	.9657 00	.9646 00	.9632 00
0.2	.7757 00	.8274 00	.8798 00	.9047 00	.9202 00	.9276 00	.9341 00	.9363 00	.9347 00	.9324 00	.9304 00	.9277 00
0.3	.6806 00	.7504 00	.8229 00	.8596 00	.8819 00	.8927 00	.9024 00	.9033 00	.9035 00	.9002 00	.8973 00	.8935 00
0.4	.5958 00	.6795 00	.7693 00	.8156 00	.8447 00	.8586 00	.8715 00	.8754 00	.8732 00	.8690 00	.8654 00	.8604 00
0.5	.5206 00	.6143 00	.7184 00	.7733 00	.8086 00	.8259 00	.8414 00	.8462 00	.8436 00	.8388 00	.8345 00	.8282 00
0.6	.4540 00	.5545 00	.6702 00	.7325 00	.7737 00	.7935 00	.8122 00	.8179 00	.8152 00	.8096 00	.8046 00	.7979 00
0.7	.3953 00	.4999 00	.6246 00	.6938 00	.7399 00	.7648 00	.7937 00	.7903 00	.7875 00	.7815 00	.7758 00	.7683 00
0.8	.3457 00	.4502 00	.5816 00	.6564 00	.7072 00	.7327 00	.7561 00	.7635 00	.7607 00	.7539 00	.7479 00	.7397 00
0.9	.2984 00	.4049 00	.5421 00	.6207 00	.6757 00	.7035 00	.7292 00	.7375 00	.7346 00	.7274 00	.7210 00	.7122 00
1.0	.2558 00	.3638 00	.5050 00	.5865 00	.6453 00	.6752 00	.7031 00	.7125 00	.7093 00	.7017 00	.6950 00	.6857 00
1.2	.1940 00	.2929 00	.4338 00	.5228 00	.5878 00	.6215 00	.6572 00	.6639 00	.6611 00	.6529 00	.6457 00	.6355 00
1.4	.1446 00	.2350 00	.3731 00	.4650 00	.5346 00	.5713 00	.6063 00	.6184 00	.6159 00	.6073 00	.5997 00	.5889 00
1.6	.1078 00	.1880 00	.3201 00	.4128 00	.4856 00	.5245 00	.5625 00	.5757 00	.5735 00	.5646 00	.5566 00	.5456 00
1.8	.8005 01-	.1500 00	.2741 00	.3658 00	.4404 00	.4812 00	.5211 00	.5356 00	.5337 00	.5248 00	.5168 00	.5054 00
2.0	.5985 01-	.1194 00	.2345 00	.3236 00	.3990 00	.4409 00	.4826 00	.4979 00	.4965 00	.4876 00	.4797 00	.4681 00
2.2	.4378 01-	.9492 01-	.1999 00	.2859 00	.3611 00	.4037 00	.4464 00	.4627 00	.4617 00	.4529 00	.4450 00	.4334 00
2.4	.3229 01-	.7528 01-	.1702 00	.2522 00	.3264 00	.3692 00	.4129 00	.4297 00	.4292 00	.4206 00	.4128 00	.4015 00
2.6	.2376 01-	.5961 01-	.1446 00	.2222 00	.2946 00	.3374 00	.3816 00	.3993 00	.3988 00	.3904 00	.3825 00	.3715 00
2.8	.1748 01-	.4713 01-	.1230 00	.1956 00	.2659 00	.3083 00	.3525 00	.3700 00	.3704 00	.3623 00	.3550 00	.3439 00
3.0	.1284 01-	.3722 01-	.1043 00	.1719 00	.2397 00	.2812 00	.3253 00	.3432 00	.3439 00	.3361 00	.3291 00	.3185 00
3.5	.5913 02-	.2052 01-	.6880 01-	.1240 00	.1843 00	.2231 00	.2677 00	.2855 00	.2853 00	.2784 00	.2721 00	.2621 00
4.0	.2708 02-	.1125 01-	.4519 01-	.8905 01-	.1411 00	.1753 00	.2164 00	.2339 00	.2362 00	.2302 00	.2247 00	.2157 00
4.5	.1236 02-	.6144 02-	.2951 01-	.6363 01-	.1076 00	.1368 00	.1737 00	.1924 00	.1952 00	.1903 00	.1854 00	.1774 00
5.0	.5625 03-	.3342 02-	.1919 01-	.4529 01-	.8186 01-	.1090 00	.1403 00	.1560 00	.1611 00	.1563 00	.1528 00	.1458 00
5.5	.2554 03-	.1812 02-	.1244 01-	.3213 01-	.6205 01-	.8584 01-	.1151 00	.1294 00	.1327 00	.1281 00	.1258 00	.1197 00
6.0	.1158 03-	.9808 03-	.8044 02-	.2273 01-	.4692 01-	.6671 01-	.9257 01-	.1059 00	.1092 00	.1062 00	.1035 00	.9850 01-
6.5	.5247 04-	.5297 03-	.5187 02-	.1604 01-	.3539 01-	.5207 01-	.7480 01-	.8654 01-	.8980 01-	.8750 01-	.8510 01-	.8064 01-
7.0	.2574 04-	.2856 03-	.3337 02-	.1129 01-	.2664 01-	.4054 01-	.6015 01-	.7059 01-	.7372 01-	.7176 01-	.6991 01-	.6612 01-
7.5	.1073 04-	.1532 03-	.2143 02-	.7956 02-	.2002 01-	.3150 01-	.4829 01-	.5751 01-	.6045 01-	.5869 01-	.5740 01-	.5429 01-
8.0	.4854 05-	.8278 04-	.1374 02-	.5587 02-	.1502 01-	.2444 01-	.3872 01-	.4680 01-	.4955 01-	.4808 01-	.4709 01-	.4446 01-
8.5	.2193 05-	.4450 04-	.8804 03-	.3899 02-	.1125 01-	.1894 01-	.3101 01-	.3804 01-	.4054 01-	.3956 01-	.3861 01-	.3655 01-
9.0	.9907 06-	.2390 04-	.5631 03-	.2727 02-	.8420 02-	.1466 01-	.2481 01-	.3089 01-	.3316 01-	.3235 01-	.3164 01-	.2975 01-
9.5	.4474 06-	.1283 04-	.3598 03-	.1905 02-	.6292 02-	.1133 01-	.1982 01-	.2506 01-	.2710 01-	.2650 01-	.2598 01-	.2435 01-
10.0	.2020 06-	.6889 05-	.2297 03-	.1329 02-	.4696 02-	.8750 02-	.1582 01-	.2031 01-	.2213 01-	.2167 01-	.2122 01-	.1992 01-
11.0	.4121 07-	.1982 05-	.9362 04-	.6457 03-	.2608 02-	.5202 02-	.1006 01-	.1331 01-	.1472 01-	.1440 01-	.1420 01-	.1331 01-
12.0	.8392 08-	.5697 06-	.3789 04-	.3126 03-	.1443 02-	.3082 02-	.6375 02-	.8703 02-	.9779 02-	.9639 02-	.9443 02-	.8890 02-
13.0	.1709 08-	.1636 06-	.1534 04-	.1509 03-	.7970 03-	.1821 02-	.4030 02-	.5674 02-	.6479 02-	.6410 02-	.6335 02-	.5929 02-
14.0	.3480 09-	.4708 07-	.6203 05-	.7271 04-	.4386 03-	.1075 02-	.2540 02-	.3691 02-	.4234 02-	.4255 02-	.4222 02-	.3950 02-
15.0		.1350 07-	.2505 05-	.3497 04-	.2411 03-	.6312 03-	.1598 02-	.2397 02-	.2828 02-	.2822 02-	.2810 02-	.2630 02-
16.0		.3872 08-	.1012 05-	.1679 04-	.1322 03-	.3705 03-	.1003 02-	.1555 02-	.1864 02-	.1868 02-	.1869 02-	.1750 02-
17.0		.1210 08-	.4074 06-	.8055 05-	.7244 04-	.2171 03-	.6290 03-	.1005 02-	.1227 02-	.1236 02-	.1242 02-	.1163 02-
18.0		.3188 09-	.1641 06-	.3860 05-	.3966 04-	.1270 03-	.3939 03-	.6499 03-	.8072 03-	.8167 03-	.8245 03-	.7731 03-
19.0			.6612 07-	.1848 05-	.2164 04-	.7428 04-	.2465 03-	.4195 03-	.5302 03-	.5392 03-	.5469 03-	.5134 03-
20.0			.2675 07-	.8842 06-	.1181 04-	.4337 04-	.1538 03-	.2705 03-	.3479 03-	.3556 03-	.3626 03-	.3407 03-
21.0			.1072 07-	.4228 06-	.6442 05-	.2529 04-	.9590 04-	.1743 03-	.2281 03-	.2344 03-	.2402 03-	.2261 03-
22.0			.4325 08-	.2020 06-	.3510 05-	.1474 04-	.5983 04-	.1121 03-	.1494 03-	.1544 03-	.1590 03-	.1499 03-
23.0			.1759 08-	.9654 07-	.1911 05-	.8586 05-	.3726 04-	.7225 04-	.9784 04-	.1016 03-	.1052 03-	.9942 04-
24.0			.6994 09-	.4610 07-	.1040 05-	.4996 05-	.2319 04-	.4637 04-	.6401 04-	.6680 04-	.6965 04-	.6589 04-
25.0			.2812 09-	.2201 07-	.5660 06-	.2906 05-	.1442 04-	.2978 04-	.4185 04-	.4390 04-	.4606 04-	.4366 04-
26.0				.1051 07-	.3077 06-	.1689 05-	.8967 05-	.1911 04-	.2735 04-	.2890 04-	.3044 04-	.2892 04-
27.0				.5042 08-	.1675 06-	.9815 06-	.5570 05-	.1226 04-	.1786 04-	.1898 04-	.2012 04-	.1915 04-
28.0				.2406 08-	.9090 07-	.5700 06-	.3459 05-	.7864 05-	.1166 04-	.1247 04-	.1329 04-	.1268 04-
29.0				.1146 08-	.4938 07-	.3309 06-	.2147 05-	.5040 05-	.7614 05-	.8189 05-	.8779 05-	.8394 05-
30.0				.5463 09-	.2681 07-	.1920 06-	.1332 05-	.3229 05-	.4967 05-	.5375 05-	.5796 05-	.5552 05-
31.0				.2604 09-	.1475 07-	.1111 06-	.8261 06-	.2068 05-	.3240 05-	.3527 05-	.3826 05-	.3676 05-
32.0					.7965 08-	.6464 07-	.5122 06-	.1324 05-	.2112 05-	.2313 05-	.2525 05-	.2432 05-
33.0					.4328 08-	.3740 07-	.3176 06-	.8474 06-	.1376 05-	.1517 05-	.1666 05-	.1609 05-
34.0					.2346 08-	.2173 07-	.1967 06-	.5422 06-	.8972 06-	.9949 06-	.1099 05-	.1064 05-
35.0					.1277 08-	.1259 07-	.1218 06-	.3466 06-	.5845 06-	.6522 06-	.7252 06-	.7041 06-
36.0					.6896 09-	.7296 08-	.7537 07-	.2218 06-	.3807 06-	.4275 06-	.4783 06-	.4656 06-
37.0					.3738 09-	.4220 08-	.4673 07-	.1418 06-	.2479 06-	.2801 06-	.3154 06-	.3079 06-
38.0					.2026 09-	.2477 08-	.2893 07-	.9066 07-	.1614 06-	.1835 06-	.2079 06-	.2036 06-
39.0						.1433 08-	.1791 07-	.5795 07-	.1051 06-	.1202 06-	.1371 06-	.1346 06-
40.0						.8296 09-	.1108 07-	.3703 07-	.6841 07-	.7877 07-	.9039 07-	.8902 07-
41.0						.4801 09-	.6866 08-	.2366 07-	.4452 07-	.5159 07-	.5958 07-	.5884 07-
42.0						.2718 09-	.4304 08-	.1512 07-	.2897 07-	.3379 07-	.3927 07-	.3890 07-
43.0							.2655 08-	.9612 08-	.1886 07-	.2212 07-	.2588 07-	.2504 07-
44.0							.1643 08-	.6257 08-	.1226 07-	.1449 07-	.1719 07-	.1701 07-
45.0							.1015 08-	.3956 08-	.8081 08-	.9585 08-	.1132 07-	.1128 07-
46.0							.6275 09-	.2546 08-	.5251 08-	.6268 08-	.7457 08-	.7454 08-
47.0							.3077 09-	.1629 08-	.3412 08-	.4100 08-	.4910 08-	.4924 08-
48.0							.2355 09-	.1036 08-	.2217 08-	.2682 08-	.3234 08-	.3253 08-
49.0								.5621 09-	.1440 08-	.1754 08-	.2129 08-	.2149 08-
50.0								.4217 09-	.9352 09-	.1147 08-	.1402 08-	.1420 08-

Table 9.1.–3. (Continued)

E_0 [MeV]											r [cm]
5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	
.9617 00	.9607 00	.9596 00	.9584 00	.9573 00	.9561 00	.9549 00	.9536 00	.9523 00	.9509 00	.9496 00	0.1
.9259 00	.9225 00	.9188 00	.9150 00	.9109 00	.9065 00	.9020 00	.8974 00	.8927 00	.8878 00	.8828 00	0.2
.8696 00	.8606 00	.8506 00	.8403 00	.8294 00	.8181 00	.8065 00	.7947 00	.7827 00	.7705 00	.7583 00	0.3
.8556 00	.8417 00	.8270 00	.8120 00	.7966 00	.7809 00	.7650 00	.7489 00	.7328 00	.7166 00	.7005 00	0.4
.8228 00	.8038 00	.7836 00	.7630 00	.7419 00	.7205 00	.6989 00	.6772 00	.6555 00	.6339 00	.6124 00	0.5
.7913 00	.7660 00	.7396 00	.7131 00	.6861 00	.6589 00	.6317 00	.6045 00	.5775 00	.5507 00	.5243 00	0.6
.7610 00	.7353 00	.7085 00	.6810 00	.6529 00	.6245 00	.5960 00	.5675 00	.5393 00	.5115 00	.4842 00	0.7
.7318 00	.7054 00	.6780 00	.6500 00	.6214 00	.5924 00	.5631 00	.5338 00	.5048 00	.4763 00	.4485 00	0.8
.7037 00	.6768 00	.6490 00	.6206 00	.5910 00	.5611 00	.5310 00	.5011 00	.4717 00	.4430 00	.4151 00	0.9
.6767 00	.6494 00	.6213 00	.5927 00	.5634 00	.5334 00	.5034 00	.4736 00	.4443 00	.4157 00	.3880 00	1.0
.6257 00	.6176 00	.6091 00	.6012 00	.5936 00	.5860 00	.5769 00	.5674 00	.5586 00	.5495 00	.5403 00	1.2
.5789 00	.5695 00	.5615 00	.5529 00	.5444 00	.5351 00	.5267 00	.5166 00	.5074 00	.4975 00	.4878 00	1.4
.5360 00	.5258 00	.5171 00	.5077 00	.4993 00	.4897 00	.4809 00	.4705 00	.4609 00	.4508 00	.4407 00	1.6
.4965 00	.4859 00	.4768 00	.4668 00	.4580 00	.4481 00	.4392 00	.4289 00	.4188 00	.4085 00	.3983 00	1.8
.4599 00	.4479 00	.4386 00	.4289 00	.4201 00	.4102 00	.4012 00	.3909 00	.3806 00	.3702 00	.3600 00	2.0
.4223 00	.4130 00	.4035 00	.3942 00	.3851 00	.3755 00	.3665 00	.3567 00	.3459 00	.3357 00	.3255 00	2.2
.3903 00	.3810 00	.3720 00	.3623 00	.3531 00	.3437 00	.3348 00	.3246 00	.3145 00	.3044 00	.2944 00	2.4
.3601 00	.3515 00	.3426 00	.3331 00	.3245 00	.3147 00	.3058 00	.2955 00	.2860 00	.2761 00	.2663 00	2.6
.3333 00	.3243 00	.3156 00	.3062 00	.2978 00	.2882 00	.2796 00	.2694 00	.2601 00	.2505 00	.2410 00	2.8
.3079 00	.2991 00	.2907 00	.2815 00	.2733 00	.2640 00	.2556 00	.2456 00	.2367 00	.2275 00	.2181 00	3.0
.2526 00	.2445 00	.2366 00	.2282 00	.2206 00	.2120 00	.2043 00	.1952 00	.1870 00	.1785 00	.1702 00	3.5
.2077 00	.1997 00	.1927 00	.1850 00	.1782 00	.1705 00	.1635 00	.1552 00	.1479 00	.1405 00	.1330 00	4.0
.1699 00	.1632 00	.1569 00	.1501 00	.1446 00	.1370 00	.1309 00	.1236 00	.1171 00	.1105 00	.1041 00	4.5
.1398 00	.1333 00	.1278 00	.1218 00	.1168 00	.1102 00	.1049 00	.9863 01	.9269 01	.8719 01	.8166 01	5.0
.1140 00	.1089 00	.1043 00	.9897 01	.9410 01	.8900 01	.8417 01	.7860 01	.7373 01	.6878 01	.6405 01	5.5
.9363 01	.8893 01	.8479 01	.8087 01	.7619 01	.7255 01	.6756 01	.6270 01	.5858 01	.5436 01	.5054 01	6.0
.7690 01	.7268 01	.6907 01	.6518 01	.6168 01	.5780 01	.5420 01	.5015 01	.4669 01	.4303 01	.3961 01	6.5
.6268 01	.5929 01	.5627 01	.5284 01	.4995 01	.4652 01	.4361 01	.4012 01	.3709 01	.3407 01	.3121 01	7.0
.5125 01	.4840 01	.4584 01	.4301 01	.4046 01	.3754 01	.3508 01	.3211 01	.2965 01	.2701 01	.2468 01	7.5
.4195 01	.3951 01	.3734 01	.3497 01	.3279 01	.3052 01	.2823 01	.2579 01	.2357 01	.2144 01	.1943 01	8.0
.3430 01	.3225 01	.3043 01	.2841 01	.2659 01	.2448 01	.2273 01	.2068 01	.1882 01	.1704 01	.1538 01	8.5
.2809 01	.2632 01	.2479 01	.2309 01	.2155 01	.1978 01	.1838 01	.1674 01	.1503 01	.1355 01	.1217 01	9.0
.2297 01	.2148 01	.2020 01	.1877 01	.1748 01	.1595 01	.1476 01	.1326 01	.1208 01	.1078 01	.9669 02	9.5
.1875 01	.1754 01	.1646 01	.1527 01	.1418 01	.1293 01	.1191 01	.1066 01	.9618 02	.8593 02	.7653 02	10.0
.1532 01	.1434 01	.1343 01	.1243 01	.1152 01	.1046 01	.9548 02	.8668 02	.7760 02	.6894 02	.6107 02	10.5
.8362 02	.7766 02	.7252 02	.6695 02	.6185 02	.5651 02	.5206 02	.4763 02	.4366 02	.3987 02	.3655 02	12.0
.5179 02	.4787 02	.4454 02	.4111 02	.3809 02	.3494 02	.3209 02	.2934 02	.2696 02	.2456 02	.2250 02	13.0
.3280 02	.3037 02	.2826 02	.2606 02	.2407 02	.2204 02	.2026 02	.1852 02	.1700 02	.1548 02	.1419 02	14.0
.2079 02	.1926 02	.1792 02	.1652 02	.1524 02	.1394 02	.1279 02	.1169 02	.1072 02	.9768 03	.8948 03	15.0
.1318 02	.1220 02	.1135 02	.1046 02	.9650 03	.8825 03	.8093 03	.7384 03	.6771 03	.6167 03	.5650 03	16.0
.8356 03	.7736 03	.7195 03	.6631 03	.6118 03	.5594 03	.5127 03	.4676 03	.4288 03	.3905 03	.3577 03	17.0
.5297 03	.4903 03	.4559 03	.4201 03	.3876 03	.3543 03	.3247 03	.2962 03	.2716 03	.2473 03	.2265 03	18.0
.3358 03	.3108 03	.2890 03	.2663 03	.2457 03	.2245 03	.2057 03	.1877 03	.1721 03	.1567 03	.1436 03	19.0
.2128 03	.1969 03	.1831 03	.1687 03	.1557 03	.1422 03	.1303 03	.1189 03	.1090 03	.9926 04	.9097 04	20.0
.1349 03	.1248 03	.1161 03	.1069 03	.9866 04	.9017 04	.8260 04	.7536 04	.6910 04	.6293 04	.5768 04	21.0
.8556 04	.7918 04	.7365 04	.6781 04	.6258 04	.5721 04	.5243 04	.4783 04	.4385 04	.3994 04	.3661 04	22.0
.5427 04	.5023 04	.4672 04	.4301 04	.3970 04	.3629 04	.3326 04	.3034 04	.2782 04	.2534 04	.2323 04	23.0
.3443 04	.3186 04	.2964 04	.2729 04	.2519 04	.2303 04	.2111 04	.1926 04	.1766 04	.1609 04	.1474 04	24.0
.2185 04	.2022 04	.1881 04	.1732 04	.1599 04	.1462 04	.1340 04	.1223 04	.1121 04	.1022 04	.9362 05	25.0
.1386 04	.1283 04	.1194 04	.1099 04	.1015 04	.9282 05	.8507 05	.7764 05	.7118 05	.6490 05	.5946 05	26.0
.8797 05	.8142 05	.7577 05	.6975 05	.6441 05	.5890 05	.5399 05	.4927 05	.4517 05	.4119 05	.3774 05	27.0
.5581 05	.5167 05	.4808 05	.4426 05	.4088 05	.3738 05	.3427 05	.3127 05	.2867 05	.2614 05	.2395 05	28.0
.3542 05	.3279 05	.3052 05	.2809 05	.2595 05	.2373 05	.2176 05	.1985 05	.1820 05	.1659 05	.1520 05	29.0
.2248 05	.2081 05	.1937 05	.1783 05	.1647 05	.1506 05	.1381 05	.1260 05	.1155 05	.1053 05	.9650 06	30.0
.1427 05	.1321 05	.1230 05	.1132 05	.1046 05	.9564 06	.8769 06	.8000 06	.7333 06	.6686 06	.6127 06	31.0
.9055 06	.8386 06	.7807 06	.7186 06	.6640 06	.6072 06	.5566 06	.5078 06	.4655 06	.4245 06	.3890 06	32.0
.5748 06	.5324 06	.4957 06	.4563 06	.4217 06	.3856 06	.3535 06	.3225 06	.2957 06	.2696 06	.2471 06	33.0
.3650 06	.3381 06	.3148 06	.2898 06	.2678 06	.2449 06	.2245 06	.2048 06	.1878 06	.1712 06	.1569 06	34.0
.2318 06	.2147 06	.1999 06	.1840 06	.1701 06	.1555 06	.1426 06	.1300 06	.1193 06	.1087 06	.9966 07	35.0
.1472 06	.1364 06	.1270 06	.1169 06	.1080 06	.9877 07	.9057 07	.8256 07	.7577 07	.6906 07	.6331 07	36.0
.9348 07	.8662 07	.8066 07	.7424 07	.6862 07	.6276 07	.5756 07	.5248 07	.4816 07	.4390 07	.4026 07	37.0
.5938 07	.5502 07	.5124 07	.4717 07	.4361 07	.3988 07	.3657 07	.3335 07	.3060 07	.2790 07	.2559 07	38.0
.3772 07	.3496 07	.3256 07	.2997 07	.2771 07	.2534 07	.2324 07	.2120 07	.1945 07	.1774 07	.1627 07	39.0
.2397 07	.2221 07	.2069 07	.1905 07	.1761 07	.1610 07	.1477 07	.1347 07	.1236 07	.1127 07	.1034 07	40.0
.1523 07	.1411 07	.1314 07	.1210 07	.1119 07	.1023 07	.9386 08	.8559 08	.7853 08	.7160 08	.6569 08	41.0
.9679 08	.8969 08	.8352 08	.7691 08	.7112 08	.6503 08	.5966 08	.5442 08	.4993 08	.4553 08	.4178 08	42.0
.6153 08	.5702 08	.5310 08	.4890 08	.4522 08	.4135 08	.3793 08	.3460 08	.3175 08	.2895 08	.2657 08	43.0
.3911 08	.3624 08	.3376 08	.3109 08	.2875 08	.2629 08	.2412 08	.2200 08	.2019 08	.1841 08	.1689 08	44.0
.2487 08	.2304 08	.2146 08	.1976 08	.1828 08	.1671 08	.1533 08	.1399 08	.1284 08	.1171 08	.1074 08	45.0
.1581 08	.1465 08	.1364 08	.1256 08	.1162 08	.1062 08	.9749 09	.8900 09	.8166 09	.7445 09	.6829 09	46.0
.1005 08	.9312 09	.8671 09	.7984 09	.7387 09	.6753 09	.6197 09	.5654 09	.5187 09	.4729 09	.4338 09	47.0
.6389 09	.5919 09	.5511 09	.5076 09	.4696 09	.4293 09	.3939 09	.3594 09	.3297 09	.3007 09	.2758 09	48.0
.4062 09	.3764 09	.3505 09	.3228 09	.2986 09	.2730 09	.2504 09	.2285 09	.2096 09	.1911 09	.1753 09	49.0
.2582 09	.2393 09	.2228 09	.2052 09	.1898 09	.1735 09	.1592 09	.1452 09	.1332 09	.1215 09	.1114 09	50.0

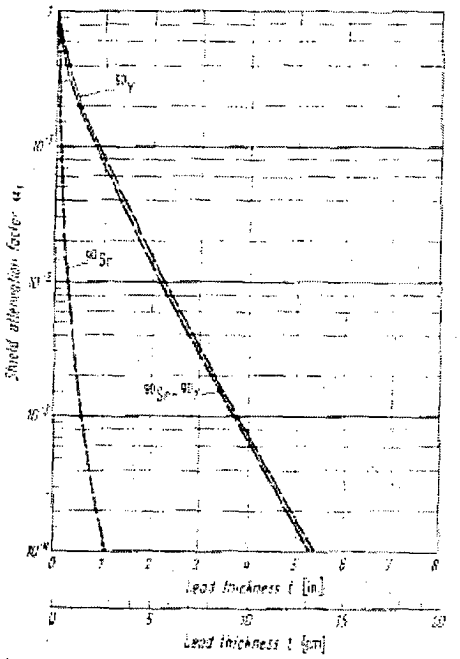


Fig. 9.1.–7. Radiation dose rate shield attenuation factor for ^{90}Sr, $^{90}Sr-^{90}Y$ and ^{90}Y as function of lead shield thickness [4].
Note: All curves are for bremsstrahlung.

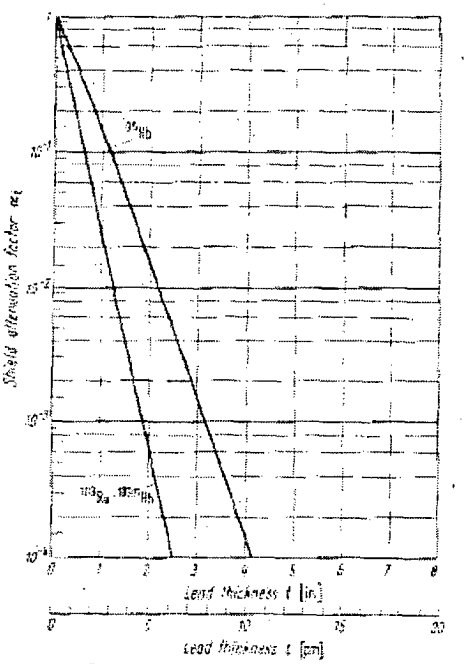


Fig. 9.1.–9. Radiation dose rate shield attenuation factor for ^{95}Nb and $^{103}Ru-^{103m}Rh$ as a function of lead shield thickness [4].

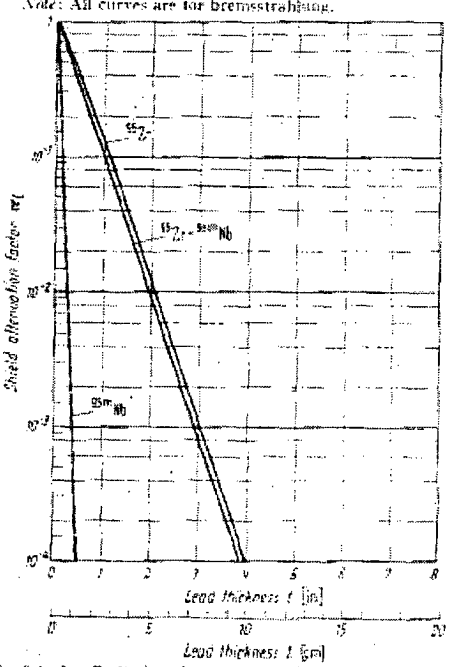


Fig. 9.1.–8. Radiation dose rate shield attenuation factor for ^{95}Zr, $^{95}Zr-^{95m}Nb$ and ^{95m}Nb as a function of lead shield thickness [4].

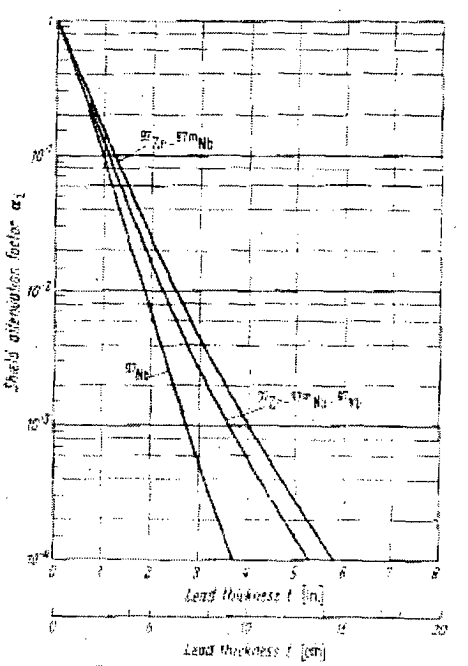


Fig. 9.1.–10. Radiation dose rate shield attenuation factor for ^{97}Nb, $^{97}Zr-^{97m}Nb$ and $^{97}Zr-^{97m}Nb-^{97}Nb$ as a function of lead shield thickness [4].

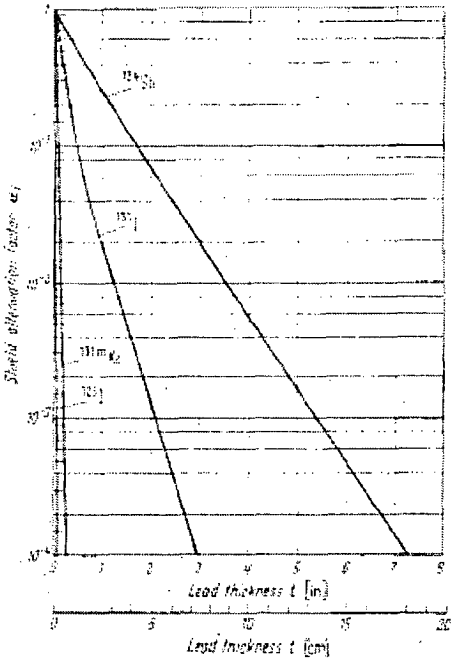


Fig. 9.1.–11. Radiation dose rate shield attenuation factor for ^{124}Sb, ^{133}I, ^{133}I and ^{135m}Xe as a function of lead shield thickness [4].

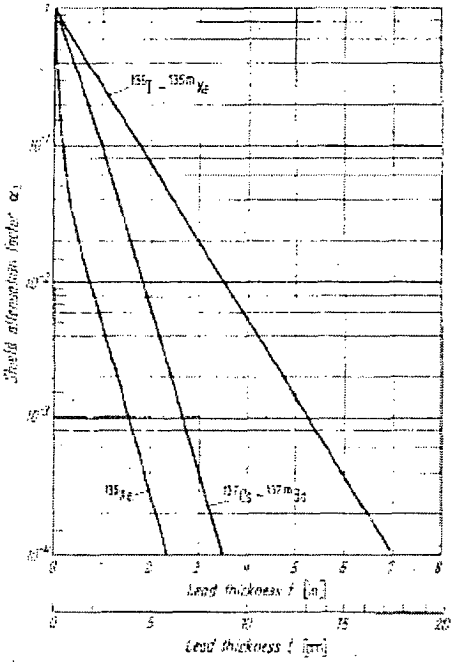


Fig. 9.1.–13. Radiation dose rate shield attenuation factor for ^{133}Xe, ^{135}I–^{135m}Xe and ^{137}Cs–^{137m}Ba as a function of lead shield thickness [4].

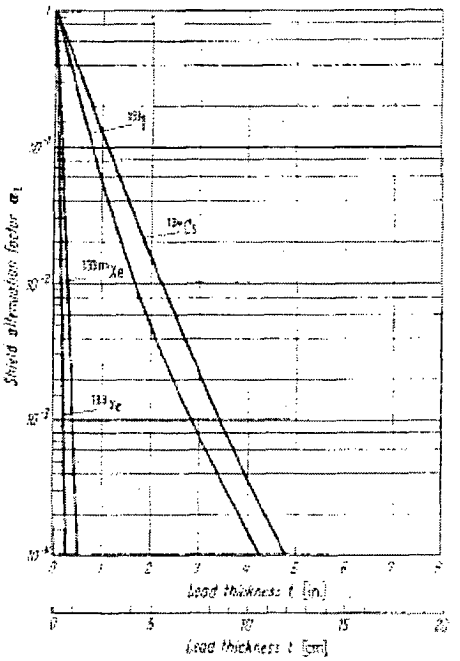


Fig. 9.1.–12. Radiation dose rate shield attenuation factor for ^{133}I, ^{133}Xe, ^{133m}Xe and ^{134}Cs a function of lead shield thickness [4].

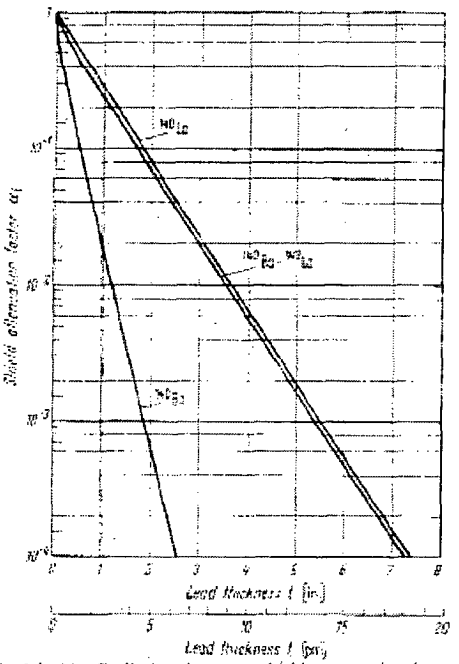


Fig. 9.1.–14. Radiation dose rate shield attenuation factor for ^{140}Ba, ^{140}La and ^{140}Ba–^{140}La as a function of lead shield thickness [4].

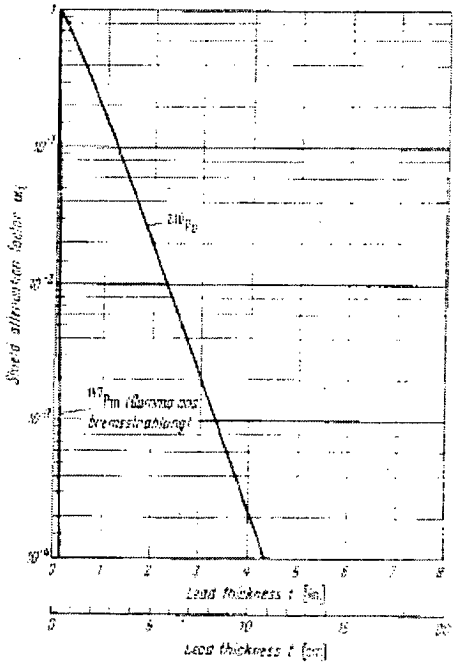


Fig. 9.1.–15. Radiation dose rate shield attenuation factor for ^{147}Pm and ^{210}Po as a function of lead shield thickness [4].

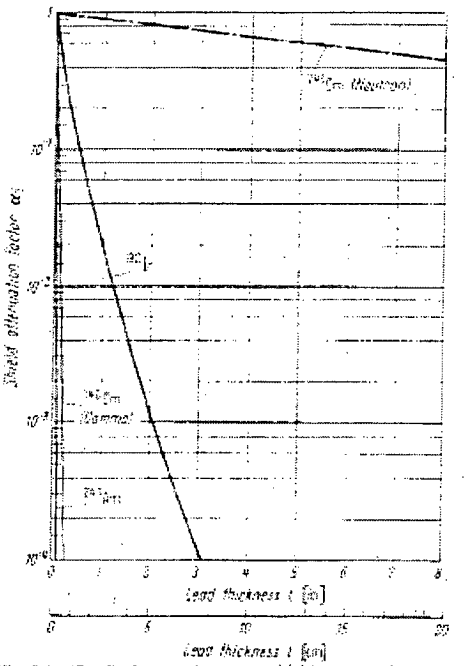


Fig. 9.1.–17. Radiation dose rate shield attenuation factor for ^{192}Ir, ^{241}Am and ^{242}Cm as a function of lead shield thickness [4].

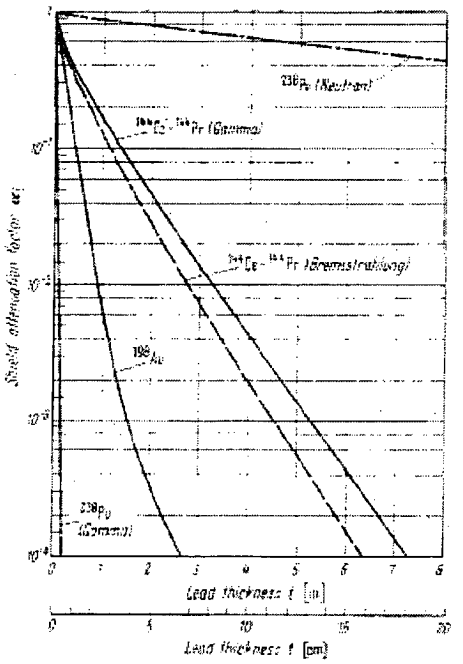


Fig. 9.1.–16. Radiation dose rate shield attenuation factor for ^{144}Ce–^{144}Pr, ^{198}Au and ^{238}Pu as a function of lead shield thickness [4].

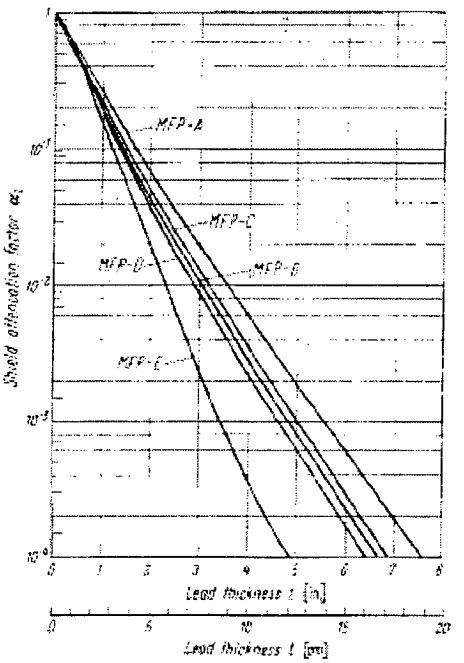


Fig. 9.1.–18. Radiation dose rate shield attenuation factor for mixed fission products as a function of lead shield thickness [4].

for conditions of infinitely long irradiation time and five specific decay times as follows:

Designation	Decay time
MFP-A	1 hour
MFP-B	1 day
MFP-C	10 days
MFP-D	1 month
MFP-E	6 months

The curves can be used to calculate the dose rate D_i at a distance R in feet from a point source containing A_i curies of radioisotope i with t inches of the specified shielding material as follows

$$D_i = A_i D_i \alpha_i [\text{mrem/h}],$$

where

D_i unshielded dose rate per curie of the radioisotope i (per watt of operating power for mixed fission products).

α_i shield (exposure) attenuation factor including buildup for isotope i.

The function D_i is shown for each isotope, isotope combination, and mixed fission product as a function of R in Sec. 9.1.14.

Figures 9.1.–3 through –18 are for a point source of radiation. Other geometrical forms for the radiation source can be approximated by the methods given in Sec. 6.7. (Vol. 1).

No significant radiation effects on the physical and mechanical properties of lead have been reported [5].

B. Physical Properties

Table 9.1.4 lists the applicable properties of lead.

Table 9.1.–4. Physical properties of lead [1].

Melting point [°C]	327.4
Density, solid [g/cm³]	
cast	11.34
extruded	11.35
rolled	11.36
at 327.4 °C	11.00
Specific heat [cal/g]	
0 °C	0.0303
25	0.0307
50	0.0309
100	0.0315
200	0.0325
300	0.0335
327.4	0.0340
Thermal conductivity [cal cm⁻¹ s⁻¹ °C⁻¹]	
0 °C	0.083
100	0.081
200	0.077
Coefficient of thermal expansion, 10^{-6} per °C	
Linear, 10 °C to 100 °C	29.5
Cubical, average	85.0
Solidification shrinkage [%]	3.85

C. Mechanical Properties

Unless alloyed, lead is a relatively weak structural material, therefore it is not used for strength purposes except to support its own weight in the shield geometry. In most cases, additional support is required to confine the lead because of its high creep and low melting point. Where stronger lead is required, antimony is the commonly used alloying agent. Heat treatments of lead to improve strength and creep have only a temporary effect. Therefore, heat treated lead should not be used for long-term installations.

Table 9.1.–5 lists the mechanical properties of lead and some of the most common lead alloys. Table 9.1.–6 lists the safe maximum allowable stress for chemical lead and 6% antimonial lead.

D. Chemical Properties

Lead possesses excellent corrosion resistance to normal shield environments including acids, e.g., the nitric acid formed when air and water appear in a radiation environment.

Table 9.1.–7 lists the chemical composition of commercially available lead and some lead alloys.

9.1.1.4. FABRICATION

Lead is easily cast, extruded, rolled, machined, and welded. It can be purchased in the form of pig, slab, sheet, shot, powder, and brick. Although lead alloys may be purchased, the nonalloyed lead is standard. Table 9.1.–8 lists standard products as to chemical composition and sizes. (*Note:* When lead is vaporized, as during casting and welding, the fumes are toxic and precautionary measures must be taken.)

ALLOYS

Alloys of lead are numerous and continuously increasing to meet specific shielding needs. These alloys are created not only to change mechanical properties but also to attenuate a broad spectrum of various types and energies of radiation (see Sec. 9.2.1.).

9.1.1.5. APPLICATIONS AND DESIGN CONSIDERATIONS

Lead is usually selected as the shielding material against gamma radiation on the basis of comparison with other gamma shield materials such as water, concrete and steel. The comparison (trade-off evaluation) normally includes factors such as gamma-energy spectra and intensities; source size and configuration; spectra of other types of radiations; material properties; area, volume, and weight limitations; environmental conditions, e.g., temperature; attenuation required; proximity of shield to source; and economics.

In addition to the standard lead products listed in Table 9.1.–8, special products are available to meet design requirements. These include pours to the required design configurations of shields, often with integral cooling provisions; mixtures and alloys with other elements to enhance certain material characteristics; and products that will attenuate broad-spectrum radiation.

Table 9.1–5. Mechanical properties of lead [6]
[1 psi = 0.07 kg/cm²]

Melting point [°C]	Lead or alloy	Form a)	Density [g/cm³]	Hardness (Brinell)	Strengths					Elong. [%]	Young's modulus [10⁶ psi]
					Tensile [psi]	Compr. (25% def.) [psi]	Yield (0.125) [psi]	Fatigue [psi]	Creep [0.2% d/yr] [psi]		
327.4	pure	c	11.34	4.0	1 900	2 200	360	—	—	45	—
	corroding	e	11.35	—	—	—	—	—	—	—	—
	refined	r	11.36	3.8	1760	—	—	470	170	53	2.0
325.6	chemical	c	11.34	5.2	2 600	2 900	1 640	—	—	45	—
	undesilverized	e	11.35	—	2 500	—	—	—	—	50	—
		r	11.36	4.7	2 400	2 600	1 250	725	225	51	2.5
326	0.04 Te	c	11.34	5.7	3 000	3 200	3 000	—	—	45	—
	chemical	r	11.36	5.5	2 800	—	—	1 000	—	47	—
251 – 299	4% Sb	c	11.04	10.0	5 400	7 200	2 700	2 100	250	25	3.0
251 – 290	5% Sb	c	10.95	10.9	6 100	8 400	2 900	2 300	240	23	3.3
251 – 285	6% Sb	c	10.88	11.6	6 600	8 600	3 000	2 500	230	22	3.5
		c	—	—	4 500	—	—	—	—	41	—
		r	—	8.7	4 300	—	2 300	1 500	—	42	—
251 – 259	10% Sb	c	10.59	13.8	7 400	9 800	3 200	2 700	—	16	4.0
246 – 256	10% Sb, 5% Sn	c	10.24	19.0	10 000	14 500	3 400	—	—	5	4.2

a) c = cast, e = extruded, r = rolled.

Table 9.1–6. Maximum allowable stress of lead [1]
[1 psi = 0.07 kg/cm²]

Temperature [°C]	[°F]	Chemical lead a) [psi]	6% antim. lead b) [psi]
20	68	200	300
40	104	180	255
60	140	162	215
80	176	144	170
100	212	127	128
120	248	110	85
140	284	90	40
160	320	70	
180	356	45	—

a) Based on 1% creep in 30 years.
b) Based on 1% creep in 4 years.

Table 9.1–7. Chemical composition of commercial lead [7]

Type	Chemical composition [wt. %]								
	Pb min.	Ag max.	Cu max.	Sn max.	Fe max.	As – Sb – Sn max.	Zn max.	Bi max.	Other
Corroding lead	99.94	0.00154	0.00154)	—	0.002	Sb + Sn, 0.0095 max.	0.0015	0.05	As, 0.0015 max.
Chemical lead	99.90	0.002 – 0.020	0.040 – 0.060	—	0.002	0.002	0.001	0.005	—
Acid lead	99.90	0.002	0.040 – 0.040	—	0.002	0.002	0.001	0.025	—
Copper lead	99.85	0.020	0.040 – 0.080	—	0.002	0.015	0.002	0.10	—
Desilverized lead A	99.85	0.002	0.0025	—	0.002	0.015	0.002	0.15	—
Desilverized lead B	99.75	0.002	0.0025	—	0.002	0.015	0.002	0.25	—
Unsilverized lead	99.93	0.002	0.04	—	0.002	0.015	0.002	0.005	—
Calcium lead	99.8	0.002 – 0.02	0.02 – 0.10	0.005			—	0.005	Ca, 0.023 – 0.033
Tellurium lead	99.84		0.06		—	—	—	—	Te, 0.05 max.

a) Silver + copper, 0.0025 maximum.

Table 9.1–8. Standard lead products[a]
(1 in. = 25.4 mm)

Form	Chemical composition[b]	Available sizes
Pig	Corroding lead Chemical lead Desilverized lead A	
Sheet	Chemical lead	1/88 in. to 1 in. thick (flat stock and rolls)
Drop shot	99.5% Pb min. 0.5% As max.	fine dust to 0.19 in.
Buck shot	Desilverized lead A	0.25 in. to 0.36 in.
Chilled shot	97.5% Pb min. 2.0% Sb max. 0.5% As max.	0.03 in. to 0.16 in.
Brick	Chemical lead	Plain – 2 in. × 3 in. × 6 in. 2 in. × 4 in. × 8 in. 2 in. × 6 in. × 8 in.
		Special – interlocking, curved surface, includes corners (sizes same as plain)

[a] Personal communication with National Lead Company.
[b] See Table 9.1–7.

For equivalent gamma-radiation attenuation, lead shields are lighter in weight than steel or concrete shields. When placed close to the source, lead is cheaper than steel for shielding against low-energy gamma rays. Because the use of lead requires a smaller volume than steel or other common shield materials for the same shielding effectiveness, it is used more often in mobile shields and shipping containers. Placing the lead near the source will usually require the least material, but the temperature near the source may limit its use or cooling may be required to dissipate the heat.

Mixtures containing lead are versatile and provide good shielding properties. Some are commercially available. For example, tests indicate that metallic mixes (lead and iron) with glycerolate binders make highly effective biological shields [6]. These shields have a density lower than that of lead; however, the shielding is more homogeneous and efficient. Stability is good up to 150 °C and mechanical strength for fixed structures is considered satisfactory. These shields contain materials more expensive than conventional materials, but are useful when small dimensions and bulk are required, e.g., shielding for transportable containers.

Problems usually arise from inadequate design and poor control of lead pours. The primary problems are voids and shrinkage (solidification shrinkage is about 4%). Inadequate design results in the inability to pour lead so that solidification can take place properly and gases can escape.

Adequate contact with heat transfer surfaces, such as container walls and cooling ducts, should be maintained. Even with good design a poor lead pour can result by use of improper procedure, such as not preheating the container; or stopping a pour before it is complete without making adequate provision to resume the pour, such as providing steps so that there is no loss of shielding effectiveness (cracks). Maintaining the correct pour temperature (too high a temperature is as detrimental as too low) and temperature control are also important. It is advisable to use virgin lead; scrap lead may contain contaminants such as tin. The contaminates can reduce the shield density or vaporize and cause gas pockets. It is advisable to check the shielding effectiveness with an isotope source as a guarantee of adequacy.

9.1.2. STEEL (IRON AND IRON ALLOYS)

by E. E. Hamer and A. E. McArthy

9.1.2.1. INTRODUCTION

For shield analysis, the properties for pure iron may often be used, even though the components themselves are made of steel. The alloying elements in steel generally are not of sufficient quantity to influence gamma ray attenuation, and only in special cases would a correction for differing density be of significance. The density of pure iron is 7.87 g/cm³ and its melting point is 1536 °C [9]. The choice of a particular steel is not based on its shielding properties alone, but also on strength, toughness, corrosion resistance, and other properties that may be needed for a particular shield design.

9.1.2.2. OCCURRENCE AND EXTRACTION

Iron ore (Hematite, Limonite, Magnetite, Siderite and Taconite) constitutes up to about 5% of the earth's crust. Pig iron is the direct product of the blast furnace; ingot iron is purified pig; wrought iron contains mechanically mixed slag; cast iron is recast pig with scrap; other forms of iron, includ-

ing steel, are made by adjusting the concentrations of alloying elements and impurities in order to develop specific properties.

9.1.2.3. PROPERTIES

A. Nuclear Properties

Iron and steel make excellent gamma shields. Tables 9.1.-1 and -2 compares thicknesses and weights of steel with five other materials for equivalent gamma ray shielding. Although not as effective as lead, the improved structural properties and economy of iron and steel may be compensating factors; namely, it may be cheaper to use iron or steel even though the volume requirement is larger than for lead.

Gamma-ray attenuation properties are generally proportional to density. Table 4.1.-3 (Vol. I, p. 174) lists values of the gamma ray mass-attenuation coefficient, μ/ϱ [cm²/g]; Table 4.1.-9 (Vol. I, p. 182) lists values of the mass-energy-transfer coefficient, μ_{tr}/ϱ, and the mass-energy-absorption coefficient, μ_{en}/ϱ. See also this volume, pages 201 and 218.

Figures 9.1.-19 and -20 and Table 9.1.-9 show the exposure-attenuation factors for broad-beam gamma radiation of a point isotropic source in steel for various energies of incident gamma radiation as a function of steel thickness [3]. Section 9.1.1. describes the use of the exposure-attenuation factor to determine the dose rate at a specified distance from a point source.

Figures 9.1.-21 through -36 show the shield (exposure)-attenuation factor, A_f, for the radiation dose rate as a function of the steel shield thickness for a large number of radioisotopes and certain isotope combinations [4]. Included are curves (Fig. 9.1.-36) for mixed fission products (MFP-) for conditions of infinitely long irradiation time and five specific decay times as follows:

Designation	Decay time
MFP-A	1 hour
MFP-B	1 day
MFP-C	10 days
MFP-D	3 month
MFP-E	6 months

Section 9.1.1. describes the use of the curves to determine the dose rate at a specified distance from a radioactive point source through a given shield thickness.

B. Physical and Mechanical Properties

Ingot iron is commercially pure iron that is tough, ductile and corrosion resistant when it is unstressed in the annealed state. It also has good magnetic and electrical properties. The microstructure of Armco ingot iron (made by the basic open-hearth process) consists of a simple network of grain boundaries characteristic of pure metals. Only the ferrite phase is present. The size and

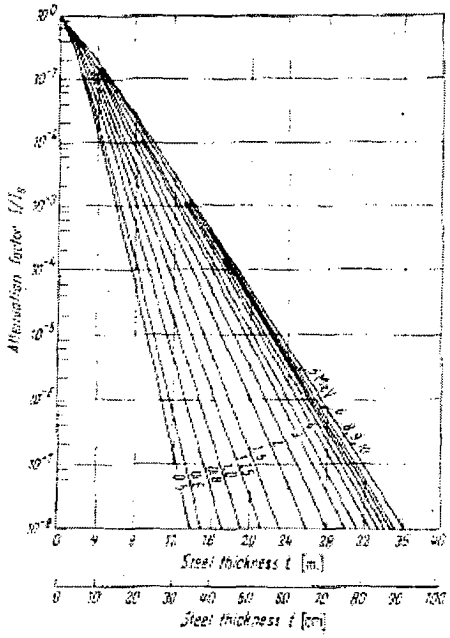


Fig. 9.1.-19. Exposure attenuation factors I/I_0 for broad-beam gamma radiation of a point isotropic source in steel (ϱ = 7860 kg/m³) in dependence on the energy of incident gamma radiation, E_0 [3].

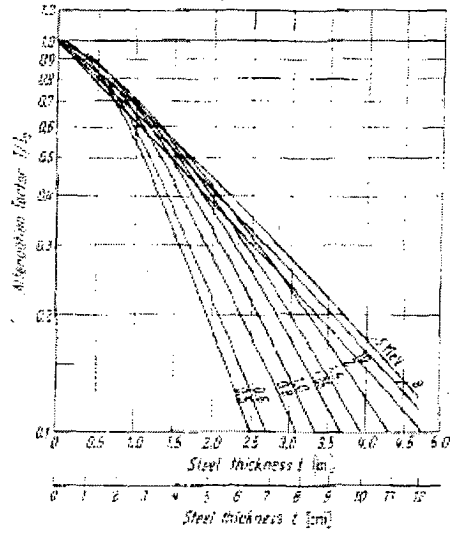


Fig. 9.1.-20. Exposure attenuation factors I/I_0 for broad-beam gamma radiation of a point isotropic source in steel (ϱ = 7860 kg/m³) in dependence on the energy of incident gamma radiation, E_0 [3].

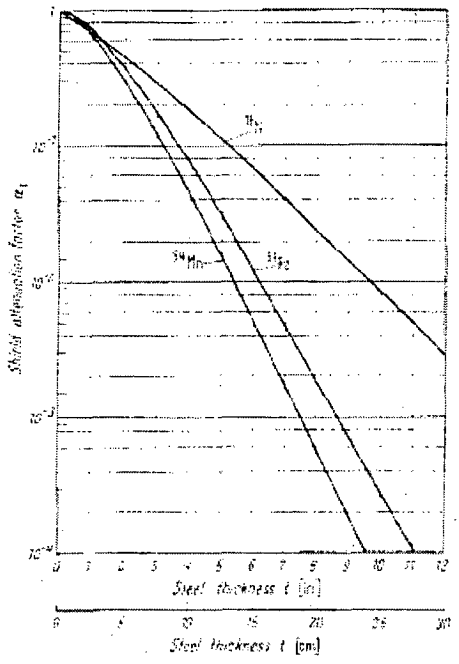


Fig. 9.1.–21. Radiation dose rate shield attenuation factor for ^{16}N, ^{54}Mn and ^{59}Fe as a function of steel shield thickness [4].

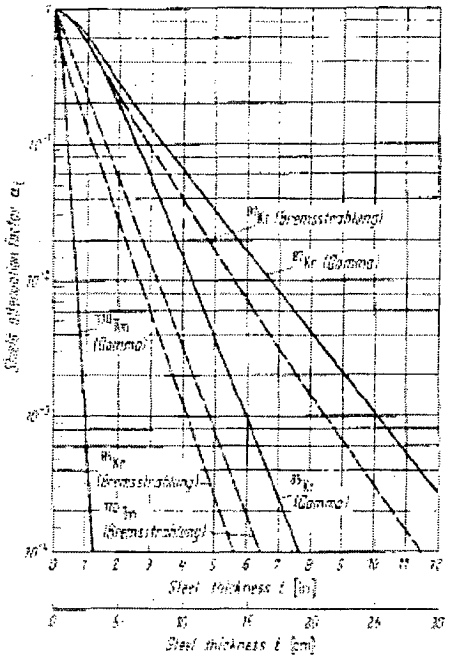


Fig. 9.1.–23. Radiation dose rate shield attenuation factor for ^{85}Kr, ^{87}Kr and ^{169}Tm as a function of steel shield thickness [4].

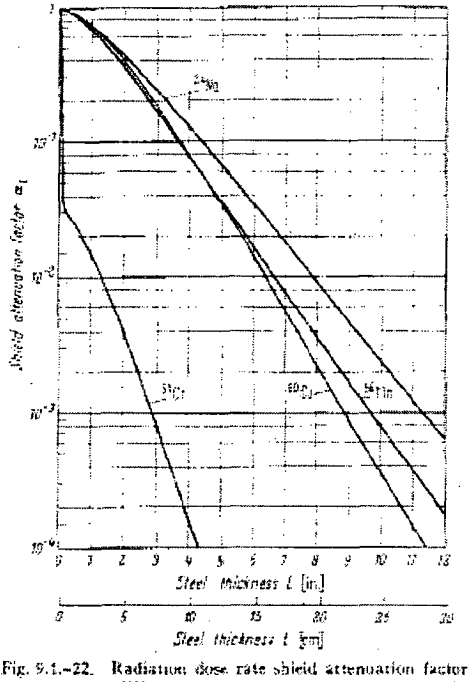


Fig. 9.1.–22. Radiation dose rate shield attenuation factor for ^{24}Na, ^{51}Cr, ^{54}Mn and ^{60}Co as a function of steel shield thickness [4].

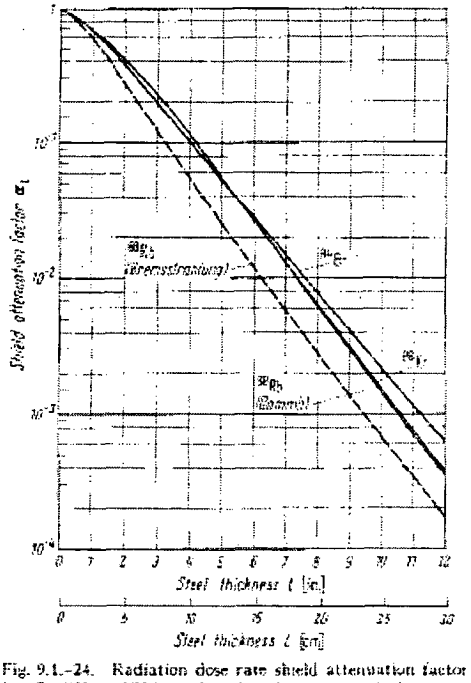


Fig. 9.1.–24. Radiation dose rate shield attenuation factor for ^{82}Br, ^{85}Kr and ^{86}Rb as a function of steel shield thickness [4].
Note: The curve for ^{85}Kr–^{86}Rb (gamma) falls between the individual curves for ^{85}Kr and ^{86}Rb (gamma). In the interest of clarity, the curve for the combined isotopes is not shown.

Table 9.1.–9. Exposure attenuation factors I/I_0 for broad beam gamma radiation of a point isotropic source in *steel* ($\varrho = 7\,860$ kg/m^3) in dependence on the energy of incident gamma radiation E_0 [1]

Note: Attenuation factor .4054 08– read: $0.4054 \cdot 10^{-8}$

r [cm]	E_0 [MeV] 0.5	0.6	0.8	1.0	1.25	1.5	2.0	2.5	3.0	3.5	4.0	4.5
0.1	.1001 01	.1001 01	.1000 01	.9995 00	.9990 00	.9980 00	.9910 00	.9893 00	.9885 00	.9877 00	.9873 00	.9869 00
0.2	.9995 00	.9994 00	.9983 00	.9955 00	.9923 00	.9888 00	.9818 00	.9756 00	.9730 00	.9714 00	.9715 00	.9753 00
0.3	.9979 00	.9946 00	.9936 00	.9907 00	.9865 00	.9818 00	.9722 00	.9617 00	.9564 00	.9539 00	.9521 00	.9598 00
0.4	.9953 00	.9872 00	.9874 00	.9844 00	.9792 00	.9739 00	.9622 00	.9565 00	.9533 00	.9505 00	.9490 00	.9465 00
0.5	.9741 00	.9775 00	.9798 00	.9767 00	.9712 00	.9655 00	.9532 00	.9468 00	.9419 00	.9385 00	.9362 00	.9332 00
0.6	.9608 00	.9650 00	.9694 00	.9678 00	.9622 00	.9559 00	.9411 00	.9336 00	.9300 00	.9256 00	.9235 00	.9201 00
0.7	.9452 00	.9524 00	.9582 00	.9577 00	.9523 00	.9460 00	.9301 00	.9219 00	.9181 00	.9131 00	.9108 00	.9070 00
0.8	.9282 00	.9374 00	.9458 00	.9466 00	.9417 00	.9359 00	.9186 00	.9101 00	.9060 00	.9006 00	.8980 00	.8940 00
0.9	.9098 00	.9212 00	.9323 00	.9345 00	.9304 00	.9246 00	.9073 00	.8982 00	.8940 00	.8881 00	.8856 00	.8811 00
1.0	.8903 00	.9050 00	.9179 00	.9227 00	.9188 00	.9130 00	.8955 00	.8862 00	.8819 00	.8757 00	.8731 00	.8685 00
1.2	.8505 00	.8665 00	.8834 00	.8941 00	.8955 00	.8899 00	.8734 00	.8632 00	.8578 00	.8509 00	.8468 00	.8429 00
1.4	.8063 00	.8266 00	.8527 00	.8682 00	.8663 00	.8635 00	.8467 00	.8373 00	.8324 00	.8255 00	.8217 00	.8180 00
1.6	.7585 00	.7851 00	.8222 00	.8428 00	.8380 00	.8372 00	.8216 00	.8127 00	.8080 00	.8019 00	.7994 00	.7935 00
1.8	.7089 00	.7489 00	.7907 00	.8204 00	.8089 00	.8122 00	.7963 00	.7881 00	.7832 00	.7776 00	.7755 00	.7694 00
2.0	.6614 00	.7006 00	.7457 00	.7873 00	.7791 00	.7826 00	.7708 00	.7635 00	.7604 00	.7546 00	.7520 00	.7457 00
2.4	.5795 00	.6177 00	.6608 00	.7006 00	.7190 00	.7270 00	.7201 00	.7150 00	.7145 00	.7075 00	.7062 00	.7000 00
2.8	.4980 00	.5396 00	.5961 00	.6548 00	.6945 00	.6747 00	.6701 00	.6676 00	.6689 00	.6625 00	.6622 00	.6581 00
3.2	.4243 00	.4672 00	.5295 00	.5925 00	.6015 00	.6175 00	.6211 00	.6217 00	.6263 00	.6194 00	.6200 00	.6163 00
3.6	.3589 00	.4019 00	.4676 00	.5335 00	.5496 00	.5683 00	.5746 00	.5776 00	.5867 00	.5761 00	.5797 00	.5745 00
4.0	.3017 00	.3431 00	.4097 00	.4758 00	.4954 00	.5184 00	.5266 00	.5324 00	.5484 00	.5368 00	.5423 00	.5366 00
4.4	.2524 00	.2926 00	.3575 00	.4229 00	.4465 00	.4743 00	.4872 00	.4964 00	.5061 00	.5014 00	.5069 00	.5000 00
4.8	.2101 00	.2479 00	.3108 00	.3761 00	.4021 00	.4340 00	.4513 00	.4675 00	.4877 00	.4861 00	.4934 00	.4870 00
5.2	.1745 00	.2099 00	.2693 00	.3357 00	.3625 00	.3980 00	.4207 00	.4418 00	.4734 00	.4587 00	.4699 00	.4650 00
5.6	.1446 00	.1781 00	.2385 00	.2775 00	.3270 00	.3661 00	.3966 00	.4183 00	.4611 00	.4413 00	.4672 00	.4604 00
6.0	.1287 00	.1477 00	.2000 00	.2435 00	.2942 00	.3396 00	.3819 00	.3970 00	.4707 00	.4317 00	.4583 00	.4566 00
7.0	.7830 01-	.9418 01-	.1564 00	.1754 00	.2111 00	.2596 00	.2705 00	.2877 00	.3656 00	.3258 00	.3536 00	.3538 00
8.0	.4345 01-	.5924 01-	.9178 01-	.1222 00	.1551 00	.1932 00	.2121 00	.2305 00	.2963 00	.2562 00	.2980 00	.2994 00
9.0	.2583 01-	.3606 01-	.6112 01-	.8534 01-	.1139 00	.1366 00	.1632 00	.1832 00	.1991 00	.2009 00	.2327 00	.2341 00
10.0	.1529 01-	.2276 01-	.4039 01-	.5912 01-	.8171 01-	.1014 00	.1260 00	.1451 00	.1603 00	.1654 00	.1942 00	.1962 00
12.0	.5283 02-	.8504 02-	.1750 01-	.2705 01-	.4281 01-	.5550 01-	.7578 01-	.8998 01-	.1007 00	.1079 00	.1258 00	.1285 00
14.0	.1799 02-	.3122 02-	.7906 02-	.1298 01-	.2121 01-	.2965 01-	.4419 01-	.5461 01-	.6608 01-	.6958 01-	.7651 01-	.7888 01-
16.0	.5976 03-	.1122 02-	.3407 02-	.5972 02-	.1007 01-	.1536 01-	.2547 01-	.3189 01-	.4038 01-	.4449 01-	.4984 01-	.5899 01-
18.0	.1942 03-	.3999 03-	.1451 02-	.2647 02-	.5211 02-	.8330 02-	.1495 01-	.1954 01-	.2580 01-	.2980 01-	.3233 01-	.3621 01-
20.0	.5987 04-	.1412 03-	.6093 03-	.1158 02-	.2547 02-	.4342 02-	.8849 02-	.1195 01-	.1578 01-	.1781 01-	.2056 01-	.2235 01-
22.0	.1899 04-	.4963 04-	.2011 03-	.5258 03-	.1237 02-	.2258 02-	.4687 02-	.7012 02-	.9661 02-	.1218 01-	.1559 01-	.1454 01-
24.0	.6011 05-	.1726 04-	.6853 04-	.2438 03-	.5972 03-	.1150 02-	.2606 02-	.4125 02-	.5914 02-	.6991 02-	.9167 02-	.9626 02-
26.0	.1899 05-	.5909 05-	.2309 04-	.1018 03-	.2899 03-	.5937 03-	.1463 02-	.2428 02-	.3606 02-	.4335 02-	.5466 02-	.6046 02-
28.0	.5978 06-	.2006 05-	.7873 04-	.4454 04-	.1373 03-	.3032 03-	.8093 03-	.1438 02-	.2191 02-	.2708 02-	.3469 02-	.3982 02-
30.0	.1875 06-	.7128 05-	.2636 05-	.1942 04-	.6552 04-	.1545 03-	.4480 03-	.8267 03-	.1328 02-	.1678 02-	.2198 02-	.2520 02-
32.0	.5806 07-	.2447 05-	.8907 05-	.8443 05-	.3117 04-	.7853 04-	.2476 03-	.4809 03-	.8027 03-	.1032 02-	.1389 02-	.1612 02-
34.0	.1811 07-	.8387 07-	.3022 06-	.3661 05-	.1479 04-	.3966 04-	.1365 03-	.2793 03-	.4861 03-	.6364 03-	.8766 03-	.1053 02-
36.0	.5706 08-	.2896 07-	.1031 06-	.1584 05-	.7004 05-	.1804 04-	.7513 04-	.1613 03-	.2913 03-	.3915 03-	.5521 03-	.6801 03-
38.0	.1806 08-	.9956 08-	.3504 06-	.6847 06-	.3318 05-	.1010 04-	.4127 04-	.9319 04-	.1750 03-	.2408 03-	.3411 03-	.4218 03-
40.0	.5857 09-	.3436 08-	.1213 06-	.2955 06-	.1568 05-	.5609 05-	.2263 04-	.5376 04-	.1050 03-	.1473 03-	.2179 03-	.2681 03-
42.0	.1796 09-	.1200 08-	.4142 07-	.1279 06-	.7366 06-	.3139 05-	.1255 04-	.3098 04-	.6251 04-	.9018 04-	.1366 03-	.1705 03-
44.0		.4094 09-	.1434 07-	.5475 07-	.3460 06-	.1809 05-	.6778 05-	.1781 04-	.3784 04-	.5514 04-	.8557 04-	.1083 03-
46.0			.4949 08-	.2353 07-	.1630 06-	.1048 05-	.3705 05-	.1023 04-	.2269 04-	.3360 04-	.5353 04-	.6775 04-
48.0			.1342 08-	.1018 07-	.7667 07-	.5231 06-	.2021 05-	.5877 05-	.1345 04-	.2057 04-	.3345 04-	.4329 04-
50.0			.4485 09-	.4331 08-	.3599 07-	.1618 06-	.1102 05-	.3371 05-	.8013 05-	.1263 04-	.2089 04-	.2762 04-
52.0			.1734 09-	.1932 08-	.1686 07-	.8079 07-	.6006 06-	.1932 05-	.4776 05-	.7635 05-	.1303 04-	.1748 04-
54.0				.8841 09-	.7904 08-	.4030 07-	.3270 06-	.1106 05-	.2845 05-	.4648 05-	.8125 05-	.1100 04-
56.0				.3512 09-	.3697 08-	.2024 07-	.1779 06-	.6333 06-	.1695 05-	.2827 05-	.5063 05-	.6904 05-
58.0					.1730 08-	.1011 07-	.9680 07-	.3622 06-	.1007 05-	.1719 05-	.3154 05-	.4319 05-
60.0					.8349 09-	.5231 08-	.5268 07-	.2073 06-	.5990 06-	.1044 05-	.1963 05-	.2701 05-
62.0					.3894 09-	.2555 08-	.2852 07-	.1183 06-	.3559 06-	.6347 06-	.1221 05-	.1761 05-
64.0					.1816 09-	.1290 08-	.1553 07-	.6750 07-	.2120 06-	.3855 06-	.7397 06-	.1111 05-
66.0						.6488 09-	.8432 08-	.3959 07-	.1255 06-	.2290 06-	.4492 06-	.7018 06-
68.0						.3295 09-	.4709 08-	.2301 07-	.7452 07-	.1425 06-	.2934 06-	.4661 06-
70.0							.2648 08-	.1357 07-	.4422 07-	.8808 06-	.1886 06-	.2986 06-
72.0							.1579 08-	.7176 08-	.2682 07-	.5218 07-	.1232 06-	.1956 06-
74.0							.9402 09-	.4000 08-	.1559 07-	.3365 07-	.7987 07-	.1300 06-
76.0							.5678 09-	.2569 08-	.9801 08-	.1918 07-	.4561 07-	.7666 07-
78.0							.3468 09-	.1558 08-	.5613 08-	.1161 07-	.2706 07-	.4566 07-
80.0							.2129 09-	.9729 09-	.3319 08-	.7054 08-	.1675 07-	.2761 07-
82.0							.1306 09-	.4996 09-	.1962 08-	.4561 08-	.1041 07-	.1737 07-
84.0								.2500 09-	.1160 08-	.2536 08-	.6617 08-	.1595 07-
86.0									.6862 09-	.1523 08-	.4055 08-	.7062 08-
88.0									.4097 09-	.9627 09-	.2534 08-	.4621 08-
90.0									.2399 09-	.6015 09-	.1568 08-	.2776 08-
92.0										.3536 09-	.9705 09-	.1743 08-
94.0										.2154 09-	.6006 09-	.1054 08-
96.0											.3717 09-	.6573 09-
98.0											.2300 08-	.4116 09-
100.0												.2710 09-

Table 9.1.9. (Continued)

E_0 [MeV] 5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	r [cm]
.9863 00	.9855 00	.9851 00	.9847 00	.9842 00	.9837 00	.9834 00	.9830 00	.9825 00	.9819 00	.9815 00	0.1
.9725 00	.9713 00	.9705 00	.9697 00	.9687 00	.9671 00	.9671 00	.9662 00	.9653 00	.9645 00	.9636 00	0.2
.9596 00	.9572 00	.9560 00	.9546 00	.9533 00	.9519 00	.9510 00	.9497 00	.9483 00	.9470 00	.9460 00	0.3
.9452 00	.9432 00	.9417 00	.9401 00	.9386 00	.9364 00	.9357 00	.9334 00	.9321 00	.9300 00	.9286 00	0.4
.9317 00	.9295 00	.9275 00	.9255 00	.9232 00	.9210 00	.9196 00	.9174 00	.9153 00	.9135 00	.9116 00	0.5
.9183 00	.9155 00	.9135 00	.9112 00	.9085 00	.9055 00	.9042 00	.9016 00	.8992 00	.8966 00	.8945 00	0.6
.9050 00	.9019 00	.8996 00	.8970 00	.8939 00	.8912 00	.8891 00	.8861 00	.8833 00	.8807 00	.8784 00	0.7
.8919 00	.8884 00	.8853 00	.8829 00	.8795 00	.8763 00	.8741 00	.8709 00	.8677 00	.8648 00	.8623 00	0.8
.8787 00	.8751 00	.8724 00	.8691 00	.8653 00	.8618 00	.8594 00	.8558 00	.8524 00	.8492 00	.8465 00	0.9
.8658 00	.8619 00	.8589 00	.8554 00	.8513 00	.8475 00	.8450 00	.8411 00	.8373 00	.8339 00	.8309 00	1.0
.8402 00	.8355 00	.8326 00	.8289 00	.8239 00	.8196 00	.8167 00	.8122 00	.8079 00	.8040 00	.8000 00	1.2
.8150 00	.8104 00	.8068 00	.8025 00	.7972 00	.7925 00	.7892 00	.7842 00	.7795 00	.7751 00	.7713 00	1.4
.7904 00	.7854 00	.7816 00	.7767 00	.7713 00	.7662 00	.7626 00	.7572 00	.7520 00	.7473 00	.7431 00	1.6
.7662 00	.7612 00	.7571 00	.7515 00	.7461 00	.7405 00	.7368 00	.7310 00	.7255 00	.7204 00	.7159 00	1.8
.7426 00	.7372 00	.7332 00	.7275 00	.7215 00	.7157 00	.7116 00	.7056 00	.6998 00	.6944 00	.6897 00	2.0
.6969 00	.6915 00	.6870 00	.6811 00	.6747 00	.6685 00	.6641 00	.6575 00	.6510 00	.6452 00	.6400 00	2.4
.6533 00	.6476 00	.6432 00	.6371 00	.6302 00	.6237 00	.6193 00	.6121 00	.6054 00	.5993 00	.5938 00	2.8
.6117 00	.6062 00	.6018 00	.5955 00	.5885 00	.5818 00	.5774 00	.5699 00	.5629 00	.5564 00	.5508 00	3.2
.5722 00	.5669 00	.5626 00	.5563 00	.5498 00	.5424 00	.5380 00	.5303 00	.5232 00	.5167 00	.5109 00	3.6
.5348 00	.5297 00	.5256 00	.5192 00	.5123 00	.5053 00	.5011 00	.4934 00	.4862 00	.4796 00	.4737 00	4.0
.4996 00	.4946 00	.4907 00	.4845 00	.4776 00	.4710 00	.4666 00	.4589 00	.4517 00	.4452 00	.4395 00	4.4
.4660 00	.4613 00	.4575 00	.4515 00	.4451 00	.4386 00	.4344 00	.4267 00	.4196 00	.4131 00	.4072 00	4.8
.4344 00	.4302 00	.4269 00	.4213 00	.4146 00	.4082 00	.4042 00	.3967 00	.3897 00	.3832 00	.3775 00	5.2
.4046 00	.4004 00	.3979 00	.3925 00	.3860 00	.3799 00	.3760 00	.3686 00	.3618 00	.3555 00	.3499 00	5.6
.3760 00	.3734 00	.3705 00	.3653 00	.3592 00	.3533 00	.3496 00	.3425 00	.3358 00	.3297 00	.3242 00	6.0
.3145 00	.3127 00	.3095 00	.3049 00	.2995 00	.2944 00	.2912 00	.2846 00	.2785 00	.2729 00	.2679 00	7.0
.2612 00	.2594 00	.2575 00	.2539 00	.2495 00	.2449 00	.2421 00	.2362 00	.2307 00	.2257 00	.2212 00	8.0
.2164 00	.2152 00	.2142 00	.2110 00	.2071 00	.2033 00	.2010 00	.1958 00	.1909 00	.1865 00	.1824 00	9.0
.1787 00	.1782 00	.1775 00	.1749 00	.1717 00	.1685 00	.1666 00	.1621 00	.1578 00	.1540 00	.1504 00	10.0
.1211 00	.1212 00	.1213 00	.1195 00	.1174 00	.1152 00	.1141 00	.1107 00	.1076 00	.1047 00	.1020 00	12.0
.8157 01-	.8192 01-	.8221 01-	.8123 01-	.7964 01-	.7845 01-	.7779 01-	.7535 01-	.7309 01-	.7101 01-	.6910 01-	14.0
.5450 01-	.5499 01-	.5548 01-	.5488 01-	.5405 01-	.5316 01-	.5281 01-	.5109 01-	.4950 01-	.4803 01-	.4668 01-	16.0
.3605 01-	.3671 01-	.3723 01-	.3691 01-	.3641 01-	.3589 01-	.3573 01-	.3454 01-	.3343 01-	.3241 01-	.3147 01-	18.0
.2375 01-	.2440 01-	.2487 01-	.2472 01-	.2444 01-	.2415 01-	.2410 01-	.2329 01-	.2253 01-	.2183 01-	.2118 01-	20.0
.1564 01-	.1616 01-	.1656 01-	.1650 01-	.1636 01-	.1620 01-	.1622 01-	.1566 01-	.1515 01-	.1468 01-	.1425 01-	22.0
.1095 01-	.1206 01-	.1098 01-	.1096 01-	.1092 01-	.1064 01-	.1088 01-	.1051 01-	.1017 01-	.9873 02-	.9556 02-	24.0
.6696 02-	.7016 02-	.7272 02-	.7294 02-	.7272 02-	.7264 02-	.7294 02-	.7046 02-	.6816 02-	.6604 02-	.6405 02-	26.0
.4362 02-	.4604 02-	.4800 02-	.4831 02-	.4833 02-	.4858 02-	.4877 02-	.4713 02-	.4561 02-	.4420 02-	.4288 02-	28.0
.2834 02-	.3014 02-	.3162 02-	.3193 02-	.3204 02-	.3212 02-	.3255 02-	.3147 02-	.3047 02-	.2955 02-	.2868 02-	30.0
.1851 02-	.1970 02-	.2079 02-	.2106 02-	.2120 02-	.2133 02-	.2170 02-	.2099 02-	.2015 02-	.1973 02-	.1916 02-	32.0
.1159 02-	.1265 02-	.1364 02-	.1387 02-	.1401 02-	.1425 02-	.1464 02-	.1398 02-	.1355 02-	.1316 02-	.1279 02-	34.0
.7585 03-	.8368 03-	.9041 03-	.9120 03-	.9252 03-	.9375 03-	.9602 03-	.9502 03-	.9026 03-	.8770 03-	.8529 03-	36.0
.4960 03-	.5441 03-	.5850 03-	.5995 03-	.6099 03-	.6201 03-	.6376 03-	.6282 03-	.6004 03-	.5839 03-	.5674 03-	38.0
.3190 03-	.3534 03-	.3825 03-	.3933 03-	.4016 03-	.4098 03-	.4230 03-	.4105 03-	.3990 03-	.3885 03-	.3784 03-	40.0
.2056 03-	.2292 03-	.2496 03-	.2577 03-	.2641 03-	.2705 03-	.2803 03-	.2725 03-	.2649 03-	.2582 03-	.2516 03-	42.0
.1322 03-	.1485 03-	.1627 03-	.1667 03-	.1735 03-	.1784 03-	.1856 03-	.1805 03-	.1758 03-	.1713 03-	.1574 03-	44.0
.8401 04-	.9617 04-	.1060 03-	.1103 03-	.1139 03-	.1178 03-	.1226 03-	.1195 03-	.1166 03-	.1138 03-	.1113 03-	46.0
.5448 04-	.6220 04-	.6905 04-	.7213 04-	.7477 04-	.7748 04-	.8121 04-	.7914 04-	.7726 04-	.7555 04-	.7394 04-	48.0
.3492 04-	.4020 04-	.4491 04-	.4711 04-	.4902 04-	.5099 04-	.5566 04-	.5235 04-	.5127 04-	.5010 04-	.4908 04-	50.0
.2257 04-	.2596 04-	.2919 04-	.3074 04-	.3211 04-	.3354 04-	.3549 04-	.3461 04-	.3397 04-	.3320 04-	.3257 04-	52.0
.1457 04-	.1675 04-	.1896 04-	.2005 04-	.2107 04-	.2205 04-	.2338 04-	.2287 04-	.2240 04-	.2199 04-	.2160 04-	54.0
.9365 05-	.1081 04-	.1231 04-	.1307 04-	.1376 04-	.1448 04-	.1540 04-	.1510 04-	.1481 04-	.1456 04-	.1432 04-	56.0
.5860 05-	.6969 05-	.7992 05-	.8517 05-	.9001 05-	.9515 05-	.1017 04-	.9970 05-	.9794 05-	.9639 05-	.9492 05-	58.0
.3745 05-	.4490 05-	.5185 05-	.5546 05-	.5884 05-	.6245 05-	.6709 05-	.6579 05-	.6471 05-	.6377 05-	.6288 05-	60.0
.2392 05-	.2892 05-	.3360 05-	.3620 05-	.3845 05-	.4098 05-	.4415 05-	.4359 05-	.4275 05-	.4217 05-	.4164 05-	62.0
.1528 05-	.1862 05-	.2177 05-	.2349 05-	.2512 05-	.2687 05-	.2907 05-	.2862 05-	.2801 05-	.2758 05-	.2757 05-	64.0
.9753 06-	.1198 05-	.1410 05-	.1527 05-	.1640 05-	.1762 05-	.1914 05-	.1885 05-	.1866 05-	.1842 05-	.1824 05-	66.0
.6225 06-	.7709 06-	.9134 06-	.9934 06-	.1070 05-	.1151 05-	.1259 05-	.1242 05-	.1228 05-	.1217 05-	.1207 05-	68.0
.3969 06-	.4955 06-	.5913 06-	.6451 06-	.6968 06-	.7568 06-	.8297 06-	.8185 06-	.8109 06-	.8062 06-	.7985 06-	70.0
.2531 06-	.3187 06-	.3826 06-	.4196 06-	.4558 06-	.4958 06-	.5450 06-	.5390 06-	.5345 06-	.5310 06-	.5280 06-	72.0
.1613 06-	.2048 06-	.2475 06-	.2725 06-	.2973 06-	.3246 06-	.3593 06-	.3548 06-	.3529 06-	.3505 06-	.3492 06-	74.0
.1028 06-	.1316 06-	.1601 06-	.1770 06-	.1938 06-	.2125 06-	.2365 06-	.2335 06-	.2321 06-	.2313 06-	.2307 06-	76.0
.6553 07-	.8458 07-	.1035 06-	.1149 06-	.1263 06-	.1391 06-	.1548 06-	.1537 06-	.1529 06-	.1525 06-	.1524 06-	78.0
.4175 07-	.5433 07-	.6695 07-	.7463 07-	.8238 07-	.9107 07-	.1017 06-	.1011 06-	.1007 06-	.1007 06-	.1007 06-	80.0
.2659 07-	.3489 07-	.4328 07-	.4843 07-	.5366 07-	.5959 07-	.6685 07-	.6652 07-	.6658 07-	.6644 07-	.6664 07-	82.0
.1695 07-	.2240 07-	.2797 07-	.3143 07-	.3497 07-	.3898 07-	.4390 07-	.4375 07-	.4371 07-	.4381 07-	.4396 07-	84.0
.1078 07-	.1438 07-	.1807 07-	.2039 07-	.2278 07-	.2549 07-	.2885 07-	.2877 07-	.2879 07-	.2888 07-	.2901 07-	86.0
.7021 08-	.9230 08-	.1167 07-	.1325 07-	.1485 07-	.1667 07-	.1963 07-	.1891 07-	.1895 07-	.1904 07-	.1915 07-	88.0
.4461 08-	.6054 08-	.7544 08-	.8582 08-	.9664 08-	.1090 07-	.1242 07-	.1245 07-	.1247 07-	.1255 07-	.1264 07-	90.0
.2854 08-	.3878 08-	.4877 08-	.5689 08-	.6441 08-	.7329 08-	.8158 08-	.8173 08-	.8209 08-	.8275 08-	.8345 08-	92.0
.1803 08-	.2484 08-	.3069 08-	.3684 08-	.4187 08-	.4771 08-	.5495 08-	.5329 08-	.5402 08-	.5451 08-	.5507 08-	94.0
.1144 08-	.1591 08-	.2009 08-	.2385 08-	.2721 08-	.3115 08-	.3600 08-	.3627 08-	.3671 08-	.3734 08-	.3655 08-	96.0
.7273 09-	.1019 08-	.1334 08-	.1544 08-	.1769 08-	.2052 08-	.2359 08-	.2379 08-	.2410 08-	.2455 08-	.2509 08-	98.0
.4621 09-	.6533 09-	.8605 09-	.9909 09-	.1149 08-	.1526 08-	.1545 08-	.1560 08-	.1588 08-	.1614 08-	.1651 08-	100.0

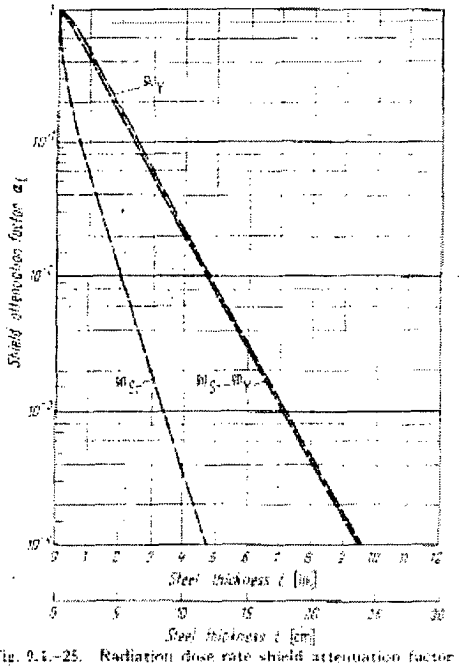


Fig. 9.1.-25. Radiation dose rate shield attenuation factor for ^{89}Sr, ^{90}Sr-^{90}Y and ^{90}Y as a function of steel shield thickness [4].

Note: All curves are for bremsstrahlung.

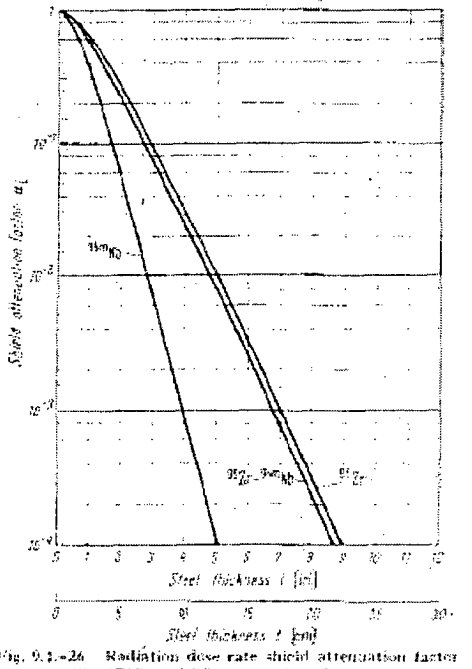


Fig. 9.1.-26. Radiation dose rate shield attenuation factor for ^{95}Zr, ^{95}Zr-^{95m}Nb and ^{95m}Nb as a function of steel shield thickness [4].

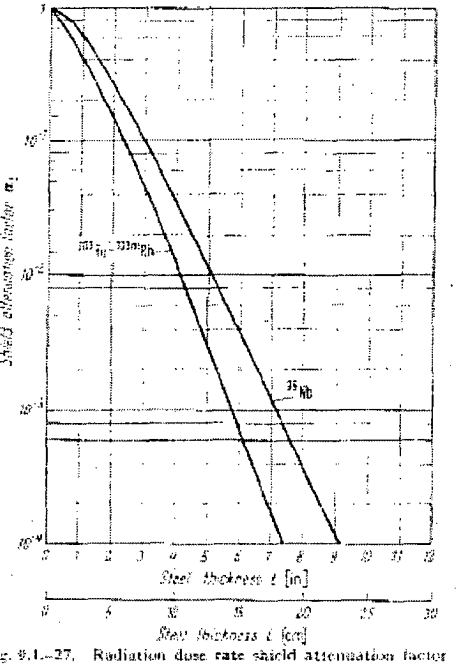


Fig. 9.1.-27. Radiation dose rate shield attenuation factor for ^{99}Nb and ^{103}Ru-^{103m}Rh as a function of steel shield thickness [4].

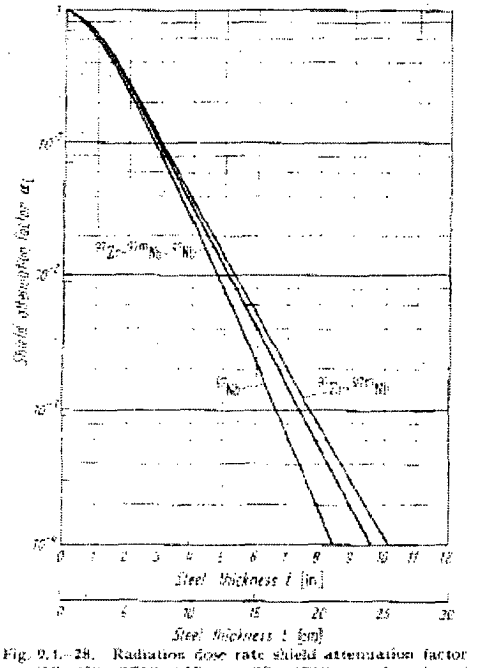


Fig. 9.1.-28. Radiation dose rate shield attenuation factor for ^{97}Nb, ^{97}Zr-^{97m}Nb-^{97}Nb and ^{97}Zr-^{97m}Nb as a function of steel shield thickness [4].

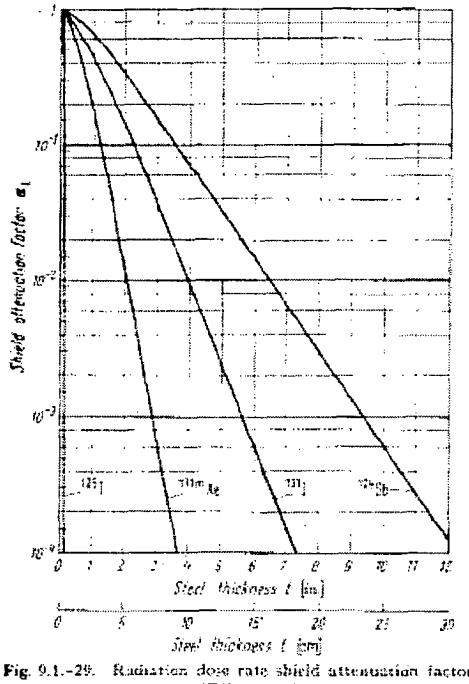


Fig. 9.1.-29. Radiation dose rate shield attenuation factor for ^{134}Sb, ^{132}I, ^{131}I and ^{131m}Xe as a function of steel shield thickness [4].

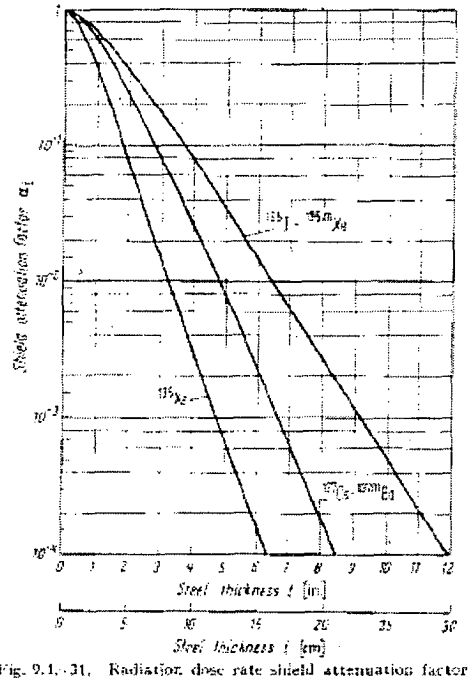


Fig. 9.1.-31. Radiation dose rate shield attenuation factor for ^{135}Xe, ^{135}I–^{135m}Xe and ^{137}Cs–^{137m}Ba as a function of steel shield thickness [4].

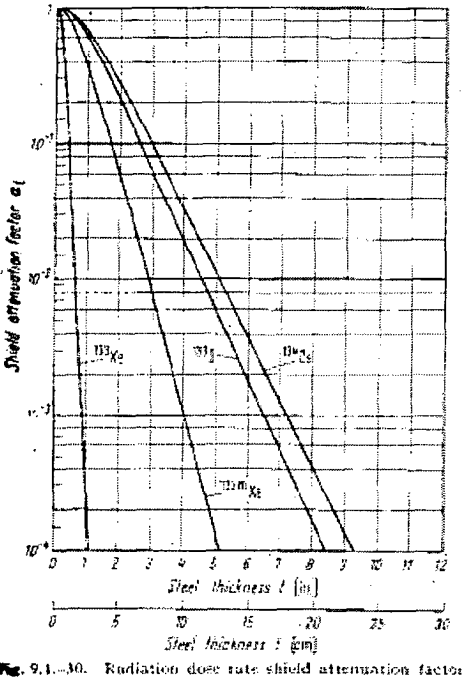


Fig. 9.1.-30. Radiation dose rate shield attenuation factor for ^{133}I, ^{133}Xe, ^{133m}Xe and ^{134}Cs as a function of steel shield thickness [4].

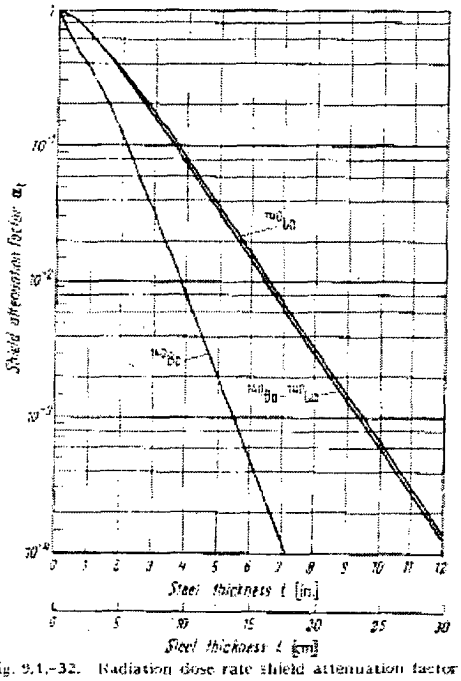


Fig. 9.1.-32. Radiation dose rate shield attenuation factor for ^{140}Ba, ^{140}La and ^{140}Ba–^{140}La as a function of steel shield thickness [4].

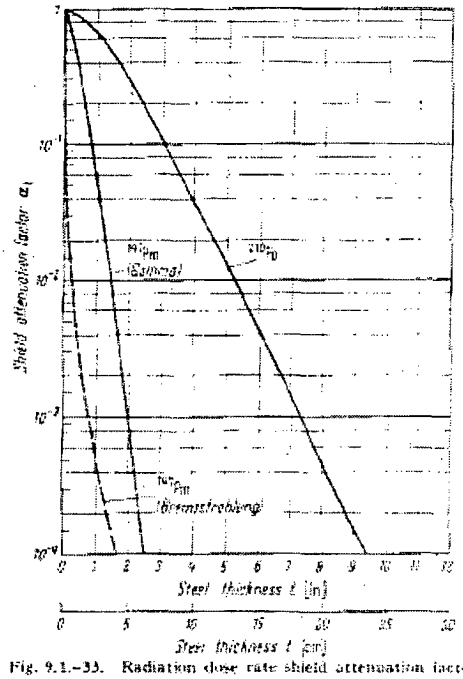


Fig. 9.1.–33. Radiation dose rate shield attenuation factor for ^{147}Pm and ^{210}Po as a function of steel shield thickness [4].

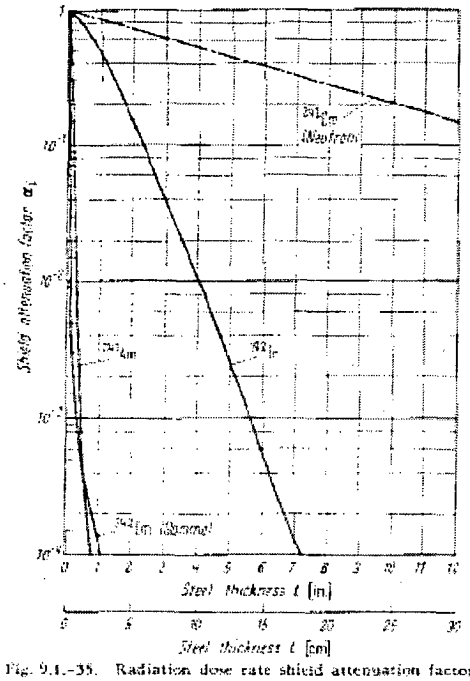


Fig. 9.1.–35. Radiation dose rate shield attenuation factor for ^{192}Ir, ^{241}Am and ^{242}Cm as a function of steel shield thickness [4].

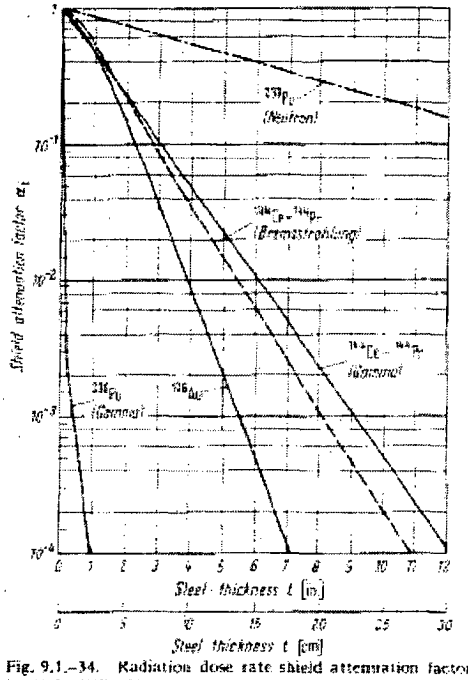


Fig. 9.1.–34. Radiation dose rate shield attenuation factor for ^{144}Ce–^{144}Pr, ^{198}Au and ^{239}Pu as a function of steel shield thickness [4].

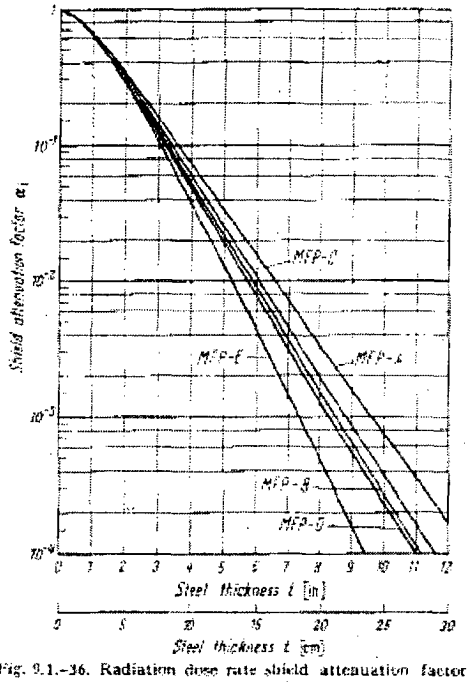


Fig. 9.1.–36. Radiation dose rate shield attenuation factor for mixed fission products as a function of steel shield thickness [4].

shape of grains differ with various mechanical and heat treatments.

Wrought iron is a low-carbon, high-phosphorous material that is high in added slag content. It is tough, ductile, and malleable; it is also readily weldable. When rolled into plate, highly directional properties, including low transverse ductility, are produced. This results in a characteristic that, when the iron is broken across the grain, it fractures as if laminated. Also, its properties are only slightly changed by heat treatment.

Many cast irons are available. For specific applications, if properties other than gamma attenuation are important, appropriate alloying elements should be considered. Basically, gray cast iron has a matrix of silicon-ferrite in which graphite

Table 9.1.-16. Physical and mechanical properties of various types of commercial iron [7]
(1 psi = 0.07 kg/cm²; 1 inch = 25.4 mm)

	Armco ingot iron	Wrought iron (Byers No. 1)	Cast iron (gray)
Density [g/cm³] at 20 °C	7.866	7.70	6.95 — 7.35
Specific heat [cal/g]			
0 °C	0.120[a]		
18 to 100 °C	0.113	0.1152[c]	0.1189[d]
Coefficient of thermal expansion, 10^{-6} per °C			
20 °C	11.72[b]		
100 °C	12.70[b]		
18 to 100 °C		11.4	10.55[e]
Thermal conductivity, cal s^{-1} cm^{-1} °C^{-1}			
18 °C	~ 0.175	0.144	~ 0.11
200 °C	~ 0.15		
Melting point [°C]	1539	1510	1230
Tensile strength, 10^3 psi			
16 °C	49.5		
200 °C	65.6		
Annealed	42 — 46		
Finished	41 — 43.8	42 — 52	25 — 50
Finished, quenched	47		
Yield strength, 10^3 psi		26 — 35	[f]
Annealed	26 — 32		
Finished	38.3 — 26.9		
Finished, quenched	30.3		
Elongation, % in 2 inches			
16 °C	45		
200 °C	26.5		
Annealed	22 — 28		
Finished	41.8 — 47.0		
Finished, quenched	36.2		
Per cent in 8 inches		25 — 40	
Compressive strength, 10^3 psi	19.4		65 — 160
Shear strength [psi]	—	—	[g]
Stress to produce a creep rate of 0.005 in./in. in 60 days, 1000 psi, at a temp. of 370 °C	15		
Elastic modulus [psi]	$30 \cdot 10^6$ [h]	—	$12 - 20 \cdot 10^6$ [i]
Hardness			
Brinell	82 — 100	105	150 — 220
Rockwell B	39 — 55		

[a] Value given for gamma iron; value for alpha iron is 0.106.
[b] Alpha iron.
[c] Temperature range 15 to 100 °C.
[d] Temperature range 20 to 100 °C.
[e] Temperature range 0 to 100 °C.
[f] Gray irons have no definite yield points.
[g] Shear strength in cast irons varies from 1.0 to 1.6 that of the tensile strength; the weakest irons have the highest shear to tensile strength ratio.
[h] The elastic modulus E varies from 27.2 to 30.6 · 10^6 psi; the value quoted is the usually accepted value; in a single crystal E varies according to the direction from 19 to 41 · 10^6 psi.
[i] No definite limits can be established for the elastic modulus of cast irons; the normal practice is to define a modulus at 25 per cent of the expected tensile strength.

flakes are embedded. This may be accompanied by iron carbide (Pearlite). Hardness increases as the matrix transition approaches all Pearlite. Normally, the carbon content range is about 3.25 to 3.75% with the silicon content range at about 1.50 to 2.50%. The cast irons are generally low in tensile strength, (compared to steel), high in compressive strength, wear and corrosion resistance, and brittle.

Steel is iron containing up to 1.5% carbon. Specific properties can be achieved by adding alloying elements or by processes such as mechanical or heat treatments. Generally, carbon steels are used for shielding, but where corrosion resistance is necessary, e. g., in water environments, stainless steels are required. Many other examples can be cited since the field of steels is broad and voluminous. Preliminary suggested reading is in [9, 16, 11]. Table 9.1-10 lists the physical and mechanical properties of various types of commercial iron.

C. Chemical Properties

Generally, iron and carbon steel are not corrosion-resistant and under similar conditions corrode at about the same rate. Wrought iron, because of the inclusion of slag (iron silicate), is more resistant to corrosion than the other irons and carbon steels; cast irons high in silicon (13-17%) have considerably more resistance to oxidation and acid attack.

Some alloy steels obtain improved chemical properties when the primary purpose for alloying is to get improved mechanical properties; e. g., nickel addition increases toughness and also increases resistance to heat and acids. The stainless steels, where chromium is the primary alloy, are among the better known corrosion resistant steel alloys (austenitic and heat treated martensitic).

Table 9.1-11 lists typical compositions of various types of commercial iron. See [9] for steels.

Table 9.1-11. Typical composition of various types of commercial iron [7].

Component	Composition [wt. %]		
	Armco ingot iron	Wrought iron (Byers No. 1)	Cast iron (gray)
Iron	99.83	98.473	92.95
Oxygen	0.11	In slag	–
Sulfur	0.025	0.01	0.10
Manganese	0.017	0.015	0.65
Carbon	0.012	0.08	3.4
Phosphorus	0.005	0.062	0.3
Silicon	Trace	0.158	2.6
Slag	–	1.20	–
Copper	–	–	–

9.1.2.4. FABRICATION

Iron and steel can be cast, rolled, machined, welded, and fabricated by an increasing number of processes. Suggested reading is [12] for information on conventional, new and also unique fabrication processes.

9.1.2.5. APPLICATIONS AND DESIGN CONSIDERATIONS

Steel is usually used as shield material against gamma radiation on the basis of comparison with other gamma-shield materials such as water, concrete and lead (see Sec. 9.1.1.5.). The primary use of steel shields is in large structures or components containing a high-curie source. (Small and portable shields normally use a predominance of lead; the steel is utilized primarily for structural purposes, although its shielding properties are also used.) Low-grade iron and steel economically obtained provides excellent gamma shielding. Economy is sacrificed if special properties, such as corrosion resistance, are required. With few exceptions, the knowledge of iron and steel is the most comprehensive of all materials and the most readily available.

9.1.3. URANIUM

by E. E. Hamer and A. E. McArthy

9.1.3.1. INTRODUCTION

Uranium is a very heavy metal having a density of 19.05 g/cm³ and a melting point of 1133 °C [6]. It is very active chemically and oxidizes rapidly on exposure to air (from a bright silvery color to a shiny black), therefore requiring a protective coating in most applications.

Depleted uranium of almost pure ^{238}U is used for shielding purposes. Alloying with elements such as molybdenum improves the corrosion and mechanical properties. Although depleted uranium is a product of the gaseous diffusion plant, it is a tailing fraction. Most of its structural properties are similar to those of steel. Fabrication is difficult and processes include casting, rolling, forging, extruding, powder metallurgy, and machining. No exceptional handling precautions are necessary except during fabrication or when the oxide can cause contamination.

9.1.3.2. OCCURRENCE AND EXTRACTION

Natural uranium consists of three radioactive isotopes 99.28% ^{238}U, 0.715% ^{235}U and 0.0058% ^{234}U. By means of the gaseous diffusion process[a] the fissionable isotope ^{235}U is separated leaving the tailing fraction of almost pure ^{238}U (up to 0.22% ^{235}U could remain). This residue is known as depleted uranium and is accumulated as a uranium hexafluoride by-product. It is then converted to the metal form for shielding use.

9.1.3.3. PROPERTIES

A. Nuclear Properties

Depleted uranium, because of its high density, is excellent as a gamma ray shield material. Table 9.1-2 compares thickness and weights of uranium with five other materials for equivalent gamma ray shieldings. In both aspects (thickness

[a] The centrifuge process has not been developed, at the time of this printing, to the point of significantly contributing to uranium isotope separation.

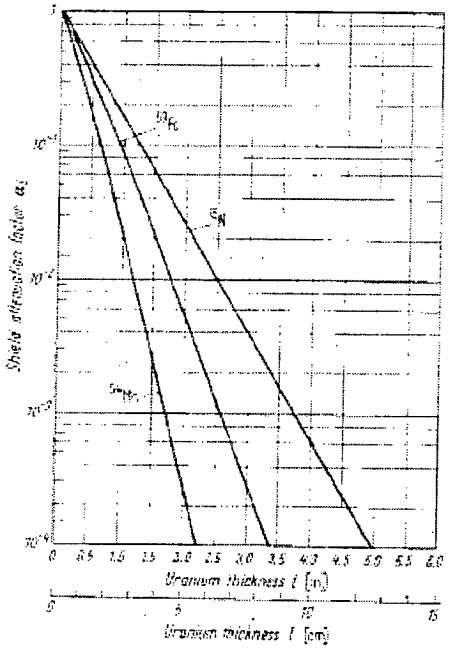


Fig. 9.1.–37. Radiation dose rate shield attenuation factor for ^{16}N, ^{54}Mn and ^{59}Fe as a function of uranium shield thickness [4].

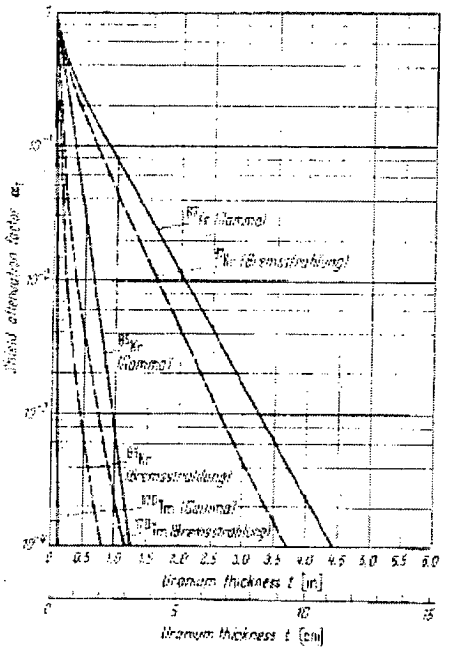


Fig. 9.1.–39. Radiation dose rate shield attenuation factor for ^{85}Kr, ^{87}Kr and ^{170}Tm as a function of uranium shield thickness [4].

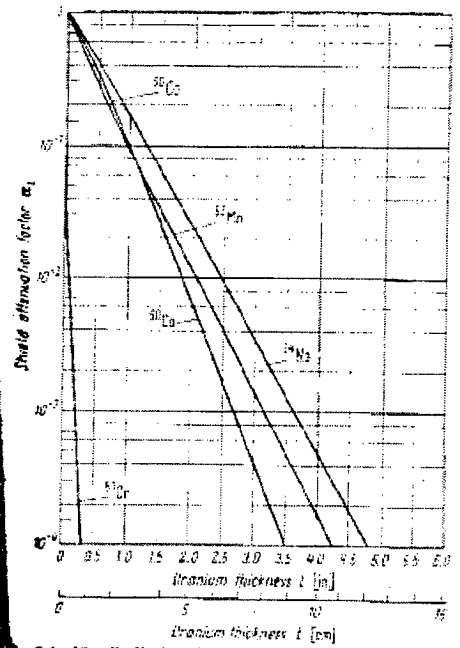


Fig. 9.1.–38. Radiation dose rate shield attenuation factor for ^{24}Na, ^{51}Cr, ^{54}Mn and ^{60}Co as a function of uranium shield thickness [4].

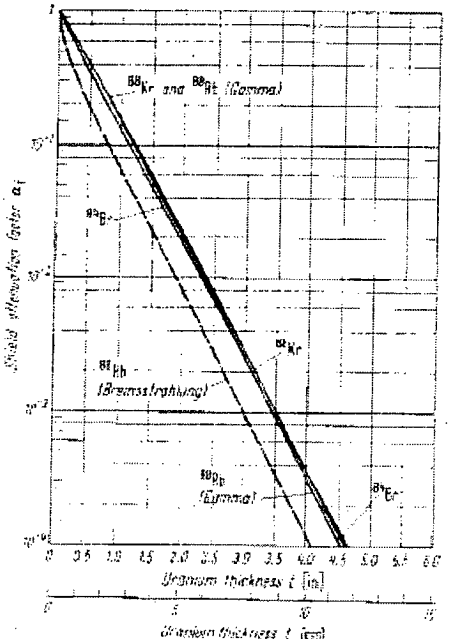


Fig. 9.1.–40. Radiation dose rate shield attenuation factor for ^{82}Br, ^{86}Kr and ^{86}Rb as a function of uranium shield thickness [4].

Note: The curve for ^{85}Kr–^{86}Rb falls between the individual curves for ^{85}Kr and ^{86}Rb. In the interest of clarity, the curve for the combined isotopes is not shown.

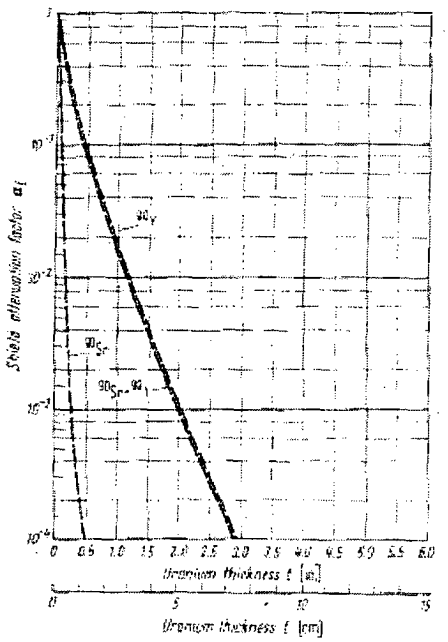


Fig. 9.1.–41. Radiation dose rate shield attenuation factor for ^{90}Sr, ^{90}Sr–^{90}Y and ^{90}Y as a function of uranium shield thickness [4].
Note: All curves are for bremsstrahlung.

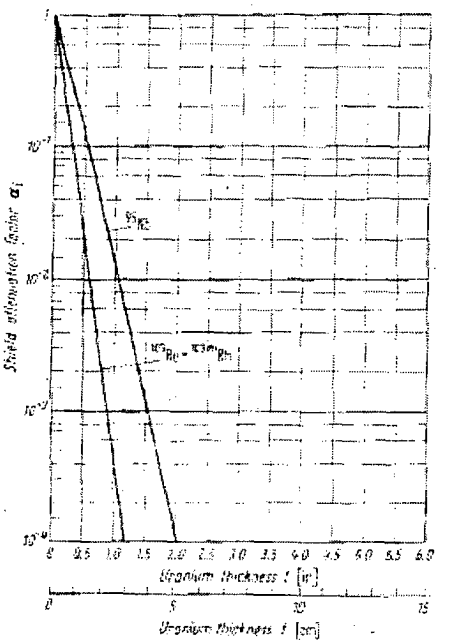


Fig. 9.1.–43. Radiation dose rate shield attenuation factor for ^{95}Nb and ^{103}Ru–^{103m}Rh as a function of uranium shield thickness [4].

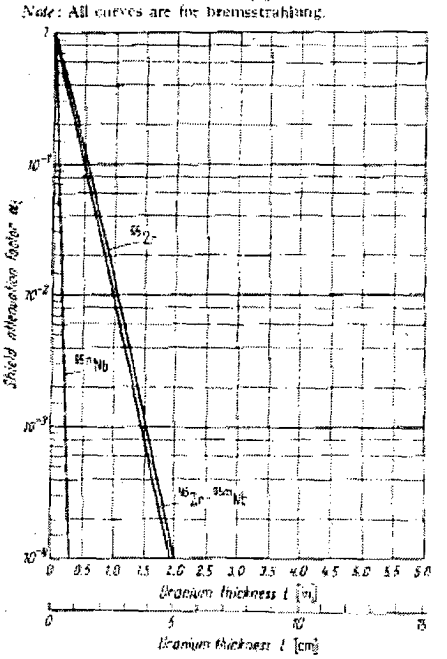


Fig. 9.1.–42. Radiation dose rate shield attenuation factor for ^{95}Zr, ^{95}Zr–^{95m}Nb and ^{95m}Nb as a function of uranium shield thickness [4].

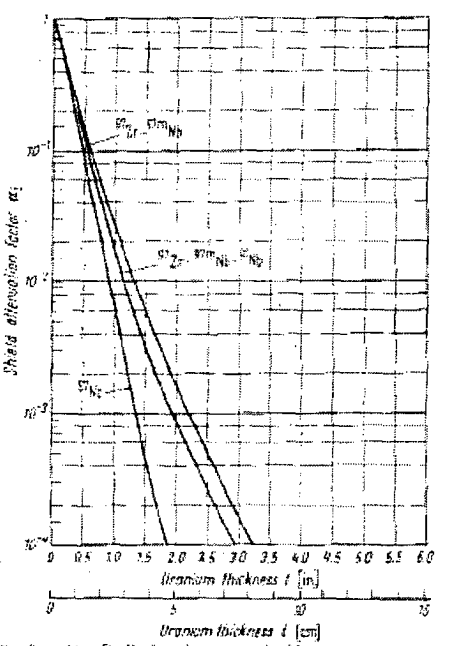


Fig. 9.1.–44. Radiation dose rate shield attenuation factor for ^{97}Nb, ^{97}Zr–^{97m}Nb and ^{97}Zr–^{97m}Nb–^{97}Nb as a function of uranium shield thickness [4].

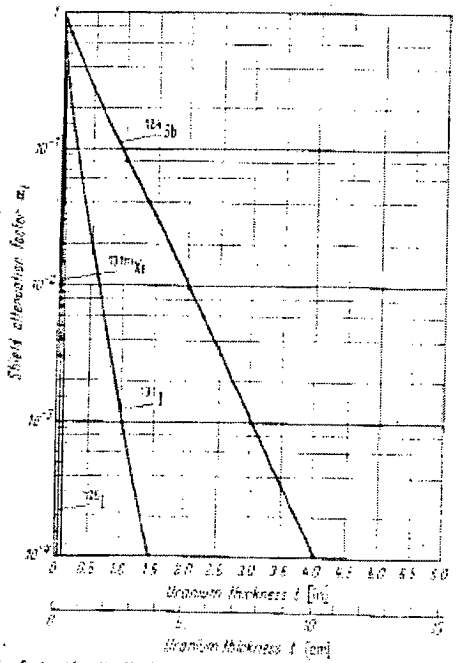


Fig. 9.1.-45. Radiation dose rate shield attenuation factor for ^{124}Sb, ^{125}I, ^{126}I and ^{133m}Xe as a function of uranium shield thickness [4].

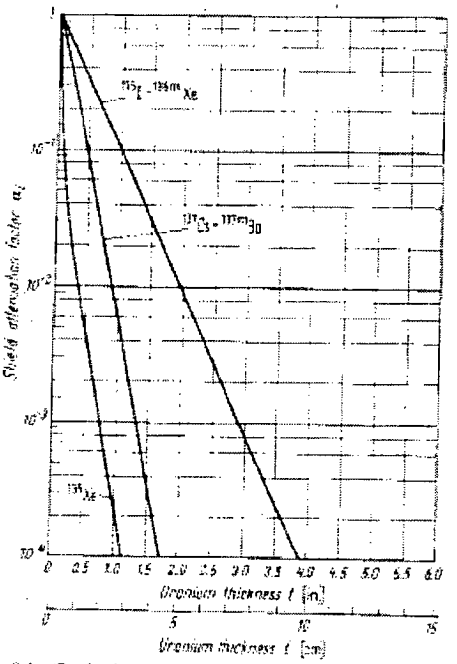


Fig. 9.1.-47. Radiation dose rate shield attenuation factor for ^{135}Xe, ^{135}I–^{135m}Xe and ^{137}Cs–^{137m}Ba as a function of uranium shield thickness [4].

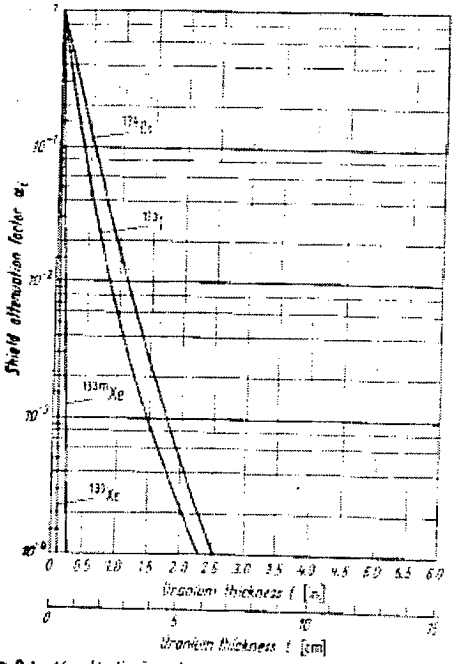


Fig. 9.1.-46. Radiation dose rate shield attenuation factor for ^{131}I, ^{133}Xe, ^{133m}Xe and ^{134}Cs as a function of uranium shield thickness [4].

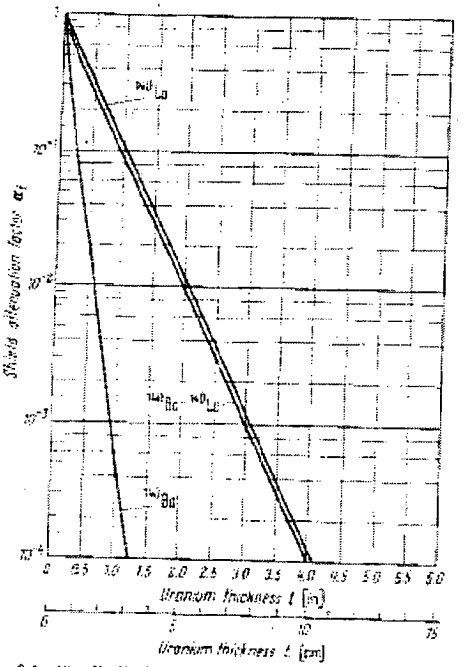


Fig. 9.1.-48. Radiation dose rate shield attenuation factor for ^{140}Ba, ^{140}La and ^{140}Ba–^{140}La as a function of uranium shield thickness [4].

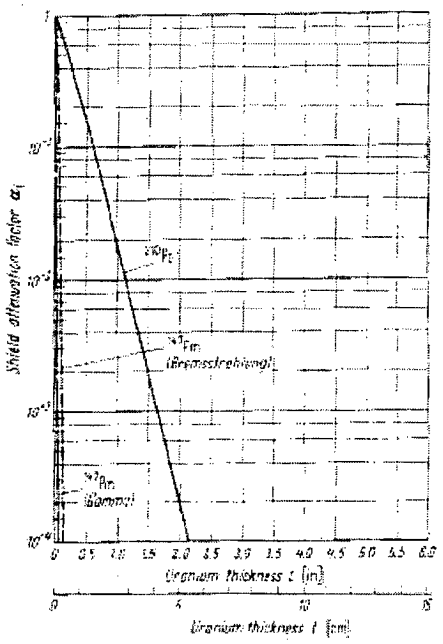


Fig. 9.1.–49. Radiation dose rate shield attenuation factor for ^{147}Pm and ^{210}Po as a function of uranium shield thickness [4].

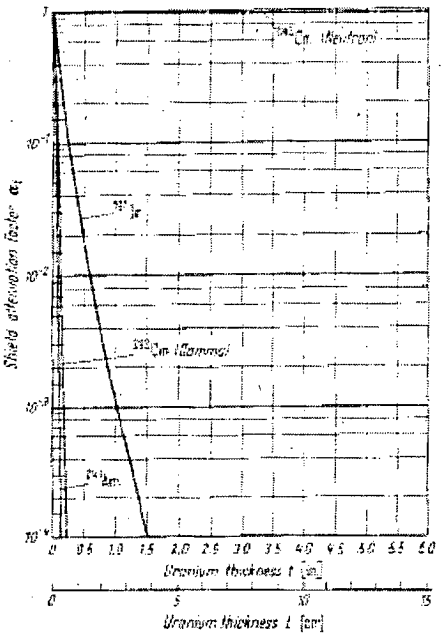


Fig. 9.1.–51. Radiation dose rate shield attenuation factor for ^{192}Ir, ^{241}Am and ^{242}Cm as a function of uranium shield thickness [4].

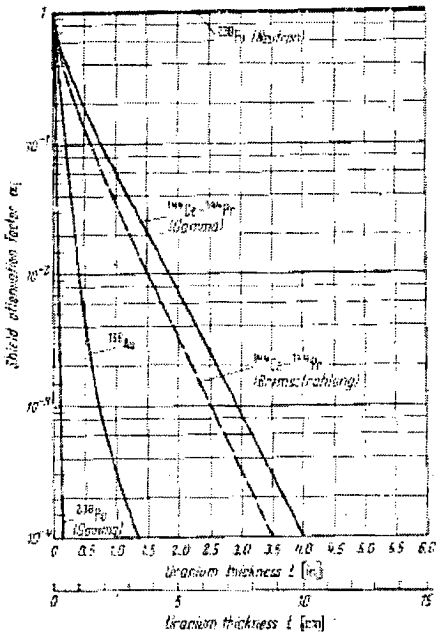


Fig. 9.1.–50. Radiation dose rate shield attenuation factor for ^{144}Ce–^{144}Pr, ^{198}Au and ^{239}Pu as a function of uranium shield thickness [4].

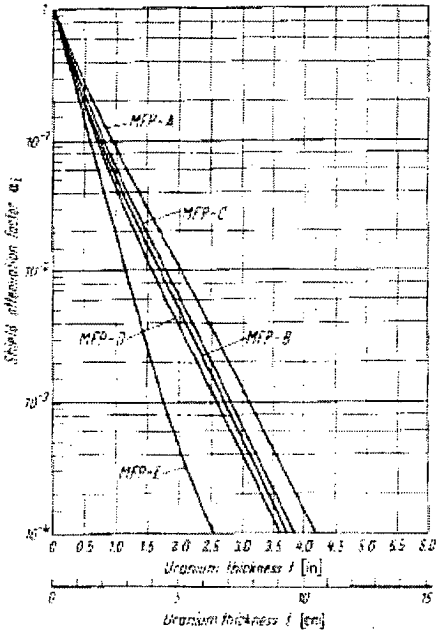


Fig. 9.1.–52. Radiation dose rate shield attenuation factor for mixed fission products as a function of uranium shield thickness [4].

and weight; uranium requirements are less than for the more commonly used lead. Because of the method by which the depleted uranium is obtained, some ^{235}U is present. Depending upon the amount and dispersion of the ^{235}U in the ^{238}U metal, fissioning may result under certain conditions; this may be undesirable. An environmental check should be made before use.

Table 4.1–3 (Vol. I, p. 175) lists values of gamma ray mass-attenuation coefficient, μ/ϱ [cm^2/g]; Table 4.1–9 (Vol. I, p. 183) lists the mass energy-transfer coefficient, μ_k/ϱ, and the mass energy-absorption coefficient, μ_{en}/ϱ.

Figures 9.1–37 through –52 show the shield (exposure)-attenuation factor, s_f, for the radiation dose rate as a function of the uranium shield thickness for a large number of radioisotopes and certain isotope combinations [4]. Included are curves (Fig. 9.1–52) for mixed fission products (MFP-) for the conditions of an infinitely long irradiation time and five specific decay times as follows:

Designation	Decay time
MFP-A	1 hour
MFP-B	1 day
MFP-C	10 days
MFP-D	1 month
MFP-E	6 months

Section 9.1.1 describes the use of the curves to determine the dose rate at a specified distance from a radioactive point source through a given shield thickness.

Table 9.1–12 compares depleted uranium and lead cylindrical shields by weight, volume, and thickness for various gamma ray energies.

Table 9.1–13 gives the measured dose rates of unplated and plated (nickel and cadmium) depleted uranium at various distances from the flat surface.

B. Physical and Mechanical Properties

Table 9.1–14 lists the physical and mechanical properties of uranium. The mechanical properties are affected by crystal orientation and temperature. Most fabrication is done in the alpha phase which can be characterized as being tough, fairly malleable, and harder than iron. The beta phase is harder and more brittle than the alpha phase. The metal is soft and plastic in the gamma phase.

Tensile strength and hardness are effected by carbon content (generally 500–700 ppm). To obtain the desired properties, the metal is rolled at about 550 °C, heat treated and slowly cooled or quenched. There are no commercial metallurgical properties of the material that can be termed "typical" since requirements are variable. Table 9.1–14 gives some mechanical properties versus fabrication methods. To obtain more comprehensive information, see [13, 14].

Table 9.1–12. Comparison of depleted uranium and lead cylindrical shields [6]

Based on an inside radius of 6 in. and a radial thickness of 12 in. of lead (1 inch = 25.4 mm)

Gamma-ray energy [MeV]	Uranium-to-lead ratios		
	Shield thickness	Shield volume	Shield weight
1	0.539	0.416	0.698
2	0.564	0.442	0.741
3	0.566	0.441	0.745
4	0.569	0.446	0.748
5–10	0.571	0.447	0.754
>10	0.596[a]	0.446[a]	0.782[a]

[a] These values would be obtained if the uranium were equivalent to lead on a weight-for-weight basis and the geometrical factor alone considered.

C. Chemical Properties

Uranium is not a corrosion resistant material and oxidizes readily in room air. It is regarded as pyrophoric, but only as fine dust or chips; on large solid pieces the oxide is relatively inert. Alloying with molybdenum improves corrosion resistance. Plating is difficult and commercially successful only with nickel and cadmium.

Table 9.1–13. Measured doses rates of depleted uranium unplated and plated with nickel and cadmium at various distances from a flat surface [6]

(1 inch = 25.4 mm)

Distance[a]	Type of radiation	mR/h			
		Bare uranium[b]	0.005 in. Ni plate[c]	0.015 in. Ni plate[c]	0.005 Cd plate[c]
Surface	Beta and Gamma	340.0	130.0	28.0	16.00[d]
1 cm (0.394 in.)	Gamma	3.0	2.5	1.0	1.40
6 inches	Beta and Gamma	25.0	11.2	3.6	4.80
6 inches	Gamma	0.9	0.8	0.7	0.20
12 inches	Beta and Gamma	8.0	3.0	2.2	1.50
12 inches	Gamma	0.6	0.5	0.4	0.06
36 inches	Beta and Gamma	–	–	–	0.20
36 inches	Gamma	–	–	–	Nil

[a] The surface dose rates were measured with Du Pont 545 film with an accuracy of ±15%. The dose rates at other distances were measured with GS and ionization meters and represent averages of three meters.
[b] 100 square-inch flat surface 70 to 1000 pound pieces.
[c] 5 inch × 5 inch × 30 inch piece. [d] Beta and gamma dose at 1 cm (.394 inches).

Table 9.1–14. Physical and mechanical properties of uranium [1,6]

1. Physical properties

Isotope	Abundance [%]	Half life [a]	Particle	Gamma [MeV]
^{234}U	0.0056	$2.48 \cdot 10^5$	alpha	0.04, 0.06, 0.31
^{235}U	0.715	$7.1 \cdot 10^8$	alpha	–
^{238}U	99.28	$4.498 \cdot 10^9$	alpha	0.045

Density [g/cm³]	
Pure	19.05
Commercial	19.00
Melting point [°C]	1133
Thermal conductivity [cal s⁻¹ cm⁻¹ °C⁻¹]	
Room temperature	0.058
100 °C	0.064
200 °C	0.071
Coefficient of expansion, 10^{-6} per °C	
Linear, parallel to [100] axis	26.5
[010]	2.4
[001]	23.9
Volume	48.6

2. Mechanical properties (1 psi = 0.07 kp/cm²)

Fabrication method	Tensile strength[a] [psi]	Elong. [%]	Yield strength[a] [psi]	Young's modulus 10^6 psi
As cast, 360 ppm carbon	50 000	6	26 300	23
As cast, 550 ppm carbon	72 000	11	29 000	25
As cast, 630 ppm carbon	75 000	17	28 000	24
As cast, 710 ppm carbon	70 000	12	28 000	23
Rolled at 550 °C (1022 °F)	96 000	11	31 000	25
Rolled-annealed 1110 °F	88 400	13.5	26 000	(alpha phase)
Rolled-annealed 1290 °F	61 700	6.0	24 600	(beta phase)

[a] Tests at room temperature.

The hardness of uranium varies from about 220 to about 260 Vickers or Brinell, somewhat lower in the alpha phase-rolled condition.

9.1.3.4. FABRICATION

Powder-metallurgy, rolling, and casting are the most acceptable fabrication methods used. Other processes, such as extrusion, are difficult but possible. Machining of uranium is difficult because of its toughness and spring-back characteristics. Machine tools used for machining steels are being used but require more rigidity, lower speeds, higher horsepower, ceramic tool tips, and cutting fluids. Welding is possible by tungsten-inert-gas and shielded-arc consumable-electrode processes; brazing is more difficult. In all fabrication processes special precautions are necessary because of the pyrophoricity, toxicity and natural radiation [15].

9.1.3.5. APPLICATIONS AND DESIGN CONSIDERATIONS

The use of depleted uranium can solve application problems for shield material selection where space is at a premium or other considerations limit the shield thickness. Also, its use is becoming more prevalent as availability increases and fabrication costs decrease with experience. [In the U.S.A., an increasing number of transportable containers [casks] are substituting depleted uranium for lead as the shield material].

In designing a depleted uranium shield, three important factors must be considered. They are:

A. Contamination

The depleted uranium oxidizes in air and can contaminate whatever (and whoever) comes in contact with it because of its radioactivity. It is primarily an alpha and beta emitter. It should be painted[1], plated (nickel or cadmium), jacketed, or confined by other structural material, depending upon the durability required. The oxide is also toxic, comparable to arsenic, lead, or mercury.

B. Fabrication

The potential hazards during fabrication and its difficulty suggests a more than usual amount of planning. It is advisable to minimize machining by pre-casting in a geometry very close to the shape desired. The shape should be as close as possible to that allowing standard vacuum-casting tech-

[1] Painting requires the use of nonpervious paints because the uranium oxide formation will cause peeling.

niques. Vacuum casting produces a good homogeneous shield. When small shields, shield inserts, or equipment parts are required, it is advisable to start with as small a billet as possible. Machining depleted uranium is difficult and is comparable to machining high nickel alloys. In addition to the toughness of the material, a high spring-back characteristic is present. The machinings (chips, dust, etc.) are highly pyrophoric (although the bulk metal is not) and must be maintained under a coolant. Welding should be discouraged since the fumes are toxic and can be radioactive. It should be noted, however, that experienced shops are doing this fabrication on a routine basis. The alloys of uranium that are available, such as uranium-molybdenum, possess greater machinability (and better mechanical properties and corrosion resistance) but have a lower density.

C. Mechanical Properties

A precautionary note — the properties of depleted uranium may be so different from other structural materials that problems may arise in a complex geometry. A case in point is when steel is used with the depleted uranium in a high temperature environment; the coefficient of expansion for the depleted uranium is about 4 times that of steel.

9.1.4. TUNGSTEN

by E. E. Hamer and A. E. McArthy

9.1.4.1. INTRODUCTION

Pure tungsten is an excellent gamma ray shield material for use in limited space and high temperature environments because of its very high density (19.30 g/cm³) and high melting point (3410 °C) [9]. Its use is limited to small shields or parts for shields primarily because fabrication is presently limited to powder-metallurgy techniques, swaging, grinding and brazing; it is also costly.

9.1.4.2. OCCURRENCE AND EXTRACTION

Tungsten is rare and not found in the pure metal state. Primary mineral sources are Scheelite ($CaWO_4$) and Wolframite ($FeWO_4$ or $MnWO_4$). Refining is difficult because of its high temperature properties. The oxide is reduced in a stream of hydrogen at a bright red heat producing a powder for fabrication into desired shapes by the powder-metallurgy techniques.

9.1.4.3. PROPERTIES

A. Nuclear Properties

The high density of tungsten makes it a good gamma-ray shielding material. Table 9.1.-2 compares thickness and weights of tungsten with the other materials for equivalent gamma ray shielding. Table 4.1.-3 (Vol. I, p. 175) lists values for the gamma ray mass-attenuation coefficient in cm^2/g.

B. Physical and Mechanical Properties

Tungsten is one of the heaviest, hardest, and most infusible metals known. It is brittle at room temperature and below. It is also pyrophoric in air when in finely powdered form. Table 9.1.-15 lists the physical and mechanical properties of tungsten.

Table 9.1.-15. Physical and mechanical properties of tungsten [16].

Density (g/cm³)	19.30
Melting point (°C)	3410 ± 20
Specific heat (cal/g)	
20 °C	6.03
1000 °C	6.63
Coefficient of linear expansion, 10^{-6} per °C	
23 — 500 °C	
As worked	4.98
Annealed	4.45
1000 °C	5.87
Thermal conductivity (cal s^{-1} cm^{-1} $°C^{-1}$)	
0 °C	0.48
Hardness, Brinell	
20 °C	262
296 °C	125

C. Chemical Properties

Tungsten is very resistant to acids but is attacked by alkalies and has a tendency to oxidize rapidly at 400–500 °C in air.

9.1.4.4. FABRICATION

Tungsten fabrication is generally by powdered-metallurgy techniques followed by sintering; namely, the tungsten powder is pressed into the desired shape under high pressure and then sintered at a high temperature [16]. The sintered form may then be rolled or drawn by frequent heating between passes. After high temperature working, the material is relatively ductile. Machining is limited to grinding. The material welds poorly but can be brazed.

9.1.4.5. APPLICATIONS AND DESIGN CONSIDERATIONS

Tungsten is not widely used as a shield material except for small high energy source applications where space is restrictive, or as specific parts of shields where additional shielding is required in the same space allocation. In another application, tungsten, or an alloy, may be used in mechanisms (e.g., as wear surfaces that also provide the necessary shielding). Tungsten should be considered as a candidate for shield material in very high temperature environments.

The primary restrictions on the use of tungsten are high cost, difficulty in fabrication and the limitation of availability in large sizes (over 2 in O.D.). By alloying tungsten with nickel (up to 7½%) and copper (up to 4%), fabrication can be made easier (no longer limited to grinding), larger billets and shapes are commercially available (up to 25 in. O.D. and 14 in. long) and the cost is less per unit weight. The alloying results in a density penalty (90% W, 6% Ni, 4% Cu has a density of 17 g/cm³).

Appendix 03

Properties of Lead (Pb)

TABLE B-20 Thermal properties of selected materials

Material	Temperature T, K	Density ρ, kg/m³	Specific Heat c_p, kJ/kg · K	Thermal Conductivity k, W/m · K	Viscosity μ, $(N \cdot s/m^2) \times$
Nonmetallic solids					
Asbestos	300	2,090	1.047	0.166	
Asphalt	300	2,115	0.920	0.062	
Brick					
Common	300	1,900	0.840	0.70	
Fire clay	1,000	2,600	0.960	1.50	
Masonry	300	1,800	0.837	0.67	
Clay	300	1,460	0.880	1.30	
Concrete	300	2,300	0.880	1.40	
Cork board	300	150	1.900	0.039	
Diamond	300		1.820		
Felt board	300			0.048	
Glass	300	2,500	0.750	1.40	
Glass fiber	300	2.70		0.0346	
Glass wool	300	50	0.70	0.038	
Gypsum board (plaster)	300	800	1.090	0.170	
Ice	273	920	2.000	2.20	
Mineral wool	300			0.049	
(batts)					
Polystyrene	300	55		0.029	
(Styrofoam)					
Polyurethane	300	80		0.023	
(foam, rigid)					
Rock wool	300	160		0.040	
Rubber					
Foam	300	70		0.042	
Hard	300	1,190	2.01	0.16	
Sand	300	1,515	0.80	0.30	
Sawdust	300	215		0.059	
Skin (human)	300		3.80	0.37	
Snow					
Loose	273	110		0.05	
Packed	273	500		0.10	
Soil	300	2,050	1.840	0.52	
Stone					
Granite	300	2,630	0.775	2.79	
Limestone	300	2,320	0.810	2.15	
Sandstone	300	2,150	0.745	2.90	
Teflon	300	2,200	1.00	0.35	
Wood (cross-grain)					
Balsa	300	140		0.055	
Pine (yellow)	300	640	2.805	0.15	
Oak	300	545	2.385	0.17	
Plywood	300	550	1.200	0.15	
Wool	300	90		0.050	
Vermiculite					
Loose	300	80	0.835	0.068	

TABLE B-20 (Continued)

Material	Temperature T, K	Density ρ, kg/m³	Specific Heat c_p, kJ/kg · K	Thermal Conductivity k, W/m · K	Viscosity μ, $(N \cdot s/m^2) \times$
Gases					
Air	300	1.036	1.007	0.026	0.0184
Ammonia	300	0.683	2.060	0.025	0.0092
Carbon dioxide	300	1.81	0.824	0.017	0.0148
Carbon monoxide	300	1.16	1.040	0.025	0.0182
Hydrogen	300	0.0813	14.304	0.180	0.0089
Nitrogen	300	1.15	1.040	0.026	0.0176
Oxygen	300	1.31	0.911	0.027	0.0200
Steam	300	0.770	1.856	0.0267	0.0134
Methane	300	0.655	2.227	0.0329	0.0134
Metallic solids					
Aluminum	300	2,700	0.902	236	
Brass	300	8,520	0.385	111	
Copper	300	8,900	0.385	401	
Iron					
Wrought	300	7,850	0.460	61	
Cast	300	7,270	0.420	80	
Lead	300	11,310	0.129	36	
Silicon	300	2,330	0.691	150	
Steel					
Carbon	300	7,800	0.473	43	
Stainless	300	7,900	0.477	15	
Liquids					
Ammonia	300	602	4.80	0.520	0.22
Benzene	300	895	1.81	0.159	0.65
Engine oil (unused)	300	886	1.89	0.145	212.0
Ethyl alcohol	300	788	2.305	0.168	1.2
Ethyl glycol	300	1,116	2.385	0.252	21.4
Glycerine	300	1,260	2.59	0.285	1490
Water	300	997	4.18	0.608	0.887
Liquid metals					
Bismuth	600	9,993	0.135	16.4	1.61
Lead	755	10,476	0.157	17.4	2.15
Lithium	600	498	4.180	48.0	0.32
Mercury	600	12,816	0.134	14.2	0.84
Potassium	600	766	0.783	44.0	0.24
Sodium	600	871	1.300	76.0	0.32

Ref: K.C. Reilly
Thermodynamics and Heat Power
MacMillan

Given below is the emissivity data for Lead Pb, this information was taken from http://www.omega.com/literature/transactions/volume1/emissivitya.html

MATERIAL	TEMP °F (°C)	e-EMISSIVITY
Iron, Wrought		
Dull	77 (25)	.94
Dull	660 (349)	.94
Smooth	100 (38)	.35
Polished	100 (38)	.28
Lead		
Polished	100-500 (38-260)	.06-.08
Rough	100 (38)	.43
Oxidized	100 (38)	.43
Oxidized at 1100¡F	100 (38)	.63
Gray Oxidized	100 (38)	.28

Appendix 04

Assay Certificate

厦门中国硬钨科技有限公司

Chinatungsten Online (Xiamen) Manu. & Sales Corp.

www.chinatungsten.com

[illegible] Wuhan Building, Sec. [illegible] Jiahe RD, Xiamen, SEZ, Fujian 361009 P.R. Chine

Fax: 0086 592 512 [illegible] Tel: 0086 592 512 9595, 512 9606, 885 3589

Email: sales@chinatungsten.com, [illegible]@chinatungsten.com

ASSAY CERTIFICATE

THE BUYER	ANALOGUE AND DIGITAL MEASUREMENTS	
CONTRACT NO.	[illegible]	
DATE	June 10th, 2004	
BATCH NO.	[illegible]	
COMMODITY	TUNGSTEN HEAVY ALLOY	
SPECIFICATIONS	Ø300 × Ø51 × 450	1PC
	Ø75 × 125	2PCS
ELEMENTS	W	92
	[illegible]	[illegible]
	[illegible]	[illegible]
DENSITY	18.5 g/cm3	
INSPECTOR	[illegible]	
Q.A. MANAGER	[illegible]	
DATE	June 10, 04.	

Appendix 05

Stainless Steel Manual Sections 3 & 4

3 Properties & performance

SECTION 3.1
CORROSION

Stainless steels are not indestructible materials, nor immune to all corrosive attack. However, stainless steels are excellent contestants of corrosion. With the correct selection of alloy, application of good design principles and proper fabrication practices, the few problems associated with corrosion in stainless steel can be overcome.

Due consideration must be given to all conditions of service, including the less obvious ones, such as plant downtimes, cleaning practices and hydrostatic testing.

The more common forms of corrosion which affect all metals and alloys, including stainless steel, are briefly outlined.

GENERAL CORROSION

General corrosion is a uniform attack on the entire metal surface. It is the least dangerous because rates of corrosion can be measured and predicted. Stainless steels have very low general corrosion rates in many aggressive environments.

GALVANIC CORROSION

Galvanic corrosion may occur when two different metals are in electrical contact and immersed in the same corrosive solution. Stainless steels are noble metals and therefore seldom suffer increased corrosion rates as a result of galvanic coupling.

EROSION/ABRASION CORROSION

Erosion/abrasion corrosion is a combination of mechanical and corrosive attack. Abrasive particles in suspension, at high velocities, expose fresh metal surfaces which then suffer high rates of corrosion. Stainless steels offer a high resistance due to the tenacious and stable passive film on their surface.

INTERGRANULAR CORROSION

Intergranular corrosion is due to the formation of chromium carbides at high temperatures (450 to 850 degrees Celsius).

These form preferentially at the grain boundaries thus reducing the chromium content and resulting in a path of lower corrosion resistance around the grain. With correct choice of material (L or stabilised grades) and care during fabrication, this form of corrosion should not occur.

PITTING CORROSION

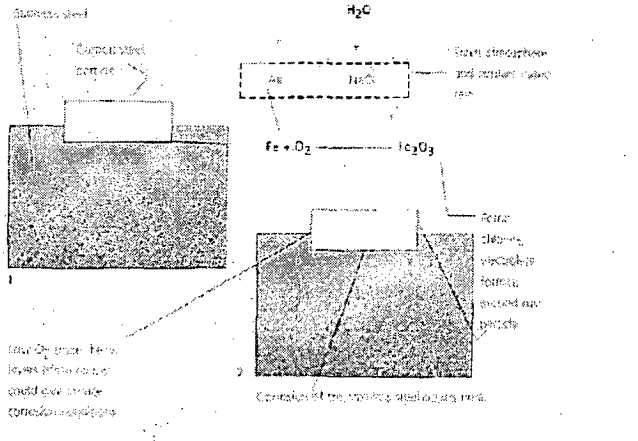
Pitting corrosion is a dangerous localised form of corrosion which results in small pits or perforations, but with little general metal loss. The chloride ion, which can break down the passive chromium rich oxide film, is usually responsible for pitting corrosion (especially in acidic solutions at elevated temperatures). Stainless steels allowed to resist pitting corrosion can be selected for environments where it is likely to occur.

Embedded iron may also give rise to pitting corrosion. This is one of the most common forms of corrosion seen on stainless steel - iron particles deposited on the surface of stainless steel through mechanical contact with, usually, carbon steels, quickly corrode and form a rust stain. If chloride ions are present this can give rise to an environment likely to cause pitting corrosion in the basic grades of stainless steel (see Figure 9). Stainless steel fabricators are cautioned against using the same tools on stainless steel as carbon steels. Embedded iron can be removed by passivation treatment.

CREVICE/SHIELDED CORROSION

Crevice/shielded corrosion occurs where the surface of stainless steel is shielded

FIGURE 9 CORROSION FROM EMBEDDED IRON



SECTION 3.4
COMPARATIVE PROPERTIES OF ANNEALED MATERIALS

TABLE 10 COMPARATIVE PROPERTIES OF ANNEALED MATERIALS

	Carbon Steel	Stainless Steels						Aluminium Alloy	Copper	Nickel	Titanium	Zinc
	AS1548-7-430	304	316	410	430	2205	2304					
Physical Properties												
Density (kg/m³)	7850	8000	8000	7700	7700	7800	7700	2700	8900	8900	4510	7130
Modulus of Elasticity GPa												
Tension	210	200	200	190	200	200	200	70	115	207	105	82-85
Torsion	79					77.9		26	44		45	
Specific Heat Capacity J/kg/K	460	500	500	460	460	490	450	890	385	4700	519	394
Thermal Conductivity W/m/K												
20°C	49	15	15	24	23	19	20	194	386	90.5	18	109
Mean Coefficient of Thermal Expansion												
20-100°C	11.8	16.0	16.0	10.8	10.4	13.0	13.0	23.2	17.0	13.3	8.6	24.0
20-200°C	12.6	17.0	17.0	10.8	10.4	13.4	13.4	24.1	17.4			
20-300°C	13.0	17.5	17.5	11.2	10.8	13.8	13.8	25.2			9.2	
Electrical Resistivity nΩm	120	720	740	580	600	850	800	26	17	93	430	59
Young's Modulus (Secant Modulus)												
	200	450	470	420	470	600	600	690	2240	660	1140	1000
Relative Magnetic Permeability												
	200	1.02	1.02	1.02			2.5 (max 1000)					
Melting Range °C	1490	1400	1375	1480	1425		1390	658	1085	1455	1670	419
	1535	1450	1400	1530	1510		1420	694	1980	1495		421
Yield Stress (0.2% Proof Stress) MPa												
	350	220	220	275	325	450	400 (650)*	43	65	105	170	105 (275)*
Tensile Strength MPa	430	540	540	490	475	640	650	110	210	405	240	200 (280)*
Elongation %	25	57	55	30	28	35	25	36	35	50	22	40 (2)*
Hardness HRB								65	70			34

SECTION 3.5
STAINLESS STEEL — THE EFFECTS OF TEMPERATURE

Stainless steels find application over a wide range of temperatures — more than any other metal.

LOW TEMPERATURE — CRYOGENIC APPLICATIONS

Austenitic stainless steels are often chosen for refrigeration plants, the processing, storage and transportation of liquefied gases and structural applications at very low temperatures. Carbon steels and ferritic, martensitic and duplex stainless steels generally undergo a transition from ductile to brittle failure as the temperature decreases. Although the strength of these materials is unaffected or may increase as the temperature decreases, they may fail without warning, particularly under impact loads. This lack of toughness restricts their use to temperatures above the ductile to brittle transition temperature (DBTT).

The exact temperature at which this transition from ductile to brittle failure occurs in ferritic steels is determined by a variety of factors, including the composition, the grain size and impurity levels. Wide variations in DBTT can occur. The common ferritic stainless steels generally have DBTTs a little below zero degrees Celsius.

Austenitic materials do not undergo brittle failure, so can be used in structural applications at temperatures down to minus 270 degrees Celsius. Austenitic stainless steels are often used and easily retain their ductility, even when welded.

ELEVATED TEMPERATURE APPLICATIONS

Metals designed for elevated temperature applications must survive corrosion arising from the high temperature environment and the effect the high temperature will have on the strength of the metal.

Stainless steels may be used at high temperatures for applications which are non-load bearing (eg furnace liners) or

4 Grade selection

Common austenitic grades (eg S30400 and S31600) may suffer from stress corrosion cracking (SCC) in chloride-containing environments, particularly in temperatures above about 50 degrees Celsius and when a tensile stress is present in the steel. The ferritic and duplex grades are highly resistant, though not immune, and should be selected if SCC is a possibility.

SELECTION FOR MECHANICAL AND PHYSICAL PROPERTIES

Martensitic (eg S41000) and precipitation hardening (eg S17400) grades are often preferred materials for products where high strength, eg shafts and valve stems.

Often, a grade is selected for the anticipated corrosion resistance, and the mechanical and physical properties of the grade are only considered in the subsequent design process. However, these properties are fundamental and should be considered as early as possible in the selection process. For example, while a duplex grade like S31803 is highly corrosion resistant, it may also be more cost-effective in the long term for a given application due to its high strength.

SELECTION FOR FABRICABILITY

Fabricability should be considered early in the grade selection process — it greatly influences the cost of the product. Table 16 lists some common grades and compares their relative fabricability on a scale of 1 to 10, with 10 indicating excellent fabricability by this method.

A compromise between desirable properties of certain grades may be necessary. For example, grade S30300 (austenitic steel known as 303) has excellent machinability, but the high sulphur content which dramatically improves the cutting speed also substantially reduces the grade's weldability, formability and corrosion resistance. Its PRE is wrong because the negative effect of sulphur is omitted making it totally inappropriate for applications where there is a likelihood of corrosive conditions of even a slightly aggressive nature.

CONCLUSION

Before selecting a grade of stainless steel, it is essential to consider the required properties such as corrosion resistance, but it is also important to consider the secondary qualities such as physical and mechanical properties and fabricability of any competing grade. The appropriate choice will ultimately provide both short and long-term benefits: cost-effective fabrication and installation and a long, trouble-free life.

Specifiers of stainless steel can obtain experienced help from independent and supplier/fabricator sources, often at no cost.

Corrosion performance, physical and mechanical properties, surface finishes and a range of information comparing stainless steels are listed elsewhere in this *Reference Manual*. Call ASSDA for the first step for your needs.

REFERENCES

ASM International (1989) *Corrosion Data*.

ASM International (1994) *ASM Specialty Handbook — Stainless Steels*.

Sedriks, AJ (1996) *Corrosion of Stainless Steels*. John Wiley & Sons.

TABLE 15 PITTING RESISTANCE EQUIVALENT NUMBER (PRE) OF COMMON STAINLESS STEEL GRADES

Grade	Alloy group	PRE
S31254 (254SMO)	Austenitic	43
S32750	Duplex	42
S32760	Duplex	41
S31803	Duplex	34
S32304	Duplex	26
S31600	Austenitic	24
S31603	Austenitic	24
S30400	Austenitic	18
S30403	Austenitic	18
S41003	Martensitic	11
S40977	Ferritic	17
S40945	Ferritic	17
S40930	Ferritic	11
S40920	Ferritic	11
S40910	Ferritic	11

* Calculated PRE using the division of longer weld-exposed S31254 tubing sub-sample.

TABLE 16 RELATIVE FABRICABILITY OF COMMON STAINLESS STEEL GRADES

Grade	Formability	Machinability	Weldability
S41003	7	6	7
S40910	7	6	7
S40920	7	6	7
S40930	7	6	7
S40945	7	6	7
S40977	7	6	7
S30400	7	6	7
S30403	7	6	7
S31600	7	6	7
S31603	7	6	7
S31803	6	5*	6
S32304	6	5*	6
S32750	5	4*	5
S32760	5	4*	5
S31254	5	4*	5

* Single-pass version of these grades offer higher machinability at some products

load bearing (eg furnace structures, pressure vessels). The maximum service temperature is usually limited by oxidation properties for non load bearing applications, or by creep behaviour where the steel is load bearing. Creep conditions are more severe and maximum service temperatures are lower.

Choice of steel grade may also need to consider precipitation reactions at elevated temperatures, which can reduce corrosion resistance and/or toughness.

OXIDATION OR SCALING

Stainless steels are particularly resistant to oxidation effects. The chromium that provides the passive corrosion resistant at room temperature also helps to resist oxidation at elevated temperatures. The generally accepted temperatures for the use of stainless steel in air are given in Table 11.

Available is based on an oxidation rate of 10 milligrams per square centimetre (10mg/sq cm) in 1000 hours. The condition with intermittent temperatures is related to the different expansion coefficients of the base metal and the scale. The nickel content of the austenitic steels provides a higher spalling resistance and hence this effect is not quite as significant with these steels.

TABLE 11 MAXIMUM SERVICE TEMPERATURE (°C)

Service	Intermittent Service	Continuous Service
[illegible]	875	845
[illegible]	540	900
[illegible]	675	925
[illegible]	660	1095
[illegible]	1035	1150
[illegible]	870	925
[illegible]	870	925
[illegible]	1035	1150
[illegible]	870	925
[illegible]	815	705
[illegible]	870	815
[illegible]	1035	900
[illegible]	1175	1095
[illegible]	815	705
[illegible]	815	760

Generally accepted maximum service temperatures in air for these stainless steels.

It should be noted that these values can only be taken as a guide, the effect of major variations in temperature cycling and atmosphere composition, particularly sulphur bearing gases, can have a marked effect on high temperature corrosion resistance. Final selection should be based on tests carried out under the conditions that apply in the actual environment.

HIGH TEMPERATURE STRENGTH — CREEP

The strength of a metal at room temperature does not accurately reflect the strength at high temperatures. At elevated temperatures time and temperature both affect the strength of the metal. The effect of time introduces creep (the failure of a metal at a load below its room temperature strength).

The creep strength of a metal can be expressed in two ways:

- The load required to produce a given elongation after a particular time at a particular temperature.
- The load to produce rupture elongation after a particular time at a particular temperature.

Although not classified as creep resisting materials, stainless steels all have relatively high creep strengths, particularly the H or higher carbon grades, and are often used at intermediate temperatures because of this. The permissible loads for some of these steels as given in AS 1210 is given in Table 12.

It must be noted that the full table in the Standard gives modifications to these values depending on the grain size and permissible deformation.

HIGH TEMPERATURE PRECIPITATION REACTIONS

Both the ferritic and duplex steels can give problems at temperatures around 370 to 540 degrees Celsius. There is a change in structure of the ferrite that gives an increase in hardness but a major decrease in room temperature toughness. The change is sometimes referred to as 475 degrees Celsius embrittlement.

Ferritic steels containing higher chromium, and particularly those with molybdenum, can also be prone to the formation of another embrittling phase, sigma, if they are held for prolonged periods above approximately 560 degrees Celsius. A similar problem with a further embrittling phase, chi, is only found in the molybdenum containing ferritic stainless steels. Austenitic grades will suffer carbide precipitation during service for extended periods in the temperature range 425 to 875 degrees Celsius, unless stabilised with niobium or titanium (eg grades 321 and 316Ti). Carbide precipitation may reduce toughness, but in practice reduced resistance to intergranular corrosion in sulphur dioxide, chloride or related environments at room temperature may be more important. L grades with carbon restricted to ≤ 0.03 percent will give better performance in this respect than the standard grade or H grade.

Martensitic and precipitation hardening steels are also unsuitable at higher temperatures. This is predominantly related to the effect the increased temperature has on tempering the steel.

Grade selection 4

Stainless steels have diverse properties which provide viable and cost-effective solutions to a vast range of applications. In practice, development of a hierarchy of required properties reduces the range to a manageable number of highly versatile materials, enabling users to choose the most appropriate grade for the particular application.

The family of stainless steels can be divided into five basic alloy groups (see Table 13).

GRADE S30400 STAINLESS STEEL

S30400 is the most specified grade. It accounts for more than 50 percent of stainless steel produced in the world and services a wide range of applications. It withstands ordinary rusting in architecture, is resistant to most food processing environments, and resists organic chemicals, dye stuffs and a wide variety of inorganic chemicals. It is used extensively in consumer products and appliances, and equipment for domestic and commercial kitchens, hospitals, transportation and waste water treatment. S30400 is also available in virtually all product forms and finishes.

TABLE 14 STAINLESS STEEL PROPERTIES

Selected property examples	Properties alloy groups and grades
Corrosion resistance	Selection depends largely upon environment
Heat resistance	Austenitic grades (eg CL to S31500, and S[illegible]) [illegible] or [illegible] [illegible] High Cr ferritic grades, eg S44500
Cryogenic-flow temperature resistance	Austenitic grades
Low magnetic response	Austenitic grades, especially higher of grades, eg [illegible] or S31500
High strength	Martensitic and precipitation hardening grades

When selecting a stainless steel, first consider the fundamental *competitive advantage* properties required. These basic properties can initially be viewed according to the five basic alloy groups (see Table 14).

For corrosive environments, take advantage of past experience. Even small amounts of some impurities and/or changes in temperature of flow conditions can have a significant effect on corrosion resistance. Specialist suppliers and other independent experts, who often provide advice at no cost, are contactable through ASSDA for assistance with a recommendation.

For resistance to environments such as strong acids, where uniform general corrosion is the controlling mechanism, refer to published tables of recommended grades and iso-corrosion curves (usually comparing several grades) that indicate the rate at which the stainless can be expected to corrode. It is again stressed that minor differences between apparently similar environments, eg presence of chloride, can significantly alter the corrosion rates. Local corrosion, such as the related mechanisms of pitting and crevice corrosion, is largely controlled by the presence of chlorides in the environment and exacerbated by elevated temperature and surface deposits. Keeping a stainless steel surface clean is an important way of minimising corrosion. Surface roughness can also help in initiating corrosion, so the smoother the surface, the better. A grade's resistance to pitting and crevice corrosion is indicated by its *Pitting Resistance Equivalent number* (PRE = %Cr + [3.3 x %Mo] + [16 x %N]) (see Table 15).

Grades with high levels of each element are more resistant. Hence, S31600 (two percent molybdenum) is standard for marine fittings. Grade S31803 (three percent molybdenum and 0.15 percent nitrogen) is more resistant to higher temperature chloride environments and the *super duplex* (eg S32750 and S32760) and *super austenitic* (eg S31254) grades have very high levels of each element and can withstand high chloride environments up to nearly boiling point.

TABLE 13 FIVE BASIC STAINLESS STEEL ALLOY GROUPS

Alloy Group	Common Grades					
Austenitic	UNS No.	S30100	S30400	S30403	S31600	S31603
	Commonly	301	304	304L	316	316L
	UNS No.	S32100	S31000	S30815	N08904	[illegible]
	Commonly	321	310	253MA™	904L	[illegible]
Ferritic	UNS No.	S40900	S43000	S41003/S40977	S44400	S44800
	Commonly	409	430	[illegible]	444	446
Martensitic	UNS No.	S41000	S42000	S43100	S44004	
	Commonly	410	420	431	440C	
Duplex	UNS No.	S32304	S31803	S32750	S32950	S32760
	Commonly	2304	2205	2507	Ferralium 255™	Zeron 100™
Precipitation Hardening	UNS No.	S17400	S17200	S15500		
	Commonly	17-4 PH or 630	17-7 PH or 631	15-5 PH		

Note: UNS numbers are used throughout this section for consistency purposes.

Appendix 06

Original Drawings

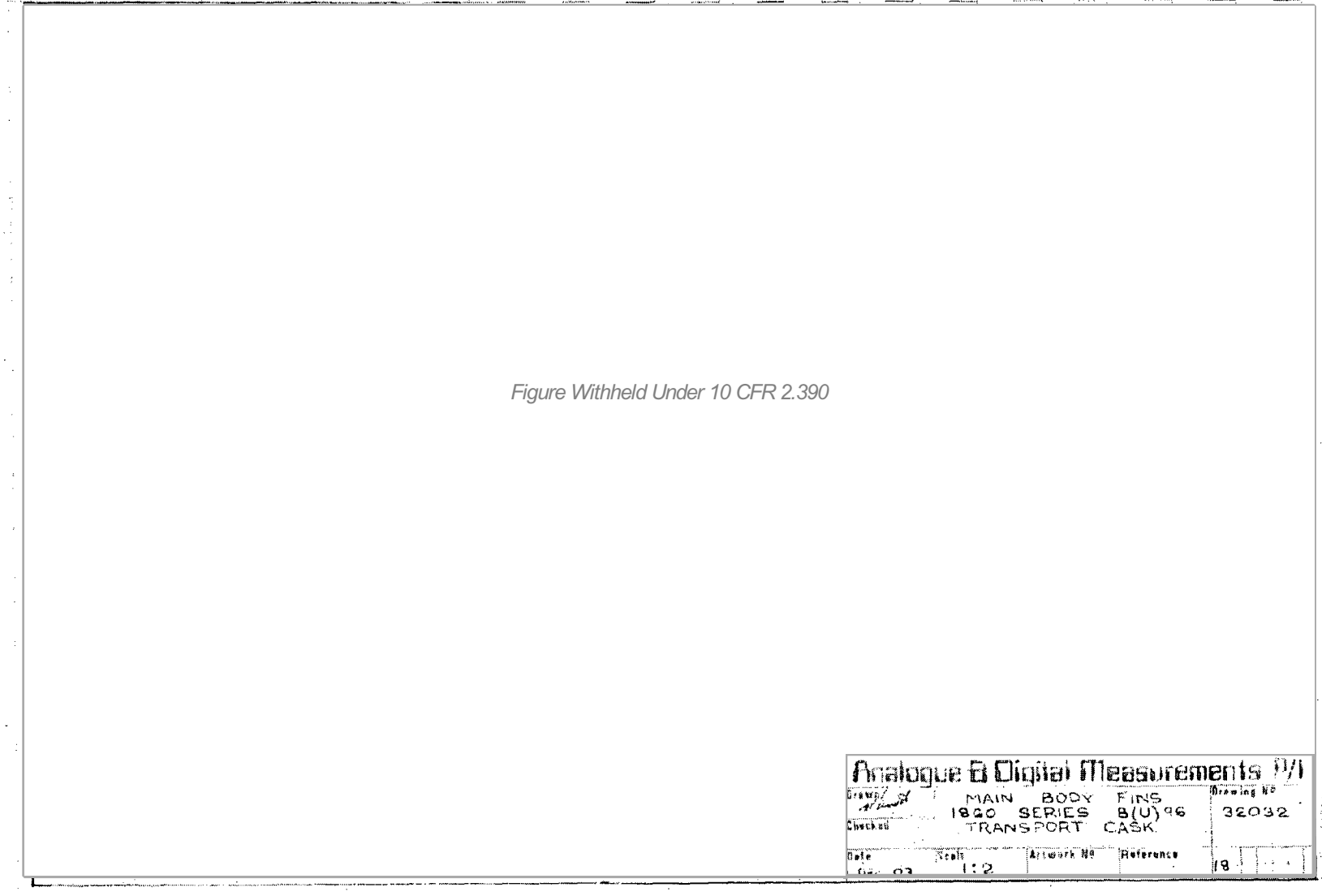


Figure Withheld Under 10 CFR 2.390

Figure Withheld Under 10 CFR 2.390

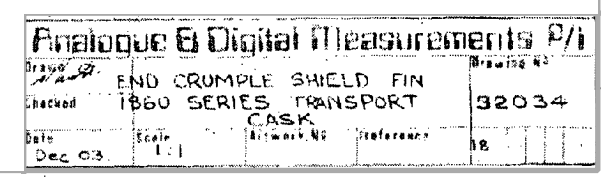


Figure Withheld Under 10 CFR 2.390

Analogue & Digital Measurements P/L				
Drawn	CONE DETAIL 1860 SERIES B(U)96 TRANSPORT CASK			Drawing No 32036
Checked				
Date 5 Dec 03	Scale 2:1 10:1	Artwork No	Reference	18

Figure Withheld Under 10 CFR 2.390

Analogue & Digital Measurements P/L

Drawn	END CAPS 1860 SERIES B(U)96 TRANSPORT CASK THERATRON 780	Drawing No 32037
Checked		
Date 8 Dec 03	Scale 1 : 1	Artwork No / Reference / 18

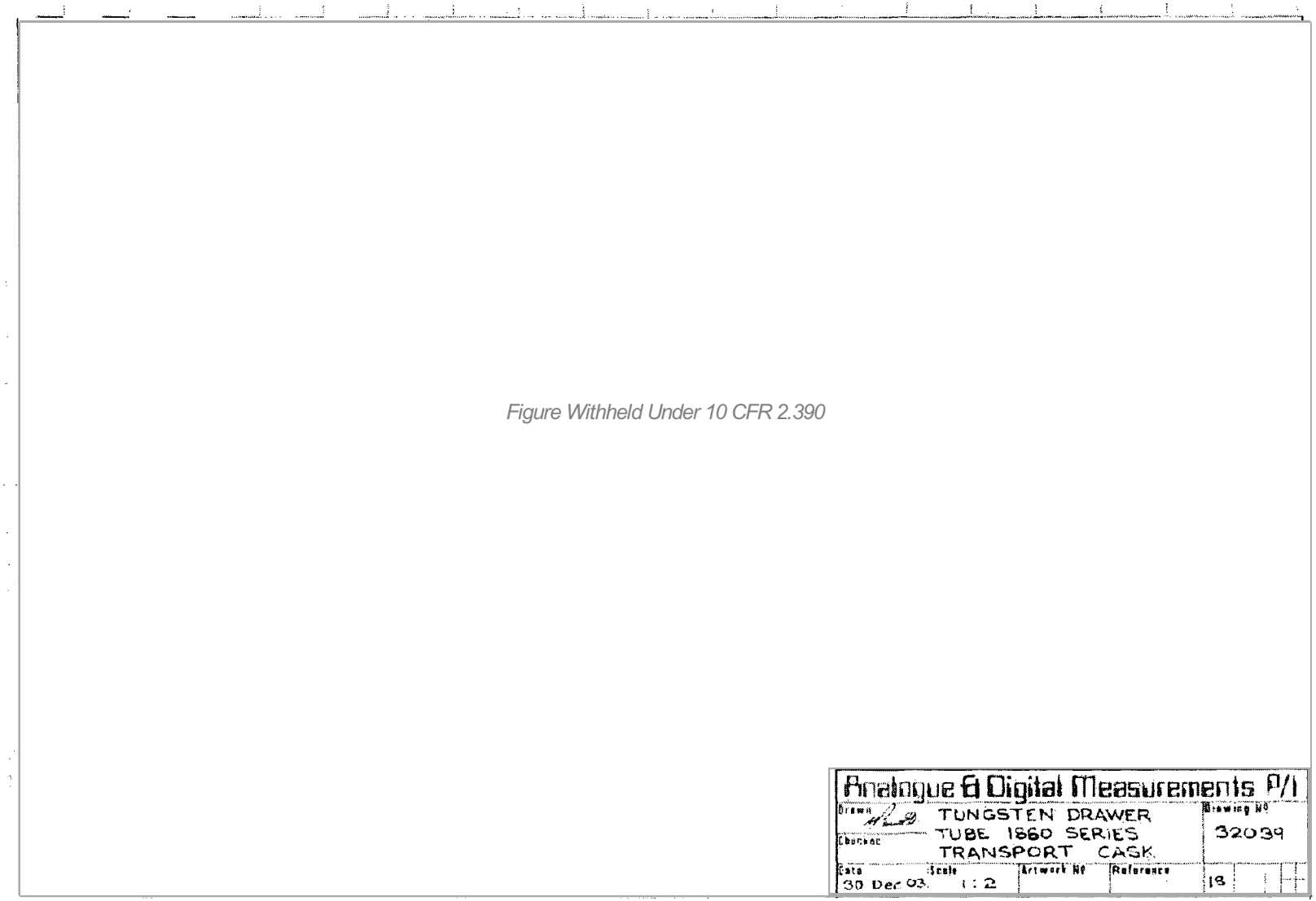


Figure Withheld Under 10 CFR 2.390
Analogue & Digital Measurements P/L
Drawn
Checked
TUNGSTEN DRAWER
TUBE 1860 SERIES
TRANSPORT CASK.
Drawing No
32039
Date
30 Dec 03.
Scale
1 : 2
Artwork No
Reference
18

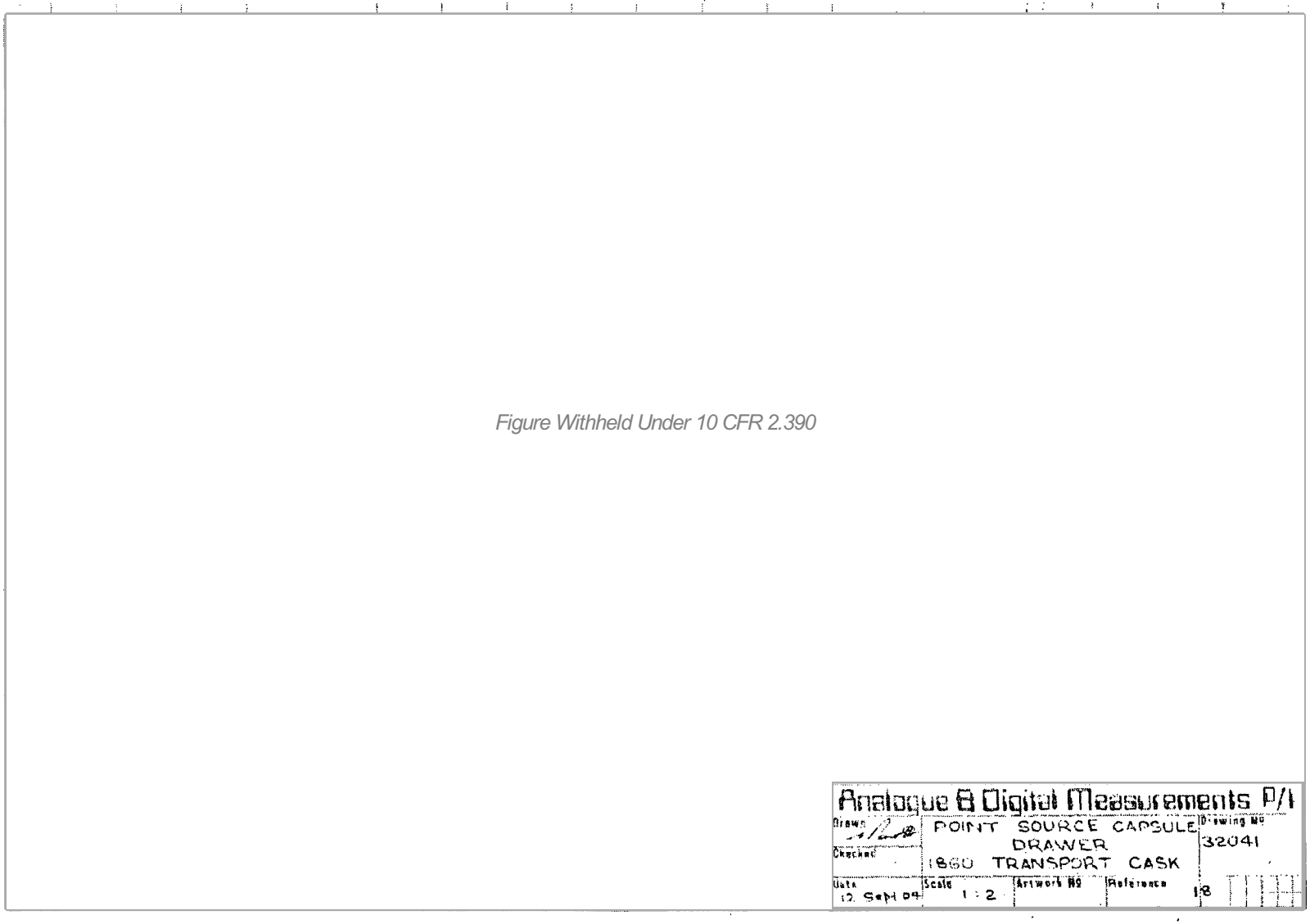


Figure Withheld Under 10 CFR 2.390
Analogue & Digital Measurements P/L
Drawn
Checked
POINT SOURCE CAPSULE
DRAWER
1860 TRANSPORT CASK
Drawing No
32041
Date
12 Sept 04
Scale
1 : 2
Artwork No
Reference
1/8

Figure Withheld Under 10 CFR 2.390

Analogue & Digital Measurements P/L		
Drawn	THERAPY SOURCE CAPSULE CAVITY & RETAINER 1860 TRANSPORT CASK	Drawing No 32045
Checked		
Date 20 March 04	Scale	Artwork No / Reference 18

Figure Withheld Under 10 CFR 2.390

Analogue & Digital Measurements P/I				
Drawn	STANDARD DRAW TUBE 1860 SERIES TRANSPORT CASK LEAD ATTENUATOR			Drawing No 32038
Checked				
Date 29 Dec 03	Scale 1:1 1:2	Artwork No	Reference	19

Appendix 07

Sequence of Construction

End Cones

Step	*Procedure*
1	Grind outside edge both sides,
2	Roll cone until ends meet, tack weld, continue to roll until round
3	Fully Weld outside of seam grind flat, fully weld inside seam
4	Check for round, roll as necessary. Check both ends sit flat on surface plate
5	With cone on Surface plate large end down, sit End Plate on ensure parallel to surface plate tack in place
6	Turn over, fully weld inside
7	Inspect welds for cracks
8	Turn back, fully Fuse outside interface of Cone to End Plate
9	Clean off weld to give smooth 3mm edge.
10	Repeat with second
11	Cone and End Plate

Center Shell

Step	*Procedure*
1	Grind outside edge both sides, (2mm chamfer)
2	Roll cylinder until ends meet, tack weld, continue to roll until round
3	Fully Weld outside of seam. grind flat, fully weld inside seam
4	Inspect welds for cracks
5	Check for round, roll as necessary

Attenuator Outer Rings,

Step	*Procedure*
1	Place 4 off 1/4 ring sections onto assembly jig
2	Tack weld
3	Turn Ring over to check symmetry
4	Tack on 2nd side

Step	Procedure
5	Remove Ring from jig weld both sides
6	Grind off welds.
7	Check for flatness.
8	Repeat for second ring

Inner Attenuator Rings

Step	Procedure
1	Place 4 off 1/4 ring sections onto assembly jig
2	Tack weld
3	Turn Ring over to check symmetry
4	Tack on 2nd side
5	Remove Ring from jig weld both sides
6	Grind off welds.
7	Check for flatness.
8	Repeat for second ring

Attenuator Case

Step	Procedure
1	Assemble the Drawer Tube, End Cones (with the short machined end of the Drawer Tube into the End cone with out the filling Ports.) and Centre Shell.
2	Tack in place (ensuring the seams are in line)
3	Fully weld centre shell to end cones.
4	Clean off welds inspect for cracks.
5	Ensure Drawer Tube is pushed home into the End Plate (without the filling ports)
6	Fully weld End Plate and Drawer Tube.
7	Check weld for cracks

Support Fins

Step	*Procedure*
1	Stand the Attenuator Case onto it's end (filling ports up)
2	Place a Threaded outer ring in it's approximate position
3	Position the lower Central Support Fin in place (opposite side to Case weld) tack weld. Using the engraved marks to position the Fin and the Outer Ring as a height gauge.
4	Position Side Support Fins in place next to the Central Fin (Using the engraved marks as above) tack in place.

Top Fin

Step	*Procedure*
1	With the Attenuator Case set up as for Support Fins
2	position the Top Fin central over the longitudinal Case weld, check position with reference to engraved marks for Fin positioning on either side.
3	Tack in place.

Peripheral Fins

Step	*Procedure*
1	With the Attenuator Case set up as for Support Fins
2	Position the remaining fins 8 off using the engraved marks to position the Fin and the Outer Ring as a height gauge.
3	Tack in place

Fit Outer Attenuator Rings

step	*Procedure*
1	With the Attenuator Case on end , position the ring central to the Drawer Tube . Tack top and bottom Fins to the Ring .
2	Centralise the Ring and tack the 3 and 9 o'clock positions
3	Ensure fins are square and spaced equally and central, tack in position the remaining fins in a cross over sequence.
4	Turn over and repeat with the other end.

Fit Inner Attenuator Rings

step	*Procedure*
1	Position a central ring onto the fins align the ring central to the Drawer Tube . Tack top and bottom Fins to the Ring .
2	Centralise the Ring and tack the 3 and 9 o'clock positions
3	Ensure fins are spaced equally and central, tack in position the remaining fins in a cross over sequence.
4	Turn over and repeat with the other end.

Weld Fins

Step	*Procedure*
1	In a circular cross over sequence weld the fins to the Attenuator Case
2	In a circular cross over sequence weld the fins to the inner ring on one end
3	In a circular cross over sequence weld the fins to the inner ring on the other end
4	In a circular cross over sequence weld the fins to the outer ring on one end
5	In a circular cross over sequence weld the fins to the outer ring on the other end

Fit the Base

Step	*Procedure*
!	Bring the two fabricated sections of the base nearly together
2	Sit the Attenuator Case with the lower central Fin between the base pieces
3	Clamp the base pieces with the fins either side just touching the base
4	Set the base so that the dimension from the base to the drawer is the same at each end to within 1mm.
%	Weld the Fins to the Base.

Assembly of End Shields

Step	*Procedure*
1	Tack Fin Pieces equally round the central tube.
2	Bolt both inner and outer rings to Attenuator
3	Sit Fin assembly onto Rings align with body Fins tack into position
4	In a circular cross over sequence weld the Fins to the outer ring
5	In a circular cross over sequence weld the Fins to the inner ring
6	In a circular cross over sequence weld the Fins to the Central Tube.

Fill with Lead

Step	*Procedure*
1	The lead ingots are to be of acceptable purity clean and dry.
2	The Crucible of adequate size to to completely fill the Cask is loaded with lead. And heated to the desired temperature as determined by the QA Officer.
3	Cask is to be pre heated to an appropriate temperature as determined by the QA Officer.
4	The Cask will be positioned so as to ensure a free flow of lead from the Crucible Valve to the filling port.
5	Slag that results from the melting is to be removed prior to pouring the lead.
6	The Crucible Valve is heated to allow a free flow of lead into the cask
7	The pour is to be continuous and spatter free
8	Once the Cask is filled, the temperature of the Sprue area shall be maintained so that the lead remains in a molten state
9	The Cask is allowed to cool so that solidification gradually advances from the bottom to the filling hole.
10	As the lead shrinks away from the Sprue it is topped up until the lead is sold up to the sprue.
11	once the Cask has cooled to room temperature the Sprue is cut off and the filling holes are cleared of lead to enable clean fitting of the port plugs

Completion of the Attenuator

Step	*Procedure*
1	Insert Port Plugs fully weld.
2	Weld Drawer Tube to end plate on the filling port end
3	Fit Identification plates to both sides
4	Fit mesh to cask
5	Line Bore the Drawer Tube
6	Fit the End Crumple Shields
7	Glass bead the unit to remove all signs of burns and assembly marks
8	Clean the bore to remove any sign of dust.
9	Install the End covers.

Appendix 08

IAEA Regulations, Section 6 Extract

EXCERPT from IAEA REGULATIONS
for the SAFE TRANSPORT of RADIOACTIVE MATERIALS(1996)
TS-R-1

GENERAL REQUIREMENTS FOR ALL PACKAGINGS AND PACKAGES

606. The *package* shall be so designed in relation to its mass, volume and shape that it can be easily and safely transported. In addition, the *package* shall be so designed that it can be properly secured in or on the *conveyance* during transport.

607. The *design* shall be such that any lifting attachments on the *package* will not fail when used in the intended manner and that, if failure of the attachments should occur, the ability of the *package* to meet other requirements of these Regulations would not be impaired. The *design* shall take account of appropriate safety factors to
cover snatch lifting.

608. Attachments and any other features on the outer surface of the *package* which could be used to lift it shall be designed either to support its mass in accordance with the requirements of para. 607 or shall be removable or otherwise rendered incapable of being used during transport.

609. As far as practicable, the *packaging* shall be so designed and finished that the external surfaces are free from protruding features and can be easily decontaminated.

610. As far as practicable, the outer layer of the *package* shall be so designed as to prevent the collection and the retention of water.

611. Any features added to the *package* at the time of transport which are not part of the *package* shall not reduce its safety.

612. The *package* shall be capable of withstanding the effects of any acceleration, vibration or vibration resonance which may arise under routine conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the *package* as a whole. In particular, nuts, bolts and other securing devices shall be so designed as to prevent them from becoming loose or being released unintentionally, even after repeated use.

613. The materials of the *packaging* and any components or structures shall be physically and chemically compatible with each other and with the *radioactive contents*. Account shall be taken of their behavior under irradiation

614. All valves through which the *radioactive contents* could otherwise escape shall be protected against unauthorized operation.

615. The design of the *package* shall take into account ambient temperatures and pressures that are likely to be encountered in routine conditions of transport.

616. For *radioactive material* having other dangerous properties the *package design* shall take into account those properties; see paras 109 and 507.

ADDITIONAL REQUIREMENTS FOR PACKAGES TRANSPORTED BY AIR

617. For *packages* to be transported by air, the temperature of the accessible surfaces shall not exceed 50°C at an ambient temperature of 38°C with no account taken for insulation.

618. *Packages* to be transported by air shall be so designed that, if they were exposed to ambient temperatures ranging from –40°C to +55°C, the integrity of containment would not be impaired.

619. *Packages* containing *radioactive material* transported by air shall have a *containment system* able to withstand without leakage a reduction in ambient pressure to 5 kPa.

REQUIREMENTS FOR TYPE A PACKAGES

633. *Type A packages* shall be designed to meet the requirements specified in paras 606–616 and, in addition, the requirements of paras 617–619 if carried by air, and of paras 634–649.

634. The smallest overall external dimension of the *package* shall not be less than 10 cm.

635. The outside of the *package* shall incorporate a feature such as a seal, which is not readily breakable and which, while intact, will be evidence that it has not been opened.

636. Any tie-down attachments on the *package* shall be so designed that, under normal and accident conditions of transport, the forces in those attachments shall not impair the ability of the *package* to meet the requirements of these Regulations.

637. The *design* of the *package* shall take into account temperatures ranging from –40°C to +70°C for the components of the *packaging*. Attention shall be given to freezing temperatures for liquids and to the potential degradation of *packaging* materials within the given temperature range.

638. The *design* and manufacturing techniques shall be in accordance with national or international standards, or other requirements, acceptable to the *competent authority*.

639. The *design* shall include a *containment system* securely closed by a positive fastening device which cannot be opened unintentionally or by a pressure which may arise within the *package*.

640. *Special form radioactive material* may be considered as a component of the *containment system*.

641. If the *containment system* forms a separate unit of the *package*, it shall be capable of being securely closed by a positive fastening device which is independent of any other part of the *packaging*.

642. The *design* of any component of the *containment system* shall take into account, where applicable, the radiolytic decomposition of liquids and other vulnerable materials and the generation of gas by chemical reaction and radiolysis.

643. The *containment system* shall retain its *radioactive contents* under a reduction of ambient pressure to 60 kPa.

644. All valves, other than pressure relief valves, shall be provided with an enclosure to retain any leakage from the valve.

645. A radiation shield which encloses a component of the *package* specified as a part of the *containment system* shall be so designed as to prevent the unintentional release of that component from the shield. Where the radiation shield and such component within it form a separate unit, the radiation shield shall be capable of being securely closed by a positive fastening device which is independent of any other *packaging* structure.

646. A *package* shall be so designed that if it were subjected to the tests specified in paras 719–724, it would prevent:
(a) Loss or dispersal of the *radioactive contents*; and
(b) Loss of shielding integrity which would result in more than a 20% increase in the *radiation level* at any external surface of the *package*.

647. The *design* of a *package* intended for liquid *radioactive material* shall make provision for ullage to accommodate variations in the temperature of the contents, dynamic effects and filling dynamics.

REQUIREMENTS FOR TYPE B(U) PACKAGES

650. *Type B(U) packages* shall be designed to meet the requirements specified in paras 606–616, the requirements of paras 617–619 if carried by air, and of paras 634–647, except as specified in para. 646(a), and, in addition, the requirements specified in paras 651–664.
651. A *package* shall be so designed that, under the ambient conditions specified in paras 653 and 654, heat generated within the *package* by the *radioactive contents* shall not, under normal conditions of transport, as demonstrated by the tests in paras 719–724, adversely affect the *package* in such a way that it would fail to meet
the applicable requirements for containment and shielding if left unattended for a period of one week. Particular attention shall be paid to the effects of heat, which may:
(a) Alter the arrangement, the geometrical form or the physical state of the *radioactive contents* or, if the *radioactive material* is enclosed in a can or receptacle (for example, clad fuel elements), cause the can, receptacle or *radioactive material* to deform or melt; or
(b) Lessen the efficiency of the *packaging* through differential thermal expansion or cracking or melting of the radiation shielding material; or
(c) In combination with moisture, accelerate corrosion.

652. Except as required in para. 617 for a *package* transported by air, a *package* shall be so designed that, under the ambient condition specified in para. 653, the temperature of the accessible surfaces of a *package* shall not exceed 50°C, unless the *package* is transported under *exclusive use*.

653. The ambient temperature shall be assumed to be 38°C.

654. The solar insulation conditions shall be assumed to be as specified in Table XI.

655. A *package* which includes thermal protection for the purpose of satisfying the requirements of the thermal test specified in para. 728 shall be so designed that such protection will remain effective if the *package* is subjected to the tests specified in

TABLE XI. INSOLATION DATA

Form and location of surface	Insolation for 12 hours per day (W/m2)

Flat surfaces transported horizontally:	
— base	none
— other surfaces	800
Flat surfaces not transported horizontally:	
— each surface	200[a]
Curved surfaces	400[a]

[a] Alternatively, a sine function may be used, with an absorption coefficient adopted and the effects of possible reflection from neighbouring objects neglected.

paras 719–724 and 727(a) and (b) or 727(b) and (c), as appropriate. Any such protection on the exterior of the *package* shall not be rendered ineffective by ripping, cutting, skidding, abrasion or rough handling.

656. A *package* shall be so designed that, if it were subjected to:
(a) The tests specified in paras 719–724, it would restrict the loss of *radioactive contents* to not more than 10–6 *A2* per hour; and
(b) The tests specified in paras 726, 727(b), 728 and 729 and the tests in paras: (i) 727(c), when the *package* has a mass not greater than 500 kg, an overall density not greater than 1000 kg/m3 based on the external dimensions,
and *radioactive contents* greater than 1000 *A2* not as *special form radioactive material*, or (ii) 727(a), for all other *packages*, it would meet the following requirements:
(i) retain sufficient shielding to ensure that the *radiation level* at 1 m from the surface of the *package* would not exceed 10 mSv/h with the maximum *radioactive contents* which the *package* is designed to contain; and
(ii) restrict the accumulated loss of *radioactive contents* in a period of one week to not more than 10 *A2* for krypton-85 and not more than *A2* for all other radionuclides.

657. A *package* for *radioactive contents* with activity greater than 105 *A2* shall be so designed that if it were subjected to the enhanced water immersion test specified in para. 730, there would be no rupture of the *containment system*.

658. Compliance with the permitted activity release limits shall depend neither upon filters nor upon a mechanical cooling system.

659. A *package* shall not include a pressure relief system from the *containment system* which would allow the release of *radioactive material* to the environment under the conditions of the tests specified in paras 719–724 and 726–729.

660. A *package* shall be so designed that if it were at the *maximum normal operating pressure* and it were subjected to the tests specified in paras 719–724 and 726–729, the level of strains in the *containment system* would not attain values which would adversely affect the *package* in such a way that it would fail to meet the applicable
requirements.

661. A *package* shall not have a *maximum normal operating pressure* in excess of a gauge pressure of 700 kPa.

662. Except as required in para. 617 for a *package* transported by air, the maximum temperature of any surface readily accessible during transport of a *package* shall not exceed 85°C in the absence of insulation under the ambient conditions specified in para. 653. The *package* shall be carried under *exclusive use*, as specified in para. 652, if this maximum temperature exceeds 50°C. Account may

be taken of barriers or screens intended to give protection to persons without the need for the barriers or screens being subject to any test.

663. A *package* containing *low dispersible radioactive material* shall be so designed that any features added to the *low dispersible radioactive material* that are not part of it, or any internal components of the *packaging* shall not adversely affect the performance of the *low dispersible radioactive material*.

664. A *package* shall be designed for an ambient temperature range from –40°C to +38°C.

Appendix 09

IAEA Regulations, Section 7 Extract

TEST PROCEDURES

DEMONSTRATION OF COMPLIANCE

701. Demonstration of compliance with the performance standards required in Section VI shall be accomplished by any of the methods listed below or by a combination thereof.
(a) Performance of tests with specimens representing *LSA-III material*, or *special form radioactive material*, or *low dispersible radioactive material* or with prototypes or samples of the *packaging*, where the contents of the specimen or the *packaging* for the tests shall simulate as closely as practicable the expected range of *radioactive contents* and the specimen or *packaging* to be tested shall be prepared as presented for transport.
(b) Reference to previous satisfactory demonstrations of a sufficiently similar nature.
(c) Performance of tests with models of appropriate scale incorporating those features which are significant with respect to the item under investigation when engineering experience has shown results of such tests to be suitable for design purposes. When a scale model is used, the need for adjusting certain test parameters, such as penetrator diameter or compressive load, shall be taken into account.
(d) Calculation, or reasoned argument, when the calculation procedures and parameters are generally agreed to be reliable or conservative.

702.After the specimen, prototype or sample has been subjected to the tests, appropriate methods of assessment shall be used to ensure that the requirements of this section have been fulfilled in compliance with the performance and acceptance standards prescribed in Section VI.

TESTS FOR SPECIAL FORM RADIOACTIVE MATERIAL

General

704. Specimens that comprise or simulate *special form radioactive material* shall be subjected to the impact test, the percussion test, the bending test, and the heat test specified in paras 705–709. A different specimen may be used for each of the tests. Following each test, a leaching assessment or volumetric leakage test shall be performed on the specimen by a method no less sensitive than the methods given in para. 710 for indispersible solid material or para. 711 for encapsulated material.

Test methods

705. Impact test: The specimen shall drop onto the target from a height of 9 m. The target shall be as defined in para. 717.

706. Percussion test: The specimen shall be placed on a sheet of lead which is supported by a smooth solid surface and struck by the flat face of a mild steel bar so as to cause an impact equivalent to that resulting from a free drop of 1.4 kg through 1 m. The lower part of the bar shall be 25 mm in diameter with the edges rounded off to a radius of (3.0 ± 0.3) mm. The lead, of hardness number 3.5 to 4.5 on the Vickers scale and not more than 25 mm thick, shall cover an area greater than that covered by the specimen. A fresh surface of lead shall be used for each impact. The bar shall strike the specimen so as to cause maximum damage.

707. Bending test: The test shall apply only to long, slender sources with both a minimum length of 10 cm and a length to minimum width ratio of not less than 10. The specimen shall be rigidly

clamped in a horizontal position so that one half of its length protrudes from the face of the clamp. The orientation of the specimen shall be
such that the specimen will suffer maximum damage when its free end is struck by the flat face of a steel bar. The bar shall strike the specimen so as to cause an impact equivalent to that resulting from a free vertical drop of 1.4 kg through 1 m. The lower part of the bar shall be 25 mm in diameter with the edges rounded off to a radius of
(3.0 ± 0.3) mm.

708. Heat test: The specimen shall be heated in air to a temperature of 800°C and held at that temperature for a period of 10 minutes and shall then be allowed to cool.

709. Specimens that comprise or simulate *radioactive material* enclosed in a sealed capsule may be excepted from:
(a) The tests prescribed in paras 705 and 706 provided the mass of the *special form radioactive material* is less than 200 g and they are alternatively subjected to the Class 4 impact test prescribed in the International Organization for Standardization document ISO 2919: "Sealed Radioactive Sources —Classification" [11], and
(b) The test prescribed in para. 708 provided they are alternatively subjected to the Class 6 temperature test specified in the International Organization for Standardization document ISO 2919: "Sealed Radioactive Sources —Classification" [11].

TESTS FOR PACKAGES

Preparation of a specimen for testing

713. All specimens shall be inspected before testing in order to identify and record faults or damage including the following:
(a) divergence from the *design*;
(b) defects in manufacture;
(c) corrosion or other deterioration; and
(d) distortion of features.

714. The *containment system* of the *package* shall be clearly specified.

715. The external features of the specimen shall be clearly identified so that reference may be made simply and clearly to any part of such specimen.

Testing the integrity of the containment system and shielding and assessing criticality safety

716. After each of the applicable tests specified in paras 718–737:
(a) Faults and damage shall be identified and recorded;
(b) It shall be determined whether the integrity of the *containment system* and shielding has been retained to the extent required in Section VI for the *package* under test.

Target for drop tests

717. The target for the drop tests specified in paras 705, 722, 725(a), 727, 735 and 737 shall be a flat, horizontal surface of such a character that any increase in its resistance to displacement or deformation upon impact by the specimen would not significantly increase the damage to the specimen.

Tests for demonstrating ability to withstand normal conditions of transport

719. The tests are: the water spray test, the free drop test, the stacking test and the penetration test. Specimens of the *package* shall be subjected to the free drop test, the stacking test and the penetration test, preceded in each case by the water spray test. One specimen may be used for all the tests, provided that the requirements of para. 720 are fulfilled.

720. The time interval between the conclusion of the water spray test and the succeeding test shall be such that the water has soaked in to the maximum extent, without appreciable drying of the exterior of the specimen. In the absence of any evidence to the contrary, this interval shall be taken to be two hours if the water spray is applied from four directions simultaneously. No time interval shall elapse, however, if the water spray is applied from each of the four directions consecutively.

721. Water spray test: The specimen shall be subjected to a water spray test that simulates exposure to rainfall of approximately 5 cm per hour for at least one hour.

722. Free drop test: The specimen shall drop onto the target so as to suffer maximum damage in respect of the safety features to be tested.

(a) The height of drop measured from the lowest point of the specimen to the upper surface of the target shall be not less than the distance specified in Table XIII for the applicable mass. The target shall be as defined in para.

717.

(b) For rectangular fibreboard or wood *packages* not exceeding a mass of 50 kg, a separate specimen shall be subjected to a free drop onto each corner from a height of 0.3 m.

(c) For cylindrical fibreboard *packages* not exceeding a mass of 100 kg, a separate specimen shall be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 m.

TABLE XIII. FREE DROP DISTANCE FOR TESTING PACKAGES TO NORMAL CONDITIONS OF TRANSPORT

Package mass (kg)	Free drop distance (m)
Package mass < 5 000	1.2
5 000 ≤ *Package* mass < 10 000	0.9
10 000 ≤ *Package* mass < 15 000	0.6
15 000 ≤ *Package* mass	0.3

723. Stacking test: Unless the shape of the *packaging* effectively prevents stacking, the specimen shall be subjected, for a period of 24 h, to a compressive load equal to the greater of the following:
(a) The equivalent of 5 times the mass of the actual *package*; and
(b) The equivalent of 13 kPa multiplied by the vertically projected area of the *package*. The load shall be applied uniformly to two opposite sides of the specimen, one of which shall be the base on which the *package* would typically rest.

724. Penetration test: The specimen shall be placed on a rigid, flat, horizontal surface which will not move significantly while the test is being carried out.
(a) A bar of 3.2 cm in diameter with a hemispherical end and a mass of 6 kg shall be dropped and directed to fall, with its longitudinal axis vertical, onto the centre of the weakest part of the specimen, so that, if it penetrates sufficiently far, it will hit the *containment system*. The bar shall

not be significantly deformed by the test performance.
(b) The height of drop of the bar measured from its lower end to the intended point of impact on the upper surface of the specimen shall be 1 m.

Tests for demonstrating ability to withstand accident conditions of transport
726. The specimen shall be subjected to the cumulative effects of the tests specified in para. 727 and para. 728, in that order. Following these tests, either this specimen or a separate specimen shall be subjected to the effect(s) of the water immersion test(s) as specified in para. 729 and, if applicable, para. 730.

727. Mechanical test: The mechanical test consists of three different drop tests. Each specimen shall be subjected to the applicable drops as specified in para. 656 or para. 682. The order in which the specimen is subjected to the drops shall be such that, on completion of the mechanical test, the specimen shall have suffered such
damage as will lead to the maximum damage in the thermal test which follows.
(a) For drop I, the specimen shall drop onto the target so as to suffer the maximum damage, and the height of the drop measured from the lowest point of thespecimen to the upper surface of the target shall be 9 m. The target shall be as defined in para. 717.
(b) For drop II, the specimen shall drop so as to suffer the maximum damage onto a bar rigidly mounted perpendicularly on the target. The height of the drop measured from the intended point of impact of the specimen to
the upper surface of the bar shall be 1 m. The bar shall be of solid mild steel of circular section, (15.0 ± 0.5) cm in diameter and 20 cm long unless a longer bar would cause greater damage, in which case a bar of sufficient length to cause maximum damage shall be used. The upper end of the bar shall be flat and horizontal with its edges rounded off to a radius of not more than 6 mm. The target on which the bar is mounted shall be as described in para. 717.
(c) For drop III, the specimen shall be subjected to a dynamic crush test by positioning the specimen on the target so as to suffer maximum damage by the drop of a 500 kg mass from 9 m onto the specimen. The mass shall consist of a solid mild steel plate 1 m by 1 m and shall fall in a horizontal attitude. The height of the drop shall be measured from the underside of the plate to the highest point of the specimen. The target on which the specimen rests shall be
as defined in para. 717.

728. Thermal test: The specimen shall be in thermal equilibrium under conditions of an ambient temperature of 38°C, subject to the solar insolation conditions specified in Table XI and subject to the design maximum rate of internal heat generation within the *package* from the *radioactive contents*. Alternatively, any of these parameters are allowed to have different values prior to and during the test, providing due account is taken of them in the subsequent assessment of *package* response. The thermal test shall then consist of:
(a) Exposure of a specimen for a period of 30 minutes to a thermal environment which provides a heat flux at least equivalent to that of a hydrocarbon fuel/air fire in sufficiently quiescent ambient conditions to give a minimum average flame emissivity coefficient of 0.9 and an average temperature of at least 800°C, fully engulfing the specimen, with a surface absorptivity coefficient of 0.8 or that value which the *package* may be demonstrated to possess if exposed to the fire specified, followed by;
(b) Exposure of the specimen to an ambient temperature of 38°C, subject to the solar insolation conditions specified in Table XI and subject to the design maximum rate of internal heat generation within the *package* by the *radioactive contents* for a sufficient period to ensure that temperatures in the specimen are everywhere decreasing and/or are approaching initial steady state conditions. Alternatively, any of these parameters are allowed to have different values following cessation of

heating, providing due account is taken of them in the subsequent assessment of *package* response. During and following the test the specimen shall not be artificially cooled and any combustion of materials of the specimen shall be permitted to proceed naturally.

729. Water immersion test: The specimen shall be immersed under a head of water of at least 15 m for a period of not less than eight hours in the attitude which will lead to maximum damage. For demonstration purposes, an external gauge pressure of at least 150 kPa shall be considered to meet these conditions.

Appendix 10

Letter to DHS

DEPARTMENT OF HUMAN SERVICES
RADIATION SAFETY SECTION
17th Floor, 120 Spencer Street
Melbourne Vic 3000

Subject B (U) Cask Test Sequence

Attention Brad Cassels

Dear Brad
Attched is the sequence of and brief out line of the tests we will be performing to prove the Characteristics of our Model 1860 B(U) TRANSPORT CASK as discussed at your office on Wednesday the 13th July.

To demonstrate Compliance to the testing and survivability of the Source, a capsule manufactured by International Isotopes to the design of Special Form USA/0707/S Rev 0 will be used. The Capsule will be subjected to I.S.O.9978 Bubble Test III (D) prior to testing and again after the sequence of tests. We would assume that if the integrity of the capsule is not compromised the Cask will have done it's job and we will receive certification subject to an appropriate design manual and users manual including an incident procedure.

Under is our answer to Design parameters as referred to from Paragraph 606 to 619 of the IAEA Document (TS-R-1)

606, 607 & 608
The weight of the Cask in it's various configurations will weigh between 950Kg & 1100Kg
The Cask is designed with the following handling features.
CRANE ATTACHMENT POINTS. The top Vertical Fin is fitted with two points reinforced to accept 19 mm shackles Spec'd to 1 tonne each
FORKLIFT SKIDS. The base of the Cask is constructed from 316 Stainless Steel to which is bolted 100 x 100mm replaceable hardwood Timbers.
TIE DOWNS There are 4 tie down points on the Attenuator Crumple Shield Rim. As part of the shipping equipment Steel Wire Ropes and Turnbuckles with be provided. In addition the outer mesh and Crumple fins are of sufficient strength to accommodate Webbing Tie downs over the top.

609
The total construction is of stainless steel and therefore will be immune to aggressive decontamination procedures. e.g. Water Detergents and Solvents.
The Drawer Cavity can be accessed without removing the end Crumple Shields for ease of Wipe testing Prior to Shipping or upon receipt at it's destination.

610
The outer covering of the Cask is a Stainless Steel Mesh. and the Attenuator is cylindrical and also of 316 Stainless steel. There is not an area that can collect water and if it could it would have no effect.

611There are two vertical plates to which all labeling will be attached, there is no provision for additional features to be added to the Cask.

612
The only access to the Radiation chamber is through the ends which are bolted on using 6 off 8mm bolts with split washers, during transit a wire is passed through holes in the heads to resist loosening and indicate that the containment has not been interfered with.

613
The cask is constructed entirely from 316 Stainless Steel and is unaffected by Radiation, Cryogenic or sustained High Temperature.

614
Not applicable

615
The Attenuator is fully welded to contain the molten lead during manufacture and to withstand the pressures encountered during the Thermal test, the End plates are constructed to with stand the 150kPa of the Water Immersion Test (729) and will therefore exceed the normal temperatures and pressures of Transport.

616
The Cask is designed to take a Drawer that will accommodate the container that holds the Isotope. This is predominantly material in Special Form Encapsulation i.e. Pencils or Capsule, where shipments not Special Form are to made, the internal container to hold the material will have to take into account any special considerations.

617
The Cask is to be tested to satisfy this requirement. Refer Test 1 on our document outlining the detail of our tests.

618
The Cask is constructed from 316 Stainless Steel which does not fracture at low temperature. however while the Temperature Test does not specify the drop tests must take place at -40deg C we have opted to drop the Cask temperature to ensure compliance.

619
A reduction of ambient pressure will in effect tighten the seal of the "O" ring seal of the End Plates.

Paragraphs 634 to 649 are the requirements for type "A"packaging and are all covered either above or by the requirements of the B(U).tests

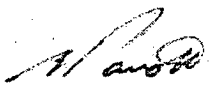
There are several tests to show the survivability during normal Transportation that are superfluous and will not be carried out unless demanded

1. Water spray test 719,720 & 721 are ineffective as the Cask has to Survive immersion to 15m of Water.
2. Drop Test 722 by the weight of our Cask the drop is 1.2M
3. Stacking Test 723 This will not be carried out as our Cask is Cylindrical and effectively precludes Stacking.
4. Penetration Test 724 A 3.2cm Bar 6Kg in weight dropped from 1M will probably not penetrate the outer mesh and hit the Attenuator.

We ask that you review the Test procedures and the comments above and advise us of any points that you would want clarified or modified.
Due to a series of applications that are backing up on us I ask that you treat this matter with a degree of haste. As the temperature rise test will take some time and there is little chance of getting this wrong I have decided to move on this test but the Destructive tests will not be carried out until we have agreement on the procedures.

Should you require any discussion on any matter relating to this Project do not hesitate to contact me.

Yours Faithfully



E.T. Parrott

Appendix 11

Destructive Test Programme

DESTRUCTIVE TEST PROCEDURES FOR THE MODEL 1860 TYPE B (U) TRANSPORT CASK

Test 1 TEMPERATURE RISE

We propose that the Cask be approved for the maximum energy dissipation not for a specific Isotope at a specific quantity But for Energy output. The proposed Energy level is 250 watts.

TEST METHOD

- The Cask will be fitted with a Drawer containing a 250 watt (240 volt) heating element
- For evidence of the test, a temperature Probe will be fitted to the outside of the Container centrally on the Top Fin.
- To obtain data for future designs two additional probes will be used a) attached centrally onto the heating Drawer b) attached to the outside of the Attenuator.
- The Cask will be placed into an environmental Chamber controlled to 38 deg C
- The Heater will be energised via a Variable Transformer with 150 Watts.
- The Test will be maintained until the temperature at the outside of the Attenuator reaches equilibrium.
- If the temperature measured at the outside of the Cask if below 50 deg C the heat input is to be increased to 200 Watts and will be maintained until the temperature at the outside of the Attenuator reaches equilibrium.
- If the temperature measured at the outside of the Cask if below 50 deg C the heat input is to be increased to 250 Watts and will be maintained until the temperature at the outside of the Attenuator reaches equilibrium.
- If the temperature measured at the outside of the Cask if below 50 deg C the test is Maintained for 1 week to verify the conditions of paragraph 651a and b
- At the end of the test the welds are inspected for cracking
- If there are no signs of Weld Failure and the temperature rise for the duration of the test remained below 50deg C the test is concluded and the Cask certified to be able to meet the criteria as set out in PARAGRAPH 617, 651 and 652

Test 2 WATER SPRAY TEST

The Water spray test as defined in 721 will have no effect as the package is designed to survive the immersion test defined in 729. Containment of the Drawer is via 12mm thick end plates bolted on with 6 x 10mm bolts, sealing is with "O" rings.

Test 3 MECHANICAL TEST

Drop test As defined in 727 (a)

- The Cask is placed in a 25deg C Cold Cell for 24 Hrs
- The test capsule is installed into the Drawer and the drawer inserted into the Cask and the end Caps installed.
- The Cask is placed in a Cryogenic Chamber and its out side temperature is dropped to -40 deg C
- As the Cask is fundamentally symmetrical the choice of attitude to cause the maximum damage will be subjective. As all welding is around the Attenuator body, all forces will be transmitted into the attenuator body, we have differing opinion on whether there will be more damage with the stiffer attitude of the fins when dropped on it's end or there will be more damage when dropped flat on it's side.

- We opt for a compromise and attempt to have it hit the target at 45deg, testing both the shear force and the compressive force onto the Attenuator body
- As there are Crane Lifting Points on the top, it is proposed to drop the cask from one of these points.
- The Cask is raised to a height of 9M From the lowest point on the underside of the Cask to the Hard stand (as specified in paragraph 717) This will effectively increase the Fall height by 120mm.
- It is probable that as the base is heavier than the end the Cask will therefore tend to rotate in flight and will not hit exactly as predicted.
- The Cask is allowed to fall onto the Hard Stand

Drop Test as Defined in 727 (b)

- The 150mm x 200mm bar is positioned central on the hard stand.
- The Cask is lifted between the two top lifting points and the base making the point of impact central on the side.
- The Cask is Raised To 1M above the Bar Defined in 727 (b)
- The Cask is dropped.

Drop Test as defined in 727 (c)

- Position the Cask in such a position and attitude on the hard stand so that when hit by the Crush Weight it will cause the maximum damage.(The exact attitude will depend upon the damage caused by tests 1and 2) It is proposed to Sit the Cask on it's Skids and dop the Weight onto the top.
- The 500Kg Weight of dimensions 1M x 1M x 67mm is raised 9M from the under side of the Weight to the top of the Cask.
- The Weight is dropped horizontally onto the Cask.

Test 4 THERMAL TEST

As defined in 728 (a)

- The Test Oven is raised to a temperature of 800deg C
- The Cask is placed into it in as close to it's normal attitude is possible.
- The oven is raised back to 800 Deg C.
- The Cask is allowed to stand in this environment for 1/2 Hour.
- At the end of the 1/2 Hr test period the cask is removed from the Oven and allowed to cool naturally.
- Inspect the outside of the Cask and the floor of the oven for signs of Lead leakage

Test 5 WATER IMMERSION TEST

- The end plates are removed and the remnants of the "O" rings are removed and the grooves cleaned.
- New "O" rings are installed
- Blue Absorbent Towel is placed in the ends of the Drawer.
- The Cask is placed into a Tank and fully immersed in water.
- The pressure is raised to 150kPa and left for a period of 8 Hrs minimum.
- After retrieval the Cask is opened and the towels inspected for signs of Water entry.
-

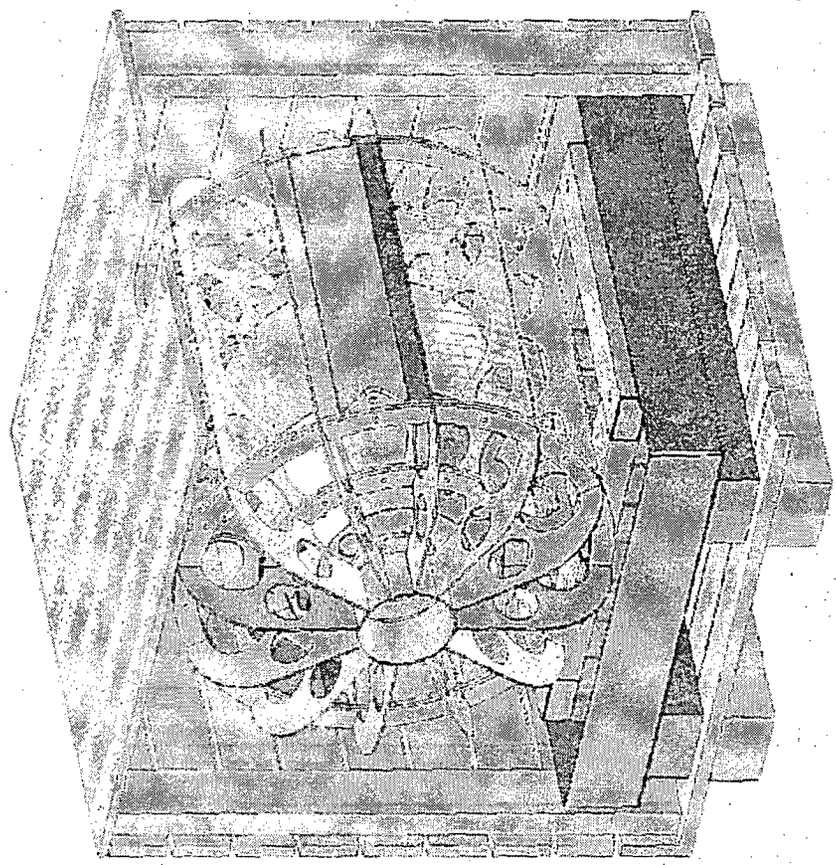
Inspection

- The Drawer is removed from the Cask. NOTE: It may be necessary to remove an End Shield due to the distortion of the Crumple Shields.
- Remove the Capsule from the Drawer.

- Carry out the Bubble Test to prove the Capsule has not been compromised.

Appendix 12

Liquid Nitrogen Test Box And Tray



Appendix 13

ANSTO Test Schedule

Figure 1. Package set up for freezing (NB: front/side wall and access hole not shown)

9. Perform 9.0 drop test. Once package is aligned over target attach 9.0m string with plum-bob attached on free end. Clear the area and lift package until plum-bob just clear of ground. After the package has been dropped and is safe to approach a post-drop temperature shall be recorded.
10. Perform 1.2m drop test (this test doubles as the Type A drop test). Orientate the package to an undamaged portion to impact onto the vertical bar (Ø150mm) from 1.2m.
11.

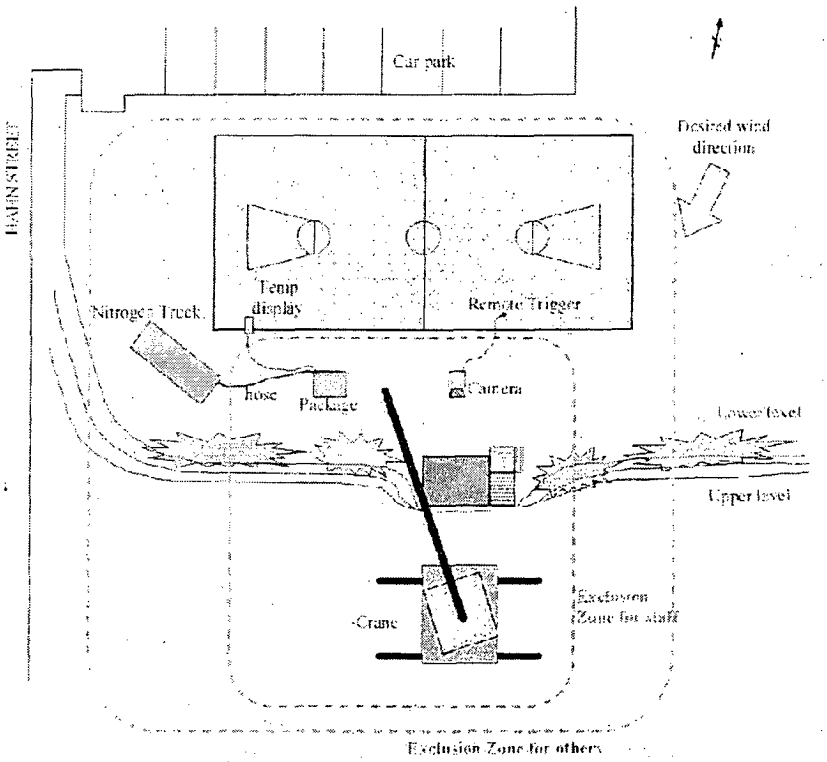
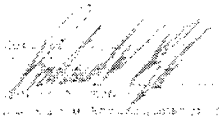


Figure 2. Drop Test site adjacent Basketball court – proposed layout for testing.

Appendix 14

International Isotopes Special Form Certificate



[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

JUN [illegible]

[illegible]

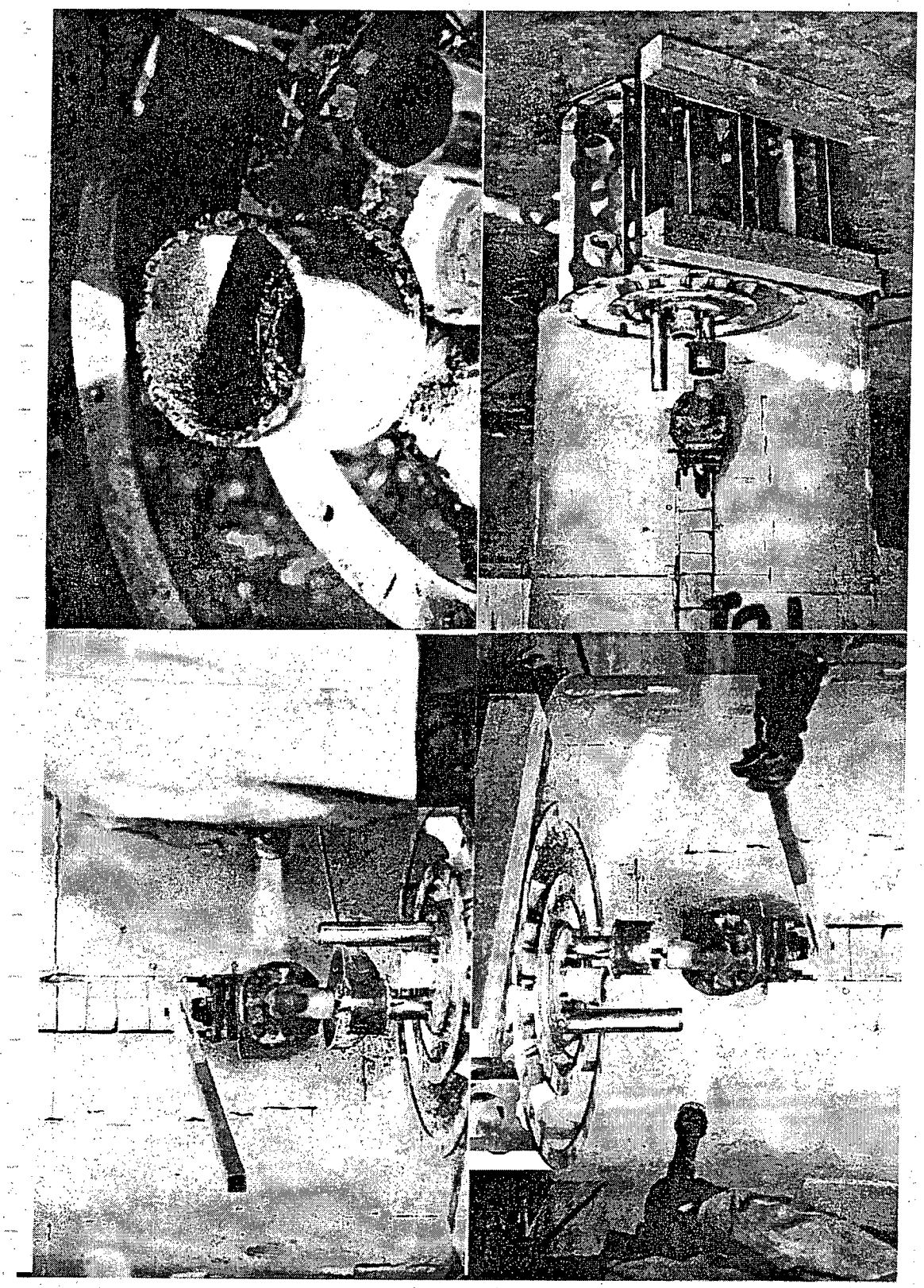
[illegible]

[illegible]

[illegible]

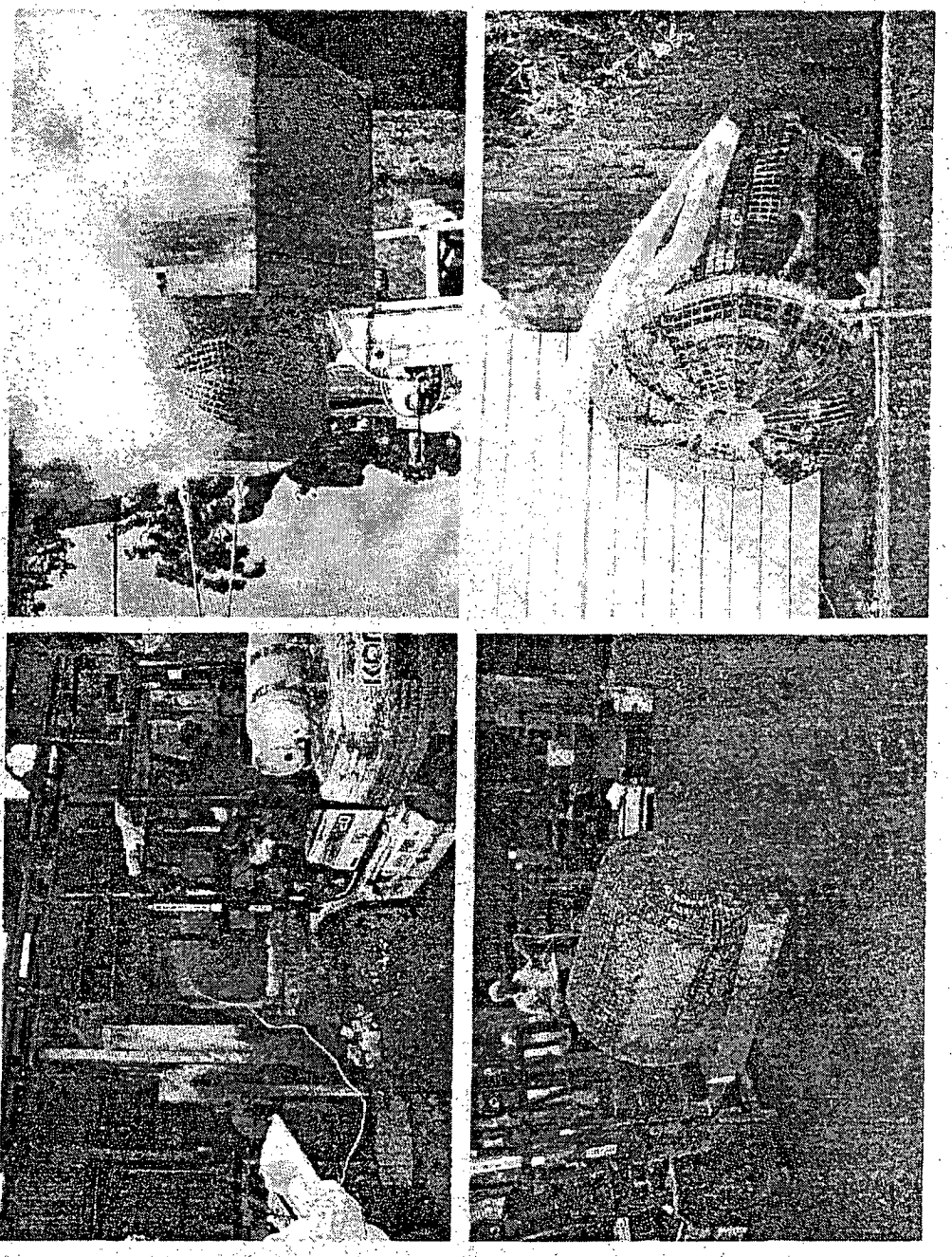
Appendix 15

Photographs of Lead Pour



Appendix 16

Photographs Of Drop and Heat Tests



Appendix 17

Placard Drawings

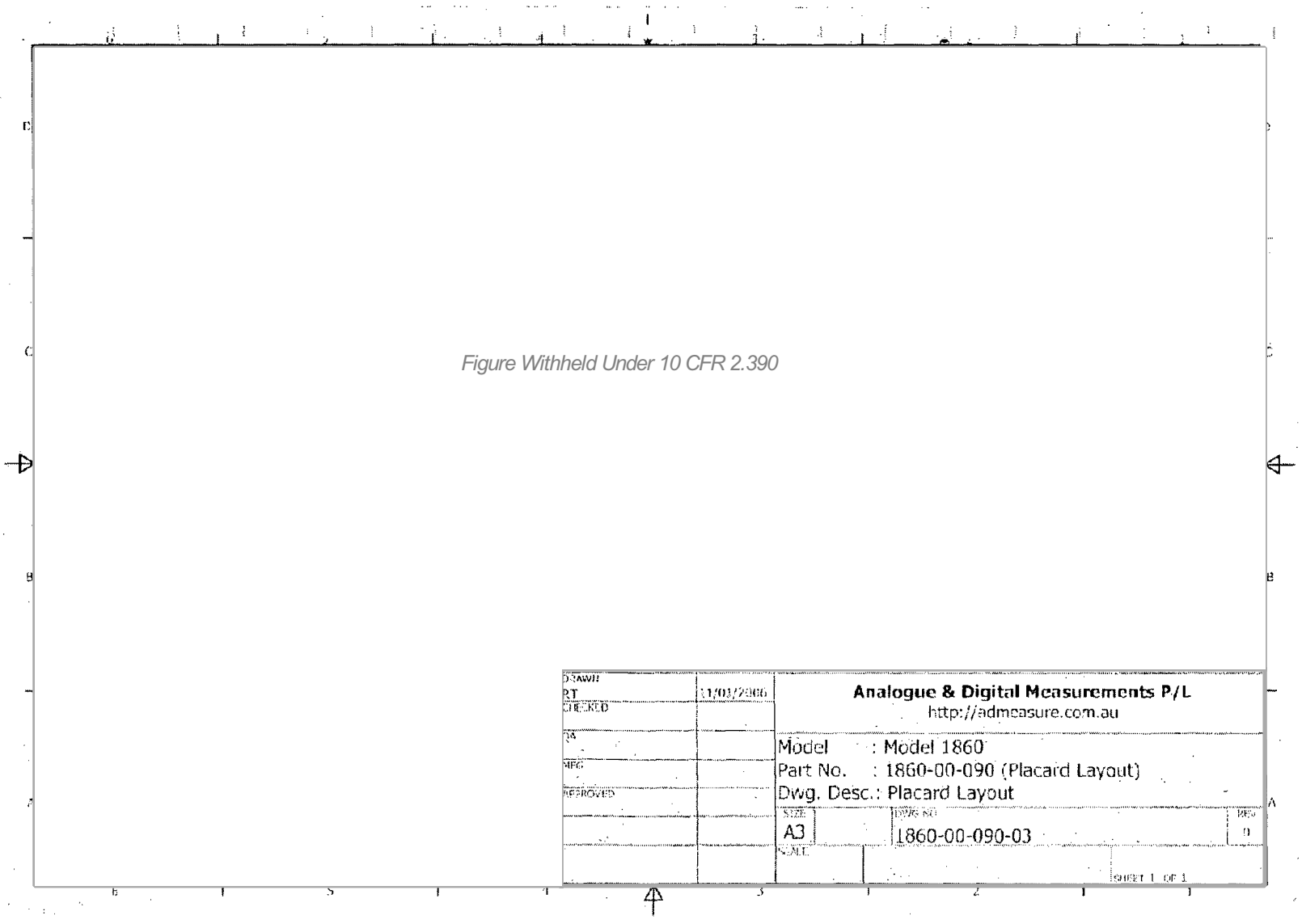


Figure Withheld Under 10 CFR 2.390
DRAWN
RT
11/01/2006
CHECKED
QA
MFG
APPROVED
Analogue & Digital Measurements P/L
http://admeasure.com.au
Model : Model 1860
Part No. : 1860-00-090 (Placard Layout)
Dwg. Desc.: Placard Layout
SIZE
A3
DWG NO
1860-00-090-03
REV
0
SCALE
SHEET 1 OF 1

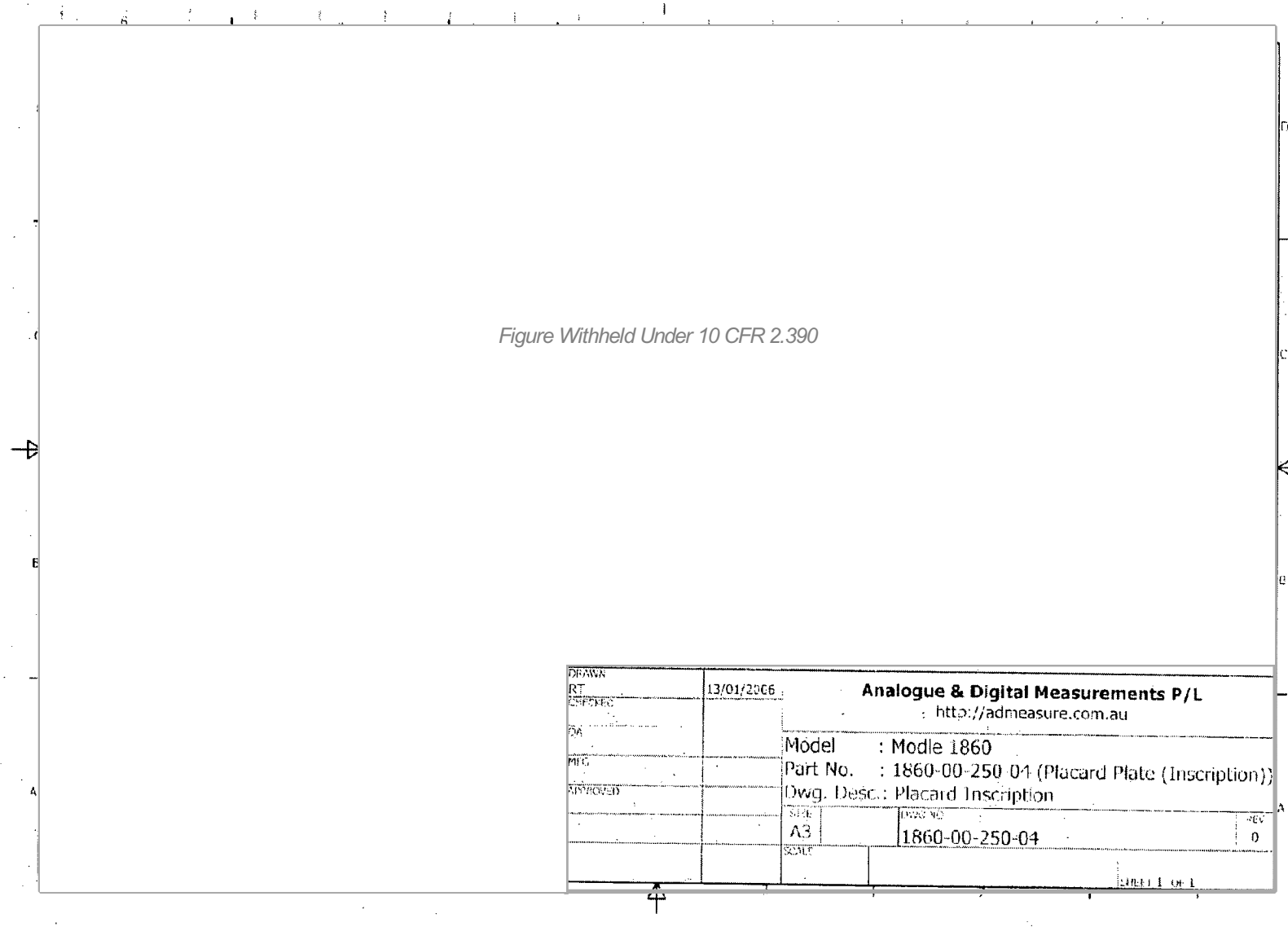


Figure Withheld Under 10 CFR 2.390
DRAWN
RT
13/01/2006
CHECKED
QA
MFG
APPROVED
Analogue & Digital Measurements P/L
http://admeasure.com.au
Model : Modle 1860
Part No. : 1860-00-250-04 (Placard Plate (Inscription))
Dwg. Desc.: Placard Inscription
SIZE
A3
DWG NO
1860-00-250-04
REV
0
SCALE
SHEET 1 OF 1

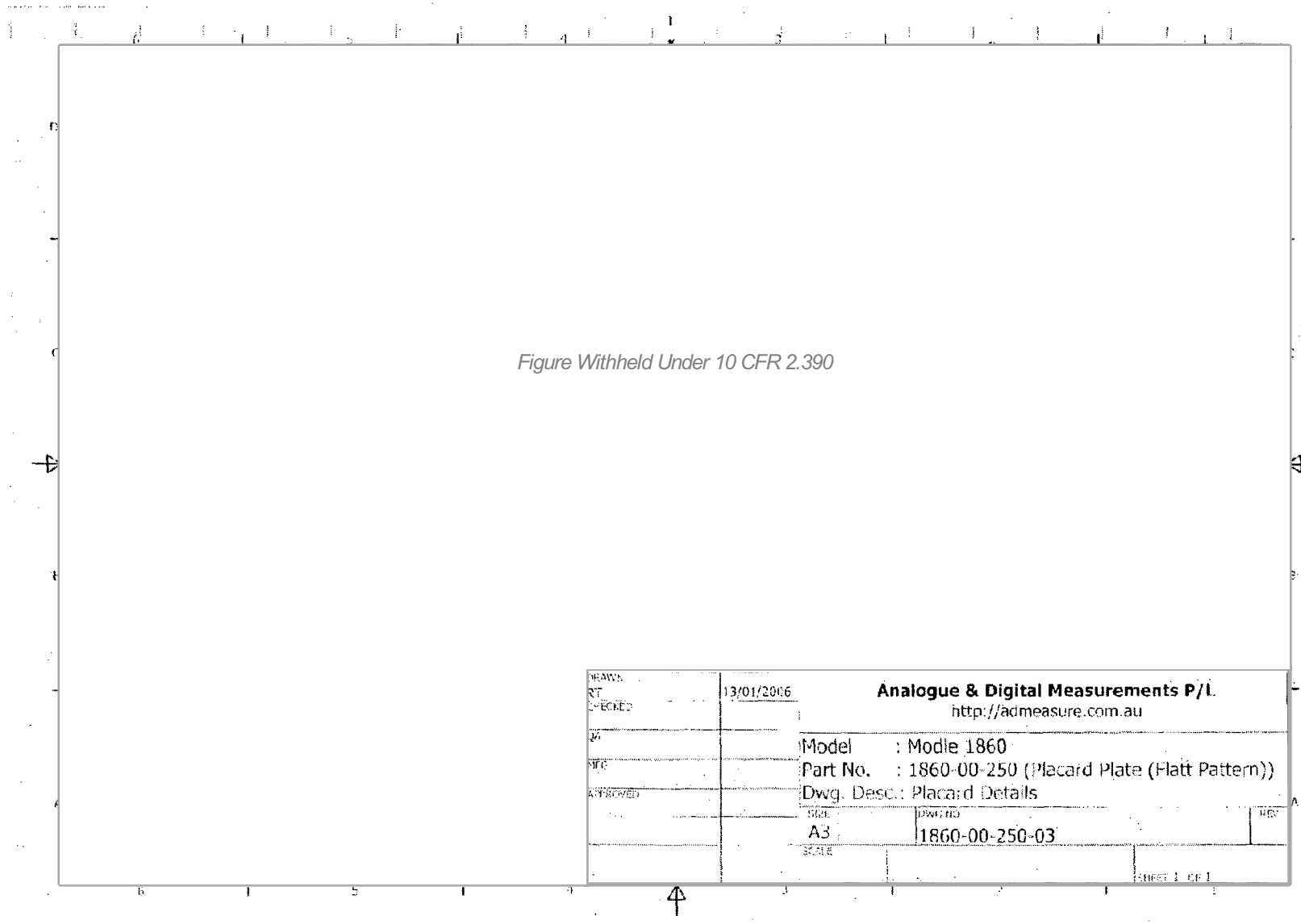


Figure Withheld Under 10 CFR 2.390
DRAWN
RT
CHECKED
APPROVED
13/01/2006
Analogue & Digital Measurements P/L
http://admeasure.com.au
Model : Modle 1860
Part No. : 1860-00-250 (Placard Plate (Flatt Pattern))
Dwg. Desc.: Placard Details
SIZE
A3
DWG NO
1860-00-250-03
REV
SCALE
SHEET 1 OF 1

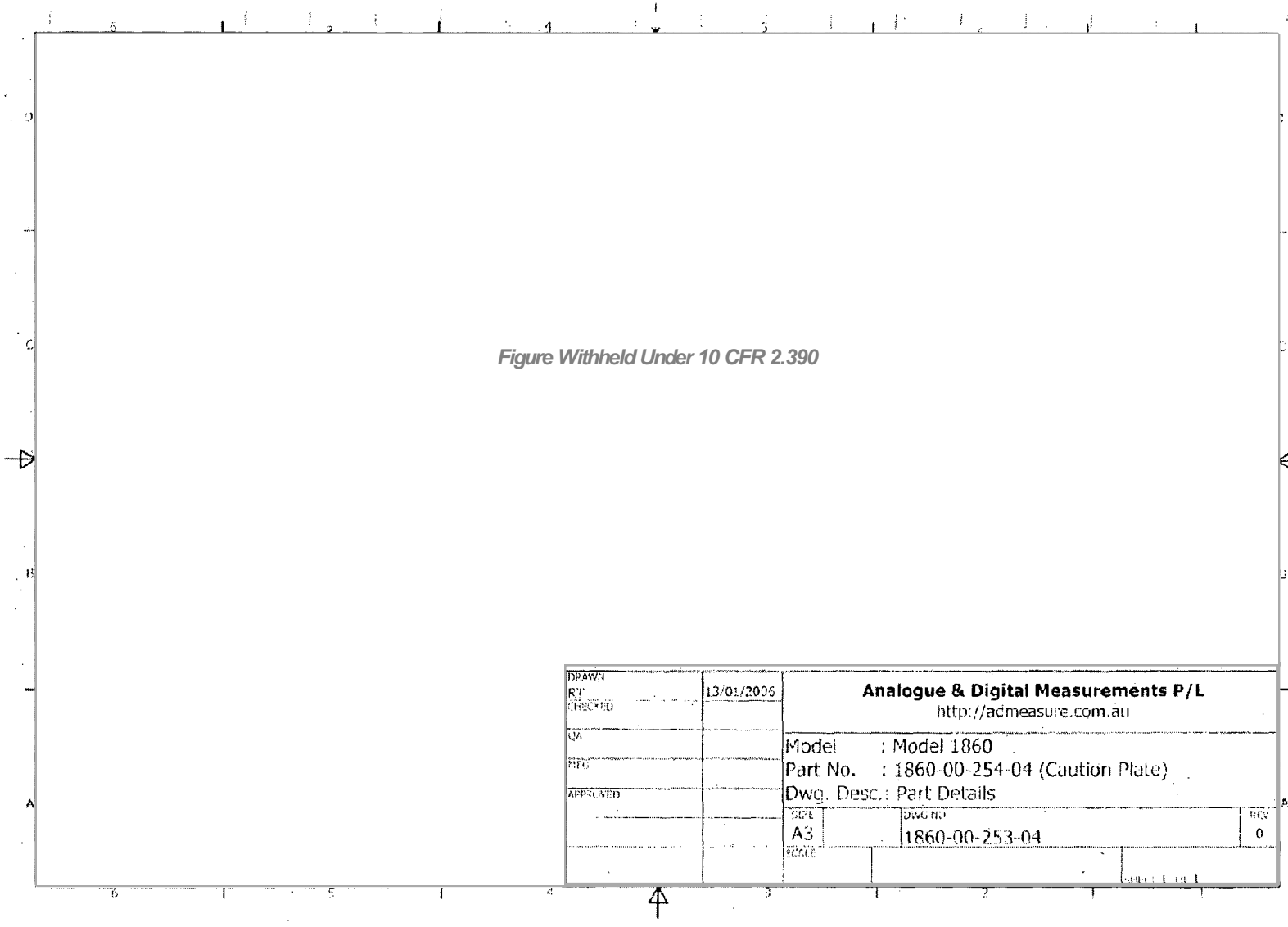


Figure Withheld Under 10 CFR 2.390
DRAWN
RT
13/01/2006
CHECKED
QA
MFG
APPROVED
Analogue & Digital Measurements P/L
http://admeasure.com.au
Model : Model 1860
Part No. : 1860-00-254-04 (Caution Plate)
Dwg. Desc.: Part Details
SIZE
A3
DWG NO
1860-00-253-04
REV
0
SCALE

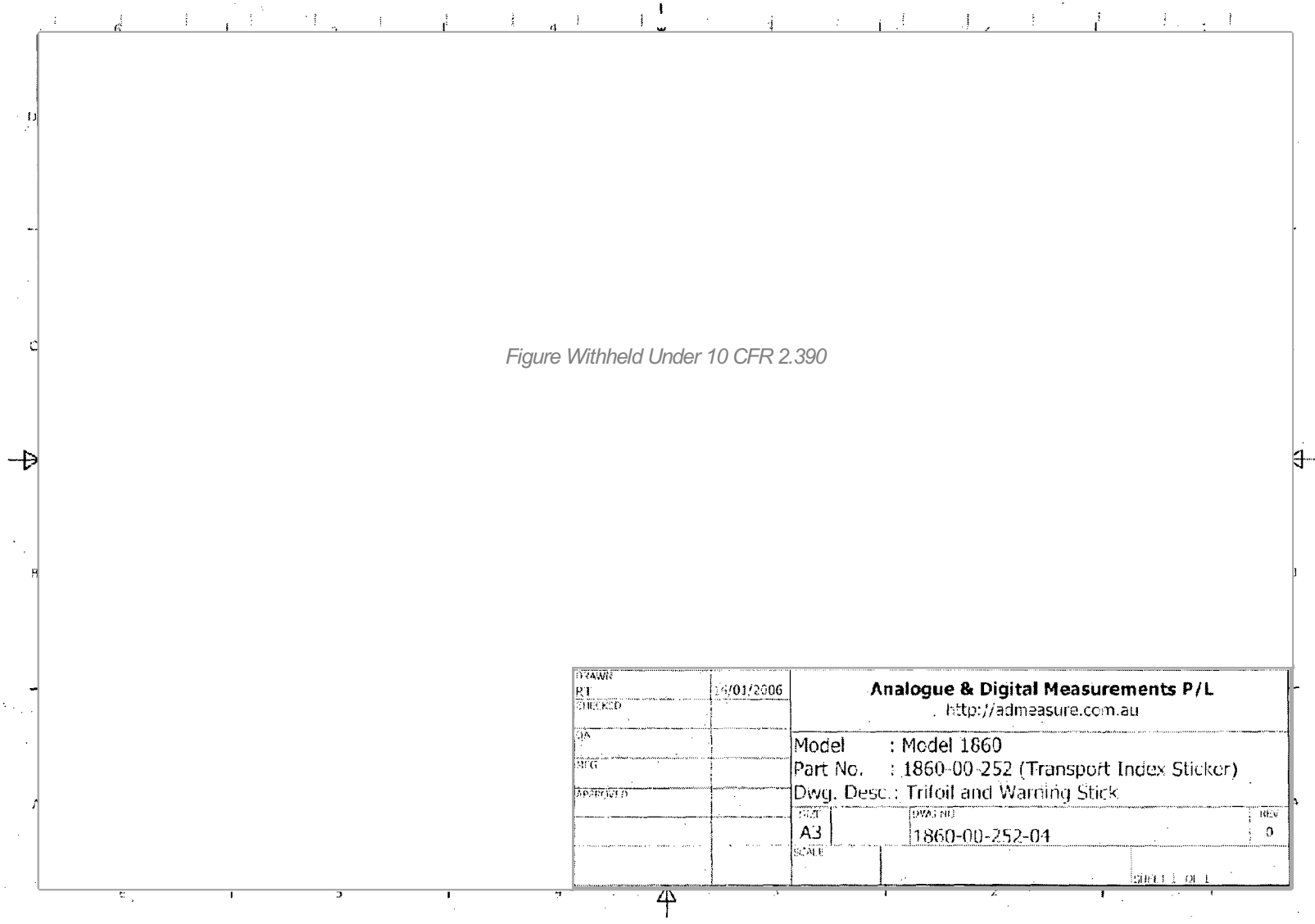


Figure Withheld Under 10 CFR 2.390
DRAWN
RT
14/01/2006
CHECKED
QA
MFG
APPROVED
Analogue & Digital Measurements P/L
http://admeasure.com.au
Model : Model 1860
Part No. : 1860-00-252 (Transport Index Sticker)
Dwg. Desc.: Trifoil and Warning Stick
SIZE
A3
DWG NO
1860-00-252-04
REV
0
SCALE
SHEET 1 OF 1

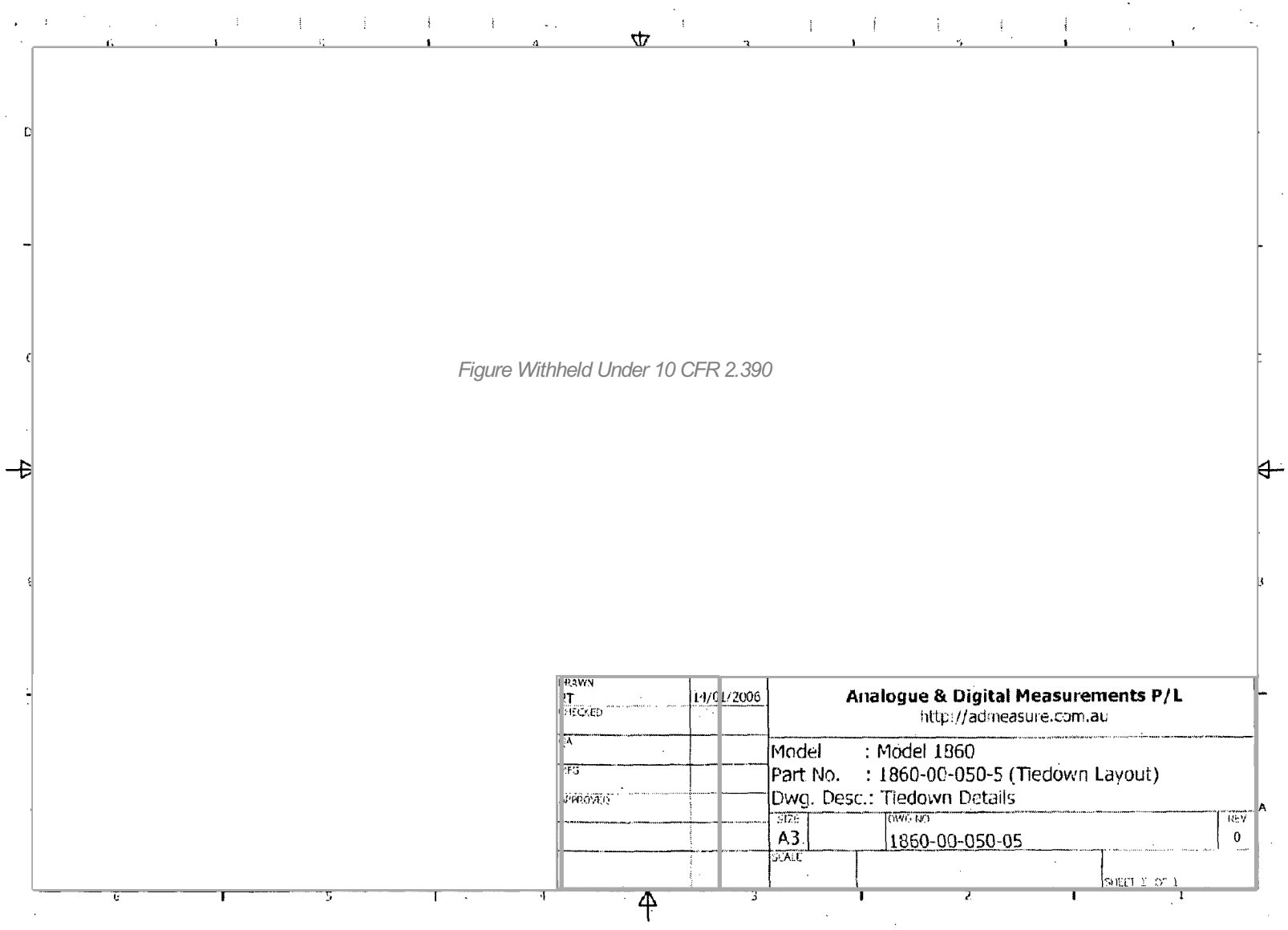


Figure Withheld Under 10 CFR 2.390
DRAWN
PT
14/01/2006
CHECKED
QA
ENG
APPROVED
Analogue & Digital Measurements P/L
http://admeasure.com.au
Model : Model 1860
Part No. : 1860-00-050-5 (Tiedown Layout)
Dwg. Desc.: Tiedown Details
SIZE
A3
DWG NO
1860-00-050-05
REV
0
SCALE
SHEET 1 OF 1

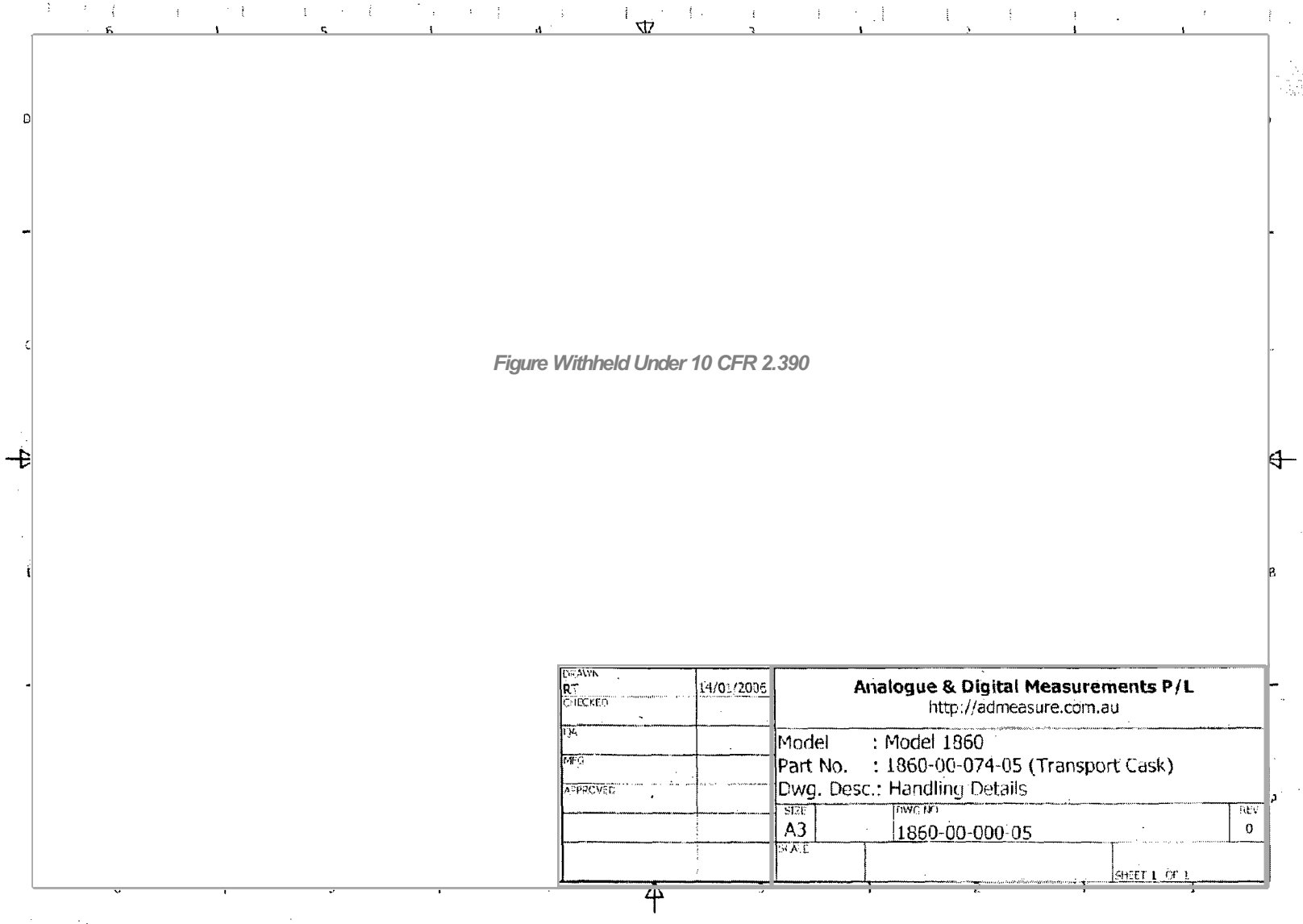


Figure Withheld Under 10 CFR 2.390
DRAWN
RT
14/01/2006
CHECKED
ENG
MFG
APPROVED
Analogue & Digital Measurements P/L
http://admeasure.com.au
Model : Model 1860
Part No. : 1860-00-074-05 (Transport Cask)
Dwg. Desc.: Handling Details
SIZE
A3
DWG NO
1860-00-000-05
REV
0
SCALE
SHEET 1 OF 1

Appendix 18

Dispatch Inspection Check List

DISPATCH INSPECTION CHECKLIST

DATE OF INSPECTION	CASK SERIAL NUMBER
SENDER INFORMATION **Address.**	**ISOTOPE**
	ISOTOPE ACTIVITY **Bq**
RECEIVER INFORMATION **Address.** **Contact Name.**	**AUTHORIZED PERSON** **Title.....** **First Name.....** **Surname.....** **Position.....** **Signature.....**

Before a model 1860 Radiation Transport Cask can be dispatched on a mission, it first must adhere to a list of checks. These checks are designed to provide assurance that the cask configuration is stable, and that the required additional items are present and accounted for. Follow the inspection sequence as given below, and tick each box as you proceed. If for any reason an inspection point fails, the cask should not be dispatched and A&DM must be contacted immediately.

	ALL DOCUMENTS ARE CURRENT AND CORRECT
	END PLATES ARE IN POSITION, AND BOLTS TORQUED TO 30 Nm
	TEST PORT PLUGS AND COPPER WASHER'S IN PLACE AND TORQUED TO 40 Nm
	BOTH LOCKS ARE IN PLACE AND LOCKED
	END CRUMPLE SHIELDS, BOLTED IN PLACE AND TORQUED TO 50 Nm
	DESTINATION PLATES ARE IN PLACE
	TRANSPORT INDEX MEASURED AND RECORDED IN HISTORY LOG
	TRANSPORT INDEX LABELS IN PLACE AND MARKED ACCORDINGLY
	TOOL BOX CONTENTS ARE COMPLETE

Appendix 19

Dispatch Documentation Check List

DISPATCH DOCUMENTATION CHECKLIST

DATE OF INSPECTION	CASK SERIAL NUMBER
SENDER INFORMATION **Address.**	**ISOTOPE**
	ISOTOPE ACTIVITY **Bq**
RECEIVER INFORMATION **Address.** **Contact Name.**	**AUTHORIZED PERSON** **Title**..... **First Name**..... **Surname**..... **Position**..... **Signature**.....

A list of documentation that must accompany the model 1860 radiation transport cask during a transport of radioactive materials is given below. Place a tick next to each item if it exists. A copy of this document must be sent to A&DM prior to shipment.

	DANGEROUS GOODS DECLARATION
	EMERGENCY RESPONSE NUMBERS
	ROUTE MAP TO DISPATCH PORT AND RECEIVE PORT
	REGULATORS ACCEPTANCE OF THE IMPORT / EXPORT
	1860 COMPETENT AUTHORITY CERTIFICATION CERTIFICATE
	ISOTOPE SPECIAL FORM CERTIFICATE
	CAPSULE / CALIBRATION CERTIFICATE
	1860 FIELD SURVEY
	1860 WIPE TEST CRTIFICATE
	AUTHORITY TO TRANSPORT, SENDERS AND RECEIVERS REGULATOR
	EMERGENCY RESPONSE PROCEDURES
	1860 USERS MANUAL
	DISPATCH INSPECTION CHECKLIST
	DISPATCH DOCUMENTATION CHECKLIST

Appendix 20

Metal Seal Information

James Walker Moorflex

Non-Metallic Gaskets

Introduction

James Walker produce cut gaskets and sheet jointings in a wide range of non-metallic materials. Gaskets are available ready-cut in most common flange sizes (ASME, DIN etc.) and customer parts can be easily produced to your requirements using state-of-the-art CNC water jet cutting equipment.

Non-Metallic gasket materials

Elastomers:

Nitrile, neoprene, ethylene-propylene, silicone and fluorocarbon, just to name a few, are among the many grades of elastomer gasket material available from James Walker. There is a wide range of specification grades to internationally recognised industrial and military requirements as well as "commercial" grades for general purpose applications.

Cork-Elastomer

The ***Nebar®*** range of cork elastomers is specified by customers world-wide. The ***Nebar®*** range is substantial, with grades covering applications from high voltage switchgear to aircraft fuelling equipment.

Calendered Fibre

A range of Compressed Non-Asbestos Fibre calendered jointing materials (***Chieftain®***, ***Centurian®***, ***Sentinel®***, and ***Inca***), covers most applications previously served by Compressed Asbestos jointings. The fibres used are typically carbon, glass and aramid or a mixture of these fibres.

The maximum temperature capabilities are, however, slightly reduced compared to asbestos, and the maximum temperature limits reduce with increasing thickness. Therefore care should always be taken to use the thinnest material wherever possible.

PTFE –

Fluolion® Integra White, and ***Fluolion® Integra Blue***, are biaxially-orientated, filled PTFE materials. These are PTFE materials having improved creep resistance to ensure greater reliability in service. They display outstanding chemical resistance, and the Integra Blue grade has increased softness and conformability for use on glass lined flanges or flanges having low bolt-load capacity.

Expanded Graphite

Supagraf® is available in a variety of grades, from plain un-reinforced sheet to nickel and stainless steel foil grades, as well as "T10", which has a tanged stainless steel reinforcing layer, giving superior physical strength and crush resistance.

Features

- *Excellent chemical resistance.*
- *Exceptionally wide temperature range: from up to 400°C in oxidising environments and under certain circumstances, to 2500°C in inert conditions.*
- *Excellent resistance to stress relaxation, even at elevated temperatures.*
- *High levels of joint stability.*
- *Outstanding sealing integrity over extended periods.*
- *Accommodates flange distortions where traditional sheet jointings fail to seal.*
- *Fire safe.*
- *Exceptionally low leachable chloride content to resist corrosion.*
- *Totally compatible with steam, air and water.*
- *Recommended for use with heat transfer fluids and demineralised water.*

The Cut Gasket service is dedicated to meeting industry immediate needs for precision gaskets produced from sheet jointing materials.

Moorflex holds stocks of gaskets to suit flange profiles found in a sectors of industry.

In the unlikely event of not having particular gaskets available immediately from stock, James Walker can readily manufacture them using highly accurate CAD/CAM controlled water-jet cutters. These machines are programmed with every gasket design to national and international standards. Large stocks are on asbestos sheet jointings, rubber and ***Supagraf*** products in all standard thicknesses are always available.

This same technology enables any shape, size or quantity of non-standard cut gaskets to be produced to the highest precision standards, working from customers' CAD/CAM files sent on disk, C.D. or e-mail. Additionally, profiles can be digitised from drawings, samples or templates, with no need for tooling.

James Walker's state of the art water-jet cutters operate with major CAD languages. Nesting pattern software, combined with video acquisition equipment to capture the shape of a sheet, ensures the maximum number of gaskets is produced with the minimum material wastage.

These systems are proven to be highly economical for prototype cutting as well as for large batch runs. For metallic materials such as ***Supagraf®*** Tanged Jointing T10, an abrasive water-jet cutter is utilised. This ensures a clean cut and eliminates the hazardous sharp edges which can occur when using conventional press cutting methods.

TYPE C

GASKET Compression

ound gaskets

AMES WALKER

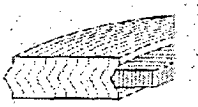
PERFORMANCE SEALING TECHNOLOGY

The construction is capable of infinite variety as the number of metal plies in relation to filler plies can be increased or decreased. The metal and filler material can be varied to suit practically any service conditions.

The use of steel supporting rings on the inside or outside of the spiral wound portion (or both) permits the application of *Metaflex*™ gaskets to be extended to full contact face flanges under high pressure duties.

- *Available in materials capable of withstanding temperatures from the cryogenic range to at least 1000°C.*
- *Can in standard form seal pressures up to 2000 bar. Higher pressures can be considered upon request.*
- *Maintain a seal under conditions of thermal cycling or vibration.*
- *Resist corrosion and leave flange faces clean.*
- *Do not require grinding of broken flange faces.*
- *Are quick to fit and remove.*
- *Can often be used as bolted or pilot flanges.*
- *Offer good performance on difficult low pressure or high vacuum applications.*

Gasket profiles

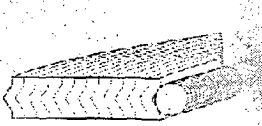


Type C

Basic construction style. Suitable for tongue and groove, male and female or flat face and recess flanges.

Type C/IR

Identical to the Type C but fitted with the protective inner ring which gives high pressure and temperature capabilities, improved sealing performance. Used on male and female flanges.

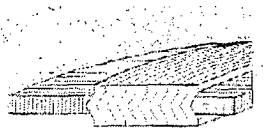


Type SG

As Type C but fitted with an external ring which accurately centralises the sealing element. In addition the ring provides extra radial strength and acts as a compression stop. Generally used on raised face and flat face flanges.

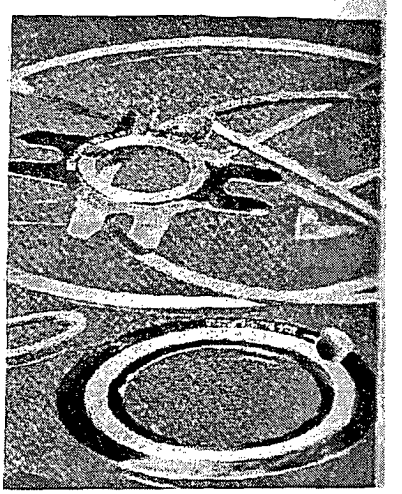
Type H and H/W

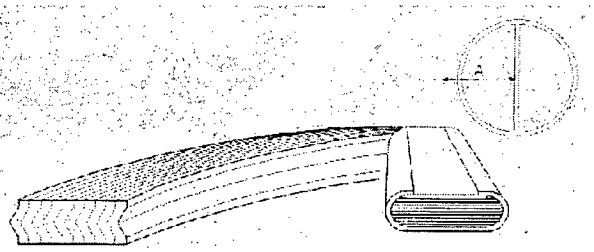
In appearance these are identical to the Type C but specifically designed for the sealing of manholes, handholes, tubeplates and plugs in boilers and vessels. They can be produced in a wide variety of shapes, the most common being circular, obround, square, oval and diamond. The H/W incorporates a thin stainless steel wire on the inner circumference which protects the inner windings and reduces the risk of extrusion under compression.



Type SG/IR

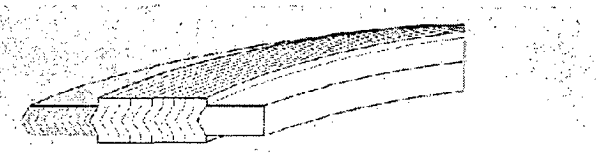
Identical to the Type SG but also fitted with an inner ring to prevent damage to the gasket bore and inner windings. It also acts as a heat shield and corrosion barrier and improves recovery characteristics and sealing performance.





Type TE

This type is identical to the Type C but is fitted with pass-partition bars for use on heat exchangers and vessels. The bars are usually manufactured metal-jacketed gaskets but can also be solid metal faced with graphite, PTFE or soft jointing material.



Type WG and WG/IR

Designed to suit the relatively narrow seating space on many heat exchangers by utilising a spirally wound steel centring ring instead of a solid ring. WG/IR has a solid inner ring.

Type WG/TE and WG/IR/TE

Identical to the WG profile but fitted with partition bars.
WG/IR/TE has an inner ring.

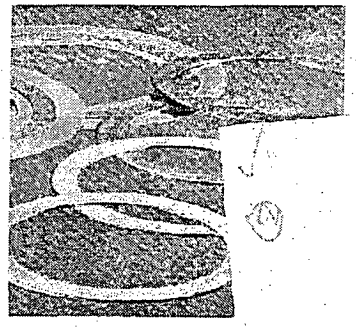
See page 26 for typical pass partition bar configurations.

Metaflex® manufacturing parameters

The standard ***Metaflex***® Type SG and SG/IR gaskets are produced with a sealing element thickness of 4.5mm and 3.0mm centring ring/inner rings. However, virtually all types are available in a variety of thicknesses from 2.5mm to 7.8mm nominal.

The following tables specify the various nominal and corresponding recommended compressed thicknesses together with maximum and minimum diameters for each thickness.

SIZES NOMINAL THICKNESS	MINIMUM DIAMETER	MAXIMUM DIAMETER
2.5mm (0.098")	22mm (¾")	300mm (12")
3.2mm (0.125")	10mm (¾")	760mm (30")
4.5 (0.175")	10mm (¾")	1520mm (60")
7.3mm (0.285")	60mm (2½")	3550mm (140")



* Whilst we do not generally s above 3550mm, we have supp SG/IR in excess of 5 metres di

Metaflex® gasket compression

Metaflex® gaskets must be compressed by a specific degree if maximum service potential is to be realised.

NOMINAL THICKNESS	COMPRESSED THICKNESS
2.5mm (0.098")	1.9/2.1mm (0.075/0.085")
3.2mm (0.125")	2.4/2.6mm (0.095/0.105")
4.5 (0.175")	3.2/3.45mm (0.125/0.135")
7.3mm (0.285")	5.00/5.25mm (0.197/0.207")

Note: Due to the compression characteristics of PTFE, full compression may not always be achieved. If flange face contact is essential then special clearances can be considered.

James Walker

Last Upda

Metaflex material data

Version: 1.0 Mar-2003

Previous menus

Home - Technical menu - Metaflex Product Data

Introduction

The chart below provides details of materials used in Metaflex gaskets. Please note that not all materials are available at all times so you need to enquire first regarding availability.

Temperature limits for metals

Temperature limits for fillers

Temperature limits for metals

Material	Minimum Temp °C	Maximum Temp °C	Abbreviation
304 SS	-195	800	304
316L SS	-100	800	316L
321 SS	-195	800	321
Carbon Steel	-40	540(1)	
Hastelloy B	-185	1090	HAST B
Hastelloy C-276	-185	1090	HAST C
Inconel 600	-100	1090	INC 600
Monel 400	-130	820	MON
Nickel 200	-195	750	NI
Titanium Gr2	-195	1090	Ti2
Titanium Gr7	-195	1090	Ti7

Notes:

1) Carbon steel: Inner ring limit = 480 °C, guide ring limit = 540 °C

Section 8 continued

Metaflex Type SG/IR suitable for BS 10 Welded Neck flanges
GASKET DIMENSIONS *Dimensions in inches*

Nominal bore	Inner Ring		Sealing Element	Centring Ring	Sealing Element	Centring Ring					Table S (1502)		Table T		Centring Ring	
	Tables O, P	Tables Q, T	Tables O, P	Table D	Table E	Tables H, J, K, R	Table F	Table H	Table J	Table K	Table S				Table S	Table T
	I/D	O/D	I/D	O/D	O/D	I/D	O/D	O/D	O/D	O/D	O/D	I/D	O/D	I/D	O/D	O/D
½	0.56	0.63	1.05	1.47	1.13	2.13	1.03	1.03	2.13	2.63	2.63	2.63	1.06	1.56	1.06	1.56	2.75	3.25
¾	0.81	0.88	1.25	1.69	2.00	2.00	1.25	1.25	2.38	2.63	2.63	2.63	1.38	1.88	1.38	1.88	2.75	3.25
1	1.06	1.13	1.56	2.06	2.75	2.75	1.56	2.13	2.81	2.81	2.81	3.13	1.63	2.19	1.63	2.19	3.25	3.50
1¼	1.38	1.56	2.38	2.94	2.94	1.88	2.50	3.25	3.25	3.25	3.25	3.25	1.88	2.50	1.88	2.50	3.50	3.88
1½	1.66	1.63	2.13	3.50	3.50	2.13	2.75	3.50	3.50	3.50	3.75	3.75	2.13	2.81	2.13	2.81	4.00	4.50
2	2.06	2.13	2.63	4.13	3.86	3.00	2.00	3.63	4.38	4.38	4.25	4.38	4.38	2.63	3.44	2.63	3.44	4.50	5.00
2½	2.56	2.63	3.25	4.88	4.38	4.38	3.25	4.50	5.13	5.13	5.00	5.00	5.00	3.13	3.94	3.25	4.06	5.00	5.63
3	3.06	3.13	3.81	4.44	5.13	5.13	3.81	4.56	5.88	5.88	5.75	5.75	5.75	3.63	4.44	3.75	4.69	5.63	6.50
3½	3.56	3.63	4.31	4.94	5.00	5.88	4.31	5.00	6.38	6.38	6.25	6.38	6.38	4.13	4.94	4.25	5.01	6.00	7.00
4	4.06	4.13	4.88	5.50	6.00	5.88	4.85	5.63	6.88	6.88	6.75	6.88	6.88	4.75	5.62	4.75	5.81	7.00	8.19
4½	4.56	4.63	5.38	6.00	6.50	6.88	5.35	6.25	7.50	7.50	7.38	7.38	7.38	5.25	6.13	5.25	6.38	7.50	8.00
5	5.06	5.13	5.88	6.50	7.63	7.63	5.85	5.75	8.50	8.50	8.38	8.00	8.38	5.75	6.62	5.75	6.88	8.38	8.63
6	6.06	6.13	7.00	7.50	8.63	8.50	6.85	7.75	9.50	9.50	9.38	9.38	9.38	6.75	7.63	6.75	7.88	9.75	11.25
8	8.06	8.13	7.88	8.63	9.63	9.50	7.85	9.88	10.75	10.75	10.63	10.50	10.50	7.75	8.52	7.75	9.00	11.38	13.13
10	10.06	10.13	9.88	10.63	10.38	10.75	9.85	9.88	12.00	12.00	11.88	11.50	11.75	8.88	10.00	8.88	10.25	12.75	14.50
12	12.06	12.13	11.88	12.63	12.13	12.00	11.85	9.88	13.13	13.13	13.00	13.00	13.00	9					
14	13.06	13.13	13.06	14.02	13.25	13.25	13.06	13.06	14.13	14.13	14.03	14.00	14.25	10					
16	15.06	15.13	14.88	15.63	14.25	14.25	12.00	13.09	15.13	15.13	15.00	15.13	15.88	11					
18	17.06	17.13	16.88	17.75	15.25	15.13	13.00	14.13	16.00	16.38	16.25	16.88	16.88	12					
20	19.06	19.13	18.88	19.75	17.25	17.25	15.00	16.38	17.63	17.50	17.38	17.75	17.25	13					
22	21.06	21.13	20.88	21.75	19.25	19.25	17.00	18.38	19.50	19.50	19.38	20.00	20.50	14					
24	23.06	23.13	22.88	23.75	21.25	21.25	19.00	20.38	21.63	21.50	21.38	21.00	21.75	15					
26			24.88	25.75	23.25	23.25	21.00	22.38	23.75	23.50	23.38	23.75	23.75	16					
28			26.88	27.75	25.25	25.25	23.00	24.38	25.88	25.50	25.38	25.88	25.88	17					
30			28.88	29.75	27.25	27.25	25.00	26.38	28.00	27.50	27.38	27.88	27.88	18					
32			30.88	31.75	29.25	29.25	27.00	28.38	30.13	29.50	29.38	30.00	30.00	19					
34			32.88	33.75	31.25	31.25	29.00	30.38	32.25	31.50	31.38	32.13	32.13	20					
36			34.88	35.75	33.25	33.25	31.00	32.38	34.38	33.50	33.38	34.25	34.25	21					
38			36.88	37.75	35.25	35.25	33.00	34.38	36.50	35.50	35.38	36.38	36.38	22					
40			38.88	39.75	37.25	37.25	35.00	36.38	38.63	37.50	37.38	38.50	38.50	23					
42			40.88	41.75	39.25	39.25	37.00	38.38	40.75	39.50	39.38	40.63	40.63	24					
44			42.88	43.75	41.25	41.25	39.00	40.38	42.88	41.50	41.38	42.75	42.75	25					
46			44.88	45.75	43.25	43.25	41.00	42.38	45.00	43.50	43.38	44.88	44.88	26					
48			46.88	47.75	45.25	45.25	43.00	44.38	47.13	45.50	45.38	47.00	47.00	27					

CLASS 150 means 150 PSI STANDARD SIZES + PRESSURES IN P.S.I

JAMES WA
HIGH PERFORMANCE SEALI

Metaflex Type O for BS 1560/ASME B 16.5 large male-female, and spigot-recess flanges.
GASKET DIMENSIONS

Dimensions in inches

Nominal Bore	Class 150-1500 Gasket I/D	Class 150-1500 Gasket O/D	Sealing element for Class 2500 flanges Gasket I/D
½	½		
¾	1	3/8	13/16
1	1 5/16	1 11/16	1 1/16
1¼	1 1/8	2	1 1/4
1½	1 7/8	2 1/2	1 5/8
2	2 1/8	2 7/8	1 7/8
2½	2 7/8	3 5/8	2 3/8
3	3 3/8	4 1/8	3
3½	4 1/4	5	3 3/4
4	5 3/16	6 3/16	4 3/4

Nominal Bore	Class 150-1500 Gasket I/D	Class 150-1500 Gasket O/D	Sealing element for Class 2500 flanges Gasket I/D
5	6 5/16	7 5/16	5 3/4
6	7 1/2	8 1/2	6 3/4
8	9 3/8	10 5/8	8 3/4
10	11 1/4	12 3/4	10 3/4
12	13 1/2	15	13
14	14 3/4	16 1/4	
16	16 3/4	18 1/2	
18	19 1/4	21	
20	21	23	
24	25 1/4	27 1/4	

Note - element O/D's are the same as for the 150-1500 series gaskets

Section 8 continued

Metallic Materials:

Material	Trade Name	Description	Temperature range	Comments
Low Carbon Steel		Sheet forged or rolled steel, sometimes referred to as Soft Iron or Armco	-50 to 540°C	For general applications only
316		An 18-12 chromium/nickel austenitic stainless steel containing approximately 2% molybdenum content for high temperature strength	815°C max	Excellent corrosion resistance, but subject to stress corrosion cracking and intergranular corrosion with certain media. Carbide precipitation may occur above 540°C
316L		Variation of 316, carbon content reduced to 0.03% maximum	815°C max	Reduced stress corrosion cracking and intergranular corrosion due to reduced carbon content
304		An 18-8 chromium/nickel austenitic stainless steel	540°C max	Excellent corrosion resistance, but subject to stress corrosion cracking and intergranular corrosion at elevated temperatures
304L		Variation of 304, carbon content reduced to 0.03% maximum	540°C max	Reduced stress corrosion cracking and intergranular corrosion due to reduced carbon content
321		An 18-10 chromium/nickel austenitic stainless steel, with a titanium addition	870°C max	Subject to stress corrosion. Reduced possibilities of intergranular corrosion
347		An 18-10 chromium/nickel austenitic stainless steel with the addition of columbium (niobium)	870°C max	Similar properties as 321. Higher temperature resistance
317		An 18-13 chromium/nickel 3% molybdenum austenitic stainless steel	815°C max	Reduced stress corrosion cracking and intergranular corrosion due to reduced carbon content
410		A 13% chromium, 0.15% carbon martensitic alloy steel	650°C max	Excellent high temperature strength, corrosion properties. Excellent resistance to oxidation, nitriding and carburisation
Titanium	Titanium	High purity titanium material	1095°C max	Excellent high temperature corrosion resistance and outstanding in oxidizing medias
Alloy 600	Inconel 600®	A 70% nickel, 15% chromium, 8% iron alloy steel	1095°C max	Excellent high temperature strength corrosion properties. Excellent resistance to oxidation, nitriding and carbonisation
Alloy 825	Incoloy 825®	A nickel/chromium alloy with substantial additions of molybdenum and columbium (niobium)	1095°C max	Outstanding corrosion resistance in a wide range of acid, neutral and alkaline environments
Alloy 800	Incoloy 800®	A 32% nickel, 20% chromium, 46% iron alloy steel	1095°C max	Excellent high temperature resistance
Alloy 825	Incoloy 825®	A nickel, chromium, iron, molybdenum, and copper alloy steel	1095°C max	High resistance to hot acid conditions and outstanding resistance to stress corrosion cracking
Alloy 200	Nickel 200	Commercially pure (99.6%) wrought nickel	760°C max	High resistance to various reducing chemicals and caustic alkalies
Alloy 400	Monel® 400	A 67% nickel, 30% copper alloy steel	820°C max	High resistance to hydrofluoric acid
Alloy B2	Hastelloy® B2	A nickel/molybdenum alloy steel	1095°C max	Excellent chemical resistance to hydrochloric acid, sulphuric, acetic and phosphoric acids
Alloy C276	Hastelloy® C276	A nickel/chromium/molybdenum alloy steel	1095°C max	Excellent corrosion resistance to both oxidizing and reducing media
Alloy 20	Carpenter 20	An iron/chromium/nickel alloy steel	760°C max	Specifically developed for applications requiring resistance to sulphuric acid
Alloy X 750	Inconel® X-750	A nickel/chromium/iron alloy steel	1095°C max	Precipitation hardened, high resistance steel
Aluminium		Commercially pure wrought aluminium	425°C max	Excellent ductility and workability
Brass		Commercial copper/zinc alloy	260°C max	General corrosion resistance
Copper		Commercially pure copper	315°C max	General corrosion resistance

James Walker

SPIRAL WOUND & GROOVED METAL GASKETS

DESCRIPTION

James Walker Metaflex® gaskets are designed to seal flanges where temperature, pressure, vibration or flow rates are beyond the capability of conventional jointing materials.

They are wound in V-profile metal strip and a softer filler material so that flange surfaces are presented with a spiral of alternate metal/filler layers.

TYPICAL APPLICATIONS

Pipelines and pressure vessels on steam, petrochemical, nuclear, marine and hydraulic plant and heat exchangers. **Metaflex** I shade gaskets are recommended for flange joints where bolt loading is limited.

PRIME FEATURES

- Gaskets are made to a wide variety of sizes and shapes.
- Combinations of metal winding strip and filler are selected to suit the flange material and operating conditions.
- Quick to install and remove.
- Operating temperatures from cryogenic up to 1000°C.
- System pressures from high vacuum to over 350bar.
- Support rings, inside and/or outside of spiral, make gasket suitable for high-pressure use on flat or raised-flange faces.

SPECIFICATIONS

Products are manufactured in accordance with all relevant gasket standards to suit flange designations to ASME B16.5, BS1560, ASME B16.47 Series A (MSS-SP44), ASME B16.47 Series B (API605), BSEN 1092 (BS4504) plus DIN, JIS and NF.

MAXIMUM OPERATING TEMPERATURES OF FILLER MATERIALS

AA Compressed non-asbestos fibre	500°C
APG Standard purity graphite (oxidising media)	500°C
SPG Standard purity graphite (inert/reducing media)	600°C
SPG Standard purity graphite (steam)	650°C
HPG High purity graphite (oxidising media)	500°C
HPG High purity graphite (inert/reducing media)	600°C
HPG High purity graphite (steam)	650°C
Fluoflon® PTFE	260°C
MTG High temperature fibre	1000°C

Aluminium and lead also available.

OPERATING PRESSURE

Metaflex gaskets are up to 350bar, although higher pressures can be considered.

METAL WINDING STRIPS

Standard materials: stainless steels 304L (.nn), 316L. Other materials include 310, 320 and 321; Monel 400 and K500; nickel 200; titanium; Inconel 600, 625 and X750; Incoloy 800 and 825; titanium; Hastelloy B2 and C276.

SUPPORT RINGS

Standard material: carbon steel. Other materials include: stainless steel 304L, 316L, 347 or 321; titanium; Monel 400 and K500; nickel 200; Fluoflon® PTFE (inner rings only); Duplex (UNS31803).

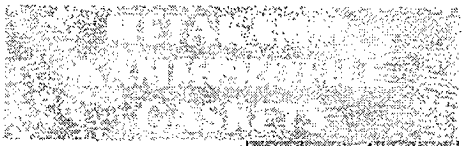
STANDARD SIZES (mm)

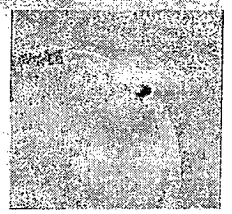
Nominal thickness	Compressed thickness	Minimum diameter	Maximum diameter
2.6	1.9/2.1	10	300
3.2	2.3/2.6	10	760
4.5	3.0/3.45	10	1520
7.2	4.7/4.9	60	3660

Larger non-standard gaskets manufactured to date are 5070mm diameter.

HOW SUPPLIED

Almost any combinations of component materials available. Profiles include circular/obround, square, oval and diamond. Gaskets for non-standard flange pressure made to order.





DESCRIPTION

These grooved metal, Kammprofile-type gaskets comprise a metal core with concentric grooves on either side, and usually a soft layer of sealing material bonded to both grooved faces.

TYPICAL APPLICATIONS

Flanges of high temperature/pressure pipework and vessels where operating conditions can fluctuate, also heat exchangers.

PRIME FEATURES

- Accommodate a wide range of operating conditions.
- High temperatures and pressures up to 1000°C or 250bar.
- Undamaged cores can often be fitted with new soft faces to reduce maintenance costs.
- *Metakamm Easi-Fit (EF type) gaskets come with two or four location lugs to aid fitting.
- **Metakamm Multifit gaskets fit Class 150 to 2500 flanges.

SPECIFICATIONS

See Metaflex specifications alongside.

MAXIMUM OPERATING TEMPERATURES OF FACING MATERIALS

AA Compressed non-asbestos fibre	450°C
SPG Standard purity graphite (oxidising media)	500°C
SPG Standard purity graphite (inert/reducing media)	600°C
SPG Standard purity graphite (steam)	650°C
HPG High purity graphite (oxidising media)	500°C
HPG High purity graphite (inert/reducing media)	600°C
HPG High purity graphite (steam)	650°C
Fluoflon® PTFE	260°C

Aluminium and silver also available.

OPERATING PRESSURE

Standard gaskets, 250bar max.

SERRATED METAL CORES

Available in stainless steels 304, 304L, 316, 316L, 316Ti, 321 and 347; Monel 400 and K500; nickel 200; Inconel 600, 625 and X750; Incoloy 800 and 825; titanium; Hastelloy B2 and C276; copper.

SIZES

Standard diameters from 10mm NB up to 3600mm NB. Standard thicknesses 3.0mm and 4.0mm cores with 0.5mm soft facings each side. Non-standard thicknesses: from 2.0mm core upwards.

HOW SUPPLIED

As size designs to suit different flange faces. Almost any combination of component materials is available. Special profiles include oval, rectangular and seal ring/groove shapes with pass bars.

*METAKAMM EASI-FIT (EF TYPE)

To facilitate easier fitting and reduce material and machining costs, large Metakamm gaskets can be supplied as types EF with either two or four location lugs. The lugs aid fitting as a minimum number of flange bolts need to be removed to allow easy and accurate gasket positioning.

**METAKAMM MULTIFIT

A variation of a Metakamm gasket with four self-locating lugs designed to minimise the number of gaskets required to fit all flange Classes from 150 to 2500. Sizes: ½-inch to 24-inch NB and equivalent DN sizes up to 600mm NB.

Appendix 21

Radiation Field Survey Form

Ansto
ENGINEERING
NUCLEAR / MECHANICAL SERVICES UNIT

Document Number 118062 Rev -
Job File Number 05/999
Engineering Job No. 0072M-9-1-28-10-1

Engineering Report

TYPE B(U) PACKAGE PERFORMANCE EVALUATION OF THE A&DM 1860 PROTOTYPE CASK

October 2005

ANSTO Engineering	Document No: 118062 Rev -
	Document Title: Type B(U) Package Performance Evaluation of the A&DM 1860 Prototype Cask
REVISION SHEET	Job No: 0072M-9-1-28-10-1

Revision Letter	Description of Revision	Print name, date and sign or initial			
		Prepared	Checked/ Reviewed	Approved	Agreed
-	Original Issue	B. Townsend	G. Breen (PAO)	S. Kim	Ted Parrot (A&DM)

Notes: 1. Revision shall be verified in accordance with the Quality Plan for the job.
2. Revision to be agreed by the Client where relevant.

DISTRIBUTION LIST	
Controlled Copy Number	Location Details
Electronic Archive Copy	P:\eris
1	Archive File Copy Building 25, ERIS Database
2	Commercial job file: 05/999
3	Client: Ted Parrot, A&DM

CONTENTS

	Page No.
1 PURPOSE	1
2 SCOPE	1
3 DETAILS OF THE A&DM SERIES 1860 PROTOTYPE PACKAGE	1
3.1 Variations in the Package Design and the Prototype Tested	1
4 PACKAGE DESIGN PERFORMANCE EVALUATION	2
4.1 Test Selection and Justification	3
4.2 Type A Test Results and Analysis	3
4.2.1 Drop Test from 1.2m (clause 722a)	3
4.3 Type B(U) Test Results and Analysis	4
4.3.1 Drop Test from 9.0m (clause 727a)	4
4.3.2 Drop Test from 1.0m onto bar (clause 727b)	5
4.3.3 Thermal Test (clause 728a)	5
4.3.4 Water Immersion Test (clause 730)	6
5 CONCLUSION & RECOMMENDATIONS	6
6 REFERENCES	7
APPENDIX 1 - A&DM1860 CASK DRG NO 32030 DEC03 (ANNOTATED FOR ANALYSIS)	8
APPENDIX 2 – MICROSHIELD SURFACE DOSE RATE CALCULATIONS	9
APPENDIX 3 – A&DM1860 PROTOTYPE PACKAGE TESTING PICTURES	14
APPENDIX 4 – ANSTO QUALITY CONTROL TEST REPORTS	17
PERFORMANCE TESTING OF THE A&DM 1860 CASK (DR5442)	19
DROP TEST NUMBER 1	19
DROP TEST NUMBER 2	20
DROP TEST NUMBER 3	21
APPENDIX 1 – LAYOUT OF EQUIPMENT FOR DROP TESTS (PLAN VIEW)	23
ANSTO QC LEAK TEST REPORT (LT0214)	24
APPENDIX 5 – THERMAL ANALYSIS OF THE A&DM1860 CASK	25

1 PURPOSE

The purpose of this report is to document the performance testing and evaluation of the 1860 transport package, herein referred to as "the package", owned by *Analogue & Digital Measurements (A&DM),* Ref 6.4. This document is intended to be used as supporting evidence in the submission to the competent authority for the certification of the A&DM 1860 series cask as a Type B(U) transport package.

2 SCOPE

This report only covers the performance testing of the A&DM 1860 cask (i.e. transport package) for compliance to the ARPANSA regulations for Type B(U) packages, Ref 6.1. Note that for radioactive material transport packages the ARPANSA regulations, herein referred to as "the regulations", is for the most part a direct endorsement of the IAEA regulations, Ref 6.2.

The report only addresses the most rigorous testing clauses from the regulations as found applicable to the package design. Note that the analysis of the package design specifications to the general design requirements of the regulations is not covered in this report.

3 DETAILS OF THE A&DM SERIES 1860 PROTOTYPE PACKAGE

The A&DM series 1860 prototype package (serial number: 1860-PT01) has a mass of approximately 980kg. The shielding (i.e. the attenuator) is a lead, cylindrical block orientated horizontally and contained in a stainless steel shell at the centre of the package, refer to A&DM drawing no 32030 issued 3-12-03, Appendix 1 (note that this drawing has annotations shown in colour detailing features analysed for this report). Outside the attenuator is a stainless steel plate structure which locates it in the centre of a cylindrical wire mesh cage. Sources are secured inside the attenuator via a draw that runs through the cylindrical axis of the attenuator. The draw is fixed in position by 2 end plates, one for each end bolted to the attenuator in a flange joint configuration. The end plates on each end are sealed via O-rings, refer to pictures 1 and 2, Appendix 3.

The dummy source used in the package was a stainless steel welded capsule of diameter 26.0mm by 38.0mm long (Serial number: A&DM-T01).

3.1 VARIATIONS IN THE PACKAGE DESIGN AND THE PROTOTYPE TESTED

Since the issue of the package drawing (Drg No 32030 Dec03) there have been some minor changes, namely the mesh on the surface of the package was changed from 40x40x2mm mesh to 25x25x2mm mesh.

As mentioned on the package drawing there are 3 different attenuator configuration options at the core of the attenuator which include:

Type A – non

Type B – Tungsten

Type C – Depleted Uranium

The attenuator option used in the prototype testing was Type A, i.e. all lead attenuator. The test results generated from this option are considered to be valid in verifying the other options since there are relatively small mass differences among the options. In terms of performance test results the attenuator consisting mainly of lead is considered to fail before any other components since lead is a relatively soft material with lowest melting point compared to the rest of the package materials.

Other variations between the prototype package and the package design were considered trivial and have no effect on the package test results. These include the absence of the lifting bosses at the two lifting points at the top of the package. These components are part of the design but were left absent to aid in the handling of the package during testing. During the first test on the package one of the wooden skids broke off prompting the removal of the other to allow ease of package handling during testing, i.e. the package needed to sit level in the freezing process, see testing picture in Appendix 3. The absence of these components was considered to be trivial as they performed no function in terms of the shielding.

4 PACKAGE DESIGN PERFORMANCE EVALUATION

The testing conducted and witnessed by ANSTO Engineering is outlined in Table 4.1 below.

Table 4.1 The relevant performance clauses evaluated by ANSTO Engineering.

Test	ARPANSA / IAEA Clause No	Test Parameters	Evaluation Method
Type A	722	1.2m drop onto flat target	Physical test
Type B(U)	727	9.0m drop onto flat target (package at -40°C, clause 618)	Physical test
	727	1.0m drop onto vertical bar	Physical test
	728	Thermal Test 800°C for ½ hour	Physical test
	730	Immerse under 200m (2MPa) of water for 1 hour	Calculation/argument

Note: Clause 726 of the regulations require that clauses 727 and 728 be conducted on the one test specimen.

The test procedure employed by ANSTO to carry out the performance tests was set out in engineering document EP121928 Rev- (Ref 6.3).

A thermal analysis of the package was also performed to evaluate the compliance of the package design to the requirements of clause 652 of the ARPANSA regulations, i.e. no external surface shall exceed 50°C under ambient conditions of 38°C. The thermal analysis employed fundamental heat transfer principles (Ref. 6.6) and verified that the package when loaded to its maximum activity limit (i.e. 250W internal heat generation) would result in a temperature of less than 50°C on the surface and therefore comply with clause 652. Details of thermal analysis are outlined in Appendix 5.

4.1 TEST SELECTION AND JUSTIFICATION

In evaluating the performance of the A&DM 1860 cask design to the requirements of the Type B(U) transport package regulations only the most rigorous tests were addressed as it is argued that if the package can survive these then it will also pass all other test clauses. The tests were done in such a manner as to provide the most conservative test results.

The combination of the tests conducted on the prototype package was selected specifically to cover all the requirements for Type B(U) package certification. In terms of Type B(U) performance testing this meant that the package was required to pass 2 sets of tests which included the following:

1. Tests for demonstrating ability to withstand normal conditions of transport (Type A packages, also required for Type B packages)
2. Tests for demonstrating ability to withstand accident conditions of transport (Type B packages)

4.2 TYPE A TEST RESULTS AND ANALYSIS

For illustration of the test results refer to the testing photographs in Appendix 3.

4.2.1 Drop Test from 1.2m (clause 722a)

The package was orientated above the target so as to impact the end of the package at an approximate angle of 45°. This orientation was reasoned to yield the most damage to the package on impact. The clearance between the target and the package was 1.2m as stipulated in clause 722a of the ARPANSA regulations since the package mass is less than 5000kg.

The package was dropped and upon impact one of the skids broke off cleanly and there was some minor indentation to the end crumple shield on the package. At the completion of testing the indentation was measured. To ensure that there wasn't a bulk movement towards the surface of the package 12 readings around the end crumple shield were taken, refer to Appendix 1 for location of

readings. The readings were tabulated by ANSTO QC, refer to report number DR5442, Appendix 4. The measurements ranged from 235mm to 253mm which agree to within ±10mm of the distance scaled from the drawing, i.e. 245mm.

The maximum indentation from the drop was also measured by measuring the distance from the attenuator to the most dented point on the surface of the end crumple shield (refer to DR5442, Appendix 4) and subtracting this from the measurement scaled off the drawing for the same location. The indentation distance (as indicated in Appendix 1 in green) was measured to be 215mm at maximum indentation. The scaled measurement for this location is approximately 240mm. Therefore the maximum indentation from the 1.2m drop test was approximately 25±10mm.

In terms of the Type A testing pass/fail criteria the surface dose rate from the impact cannot exceed a 20% increase (clause 646). MicroShield calculations show that for the drop test orientation exploited that the allowed indentation is approximately 50mm, refer to Appendix 2. Therefore it is fair to say that the package complies with this criteria and therefore passes clause 722. A MicroShield calculation was also done for the side of the package yielding an allowable indentation of 30mm, however it was reasoned that the indentation on side where there is a large surface area would be less than that sustained on the package end impacting at an angle.

4.3 TYPE B(U) TEST RESULTS AND ANALYSIS

4.3.1 Drop Test from 9.0m (clause 727a)

Prior to the 9.0m drop test the package was chilled to well below -40°C via liquid nitrogen. The package was orientated in the same manner as the 1.2m drop test but was aligned to impact on the opposite end to that impacted on for the 1.2m drop test. Details of the test are outlined in ANSTO QC report DR5442, Appendix 4.

The package was dropped onto the target and a post drop temperature reading was taken to verify that the package temperature was approximately -40°C. The package was visually examined after the drop test to identify which components of the assembly were damaged. The inspection revealed that the damage was restricted to the crumple shield surrounding the attenuator. The shielding was undamaged and the dummy source was still secured in the shielded position.

In terms of pass/fail criteria the package is to be subjected to the cumulative effects of the 9.0m drop test, 1.0m drop onto a bar, and the thermal test (clause 726), refer to Section 4.3.3 *Thermal Test* below for final evaluation.

4.3.2 Drop Test from 1.0m onto bar (clause 727b)

After the 9.0m drop test the package was subjected to drop onto a vertical bar from 1.0m. The package was orientated so as to impact on the side of the package where it would inflict the most damage.

The package when dropped onto the bar sustained localized damage to the crumple shield. A visual inspection of the package revealed that the bar penetrated through the crumple shield to impact onto the attenuator. The attenuator sustained only minor damage, i.e. the mesh left a few shallow markings on the surface of the stainless steel shell of the attenuator. The shielding was still intact and the dummy source was still securely fixed in the shielded position.

In terms of pass/fail criteria the package is to be subjected to the cumulative effects of the 9.0m drop test, 1.0m drop onto a bar, and the thermal test (clause 726), refer to Section 4.3.3 *Thermal Test* below for final evaluation.

4.3.3 Thermal Test (clause 728a)

At the completion of all of the mechanical tests (i.e. drop test) the package was then subjected to the thermal test. The package was placed inside an industrial oven that was preheated to a temperature above 800°C and was left in the oven for a period of 30 minutes where the average temperature of the environment was above 800°C for the entire duration.

At the completion of the thermal test the package was visually examined to see if there was any damage sustained to the shielding. There were no signs of lead leakage from the attenuator body and no lead in the tray under the package. The package mass was compared before and after the thermal test and also indicated that there was no significant change in mass. The dummy source was still securely fixed in the shielded position.

In terms of the pass/fail criteria the package is allowed to have a dose rate of 10mSv/hour at 1.0m from the surface of the package (clause 656). It is argued that if the shielding within the package remains intact and the source securely in position at the conclusion of the testing then the package would comply with the 10mSv/hour at 1.0m since the surface dose rate for the package must initially be 2mSv/hr or less as required by the regulations (clause 531). To illustrate suppose for example that the crumple shield is 1.0m thick and that it was fully collapsed from the 9.0m drop, then at 1.0m from the package the dose would still be the original 2mSv/hr or less provided the source is secured and the shield is undamaged. A crumple shield of less than 1.0m has less potential for dose rate increase; the A&DM 1860 package has a crumple shield of just 150mm, therefore the package complies with this logic and therefore the requirements of this clause.

4.3.4 Water Immersion Test (clause 730)

This test was not physical conducted since there was insufficient time to conduct, only one prototype package, and because there is sufficient evidence to demonstrate compliance with this clause by reasoned argument (as allowed by clause 701d of the regulations). The arguments for this clause are based on the readily available specifications for o-ring seals which is used to seal the package and is considered to be the most vulnerable point in terms of the water immersion test.

The package contains O-rings under each of the 2 end plates which maintain an air tight joint seal. The details of the o-ring are currently not specified on the 1860 cask drg 32030, however the prototype package did have o-rings in its assembly, refer to picture 2 in Appendix 3. It is easily shown that there are o-rings available that can withstand the pressure requirements of 2MPa (20Bar), refer to the *Bearing Service Centre* (BSC) O-ring online o-ring catalogue at: http://www.bsc.com.au/PDF-bsc04/7ORINGS.PDF

5 CONCLUSION & RECOMMENDATIONS

From the limited testing conducted by ANSTO Engineering it was verified that the *Analogue & Digital Measurements* radioactive material transport package A&DM 1860 is compliant with the performance requirements of the Type B(U) regulations set out in the ARPANSA Code of Practice.

In completing the evaluation of the A&DM 1860 prototype package in terms of performance, ANSTO engineering has several recommendations to offer;

1. It is recommended that the package design specifies an o-ring that is compatible with the environmental variations as set-out in the regulations, i.e. -95kPa to 2000kPa; -40°C to 70°C; radiation.
2. It is recommended that a door be fixed to cover the attenuator end plate access holes at each end of the package. These doors should be able to be locked ensuring a tamper evident seal and preventing unauthorized opening of the package. It also ensures that all accessible parts of the package are strictly the wire mesh cage which complies with surface temperature requirements when package is loaded to maximum activity or maximum internal heat generation.

6 REFERENCES

6.1 ARPANSA Code of Practice, Safe Transport of Radioactive Material, 2001 Edition.

6.2 IAEA Safety Standard Series No. TS-R-1 :- Regulations for the Safe Transport of Radioactive Material, 2005 Edition.

6.3 ANSTO Engineering Procedure – Type B(U) Test Procedure For A&DM Prototype Package, EP121928, September 2005.

6.4 *Analogue & Digital Measurements Pty Ltd* trading as *Nuclear Stuff*,
27 Cumberland Drive Seaford,
Victoria, Australia, 3198
ph: +61-3-8770-6565
fax: -61-3-8770-6592
sales@nuclearstuff.com
http://www.nuclearstuff.com

6.5 Bearing Service Centre BSC Motion Technology website, www.bsc.com.au

6.6 Frank P. Incropera, David P. DeWitt, Fundamentals of Heat & Mass Transfer, 4th edition, John Wiley & Sons Inc, USA, 1996.

APPENDIX 1 - A&DM1860 CASK DRG NO 32030 DEC03 (ANNOTATED FOR ANALYSIS)

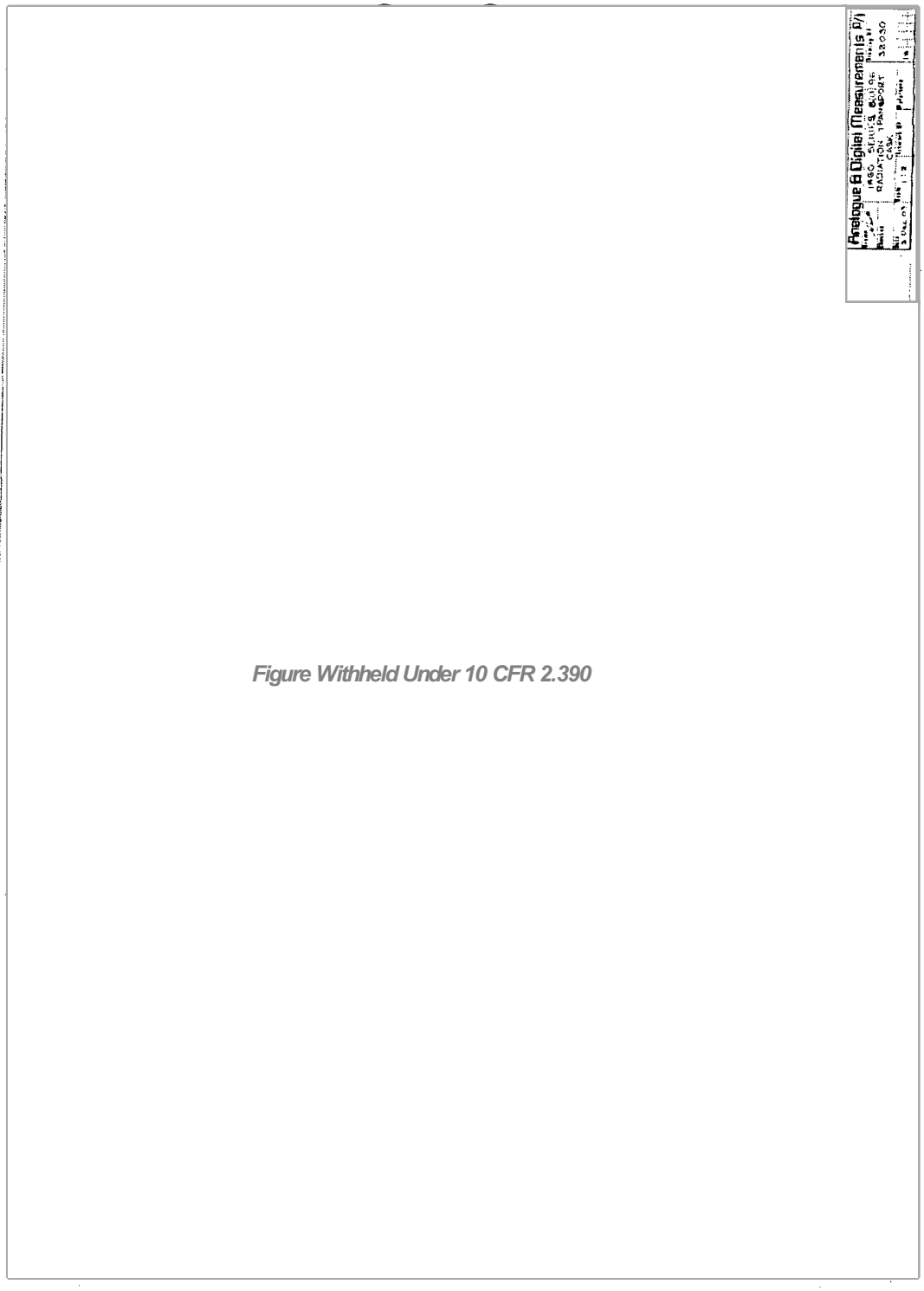


Figure Withheld Under 10 CFR 2.390

APPENDIX 2 – MICROSHIELD SURFACE DOSE RATE CALCULATIONS

The following 2 MicroShield Calculations determine the amount of allowable indentation of the A&DM 1860 crumble zone to be compliant with a 20% surface dose rate increase or less. The calculations can be summarized as follows:

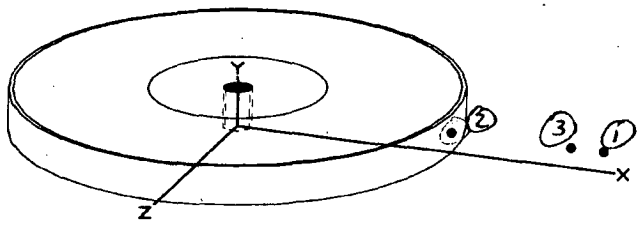
1. The first calculations finds the allowed indentation for a side impact.
2. The second calculation finds the allowed indentation for impact on the package end at an approximate angle of 45° as this was deemed to be the worst package orientation that would yield the most damage i.e. most conservative case.

MicroShield v6.02 (6.02-00278)
ANSTO

Page : 1
DOS File : ADM1860-ATR-MSH.ms6
Run Date: August 30, 2005
Run Time: 6:56:07 PM
Duration : 00:00:03

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

Case Title: A&DM 1860 Type B(U)
Description: Case 1 - Surface dose at mesh (surface of package)
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	3.8 cm	1.5 in
Radius	1.1 cm	0.4 in

Dose Points

	X	Y	Z
# 1	36.3 cm	1.9 cm	0 cm
	1 ft 2.3 in	0.7 in	0.0 in
# 2	21.3 cm	1.9 cm	0 cm
	8.4 in	0.7 in	0.0 in
# 3	33.1 cm	1.9 cm	0 cm
	1 ft 1.0 in	0.7 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	14.445 cm³	Iron	7.86
Shield 1	7.0 cm	Tungsten	19.3
Shield 2	12.6 cm	Lead	11.34
Shield 3	.4 cm	Iron	7.86
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	.2 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Co-60	1.0000e+003	3.7000e+013	6.9228e+007	2.5614e+012

Buildup
The material reference is : Shield 1

Integration Parameters

Radial	10
Circumferential	10
Y Direction (axial)	20

Results - Dose Point # 1 - (36.3,1.9,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	6.035e+09	4.136e-07	2.336e-06	7.985e-10	4.510e-09
1.1732	3.700e+13	1.049e+02	7.628e+02	1.874e-01	1.363e+00
1.3325	3.700e+13	4.842e+02	3.619e+03	8.400e-01	6.279e+00
TOTALS:	7.401e+13	5.891e+02	4.382e+03	1.027e+00	d_1 = 7.642e+00

1.2 × 7.642 = 9.170+

Results - Dose Point # 2 - (21.3,1.9,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	6.035e+09	1.178e-06	6.655e-06	2.274e-09	1.285e-08
1.1732	3.700e+13	3.010e+02	2.190e+03	5.379e-01	3.913e+00
1.3325	3.700e+13	1.391e+03	1.040e+04	2.413e+00	1.805e+01
TOTALS:	7.401e+13	1.692e+03	1.259e+04	2.951e+00	d_2 = 2.196e+01

Results - Dose Point # 3 - (33.1,1.9,0) cm

$d_2 = 2.87 \times d_1$

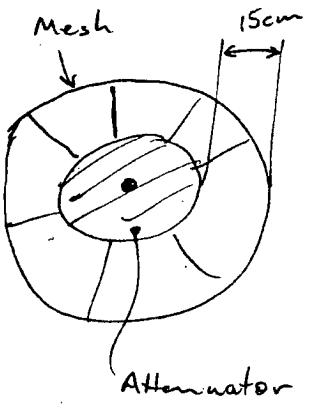
Page : 2
DOS File : ADM1860-ATR-MSH.ms6
Run Date: August 30, 2005
Run Time: 6:56:07 PM
Duration : 00:00:03

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	6.035e+09	4.965e-07	2.805e-06	9.586e-10	5.415e-09
1.1732	3.700e+13	1.260e+02	9.164e+02	2.252e-01	1.638e+00
1.3325	3.700e+13	5.817e+02	4.348e+03	1.009e+00	7.544e+00
TOTALS:	7.401e+13	7.077e+02	5.265e+03	1.234e+00	d_3: 9.182e+00

$d_3 \simeq 1.2\, d_1$

At Point 3:

Indentation allowed = 36.3 - 33.1
= 3.2 cm

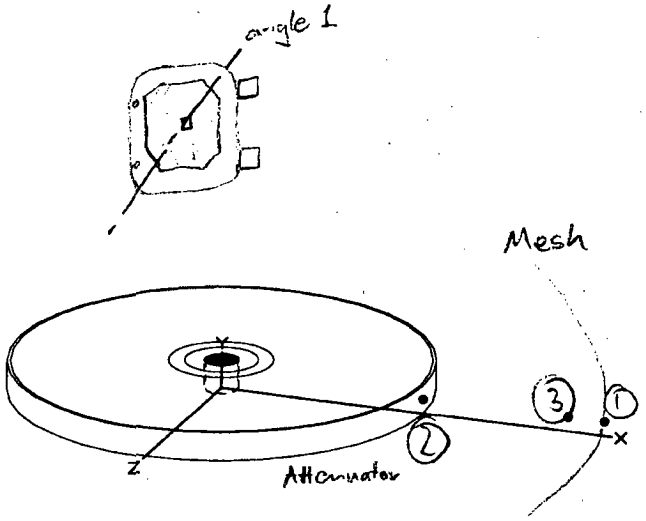


MicroShield v6.02 (6.02-00278)
ANSTO

Page : 1
DOS File : ADM1860-ATR-MSH angle1.ms6
Run Date: September 6, 2005
Run Time: 6:36:28 PM
Duration : 00:00:03

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

Case Title: A&DM 1860 Type B(U)
Description: Surface Dose at mesh (surface of package) - Impacted angle1
Geometry: 7 - Cylinder Volume - Side Shields



Source Dimensions

Height	3.8 cm	1.5 in
Radius	2.0 cm	0.8 in

Dose Points

	X	Y	Z
# 1	51.5 cm	1.9 cm	0 cm
	1 ft 8.3 in	0.7 in	0.0 in
# 2	27 cm	1.9 cm	0 cm
	10.6 in	0.7 in	0.0 in
# 3	46.5 cm	1.9 cm	0 cm
	1 ft 6.3 in	0.7 in	0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	47.752 cm³	Iron	7.86
Shield 1	2.4 cm	Air	0.00122
Shield 2	2.0 cm	Tungsten	19.3
Shield 3	20.0 cm	Lead	11.34
Shield 4	.4 cm	Iron	7.86
Transition		Air	0.00122
Air Gap		Air	0.00122
Wall Clad	.2 cm	Iron	7.86

Source Input
Grouping Method : Actual Photon Energies

Nuclide	curies	becquerels	µCi/cm³	Bq/cm³
Co-60	3.3058e+003	1.2231e+014	6.9228e+007	2.5614e+012

Buildup
The material reference is : Shield 2

Integration Parameters

Radial	10
Circumferential	10
Y Direction (axial)	20

Results - Dose Point # 1 - (51.5,1.9,0) cm

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.995e+10	6.903e-07	3.892e-06	1.333e-09	7.513e-09
1.1732	1.223e+14	2.198e+02	1.575e+03	3.928e-01	2.815e+00
1.3325	1.223e+14	1.025e+03	7.530e+03	1.779e+00	1.306e+01
TOTALS:	2.446e+14	1.245e+03	9.105e+03	2.172e+00	1.588e+01

Results - Dose Point # 2 - (27,1.9,0) cm

At 20% Increase 1.2 × 1.588×10¹ = 1.91×10¹

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.995e+10	2.500e-06	1.410e-05	4.826e-09	2.721e-08
1.1732	1.223e+14	7.992e+02	5.729e+03	1.428e+00	1.024e+01
1.3325	1.223e+14	3.730e+03	2.739e+04	6.471e+00	4.752e+01
TOTALS:	2.446e+14	4.529e+03	3.312e+04	7.899e+00	5.776e+01

Results - Dose Point # 3 - (46.5,1.9,0) cm

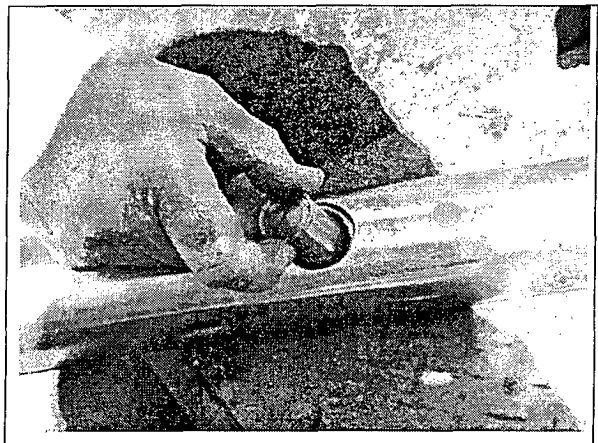
3-6 times greater

At Pt ③ dose = 1.95e+01

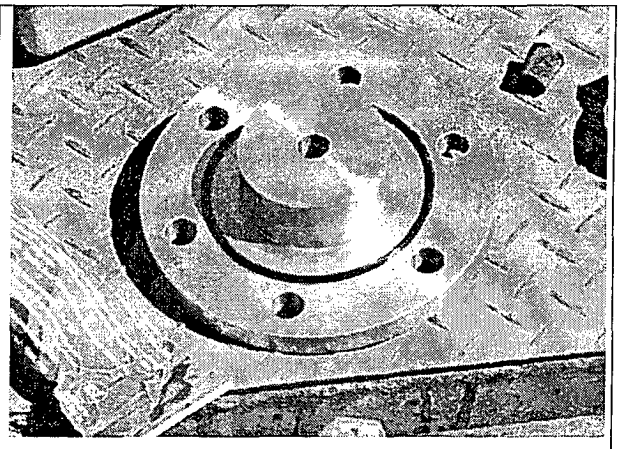
DOS File : ADM1860-ATR-MSH angle1.ms6
Run Date: September 6, 2005
Run Time: 6:36:28 PM
Duration : 00:00:03

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6938	1.995e+10	8.468e-07	4.774e-06	1.635e-09	9.218e-09
1.1732	1.223e+14	2.697e+02	1.933e+03	4.820e-01	3.455e+00
1.3325	1.223e+14	1.258e+03	9.240e+03	2.183e+00	1.603e+01
TOTALS:	2.446e+14	1.528e+03	1.117e+04	2.665e+00	1.948e+01

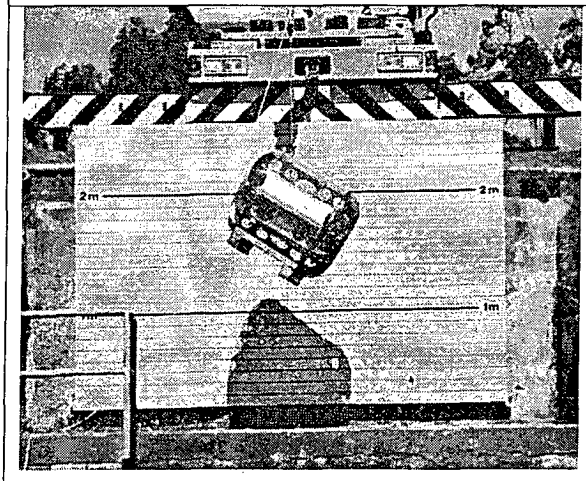
APPENDIX 3 – A&DM1860 PROTOTYPE PACKAGE TESTING PICTURES



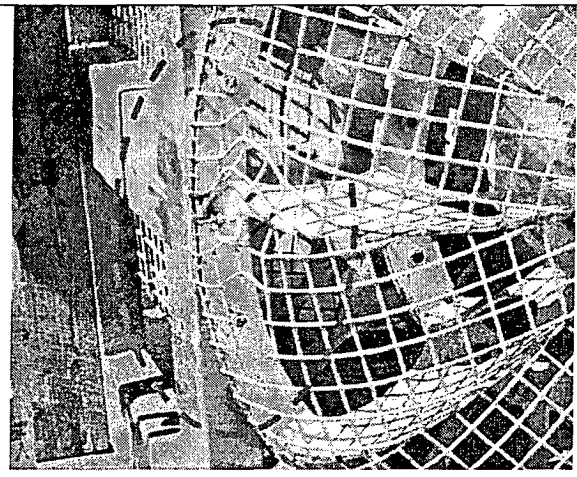
Pic 1. Dummy source being loaded into draw to be loaded into the A&DM1860 prototype cask.



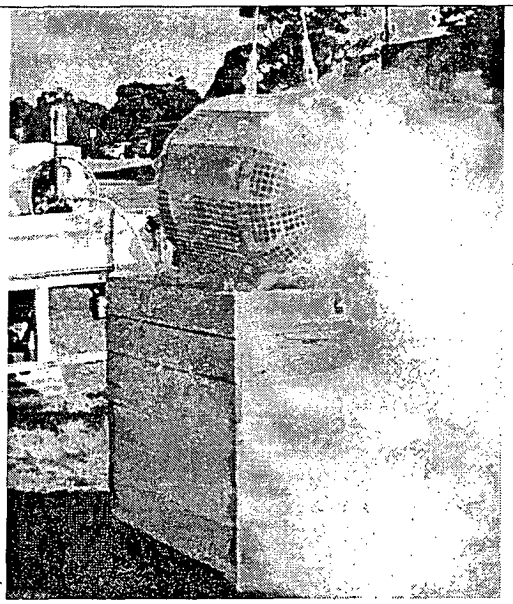
Pic 2. End plate that locates draw in 1860 cask



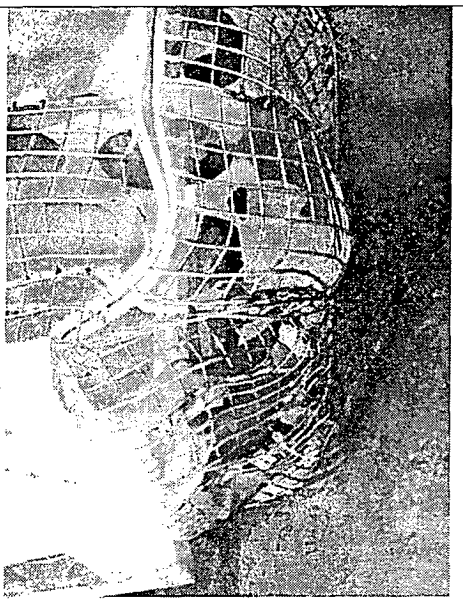
Pic 3. Prototype 1860 orientated for 1.2m drop test.



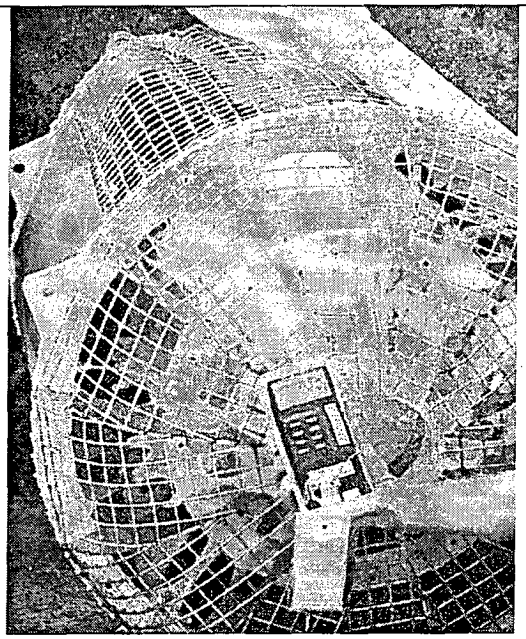
Pic 4. Damage sustained after 1.2m drop test.



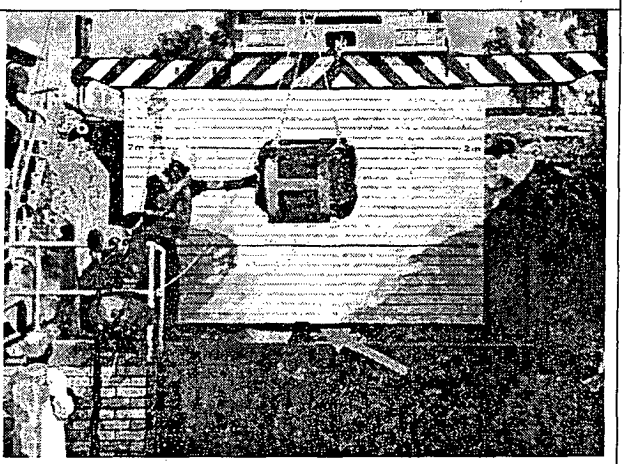
Pic 5. Chilling of prototype to below -40°C prior to 9.0m drop test.



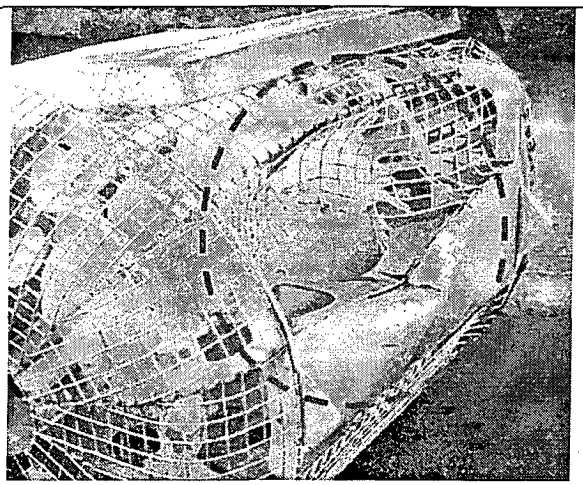
Pic 6. Damage sustained to prototype as a result of the 9.0m drop test, note the folding of the joint.



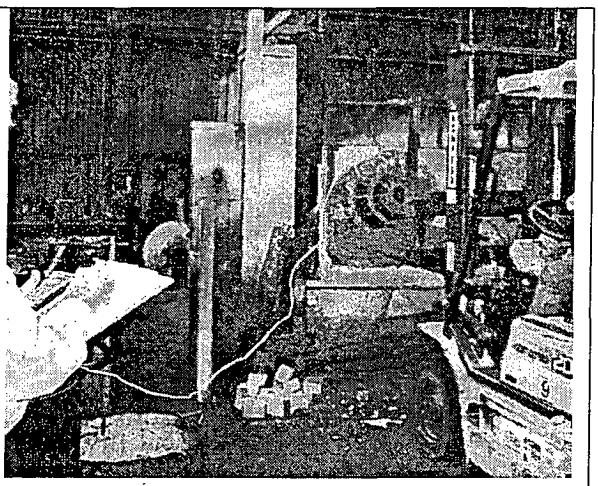
Pic 7. Post 9.0m drop test temperature reading (-42.0°C).



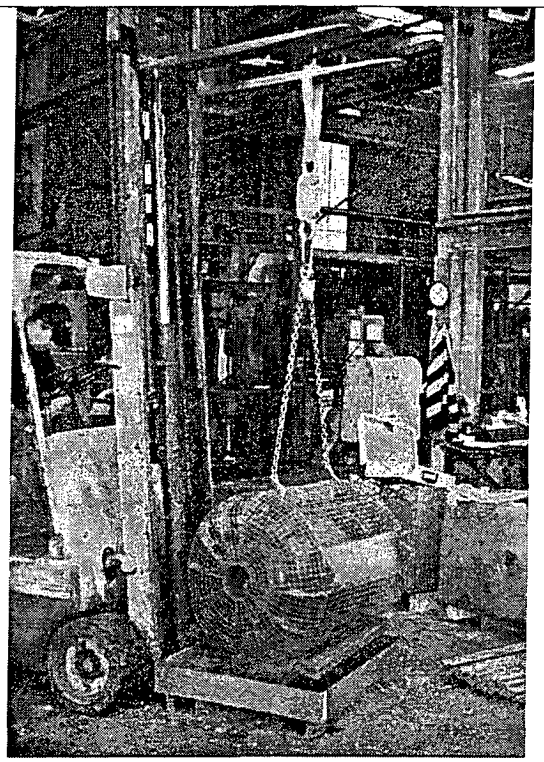
Pic 8. Prototype 1860 package orientated for 1.0m drop onto a vertical bar.



Pic 9. Damage sustained by the 1.0m drop on to vertical bar. Bar penetrated through to shield.



Pic 10. Prototype package at the conclusion of the thermal test.



Pic 11. Prototype mass after the thermal test. Load cell reading was 974kg.

APPENDIX 4 – ANSTO QUALITY CONTROL TEST REPORTS

ANSTO Quality Control (NATA Accreditation No 2963), a unit within ANSTO Engineering, witnessed and recorded the transport package testing of the prototype A&DM 1860 cask. The testing details are recorded in the following two documents:

1. DR5442 – Package Testing on A&DM-1860 cask
2. LT0214 – Leak test of dummy source

Ansto
Engineering Services

Australian Nuclear Science and Technology Organisation
New Illawarra Road, Lucas Heights
Postal Address: Private Mail Bag 1, MENAI, NSW 2234, Australia

Quality Endorsed Company

ORIGINAL TEST DATA RECORD

File No.	0072M-9-1-28-10-1-1	**Date**	19 September 2005	**DR**	5442

Project Description	Testing of A&DM Type B (U) Transport Package		
Sample Identification	**Prototype Package**		
Drawing No./Issue/Sheet	N/A	**Quantity**	1
Project Authorisation	Engineering Addendum to RFS	**Test Method**	Refer Below
Supplier	**Nuclear Mechanical**	**Supplier's Reference**	W.O. No 5016581

Test Observations/Calculations/Results

REFER TO PAGES 1 – 5 ATTACHED.

Test Equipment (MMD No.) /Calibration Expiry Date	**Pressure Transducer, QCT 0563 20/5/06**	**Load Cell, QCP 1011 2/5/07**	**Thermocouple, QCP 0717 15/7/06**		
EVALUATION	☐ **Acceptable**	☐ **Not Acceptable**	☐ **Refer to Responsible Officer**		
Other relevant information attached	**YES/NO**	**NC Report No.**	N/A		
Performed by	**S. Sinclair**	**Signature**	S Sinclair	**Date**	19/9/05
Checked by	H. Rivena	**Signature**		**Date**	21 Sept 05

PERFORMANCE TESTING OF THE A&DM 1860 CASK (DR5442)

In accordance with the ARPANSA Code of Practice for the Safe Transport of Radioactive Materials 2001 Edition and IAEA Safety Standard Series No. TS-R-1:- Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), Type A and Type B (U) tests were conducted on an A&DM prototype transport package serial number 1860-PT01.

The equipment was set-up as shown in Appendix 1. When all test gear was set-up, a dry run was conducted with a 20 litre drum half full of sand. Before starting the test the package was loaded with a dummy radioactive source (also supplied by client), serial number A&DM T01.

DROP TEST NUMBER 1

The package was connected to a crane hook and chain sling using only one of the 2 lifting points located along the centre line at top of package to allow the package to hang at an angle of 45^0 (approximately). The package was then lifted to a height of 1.2m and released by means of a quick-release mechanism attached to the crane hook, to impact onto a fixed horizontal flat steel plate.

Note: Measurements taken between the outer surface of the *end crumple shield* and the surface of the attenuator body at twelve positions around the circumference of the package (refer to figure 1) were recorded as shown in Table 1. Refer to drawing reference attached.

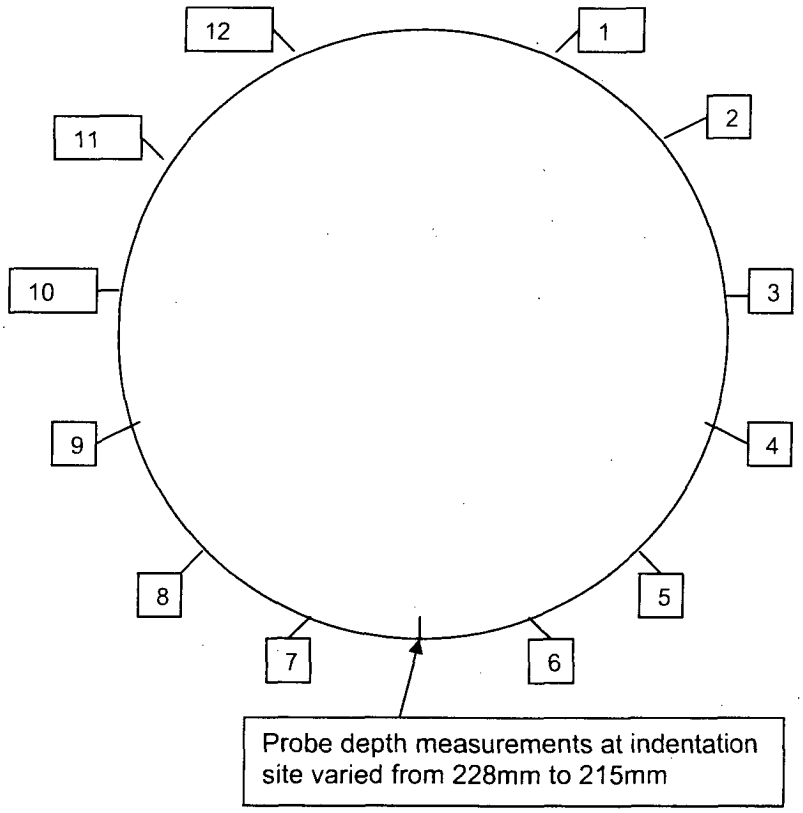


Figure 1. Measurement locations around the End Crumple Shield impacted from 1.2m.

POSITION NUMBER	MEASURED DISTANCE
1	240 mm
2	238 mm
3	240 mm
4	**235 mm**
5	244 mm
6	247 mm
7	253 mm
8	**253 mm**
9	237 mm
10	244 mm
11	246 mm
12	242 mm

TABLE 1

DROP TEST NUMBER 2

The package was set-up for freezing by connecting the crane hook to the package via its 2 lifting points along centre line at top of package. Thermocouples were positioned on the package, i.e. one inside the package and the other on the outside of the package.

The package was then lifted into a wooden crate (refer to Figure 2), and the crane cable fed out across to the corner of the crate to allow enough slack in the wire slings. The crate was located well clear of the drop test site with the access corner located in the upwind direction to allow ample ventilation.

A hose was run from a liquid nitrogen tank supply into the container and down into the metal tray under the package. A lid was placed on the box so as not to interfere with the slings or hose, and the liquid nitrogen fed into the package via a hole in the box lid. The hole also allowed Nitrogen vapour to vent out of the crate.

Thermocouples indicated when the package reached a temperature of -90°C at which point the liquid nitrogen was turned off, vapours allowed to settle and the lid removed.

The package was lifted out of the crate, thermocouples removed, and the opposite end of the package from the 1.2 metre drop test orientated at an angle of 45^0 to allow the package to impact on the nominated point.

With the package aligned over the target, a 9.0 metre long string with plumb bob attached was tied onto the free end. The package was lifted until the plumb bob just cleared the ground, and using a secondary string attached to the plumb bob, the plumb bob was pulled aside.

When the area was cleared of all personnel, the package was raised to a height of 9.0 metres and dropped to impact on a steel plate in the target area.

Note: A post-drop temperature of the package was recorded as -41°C. The wire cage mesh came apart from the package in several areas, and the flange joint and fins on the End Crumple Shield sustained extensive deformation in terms of the components folding and bending. The shielding (i.e. attenuator) and all components locating the radioactive source within the shielding were intact, functioning and not compromised, i.e. damage was restricted to the crumple shield/zone.

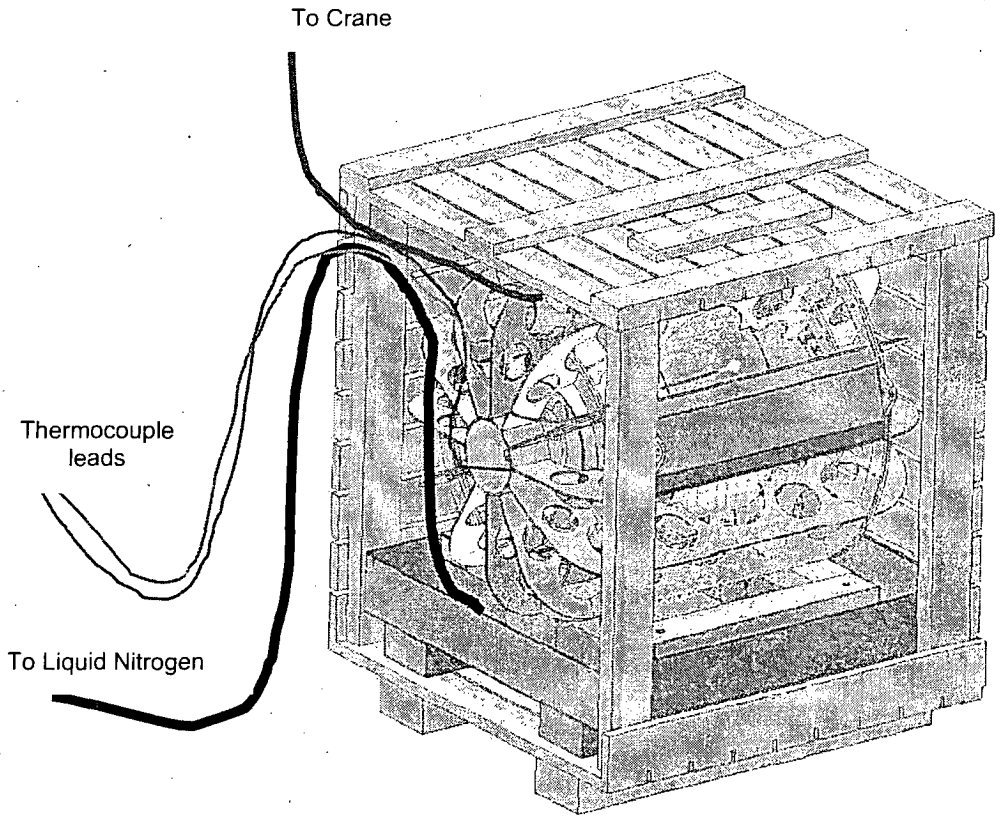


Figure 2. Package set up for freezing (Note: front, side and access hole not shown for clarity)

DROP TEST NUMBER 3

The package was aligned using 2 tie down points on the same side (as nominated for test) to allow the package to impact directly onto its side. The package was suspended 1.0 metre above the vertical bar (Ø150mm by 200mm long) positioned on the drop test area, and released onto the bar by means of a quick-release mechanism connected to the crane hook.

Note: The bar penetrated through the crumple shield to impact onto the attenuator. The shielding (i.e. attenuator) and all components locating the radioactive source within the shielding were intact, functioning and not compromised, i.e. damage was restricted to the crumple zone. At the completion of the drop testing the package was lifted clear and its mass recorded as 973 kg using a 5 tonne load-cell.

THERMAL TEST

The oven was preheated to 900°C. A 5 metre ceramic covered cable, thermocouple and Fluke thermometer were connected to the package. The package was then placed into the oven, and temperature readings recorded every five minutes to ensure that the average temperature of the environment was above 800°C. Refer to Table 2 below.

TIME (Minutes)	OVEN TEMPERATURE (° C)	OVEN SENSOR TEMPERATURE (° C)
0	700	907
5	800	930
10	861	933
15	446*	922
20	402*	890
25	817	877
30	1017	872
35	820	870

Table 2

Note: *The oven door was opened after 10 minutes to maintain the temperature at 800 ° C. The temperature deviation in the 2 low readings indicated was a result of the door closing on the cable causing a failure in the fiberglass covered wire connecting the thermocouple to the thermometer.

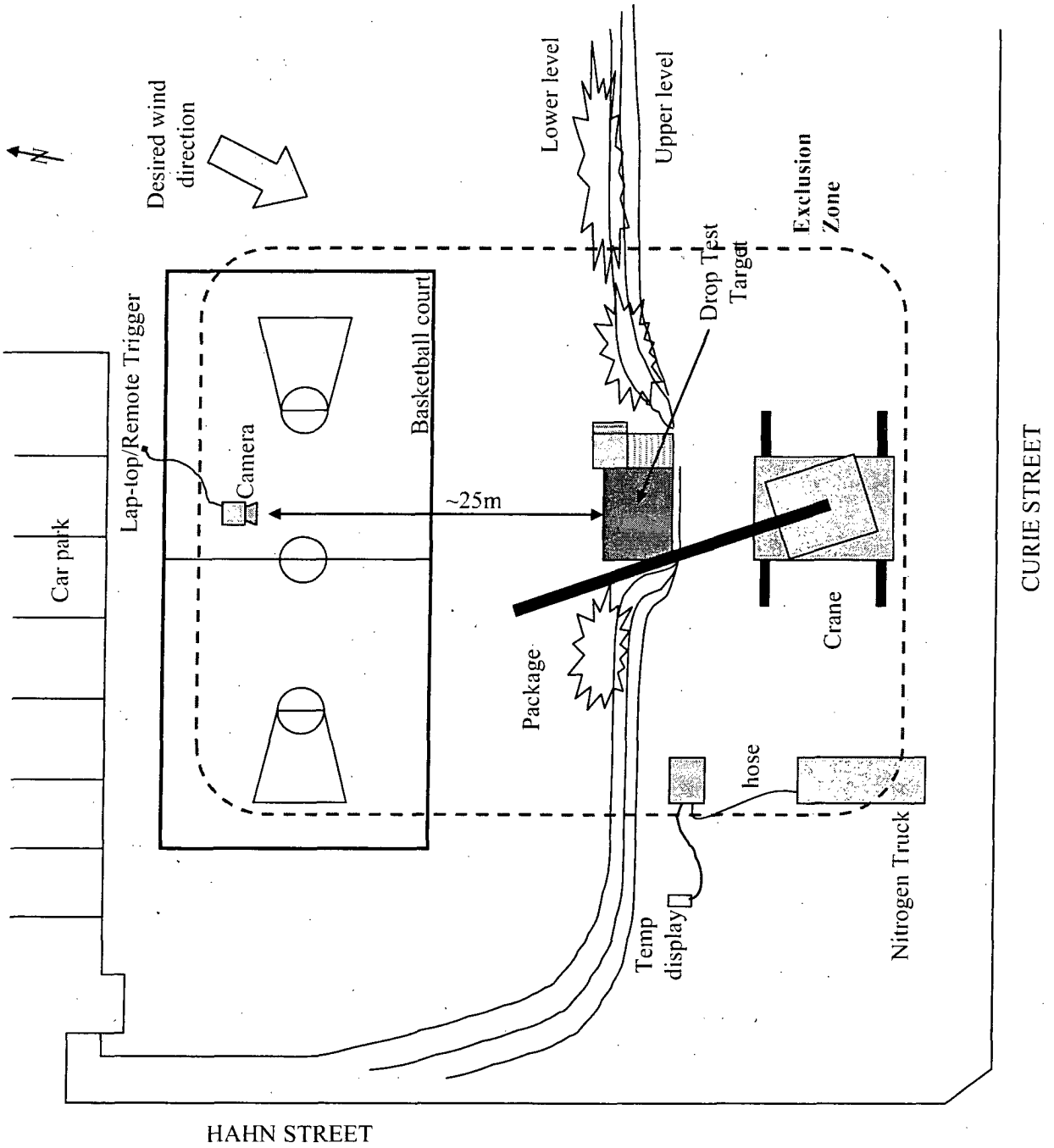
At the end of the test period, the package was removed from the oven and allowed to cool naturally.

Note: A visual inspection of the package showed no evidence of lead leakage from the attenuator body. Also there was no obvious distortion resulting from the thermal test other than what was sustained in the drop tests conducted previously.

The post thermal test package mass was recorded as 974 kg.

Upon the package cooling the dummy source was removed and a post testing leak test performed, refer to Leak Test report LT0214.

APPENDIX 1 – LAYOUT OF EQUIPMENT FOR DROP TESTS (PLAN VIEW)



ANSTO QC LEAK TEST REPORT (LT0214)

QUALITY CONTROL SECTION Ansto Engineering	LEAK TEST RECORD	Index No.: N.A.	LT 0214
		File No: 0072M-9-1-28-10	Page 1 of 1
Project: A&DM TYPE B(U) TRANSPORT PACKAGE	Assembly/Sub assembly: CAPSULE / SOURCE	Component: CAPSULE	
Drawing No./Issue/Sheet: N.A.	Material: STAINLESS STEEL	Quantity: 1.	
Component Specification: ISO 2919 - 1999	Process Specification: N.A.	Examination Instruction: TM-005	
Ansto Order No./LH File No: N.A.	Supplier: W. TOWNSEND NUCLEAR MECHANICAL	Supplier's Reference: W.O. No 5016581	
Condition: AS WELDED			
Design Pressure: N.A.	Design Temperature: N.A.	Volume: N.A.	
Leak Test Method: BUBBLE EMISSION	Test Medium: HELIUM	Temperature: AMBIENT	
Test Pressure: 1 MPa	Holding Time: 15 MINUTES	Allowable Leak Rate (mar): NONE	
Type of Gauge/Manufacturer: PRESSURE TRANSDUCER / DRUCK	Size/Range/Serial No. QCT 0502 0 - 13500 KPa / 201862	Calibration Expiry Date: 20/5/06	
Temp Indic/Manufacturer: THERMOMETER / FLUKE	Range/Serial No.: -200°C to 1370°C / 201972	Calibration Expiry Date: 16/9/05	
Leak Tester/Manufacturer: VACUUM CHAMBER	Size/Range/Serial No.: N.A.	Date Calibrated N.A.	
Calib. Leak/Manufacturer: N.A.	Size/Range/Serial No: N.A.	Calibration Expiry Date: N.A.	
Test Pressure: N.A.	Hold Time: N.A.	Measured Leak Rate: N.A.	

Remarks: In accordance with ISO 2919-1999 Radiation protection – Sealed radioactive sources – General requirements and classification, a test capsule containing a dummy source was pressurized with helium and leak tested before and after the A&DM series 1860 package tests listed in Engineering Test Procedure Number EP 121928 Rev 0.

(a) The capsule was wiped with acetone and dried thoroughly.
(b) The capsule (serial number A&DM TO1) was then placed into a pressure vessel.
(c) Using helium, the vessel was purged of air.
(d) The vessel was pressurized with helium to 1 MPa, and maintained for 15 minutes.
(e) The vessel was depressurized and the capsule removed.
(f) The capsule was cleaned with acetone.
(g) The capsule was placed into a vacuum chamber containing glycol, which was then evacuated.
(h) A bubble test applied to the capsule showed no evidence of leaks.

Note: The capsule had a small triangular indentation 5mm x 3mm on one side prior to testing.

Evaluation: ☑ Acceptable / no indications ☐ Permanent Record
☐ Acceptable / with indications ☐ Annex
☐ Not acceptable / refer to Responsible Officer ☐ NC Report No. | | | | | |

Prepared by: S. SINCLAIR	Reviewed by:	Approved by: A. RIVERA
Signature: S Sinclair	Signature:	Signature:
Date: 15/9/05	Date:	Date: 21 Sept 05

THIS DOCUMENT FORMS PART OF THE ANSTO QUALITY ASSURANCE SYSTEM

APPENDIX 5 – THERMAL ANALYSIS OF THE A&DM1860 CASK

The following analysis of the package has been conducted to verify the compliance of the package to the requirements of clause 617 of the ARPANSA regulations. For the A&DM1860 package loaded up to its maximum activity limit the internal heat generation (heat capacity) is specified as being 250W, refer to the A&DM website: http://www.nuclearstuff.com/transport_cask.htm.

In performing the thermal analysis of the package several assumptions were made so as to make use of fundamental heat transfer principles. Estimates and assumptions made were done so as to yield a conservative result where the result itself determined whether further model refinement was needed or computer simulation required.

The two heat transfer principles employed were the heat conduction for cylinders and heat convection for fins. The cylinder analysis gave the surface temperature of the attenuator which was used in the fin analysis to calculate the temperature on the surface of the package. In performing the analysis the assumptions and estimates made include the following:

1. Internal heat generation from maximum activity source is 250 Watts. This heat is evenly distributed on the inner cavity surface of the attenuator. The draw that holds the source inside the package and the stainless steel cavity lining would aid in distributing this energy on the inner surface of the attenuator.
2. Steady state conditions. Ambient temperature is constant at 38°C.
3. One dimensional heat flow, i.e. in the radial direction. For a simple model the heat is assumed to pass through only the mid section of the cylinder which is conservative since it equates to a higher heat flux for the same internal heat generation, i.e. the heat is concentrated over a smaller area.
4. Homogeneous properties, eg constant material properties (no air pockets in lead).
5. No radiation heat losses in terms of light.
6. Perfect thermal contact between different materials, i.e. no temperature drop due to the thermal resistance at the interface.
7. Fin can employ the infinite long model, i.e. fin thickness is relatively thin. Fins are assumed to be continuous with no holes maximizing heat transfer from the attenuator to the package surface.

5.1 CYLINDER THERMAL ANALYSIS

The attenuator / main shield was modeled as a single cylinder of constant wall thickness of the same length as the main body of the shield, i.e. excluding the tapered sections on each end. The model is illustrated in Figure A5.1.

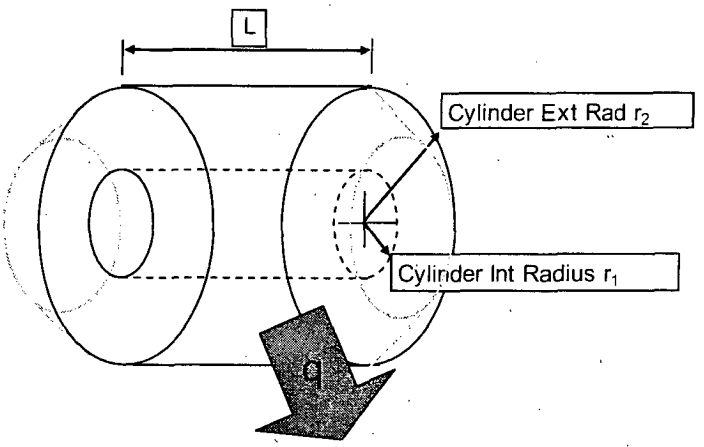


Figure A5.1 Attenuator model for thermal analysis. Note that only the heat path through the cylinder wall was considered for thermal losses.

Applying fundamental heat transfer principles the heat flow through the cylinder wall can be stated as:

$$q_r = \frac{T_{\infty,1} - T_{\infty,2}}{R_{Total}} = UA(T_{\infty,1} - T_{\infty,2}), \text{ where}$$

$$U = \frac{1}{\frac{r_1}{kA}\ln\frac{r_2}{r_1} + \frac{1}{h_2}}$$ Eqn 3.30 & 3.31, Ref 6.6

At the surface of the cylinder the heat is assumed to be transferred to the ambient air via natural (unforced) convection and not aided by fins, this is a conservative assumption since fins serve to transfer heat from the surface. The free convection coefficient for gases can range from 2 to 25 W/m^{2}K, a typical value for air is 20 W/m^{2}K, Ref 6.6. For a heat input of 250W, an ambient temperature of 38°C (311K) and the cylinder dimensions given in Figure A5.1, the above equations can be rearranged to find the temperature on the surface of the attenuator as set out in the following.

$$q_r = \frac{T_{s,2} - T_{\infty,2}}{1/(2\pi.L.h_2 r_2)} = \frac{T_{s,2} - 311}{1/((20)(2\pi)(0.23)(0.26))} = 250$$

$$T_{s,2} = 34403K \qquad (71.1°C)$$

5.2 FIN THERMAL ANALYSIS

The crumple zone was modeled as fins extending in a radial direction from the attenuator running the length of the cylinder. The fins are spaced at 12 evenly distributed points around the circumference of the cylinder that was modeled above. The fins are assumed to be solid one piece fins in perfect thermal contact with the cylinder, i.e. no temperature drop over the interface, refer to Figure A5.2. This assumption is conservative since there are relatively large holes in the fins limiting the thermal contact area between the fin and cylinder, refer to A&DM1860 cask drawing, Appendix 1. The temperature distribution along a single fin was then calculated assuming the base temperature of the fin was maintained at the same temperature as the rest of the attenuator surface, i.e. 71°C. In applying some thermodynamic principles to the fin the same assumptions and estimations made above are also reapplied here.

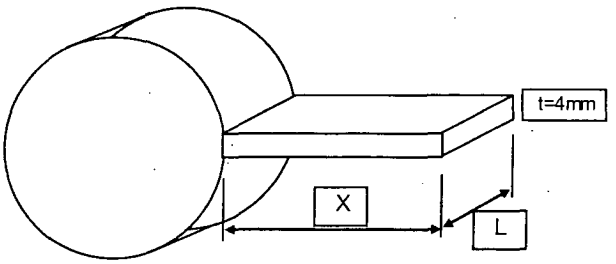


Figure A5.2 Crumple zone modeled as fins (fin size exaggerated for clarity)

The temperature distribution along the fin can be calculated using the following equations.

$$q_f = \sqrt{hPkA_c}(T_b - T_\infty)$$ Eqn 3.80, Ref 6.6

Rearranging to find the temperature T at a distance of x along the fin yield the following equations.

$T = T_\infty + (T_b - T_\infty)e^{-mx}$, where $m = \sqrt{hPkA_c}$

P=2(4+260)/1000=0.258m (Fin perimeter)

A_c=(0.004)(0.260)=1.04x10^{-3}m^2 (Fin cross-sec area)

h=20W/m^{2}K (Convection coefficient air)

k=14W/m^{2}K (Conduction coefficient lead)

The above equation was entered into Microsoft Excel spreadsheet to calculate the temperature at a number of intervals along the fin. The resulting temperature distribution was then plotted and is shown in Figure A5.3. From the plot it can be seen that the temperature of the fin drops off quickly

with respect to distance and falls below the required 50°C at a distance of approximately 40mm from the surface of the attenuator or at a depth greater than 100mm from the surface of the package. Note that the outer end of the fin (distance = 150mm) is regarded as the surface of the package at which point the temperature is 39°C, i.e. 1°C above the ambient temperature.

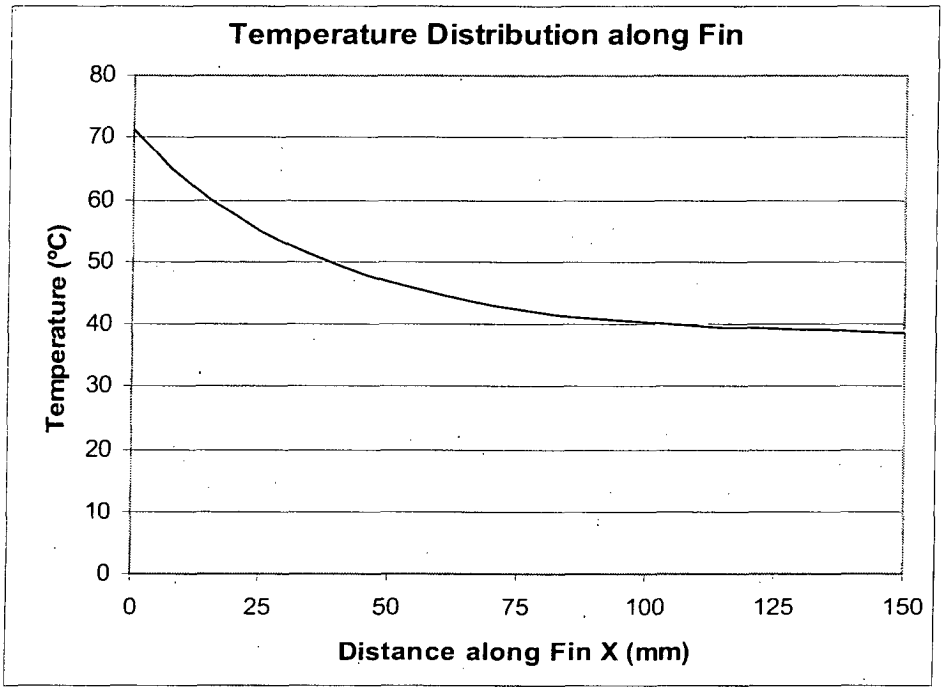


Figure A5.3 Plot of temperature distribution along the fin. Note that at zero distance the temperature is the temperature of the surface of the cylinder (Attenuator surface), i.e. 71°C.

As a final check to verify that the fin can be accurately modeled as an infinitely long fin the following equation was evaluated to show that *m.L > 2.65* as required to be valid, Section 3.6.2 Ref 6.6.

$$m.L = 26.93 \times 0.26 = 7.0$$

Therefore m.L > 2.65 and infinite long fin assumption is valid.

5.3 THERMAL ANALYSIS CONCLUSION

The thermal analysis of the A&DM 1860 cask design loaded to maximum capacity (i.e. thermal load of 250W) has shown that the package surface temperature does not exceed 50°C in an ambient environment of 38°C as required by clause 652 of the ARPANSA regulations.

Figure Withheld Under 10 CFR 2.390

DRAWN RT	26/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-018**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Case			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-018-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	26/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-018**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Case			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-018-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	23/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-038**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Outer Ring			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-037-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	23/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-037**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Inner Ring			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-037-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	23/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-038**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Outer Ring		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-038-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	23/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-038**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Outer Ring			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-038-03	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	27/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-039**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Top Fin Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-039-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	27/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-039**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Top Fin Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-039-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	22/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-042**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transverse Base Section Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-042-03	SHEET 1 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	22/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-042**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transverse Base Section Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-042-03	SHEET 2 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	22/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-044**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Plastic Skid Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-044-03	SHEET 1 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	22/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-044**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Plastic Skid Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-044-03	SHEET 2 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	22/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-048**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Outer Base Section Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-048-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	22/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-048**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Outer Base Section Assembly		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-048-03	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	22/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	8/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-062**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Fins And Rings			
MANUFACTURE QA		Drawing Description	Sub Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-062-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	22/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	8/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-062**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Fins And Rings		
MANUFACTURE QA		Drawing Description	Sub Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-062-03	SHEET 2 OF 2 / REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	7/11/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	22/08/2006	Component Number	**1860A-01-064**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Mesh			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-064-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	7/11/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	22/08/2006	Component Number	**1860A-01-064**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Mesh			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-064-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	23/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-067**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Inner Ring			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-067-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	23/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-067**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Inner Ring			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-067-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	31/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	31/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-068**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Outer Ring			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-068-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	31/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	31/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-068**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Outer Ring			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-068-03	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**Model 1860**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-119**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Shell Centre		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-119-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**Model 1860**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-119**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Shell Centre			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-119-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**Model 1860**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-120**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Locking Sleeve		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-120-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**Model 1860**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-120**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Locking Sleeve			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-120-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	26/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-125**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Shell End			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-125-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	26/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-125**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Shell End			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-125-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-141**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Base Skid Bolt Support			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-141-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-141**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Base Skid Bolt Support			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-141-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-142**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Base End Cover			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-142-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-142**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Base End Cover			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-142-03	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	7/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-144**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transverse Base Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-144-03	SHEET 1 OF 2	REV 2

Template Revision 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	7/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-144**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transverse Base Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-144-03	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	7/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-145**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Base Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-145-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	7/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-145**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Base Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-145-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-171**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Top Fin			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-171-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-171**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Top Fin			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-171-03	SHEET 2 OF 2	REV 3

Template Revision 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-172**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Lower Support Fin			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-172-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-172**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Lower Support Fin			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-172-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-173**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Side Support Fin			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-173-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-173**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Side Support Fin			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-173-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-174**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Standard Fin			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-174-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
RT						
ENGINEERING CHECKED	17/07/2006	Project / Model	**1860A**			
ETP						
DRAWING QA CHECK	21/08/2006	Component Number	**1860A-01-174**			
LJG						
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Standard Fin			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE	SCALE	DWG NO	SHEET 2 OF 2	REV
		A3	N.T.S	1860A-01-174-03		2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-175**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Shield Inner Ring Section		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-175-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-175**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Shield Inner Ring Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-175-03	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-176**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Shield Outer Ring Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-176-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-176**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Centre Shield Outer Ring Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-176-03	SHEET 2 OF 2	REV 2

Template Revision: 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-179**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Tie Down Strap		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-179-03	SHEET 1 OF 2 / REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-179**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Tie Down Strap		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-179-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-180**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Lifting Eye Support		
MANUFACTURE QA		Drawing Description .	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-180-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-180**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Lifting Eye Support		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-180-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-181**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Tiedown Bracket			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-181-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-181**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Tiedown Bracket		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-181-03	SHEET 2 OF 2	REV 2

Template Revision: 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-191**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Shield Tube			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-191-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-191**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Shield Tube			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-191-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETO	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-192**			
TOLERANCE (UNLESS SPECIFIED)	mm	Component Description	End Fin			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-192-03	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETO	1/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-192**		
TOLERANCE (UNLESS SPECIFIED)	mm	Component Description	End Fin		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-192-03	SHEET 2 OF 2 / REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-196**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Shield Inner Ring Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-196-03	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-196**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Shield Inner Ring Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-196-03	SHEET 2 OF 2	REV 3

Template Revision 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-197**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Shield Outer Ring Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-197-03	SHEET 1 OF 2	REV 3

Template Revision: 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-197**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Shield Outer Ring Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-197-03	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/01/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	27/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-250**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Placard Base Plate			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-250-03	SHEET 1 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/01/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	27/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-250**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Placard Base Plate			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-250-03	SHEET 2 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	26/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-257**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Index Plate		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-257-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	26/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-257**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Index Plate		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-257-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	20/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-265**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Tool Box Mounting Bracket		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-265-00	SHEET 1 OF 2 REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	20/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	26/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-265**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Tool Box Mounting Bracket			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-265-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	17/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	2/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-311**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Plug			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-311-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	17/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	2/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-311**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Plug			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-311-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	2/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-341**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Base Jack Bolt Support		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-341-03	SHEET 1 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	2/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-341**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Base Jack Bolt Support			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-341-03	SHEET 2 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-343**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Outer Base Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-343-00	SHEET 1 OF 2	REV 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-343**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Outer Base Section			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-343-00	SHEET 2 OF 2	REV 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	9/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-360**			
TOLERANCE (UNLESS SPECIFIED)	1mm	Component Description	Top Mesh			
MANUFACTURE QA		Drawing Description	Component Datails			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-360-00	SHEET 1 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	9/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-360**			
TOLERANCE (UNLESS SPECIFIED)	1mm	Component Description	Top Mesh			
MANUFACTURE QA		Drawing Description	Component Datails			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-360-00	SHEET 2 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	9/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-370**			
TOLERANCE (UNLESS SPECIFIED)	1mm	Component Description	Bottom Side Mesh			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-370-00	SHEET 1 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	9/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-01-370**		
TOLERANCE (UNLESS SPECIFIED)	1mm	Component Description	Bottom Side Mesh		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-01-370-00	SHEET 2 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	21/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-000**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly		
MANUFACTURE QA		Drawing Description	Assembly Drawing		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-000-00	SHEET 1 OF 4	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	21/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-000**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly		
MANUFACTURE QA		Drawing Description	Assembly Drawing		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-000-00	SHEET 2 OF 4	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	21/08/2006	Project / Model				
DRAWING QA CHECK LJG	21/08/2006	Component Number				
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description				
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-000-00	SHEET 3 OF 4	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	21/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-005**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator, Rings & Fin and Base Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-000-00	SHEET 4 OF 4	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-017**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "A"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-017-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/08/2006	Project / Model.	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-017**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "A"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-017-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	2/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	2/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-019**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-019-00	SHEET 1 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	2/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	2/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-019**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-019-00	SHEET 2 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-023**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-023-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-023**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-023-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-024**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-024-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-024**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-024-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-028**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-028-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-028**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-028-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/05/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/11/2006	Project / Model	**1860A**			
DRAWING QA CHECK L. GROGAN	3/11/2006	Component Number	**1860A-A1-109**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-109-00	SHEET 1 OF 2	REV 7

Figure Withheld Under 10 CFR 2.390

DRAWN	25/05/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
RT						
ENGINEERING CHECKED	1/11/2006	Project / Model	**1860A**			
ETP						
DRAWING QA CHECK	3/11/2006	Component Number	**1860A-A1-109**			
L. GROGAN						
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE	SCALE	DWG NO	SHEET 2 OF 2	REV
		A3	N.T.S	1860A-A1-109-00		7

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-121**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Flange Blank			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-121-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-121**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Flange Blank			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-121-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	21/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-122**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-122-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	21/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-122**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Flange		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3 / SCALE N.T.S	DWG NO 1860A-A1-122-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	21/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-123**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-123-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	21/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-123**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-123-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-124**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Cover			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-124-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	25/10/2005	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-124**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Cover			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-124-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	20/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-131**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-131-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	9/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	20/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-131**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-131-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	12/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED		Project / Model			
DRAWING QA CHECK LJG	25/08/2006	Component Number			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description			
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-313-00	SHEET 1 OF 2 / REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	12/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED		Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-A1-313**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Copper Washer			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-313-00	SHEET 2 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	18/10/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/10/2006	Project / Model	**1860A**			
DRAWING QA CHECK L. GROGAN	30/10/2006	Component Number	**1860A-A1-382**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Metaflex Seal			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-382-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	18/10/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/10/2006	Project / Model	**1860A**			
DRAWING QA CHECK L. GROGAN	30/10/2006	Component Number	**1860A-A1-382**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Metaflex Seal			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-A1-382-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-B1-000**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-000-00	SHEET 1 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-B1-000**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-000-00	SHEET 2 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model				
DRAWING QA CHECK LJG	25/08/2006	Component Number				
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description				
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-000-00	SHEET 3 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	25/08/2006	Project / Model			
DRAWING QA CHECK LJG	25/08/2006	Component Number			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description			
MANUFACTURE QA		Drawing Description	Assembly Drawing		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-000-00	SHEET 4 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	14/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-010**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "B"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-010-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	14/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-010**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "B"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-010-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-011**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Drawer Tube			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-011-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-011**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Drawer Tube			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-011-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-012**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port End Drawer Tube			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-012-00	SHEET 1 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-012**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port End Drawer Tube			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-012-00	SHEET 2 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	11/04/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-016**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-016-00	SHEET 1 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	11/04/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-016**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Assembly		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-016-00	SHEET 2 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-017**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "B"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-017-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-017**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "B"		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-017-00	SHEET 2 OF 2 / REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	3/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-019**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-019-00	SHEET 1 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	3/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-019**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-019-00	SHEET 2 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-A1-023**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-023-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-023**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-023-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-024**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange Assembly		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-024-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-024**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-024-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**Model 1860**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-028**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-028-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**Model 1860**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-028**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-028-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-101**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-101-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-101**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-101-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-102**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-102-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-102**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-102-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-103**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Sleeve			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-103-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	3/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-103**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Sleeve			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-103-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-104**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port End Sleeve		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-104-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-104**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port End Sleeve			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-104-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	16/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	11/04/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-105**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Primary Attenuator			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-105-00	SHEET 1 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	16/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	11/04/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-105**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Primary Attenuator			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-105-00	SHEET 2 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	31/05/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	24/08/2006	Component Number	**1860A-B1-108**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Shine Shield			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-108-00	SHEET 1 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	31/05/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	24/08/2006	Component Number	**1860A-B1-108**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Shine Shield			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-108-00	SHEET 2 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	12/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/11/2006	Project / Model	**1860A**			
DRAWING QA CHECK L. GROGAn	3/11/2006	Component Number	**1860A-B1-109**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-109-00	SHEET 1 OF 2	REV 8

Figure Withheld Under 10 CFR 2.390

DRAWN RT	12/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/11/2006	Project / Model	**1860A**			
DRAWING QA CHECK L. GROGAn	3/11/2006	Component Number	**1860A-B1-109**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-109-00	SHEET 2 OF 2	REV 8

Figure Withheld Under 10 CFR 2.390

DRAWN RT	21/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-122**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-122-00	SHEET 1 OF 2	REV 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	21/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	17/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-122**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-122-00	SHEET 2 OF 2	REV 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	14/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-123**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-123-00	SHEET 1 OF 2	REV 6

Figure Withheld Under 10 CFR 2.390

DRAWN RT	14/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-B1-123**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-123-00	SHEET 2 OF 2	REV 6

Template Revision: 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	18/10/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/10/2006	Project / Model	**1860A**			
DRAWING QA CHECK L. GROGAN	30/10/2006	Component Number	**1860A-B1-382**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Metaflex Seal			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-B1-382-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN	18/10/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
RT						
ENGINEERING CHECKED	25/10/2006	Project / Model	**1860A**			
ETP						
DRAWING QA CHECK	30/10/2006	Component Number	**1860A-B1-382**			
L. GROGAN						
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Metaflex Seal			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE	SCALE	DWG NO	SHEET 2 OF 2	REV
		A3	N.T.S	1860A-B1-382-00		3

Template Revision 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-C1-000**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly		
MANUFACTURE QA		Drawing Description	Assembly Drawing		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-000-00	SHEET 1 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-C1-000**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-000-00	SHEET 2 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model				
DRAWING QA CHECK LJG	25/08/2006	Component Number				
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description				
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-000-00	SHEET 3 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	25/08/2006	Project / Model			
DRAWING QA CHECK LJG	25/08/2006	Component Number			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description			
MANUFACTURE QA		Drawing Description	Assembly Drawing		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-000-00	SHEET 4 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	14/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	11/04/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-C1-010**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "C"		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-010-00	SHEET 1 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	14/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	11/04/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-C1-010**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "C"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-010-00	SHEET 2 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-C1-017**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "C"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-017-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/07/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-C1-017**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "C"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-017-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	3/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-C1-019**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Assembly		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-019-00	SHEET 1 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	3/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	4/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-C1-019**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-019-00	SHEET 2 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	16/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED ETP	11/04/2006	Model Number: 1860A Component Name: 1860A-C1-105 Component Desc: Attenuator Primary Drawing Desc: Part Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-105	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	16/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED ETP	11/04/2006	Model Number: 1860A Component Name: 1860A-C1-105 Component Desc: Attenuator Primary Drawing Desc: Part Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-C1-105	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-D1-000**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-000-00	SHEET 1 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-D1-000**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-000-00	SHEET 2 OF 4	REV 2

Template Revision 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model				
DRAWING QA CHECK LJG	25/08/2006	Component Number				
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description				
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-000-00	SHEET 3 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	25/08/2006	Project / Model			
DRAWING QA CHECK LJG	25/08/2006	Component Number			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description			
MANUFACTURE QA		Drawing Description	Assembly Drawing		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-000-00	SHEET 4 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	14/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-010**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "D"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-010-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN	14/06/2006	**Analogue & Digital Measurements P/L**	
RT		http://admeasure.com.au	
ENGINEERING CHECKED	6/08/2006	Project / Model	**1860A**
ETP			
DRAWING QA CHECK	21/08/2006	Component Number	**1860A-D1-010**
LJG			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "D"
MANUFACTURE QA		Drawing Description	Assembly Details

SIZE	SCALE	DWG NO		REV
A3	N.T.S	1860A-D1-010-00	SHEET 2 OF 2	2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-011**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Drawer Tube			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-011-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-011**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Drawer Tube			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-011-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-012**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port End Drawer Tube			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-012-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-012**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port End Drawer Tube			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-012-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-017**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "D"		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-017-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-017**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "D"		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-017-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	3/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-019**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-019-00	SHEET 1 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	3/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-019**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Assembly		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-019-00	SHEET 2 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	30/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-D1-101**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube			
MANUFACTURE QA		Drawing Description	Part Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-D1-101-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN	30/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
RT						
ENGINEERING CHECKED	6/08/2006	Project / Model	**1860A**			
ETP						
DRAWING QA CHECK	21/08/2006	Component Number	**1860A-D1-101**			
LJG						
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube			
MANUFACTURE QA		Drawing Description	Part Details			
		SIZE	SCALE	DWG NO	SHEET 2 OF 2	REV
		A3	N.T.S	1860A-D1-101-00		2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-E1-000**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-000-00	SHEET 1 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-E1-000**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-000-00	SHEET 2 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model				
DRAWING QA CHECK LJG	25/08/2006	Component Number				
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description				
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-000-00	SHEET 3 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model				
DRAWING QA CHECK LJG	25/08/2006	Component Number				
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description				
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-000-00	SHEET 4 OF 4	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-010**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-010-00	SHEET 1 OF 2 / REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-010**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-010-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/04/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED ETP	28/04/2006	Model Number: 1860A Component Name: 1860A-E1-015 Component Desc: Primary Attenuator SA Drawing Desc: Assembly Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-015-00	SHEET 1 OF 2	REV 7

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/04/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED ETP	28/04/2006	Model Number: 1860A Component Name: 1860A-E1-015 Component Desc: Primary Attenuator SA Drawing Desc: Assembly Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-015-00	SHEET 2 OF 2	REV 7

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	11/04/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-016**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Sub Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-016-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	11/04/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-016**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Sub Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-016-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-017**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "E"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-017-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-017**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "E"		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-017-00	SHEET 2 OF 2 / REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	3/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-019**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "E" Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-019-00	SHEET 1 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN	3/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
RT					
ENGINEERING CHECKED	6/08/2006	Project / Model	**1860A**		
ETP					
DRAWING QA CHECK	21/08/2006	Component Number	**1860A-E1-019**		
LJG					
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "E" Assembly		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE: A3	SCALE: N.T.S	DWG NO: 1860A-E1-019-00	SHEET 2 OF 2 / REV: 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-023**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-023-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-023**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-023-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-024**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-024-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-024**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-024-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED		Project / Model	**Model 1860**		
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-E1-028**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Assembly		
MANUFACTURE QA		Drawing Description	Assembly Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-028-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	13/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED		Project / Model	**Model 1860**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-E1-028**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap Assembly			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-028-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	8/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-101**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Plate A		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-101-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	8/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-101**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube Plate A		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-101-00	SHEET 2 OF 2	REV 2

Template Revision 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	8/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-102**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Plate Side B			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-102-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN	8/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
RT						
ENGINEERING CHECKED	6/08/2006	Project / Model	**1860A**			
ETP						
DRAWING QA CHECK	21/08/2006	Component Number	**1860A-E1-102**			
LJG						
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Plate Side B			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE	SCALE	DWG NO	SHEET 2 OF 2	REV
		A3	N.T.S	1860A-E1-102-00		2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	7/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED		Model Number: 1860A Component Name: 1860A-E1-103 Component Desc: Primary Attenuator Block Drawing Desc: Part Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-103-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	7/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED		Model Number:				
QA		Component Name:				
MFG		Component Desc:				
APPROVED		Drawing Desc: Part Details				
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-103-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	17/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-104**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Ring		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860-02-104-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	17/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-104**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Ring		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860-02-104-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN		**Analogue & Digital Measurements P/L**			
RT	8/06/2006	http://admeasure.com.au			
ENGINEERING CHECKED		Project / Model	**1860A**		
ETP	6/08/2006	Component Number	**1860A-E1-105**		
DRAWING QA CHECK		Component Description	Drawer Ring Pedestal B		
LJG	21/08/2006	Drawing Description	Component Details		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	SIZE	SCALE	DWG NO	REV
MANUFACTURE QA		A3	N.T.S	1860A-E1-105-00	2
				SHEET 1 OF 2	

Figure Withheld Under 10 CFR 2.390

DRAWN RT	8/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au	
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**
DRAWING QA CHECK UG	21/08/2006	Component Number	**1860A-E1-105**
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Ring Pedestal B
MANUFACTURE QA		Drawing Description	Component Details

SIZE	SCALE	DWG NO		REV
A3	N.T.S	1860A-E1-105-00	SHEET 2 OF 2	2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	8/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-106**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Ring Pedestal A			
MANUFACTURE QA		Drawing Description	Part Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-106-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	8/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-106**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Ring Pedestal A			
MANUFACTURE QA		Drawing Description	Part Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-106-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	17/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-107**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port End Ring		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860-02-107-03	SHEET 1 OF 2 / REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	17/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-107**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port End Ring			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860-02-107-03	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	17/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED		Model Number: 1860A Component Name: 1860A-E1-108 Component Desc: Draw Shine Attenuator Drawing Desc: Part Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-108-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	17/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED		Model Number: 1860A Component Name: 1860A-E1-108 Component Desc: Draw Shine Attenuator Drawing Desc: Part Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-108-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN	11/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
RT					
ENGINEERING CHECKED	1/11/2006	Project / Model	**1860A**		
ETP					
DRAWING QA CHECK	3/11/2006	Component Number	**1860A-E1-109**		
L. GROGAN					
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE: A3	SCALE: N.T.S	DWG NO: 1860A-E1-109-00	SHEET 1 OF 2	REV: 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	11/07/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	1/11/2006	Project / Model	**1860A**			
DRAWING QA CHECK L. GROGAN	3/11/2006	Component Number	**1860A-E1-109**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	End Cap			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-109-00	SHEET 2 OF 2	REV 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	21/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-122**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Flange		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-122-00	SHEET 1 OF 2	REV 4

Template Revision: 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	21/02/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-122**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter End Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-122-00	SHEET 2 OF 2	REV 4

Figure Withheld Under 10 CFR 2.390

DRAWN RT	15/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-123**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-123-00	SHEET 1 OF 2	REV 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	15/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-123**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Flange		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-123-00	SHEET 2 OF 2	REV 5

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-124**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Cover		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-124-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au			
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**		
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-E1-124**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Filling Port Cover		
MANUFACTURE QA		Drawing Description	Component Details		
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-124-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	18/10/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/10/2006	Project / Model	**1860A**			
DRAWING QA CHECK L. GROGAN	30/10/2006	Component Number	**1860A-E1-382**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Metaflex Seal			
MANUFACTURE QA		Drawing Description	Component Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-382-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	18/10/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/10/2006	Project / Model	**1860A**			
DRAWING QA CHECK L. GROGAN	30/10/2006	Component Number	**1860A-E1-382**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Metaflex Seal			
MANUFACTURE QA		Drawing Description	Component Details.			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-E1-382-00	SHEET 2 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-F1-000**			
TOLERANCE (UNLESS SPECIFIED)	0mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-000-00	SHEET 1 OF 4	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-F1-000**			
TOLERANCE (UNLESS SPECIFIED)	0mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-000-00	SHEET 2 OF 4	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	25/08/2006	Component Number	**1860A-F1-000**			
TOLERANCE (UNLESS SPECIFIED)	0mm	Component Description	Transport Cask Assembly			
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-000-00	SHEET 3 OF 4	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	29/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	25/08/2006	Project / Model				
DRAWING QA CHECK LJG	25/08/2006	Component Number				
TOLERANCE (UNLESS SPECIFIED)	0mm	Component Description				
MANUFACTURE QA		Drawing Description	Assembly Drawing			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-000-00	SHEET 4 OF 4	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/04/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED ETP	28/04/2006	Model Number: 1860A Component Name: 1860A-F1-015 Component Desc: Primary Attenuator Assembly Drawing Desc: Assembly Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-015-00	SHEET 1 OF 2	REV 6

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/04/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED ETP	28/04/2006	Model Number: 1860A Component Name: 1860A-F1-015 Component Desc: Primary Attenuator Assembly Drawing Desc: Assembly Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-015-00	SHEET 2 OF 2	REV 6

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-F1-017**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "F"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-017-00	SHEET 1 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	28/06/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-F1-017**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Attenuator Assembly Configuration "F"			
MANUFACTURE QA		Drawing Description	Assembly Details			
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-017-00	SHEET 2 OF 2	REV 2

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-F1-019**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "F" Assembly			
MANUFACTURE QA		Drawing Description				
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-019-00	SHEET 1 OF 2	REV 1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/08/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
ENGINEERING CHECKED ETP	6/08/2006	Project / Model	**1860A**			
DRAWING QA CHECK LJG	21/08/2006	Component Number	**1860A-F1-019**			
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Drawer Tube "F" Assembly			
MANUFACTURE QA		Drawing Description				
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-019-00	SHEET 2 OF 2	REV 1

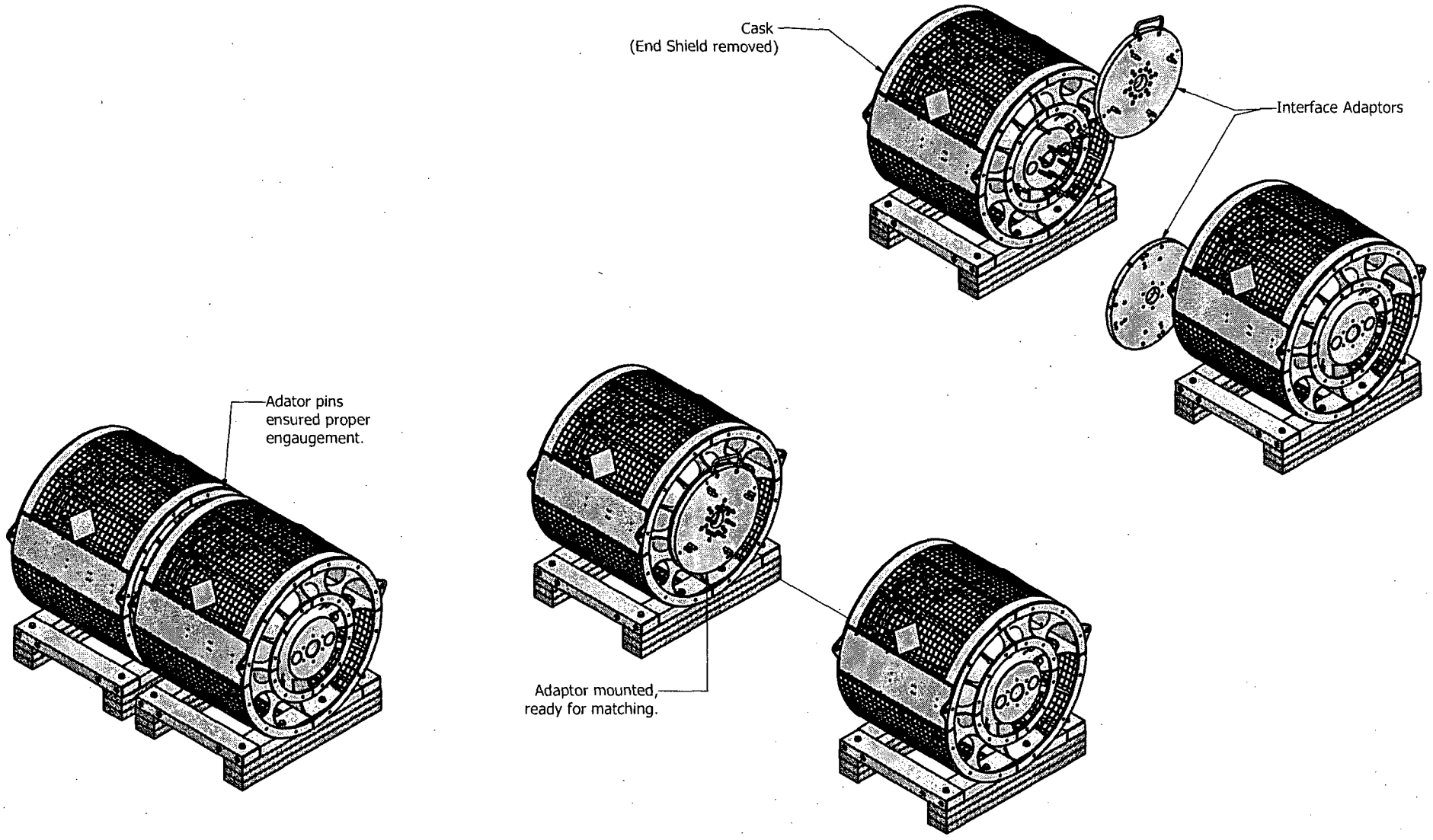
Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/04/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED ETP	28/04/2006	Model Number: 1860A Component Name: 1860A-F1-103 Component Desc: Primary Attenuator Block Drawing Desc: Part Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-103-00	SHEET 1 OF 2	REV 3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	27/04/2006	**Analogue & Digital Measurements P/L** http://admeasure.com.au				
CHECKED ETP	28/04/2006	Model Number: 1860A Component Name: 1860A-F1-103 Component Desc: Primary Attenuator Block Drawing Desc: Part Details				
QA						
MFG						
APPROVED						
		SIZE A3	SCALE N.T.S	DWG NO 1860A-F1-103-00	SHEET 2 OF 2	REV 3

File:	C:\admwork\Model1860\Drawings\Inventor\1864\Assemblies\Drawer Transfer - Cask to Cask.idw	Model / Component Rev:



WARNING: This drawing MUST NOT be used for production unless it contains a GREEN STAMP

NOTE:

Figure Withheld Under 10 CFR 2.390

DRAWN: richard	17/07/2007	**Nuclear Australia Pty. Ltd.** http://nuclearaustralia.com.au	STOCK / DATABASE REF:
ENGINEERING CHECKED		Project / Model	**1864 - Drawer Transfer Adapter**
DRAWING QA CHECK: L. GROGAN		Component Number	**1864-01-009**
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Cask Interface Plate Assembly
MANUFACTURE QA:		Drawing Description	Component Detail

SIZE	SCALE	DWG NO		REV
A3	N.T.S	1864-01-009-00	SHEET 1 OF 2	1

Figure Withheld Under 10 CFR 2.390

DRAWN: richard	17/07/2007	**Nuclear Australia Pty. Ltd.** http://nuclearaustralia.com.au	STOCK / DATABASE REF:
ENGINEERING CHECKED		Project / Model	**1864 - Drawer Transfer Adapter**
DRAWING QA CHECK: L. GROGAN		Component Number	**1864-01-009**
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Cask Interface Plate Assembly
MANUFACTURE QA:		Drawing Description	Component Detail

SIZE	SCALE	DWG NO		REV
A3	N.T.S	1864-01-009-00	SHEET 2 OF 2	1

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/09/2006	**Nuclear Australia Pty. Ltd.** http://nuclearaustralia.com.au	STOCK / DATABASE REF:
ENGINEERING CHECKED		Project / Model	**1864 - Drawer Transfer Adapter**
DRAWING QA CHECK		Component Number	**1864-01-007**
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Adapter Interface Plate Assembly
MANUFACTURE QA:		Drawing Description	Assembly Details

SIZE	SCALE	DWG NO		REV
A3	N.T.S	1864-01-007-03	SHEET 1 OF 2	3

Figure Withheld Under 10 CFR 2.390

DRAWN RT	4/09/2006	**Nuclear Australia Pty. Ltd.** http://nuclearaustralia.com.au	STOCK / DATABASE REF:
ENGINEERING CHECKED			
DRAWING QA CHECK			
TOLERANCE (UNLESS SPECIFIED)	0.2mm		
MANUFACTURE QA:			

Project / Model	**1864 - Drawer Transfer Adapter**
Component Number	**1864-01-007**
Component Description	Adapter Interface Plate Assembly
Drawing Description	Assembly Details

SIZE	SCALE	DWG NO		REV
A3	N.T.S	1864-01-007-03	SHEET 2 OF 2	3

Analogue & Digital Measurements P/L
ABN: 57 005 531 484

http://admeasure.com.au
sales@admeasure.com.au

27 Cumberland Drive
Seaford, 3198
Victoria Australia

Ph: 03 8770 6500
Fax: 03 8770 6590

A&DM – Quality Systems

Master Quality Manual

Document Identifier:

Master_Quality_Manual.odm

Location:

C:\admwork\Documents\Quality_Systems\Master_Quality_Manual\

Contributors:

Lachlan Grogan, eQuipment Safety Systems (lockie@eqss.com.au)

Kieren Grogan, eQuipment Safety Systems (kieren@eqss.com.au)

Abstract:

This is the quality systems manual for A&DM

Document Status:

Working Revision

Revision History

Revision History for this document. This section only notes major contributions by the editors. Further information may be found in VSS.

Revision	*Author*	*Notes*
1.4	LJG	Major updates.
1.3	LJG	Major additions to all facets of quality manual as per quality review. These changes include additions to supplier performance measures and updates that reflect changes in technologies used at A&DM.
1.2	LJG	Adjusted serial numbering format to suit Radiation Source Holders and Code of Practice Requirements.
1.1	LJG	Added extra detail for use of Autodesk Inventor.
1.0	LJG	Initial Revision

Table 1: Document Revision History

Control History

Controlled Document

DO NOT make copies of this document. The latest version of this document (Master_Quality_Manual) may be obtained from the following location(s):

Location	*Path*
1 - VSS	\admwork\documents\Quality_Systems
2 - Server	\\eqss-server-01\\admwork\documents\Quality_Systems
3 - Web	http://admeasure.com.au

This document has been issued to the following parties:

Issue	*Party*	*Reason*
1	ARPANSA	Model 1860 Radiation Transport Cask, Approval Submission
2		
3		
4		
5		

Table 2: Issue Control History

Documentation Conventions

The list below highlights important documentation conventions.

Text presented in this manner is intended to provide the user with some general information. The user should ensure information presented in this manner is clearly understood.

Text presented in this manner provides the user with information to assist in completion of the current procedure being explained.

Text presented in this manner indicates that further actions are required by the user.

Text presented in this manner indicates that a failure to follow directions could result in damage to equipment, loss of information, bodily harm, or loss of life.

Important Information

Information contained in this publication regarding this devices applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications.

ANALOGUE & DIGITAL MEASUREMENTS P/L MAKE NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE.

ANALOGUE & DIGITAL MEASUREMENTS P/L disclaims all liability arising from this information and its use. ANALOGUE & DIGITAL MEASUREMENTS P/L's products as critical components in life support systems is not authorized except with express written approval by ANALOGUE & DIGITAL MEASUREMENTS P/L. No licenses are conveyed, implicitly or otherwise, under any ANALOGUE & DIGITAL MEASUREMENTS P/L intellectual property rights.

Table of Contents

Quality Management System 15
Requirements 16
General 16
The Quality Policy Statement 16
Accessing the Quality Manual 18
Documentation Requirements 19
Overview 19
Requirements 19
General 19
Quality Manual 20
Document Control 21
Control Of Records 22
Quality Manual 23
Document Control 23
Document Awareness 23
Open Standard Policy 23
General Consideration 24
File Locations 25
Standard directory structure 25
Distribution Control 26
Control Mechanisms 26
Document Approvals 27
Document Approval Requirements 27
Approval Example 27
Approval Check List 28
Document Review 29
Review Procedures 29
Changes and Revision Control 30
Visual Source Safe 30
Theory 30
Connecting to a database 31
Databases 31
Setting Working Directory 31
Shadow Folders 33
Creating A Project 34
Directory Structure 36
Creating the directory structure 36
Adding A Folder 37
To add a file 39
Checking Out 42
Checking Back In 43

Version History 44
Labels 46
Label Format 46
ECN Process 47
Document Distribution 49
Document Legibility 49
External Documents 49
Obsolete Documents 50
Control of Records 51
VSS Database 51
Database Location 51
Database Folders 51
Documentation Standards 52
Introduction 52
Requirements 52
Structure Requirements 52
Document Headings 54
Captions 55
Cross References 55
Equations 55
Document Templates 56
List Of Templates 56
Indexes and Tables 57
Alphabetical Index 57
Images 57

Management Responsibility 58
Requirements 58
Management Commitment 58
Customer Focus 58
Quality Policy 59
Planning Quality Objectives 59
Quality Management System Planning 59
Responsibility & Authority 60
Management Representative 60
Internal Communication 60
Management Review Requirements 61
General 61
Review Input 61
Review Output 62
Management Commitment 63
Introduction 63
QMS Development & Implementation 64
Quality Policy Establishment 64

Management Reviews 64
Resource Availability 65
Customer Focus 66
Privacy Policy 66
Collection and Storage – Personal Information 66
Customer Satisfaction 66
Responsibility, Authority and Communication 67
Introduction 67
Management Representative 67
QMS General 67
Reporting 68
QMS Awareness 68
Management Review 68
General 68
Review Input 68
Review Output 69

Resource Management 70
Requirements 70
Provision Of Resources 70
Human Resources 70
Competence, Awareness & Training 71
Company Structure & Authority 72
Organizational Information 72
Responsibility 72
Authority 73
Structure 74
Position Descriptions 75
Ted Parrott – Managing Director 75
CHARACTERISTICS OF POSITION 75
Key Responsibilities 75
Skills 76
Decision Making Authority 76
Lachlan Grogan – R&D Manager 77
CHARACTERISTICS OF POSITION 77
Key Responsibilities 77
Key Relationships 77
Decision Making Authority 77
Problem Solving Responsibilities 78
MINIMUM COMPETENCIES REQUIRED 78
Experience 78
Skills 78
Education 78
Kieren Grogan – Nuclear Systems Engineer 79

Characteristics Of Position 79
Key Responsibilities 79
eQSS 79
Key Relationships 80
Decision Making Authority 80
Problem Solving Responsibilities 80
Skills 80
Education 80
Bill Flatman – Sales and Marketing 81
CHARACTERISTICS OF POSITION 81
Key Responsibilities 81
Key Relationships 82
Decision Making Authority 82
Problem Solving Responsibilities 83
MINIMUM COMPETENCIES REQUIRED 83
Experience 83
Skills 83
Andrew Dowell – Digital Hardware Engineer 84
CHARACTERISTICS OF POSITION 84
Key Responsibilities 84
Key Relationships 85
Decision Making Authority 85
Problem Solving Responsibilities 85
MINIMUM COMPETENCIES REQUIRED 85
Experience 85
Skills 85
Ulf Leonhard – Nuclear 86
CHARACTERISTICS OF POSITION 86
Key Responsibilities 86
Key Relationships 87
Decision Making Authority 87
Problem Solving Responsibilities 87
MINIMUM COMPETENCIES REQUIRED 87
Experience 87
Skills 87
Jodi Sharkey – Office Management 88
CHARACTERISTICS OF POSITION 88
Key Responsibilities 88
Key Relationships 89
Decision Making Authority 89
Problem Solving Responsibilities 89
MINIMUM COMPETENCIES REQUIRED 90
Experience 90
Skills 90

Richard Teh – Mechanical Engineer 91
CHARACTERISTICS OF POSITION 91
Key Responsibilities 91
Decision Making Authority 91
Skills 91
Education 91
Andrew Donegan – Software Engineer 92
Key Responsibilities 92
Key Relationships 93
Decision Making Authority 93
Problem Solving Responsibilities 93
MINIMUM COMPETENCIES REQUIRED 93
Experience 93
Skills 93
Minimum Job Qualifications 94

Product Realization 95
Introduction 95
Requirements 95
Product Planning 96
Planning 96
Introduction 97
Project Life Cycle 97
CS 97
DFR 97
CR 98
DR 98
MR 98
SR 99
FCS 99
Discontinuance and Obsolescence 99
Model Number Allocation 100
Company Categories 100
Series Numbers 100
Model Numbers 101
Serial Numbers 102
Format 102
Model Number 102
Date Code 102
Sequence Number 102
Example 102
Serial Number Spreadsheet 103
Special Cases 104
Terminology 105

Product Number Allocation 105
Configuration And Revision Identifier 106
Assembly & Component Numbering 107
Logging Spreadsheet 107
Drawing Numbering 107
Autodesk® Inventor™ Specific Requirements 108
Document Storage 108
Suggested Directory Structure 108
Example Storage System (Simple Product) 109
Example Storage System (Advanced Product) 110
Customer Processes 111
Requirements 111
Determination of Customer Requirements 111
Review of Customer Requirements 111
Customer Communication 111
Design and Development 112
Requirements 112
Design & Development Planning 112
Design & Development Inputs 113
Design & Development Outputs 113
Design & Development Review 114
Design & Development Verification 114
Design & Development Validation 115
Control of Design & Development Changes 115
Development Planning 116
Document Storage 116
Project Planning 116
Project Task Websites 116
Development Inputs 117
Further Inputs 117
Qualitative Acceptance 117
Development Outputs 118
Revision Control 118
Autodesk® Inventor™ Specific Outputs 118
Drawing Layout 118
Drawing Requirements 118
Drawing Specifics 119
Development Review 121
Review Frequency 121
Review Outputs 121
Development Verification 122
Approval of Drawings 122
Control of Development Changes 123
Purchasing 124

Requirements 124
Purchasing Process Requirements 124
Purchasing Information 125
Verification Of Purchased Product 125
Supplier Selection Criteria 126
Performance Records 126
Purchasing Process 127
Material Purchase 127
Step 1 – Material Description 127
Example 128
Step 2 – Purchase Order 129
Step 3 – Storage Of Records 130
Verification of Purchased Product 131
Verification Records 131
Verification Of Materials 132
Identification 132
Internal Part Number Allocation 133
Part Number Database 133
Access The Database 133
Add a Part 134
Find a Part 134
Delete a Part 134
Number Format 135
Example 135
Component Categories 136
Materials 136
Assemblies and Bill Of Materials 137
Add an Assembly 137
Find an Assembly 137
Bill Of Materials 137
Add Item 138
Add Part 138
Add Sub-Assembly 138
Modify Quantity 138
Remove Item 138
Save As CSV 138
Setting Windows File Associations 140
Circular Reference Error 141
Production And Service 143
Requirements 143
Control of Production and Service Provision 143
Validation of Processes for Production and Service provision 144
Identification and Traceability 144
Customer Property 145

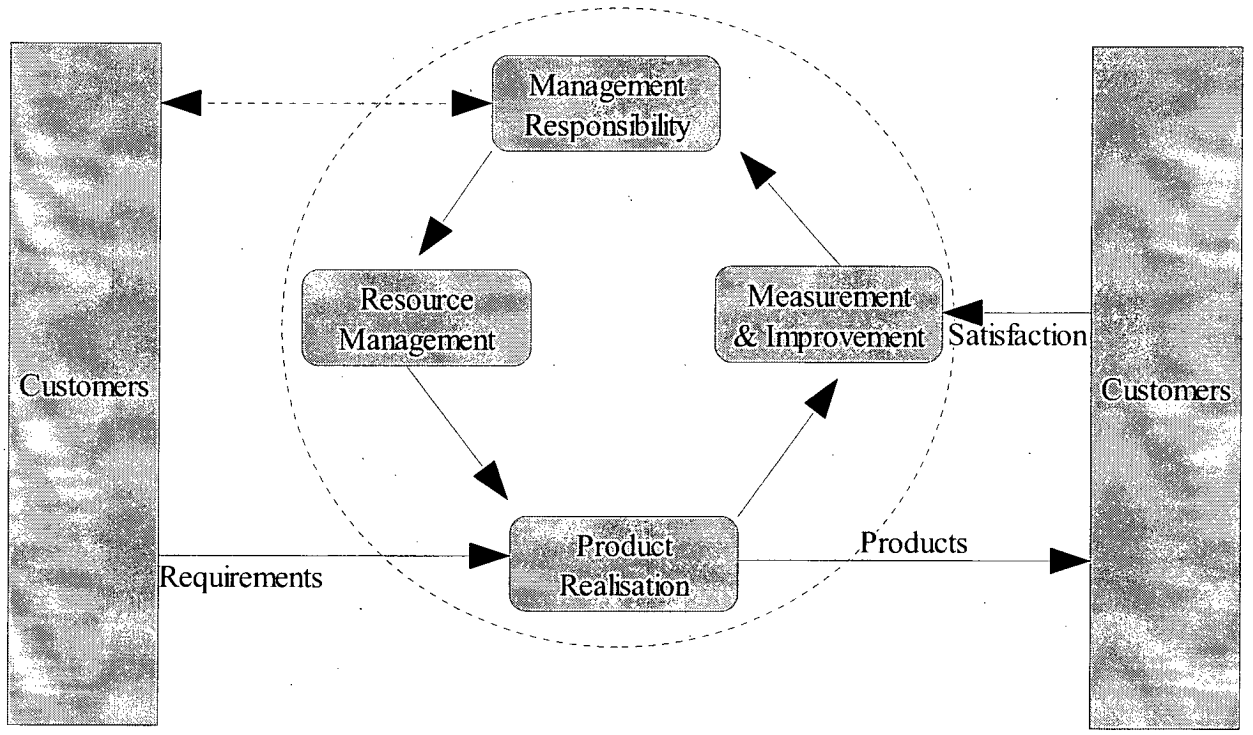
Preservation of Product 145
Control of Monitoring and Measuring Devices 147
Quality Assurance Inspection, Component Failure 148
Realization of Component Failure 148
Course of Action 148
QA Component Failure Certificate 149
Customer Property 150
Preservation Of Product 151
Materials 151
Service Testing 152
Measuring Devices 153
Requirements 153
Control of Monitoring and Measuring Devices 153

Measurement, Analysis and Improvement 154
Requirements 154
General 154
Monitoring and Measurement 155
Internal Audit 155
Monitoring and Measurements 156
Customer Satisfaction 156
Internal Audits 156
Basic Procedures 156
Monitoring and Measurement of Processes 157
Monitoring and Measurement of Product 158
Improvement 159
Continual Improvement 159
Corrective Action 159
Hardware Failures 159
Software Failures 160
Documentation Deficiencies 160
Preventative Action 160
Management Of Non-Conformities 161

Indexes 162

Quality Management System

This adoption and development of this quality management system has been a strategic decision by Analogue & Digital Measurements Pty. Ltd. ("A&DM"). The design and implementation of this Quality Management System ("QMS") has been influenced by a large array of needs, objectives products and processes.



Text 1: Quality management System Overview

Requirements

General[1]

Item	*Requirement*
1.	The organization shall establish, document, implement and maintain a quality management system and continually improve its effectiveness in accordance with the requirements of this document.
2.	The organization shall 1. identify the processes needed for the quality management system and their application throughout the organization 2. determine the sequence and interaction of these processes, 3. determine criteria and methods needed to ensure that both the operation and control of these processes are effective, 4. ensure the availability of resources and information necessary to support the operation and monitoring of these processes, 5. monitor, measure and analyse these processes, and 6. implement actions necessary to achieve planned results and continual improvement of these processes.
3.	These processes shall be managed by the organization in accordance with the requirements of this document.
4.	Where an organization chooses to outsource any process that affects product conformity with requirements, the organization shall ensure control over such processes. Control of such outsourced processes shall be identified within the quality management system. NOTE Processes needed for the quality management system referred to above should include processes for management activities, provision of resources, product realization and measurement.

Table 3: QMS - General Requirements

The Quality Policy Statement

The purpose of this quality policy statement is to define the intentions and direction of the quality management system. It demonstrates A&DM's commitment to quality with clear leadership by top management.

All employees are stake holders in the companies success, and as such are empowered and committed to delivering flawless products and technology. Everyone

1 Referenced Directly From AS9001:2000

who works with us is expected to ensure ownership for quality.

To provide the highest quality products and services to its customers A&DM commits to.

1. Meet all customer's requirements; applicable regulatory, statutory and contractual requirements; and relevant national / international standards.
2. Evaluate and continually improve the effectiveness of its services
3. Ensure that this quality policy is communicated and understood by all employees.
4. Provide a process for establishment, review and modification of quality objectives
5. Review and modify this policy, regularly, for continued suitability.

Accessing the Quality Manual

The quality manual can be accessed by all staff members and outside contractors in several ways.

Item	*Access Method*
1.	Direct access to the latest addition of the quality manual in PDF format: \\eqss-server-02\admwork\quality_systems\master_quality_manual\master_quality_manual.pdf
2.	Access from the companies internal web site http://companyweb/ Announcements QUALITY SYSTEMS 5/30/2006 8:29 AM by Lachlan Grogan ADM QUALITY MANUAL An updated copy of the quality systems manual may be found in: \\eqss-server-02 \admwork\documents\quality_systems\master_quality_manual\master_quality_manual.pdf *Illustration 1: Web Site Image*
3.	Via our web site (Please note you will be required to contact lockie@eqss.com.au to obtain access) http://admeasure.com.au/

Documentation Requirements

Overview

The quality manual and any documents covered by the A&DM Quality System (See General Consideration on Page 24), are required to conform to the documentation requirements covered in this section.

Requirements

These requirements have been referenced from AS9001:2000.

General[2]

Item	*Requirement*
1.	The quality management system documentation shall include 1. Documented statements of a quality policy and quality objectives, 2. A quality manual, 3. Documented procedures required by AS9001:2000 4. Documents needed by the organization to ensure the effective planning, operation and control of its processes 5. Records required by this International Standard (See Table 4: General Requirements Item 1 on page 22).
2.	Where the term "documented procedure" appears within this Quality Manual, this means that the procedure is established, documented, implemented and maintained
3.	The extent of the quality management system documentation can differ from one organization to another due to 1. the size of organization and type of activities, 2. the complexity of processes and their interactions, and 3. the competence of personnel.
4.	The documentation can be in any form or type of medium.

Table 4: General Requirements

2 Referenced directly from AS9001:2000

Quality Manual[3]

Item	*Requirement*
1.	The organization shall establish and maintain a quality manual that includes the scope of the quality management system, including details of and justification for any exclusions.
2.	The organization shall establish and maintain a quality manual that includes the documented procedures established for the quality management system, or reference to them.
3.	The organization shall establish and maintain a quality manual that includes a description of the interaction between the processes of the quality management system.

Table 5: Quality Manual Requirements

3 Referenced Directly From AS9001:2000

Document Control[4]

Please see Document Control on page 23

Item	*Requirement*
1.	Documents required by the quality management system shall be controlled. (See Document Control on Page 23)
2.	Records are a special type of document and shall be controlled according to the requirements given in Table 4: General Requirements, on Page 19
3.	A documented procedure shall be established to define the controls needed 1. to approve documents for adequacy prior to issue, (See Document Approvals on Page 27) 2. to review and update as necessary and re-approve documents, (See Document Review on Page 29) 3. to ensure that changes and the current revision status of documents are identified, (See Changes and Revision Control on Page 30) 4. to ensure that relevant versions of applicable documents are available at points of use, 5. to ensure that documents remain legible and readily identifiable, 6. to ensure that documents of external origin are identified and their distribution controlled, and 7. to prevent the unintended use of obsolete documents, and to apply suitable identification to them if they are retained for any purpose

Table 6: Control Of Documents - Requirements

4 Referenced Directly From AS9001:2000

Control Of Records[5]

Item	*Requirement*
1.	Records shall be established and maintained to provide evidence of conformity to requirements and of the effective operation of the quality management system.
2.	Records shall remain legible, readily identifiable and retrievable.
3.	A documented procedure shall be established to define the controls needed for the identification, storage, protection, retrieval, retention time and disposition of records.

Table 7: Control Of Records - Requirements

5 Referenced Directly From AS9001:2000

Quality Manual

This document forms the quality manual for Analogue and Digital Measurements.

Document Control

This section details how A&DM handles document control.

Document Awareness

The quality officer is responsible for ensuring that communication is maintained between parties to ensure that all parties are aware when a controlled document changes. All staff members are also mode aware of how to check if they have the latest revision of a document before commencing any work.

Open Standard Policy

Where practical all documents will be stored in an open standard document type. A&DM relies on the OASIS (www.oasis-open.org). Where practical if an open format application exists it will be used in place of a proprietary format application.

A&DM makes extensive use of the OpenOffice.org suite of applications which support the OASIS XML file format allowing interoperability between almost any office application.

General Consideration

Consideration must be placed when deciding the type of document being developed and if it will need to meet the requirements of the A&DM Quality System. In general any document which forms part of a final product must meet the control requirements for documentation.

To assist the rapid development and compliance with this required of AS9001:2000 many templates have been developed and are available to assist in this process.

All documents and files used in a project must be stored appropriately. The following document types are examples of what will be applicable to this quality system.

Item	*Type*
1.	Mechanical Drawings 1. Autodesk Inventor™ 2. Autodesk AutoCAD™
2.	Electronic Design 1. Altium Designer™
3.	Firmware 1. C/C++ Source Code 2. VHDL (Including Test Scripts) 3. Assembly Language
4.	Documentation 1. Specifications 2. User Manuals 3. Factory Manuals 4. Quality Assurance Related Documents 5. Product Brochures, Data sheets, Etc. 6. Engineering Change Notifications (ECN's) 7. Project Management
5.	Public Electronic Information 1. Web Sites(s) 2. Marketing 3. Flyers & Brochures

Table 8: General Considerations - Document Types

File Locations

The storage of our electronic data during project development is of utmost importance to the management of any project. As a result a standard folder name conventions will be adhered to.

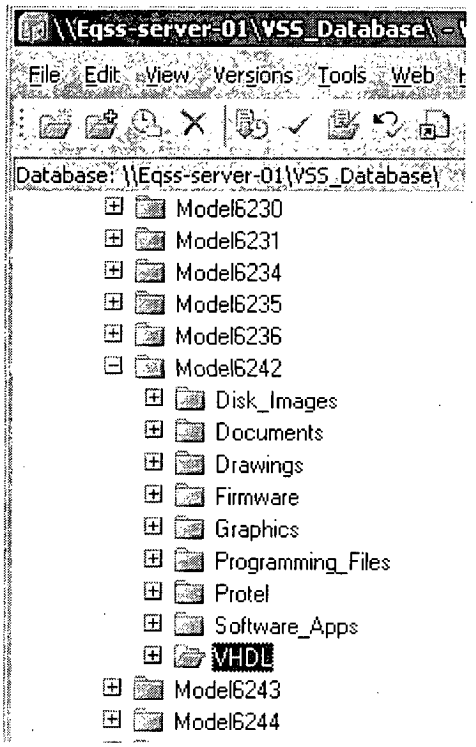


Illustration 2: Standard Directory Structure

Visual Source Safe ("VSS") will contain a standard directory structure for each project and this will be mirrored on the server. It is up to the individuals with some guidance from this document to decide if their files should be placed in version control. See Visual Source Safe on Page 30 for more information about VSS.

Standard directory structure

The standard directory structure will allow everyone to become familiar with the locations of particular documents, and so in the future it will be easy to go back to a previous project and quickly find the relevant documents. The directory structure must be explicit enough to ensure that there is only one logical place to store a particular document, whilst not over policing and therefore confusing the structure.

Distribution Control

The control of distribution of documents ensures that all parties have the correct and up to date information for the task they are completing. As a result a heavy emphasis is placed on ensuring that documents are stored in electronic format and that the electronic copies are controlled for:

Item	*Requirement*
1.	Unauthorised Access
2.	Unauthorised Modifications
3.	Incorrect Revision Information.

Table 9: Distribution Control - Requirements

Control Mechanisms

Visual Source Safe (See: Visual Source Safe on page 30) will be used as the control mechanism. It can control each user's rights, as well as global project rights.

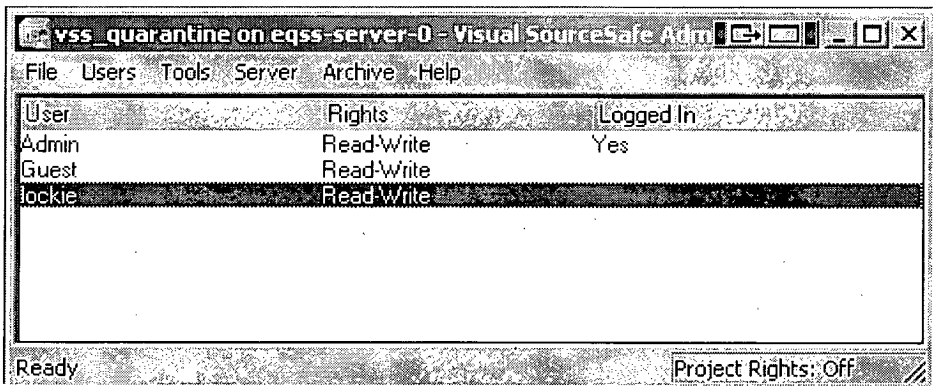


Illustration 3: Visual Source Safe Administration

Document Approvals

All documents that are used in the production, sale or replication of any product will require approval by an appropriately qualified person (such as the QA Officer) prior to release.

A list of these document types may be found in Table 8: General Considerations - Document Types on page 24.

Document Approval Requirements

Each document must carry an approval mark stating that the document has been approved for release. The approval mark can is to contain the following information:

Item	*Requirement*
1	QA Mark (i.e. "QA Approved")
2	Name of Authorised Person
3	Date of Authorisation

Table 10: Document Approval Requirements

Approval Example

An example of an approval mark on a PDF file is shown below.

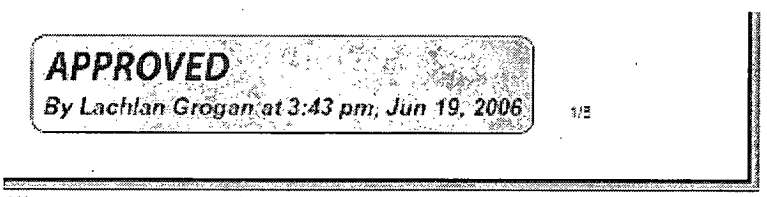


Illustration 4: Example Approval Mark

Approval Check List

The following items should be checked prior to submitting a document to the QA Officer for final checking.

Item	*Requirement*
1.	The document is in electronic format.
2.	The document is stored in Visual Source Safe if it meets the requirements as set out in Table 5: Quality Manual Requirements on Page 20
3.	The document's accessibility is controlled to prevent unauthorised changes.
4.	The document is complete and is accurate
5.	The document meets the documentation standards as set out in the section Documentation Standards on Page 52

Table 11: Approval Check List

Document Review

It is policy that any document required by this quality system be reviewed for its accuracy and completeness. Table 5: Quality Manual Requirements On Page 20, lists the types of documents that are applicable to review.

Review Procedures

A&DM will review its documents on a per use basis. Changes to documents are made as a result of many factors and as such documents must be reviewed before they are used.

Changes and Revision Control

Visual Source Safe

Visual Source Safe ("VSS") is a revision control system running on our servers. VSS consists of a database stored on the server, a shadow folder stored on the server and a client application run on your local computer.

Theory

VSS is like a huge library containing all of your files. They are stored on the server and each file, as it is changed is given a new version number. When you wish to edit a file you will need to "check out" the file from VSS. This process is similar to borrowing a book from a library. Once you have the file on your local computer it is yours and no-one else can edit it, but everyone can view it. Once you are finished making changes you can check the file back in (return the book) and VSS automatically catalogues it and gives it a new version number.

As projects are completed the entire project can be labelled (example "Revision1").

Example:

Lets just say a project was complete and went to manufacture, 100 units were produced, and the project was labelled "Revision1" in VSS. Through field testing we need to make some changes to a auto cad drawing. The engineer responsible would check the CAD drawing out of VSS to their local machine, make the necessary changes and check it back in. As a result some documentation was updated and checked back in also. The project manager could then label the entire project "Revision2" as the necessary components were manufactured and the product sold. In 6 month time a customer rings up and asks for a user manual for Revision1. Using VSS we can find the user manual (even though it was changed in revision 2) and get a copy of the manual as at revision 1, this can then be sent to the customer without any fear of damaging the revision 2 manual.

Connecting to a database

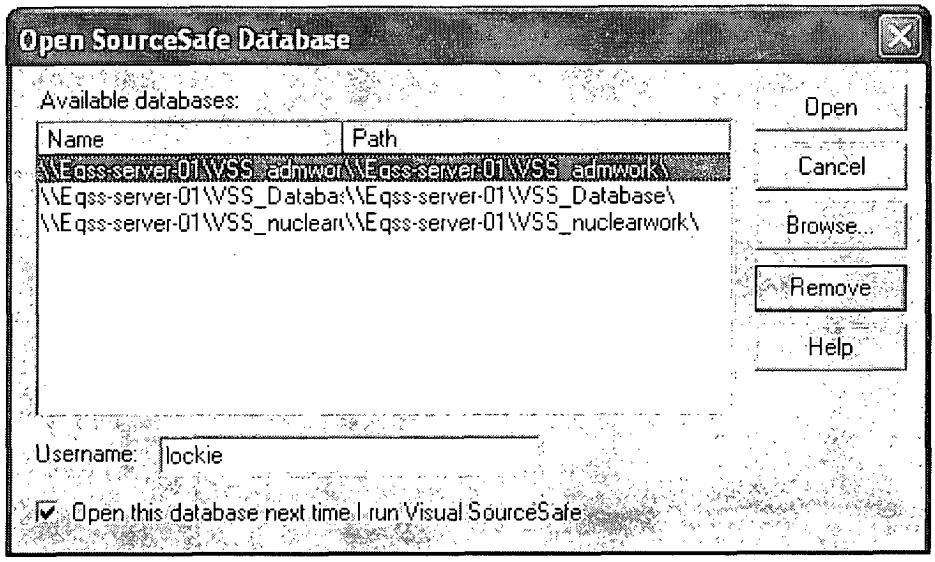


Illustration 5: Connecting to VSS Database

As a user you will need to connect to a database which is located on the server. Depending on what involvement you have in a project may depend on what rights you have to change information within a project. You can only have one database open at a time.

From the file menu in VSS choose "Open".

You might need to browse to the server to find the srcsafe.ini file located in a source safe database. (See Below)

Databases

There are 3 databases in existence, you should connect to a database dependant on what project you are currently working on

Company Category	*Database Path*
EQSS	\\eqss-server-01\VSS_Database\
ADM	\\eqss-server-01\VSS_admwork\
NS	\\eqss-server-01\VSS_nuclearwork\

Table 12: VSS Databases

Setting Working Directory

It is very important to ensure that your working directory is always set correctly.

You should only need to do this once for each database. When your using VSS, the copies of the work your editing are stored on your local machine. Example:

Database	*Local Path*
EQSS	C:\eqsswork\
ADM	C:\admwork\
NS	C:\nuclearwork\

Table 13: VSS Working Directories

And as such you will need to ensure that the root directory of a project ($/) is set to the correct directory. You will only ever need to do this once.

For Example in the ADM Database:

Illustration 6: Set Working Directory - Step 1

Select The ($/) folder from the top of the tree and right click with your mouse.

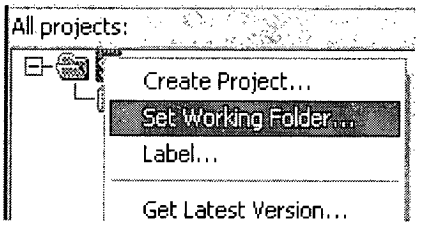


Illustration 7: Set Working Directory - Step 2

The select "Set Working Folder"

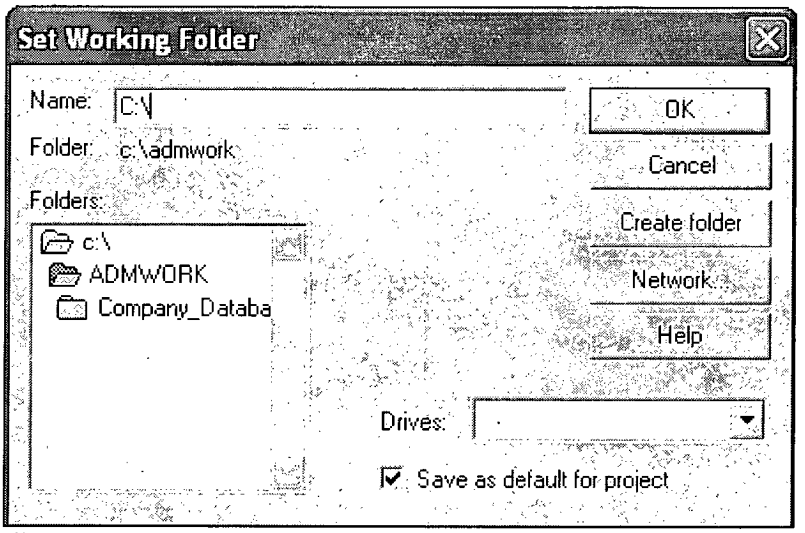


Illustration 8: Set Working Directory - Step 3

Enter C:\

Press OK to continue.

Your working folder is now set, you should not need to do this ever again for this database.

Shadow Folders

As files are checked in to VSS, the files are made read-only and shadowed on our server.

Category	*Shadow Folder*
EQSS	\\eqss-server-02\eqsswork\
ADM	\\eqss-server-02\admwork\
NS	\\eqss-server-02\nuclearwork\

Table 14: VSS Shadow Folders

This ensures that all project information is available to everyone in the company at any time, even if they are not a user of VSS. All information in the shadow folders is read only and MUST NOT be changed.

Creating A Project

Under the root directory of a VSS database ($/) are a list of the projects.

Example of the eQSS Database:

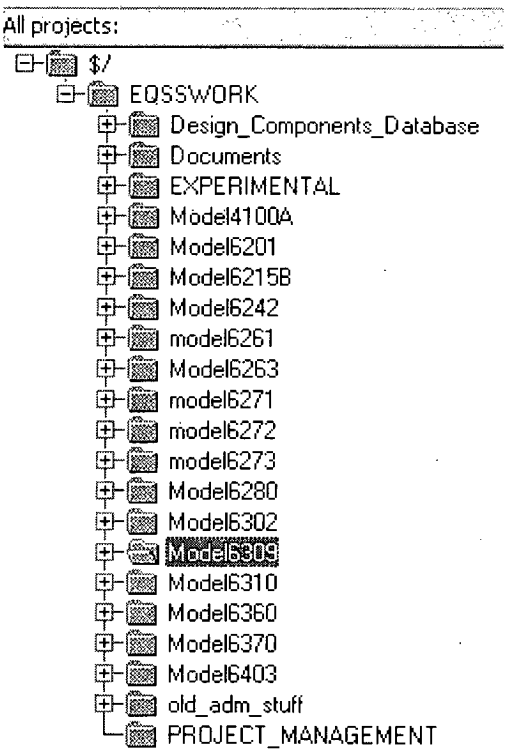


Illustration 9: Create Project - Step 1

Please note the folder structure.

To create a project of your own:

(I will use the ADM database to demonstrate)

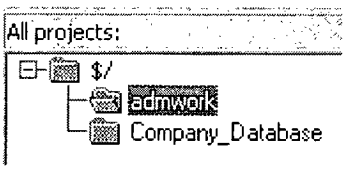


Illustration 10: Create Project - Step 2

Select the ADM Work Database from ($/)

Right Click on "admwork" and select Create Project

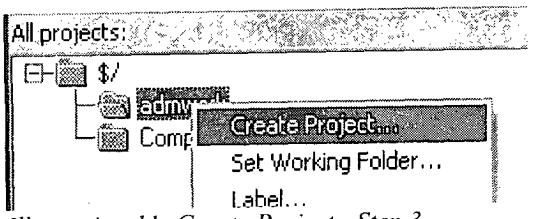


Illustration 11: Create Project - Step 3

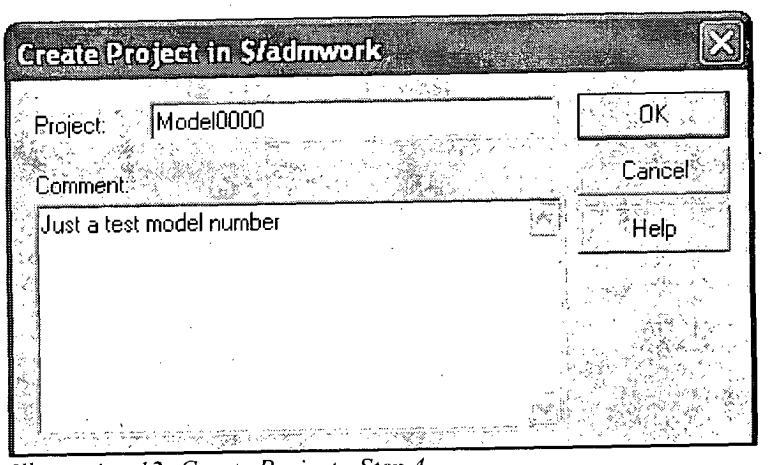


Illustration 12: Create Project - Step 4

In the dialogue box, type in your project name, and a comment for the project. Then select "OK".

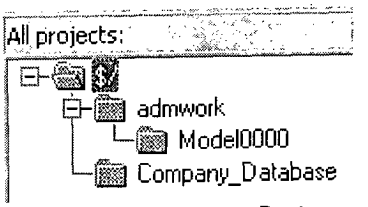


Illustration 13: Create Project - Step 5

You will then see the new model number project created under ADM work.

Directory Structure

In keeping with standards each project will have a standard directory structure, this may vary slightly between projects.

A Project should contain the following directories

Name	*Description*
Documents	All documents, stored in appropriate folders related to the project
Drawings	All auto cad, or inventor drawings, scans of hand drawings, etc.
Graphics	All graphics, including photographs, line drawings, mock images, etc.
Protel	Altium Designer (Protel) projects
VHDL	VHDL files and test benches
Firmware	Firmware source files
Experiments	Experimental data, test applications, etc.

Table 15: VSS - Example Directory Structure

Please note that all directories should start with a capital letter, and should NEVER contain any spaces. If you need to use a space, please insert an "_" underscore.

Creating the directory structure

The easiest way to create a directory structure under a project is to follow the same procedure to create a project:

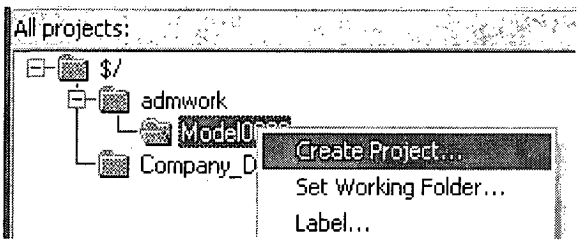


Illustration 14: Create Directory - Step 1

Select the project you wish use, right click and select "Create Project" For this example I am going to create the Documents directory

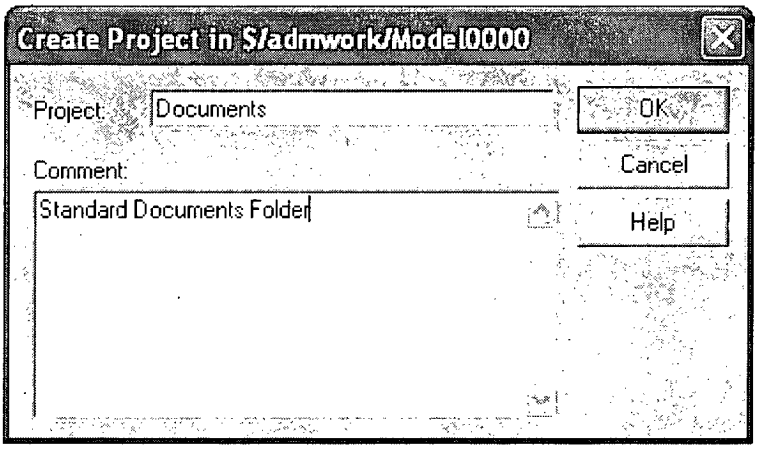


Illustration 15: Create Directory - Step 2

Enter the name of your Project ("Documents") and a brief description. Press OK

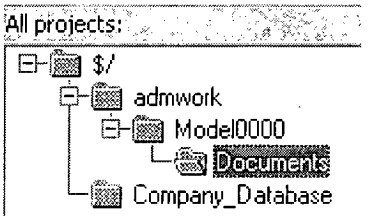


Illustration 16: Create Directory - Step 3

You will then see the documents folder appear in the project.

Adding A Folder

So you've got this far and have created a documents folder in the VSS database. But how do you get the folder on your computer so as you can add files to it. The easiest way is to use "Get Latest Version". Only do this if you have just created a project or directory and no files exist.

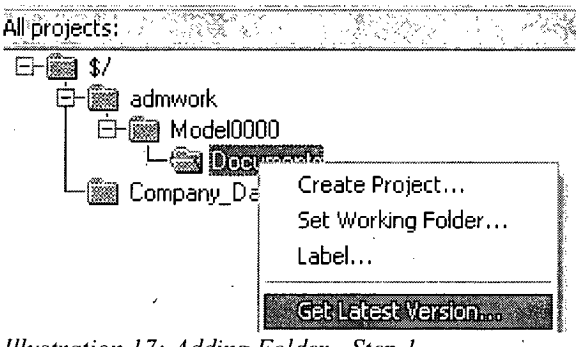


Illustration 17: Adding Folder - Step 1

Browse to the folder you've just created and select "Get Latest Version".

Always ensure that "Recursive" check box is checked, and select OK. You will not need to fill in any other information.

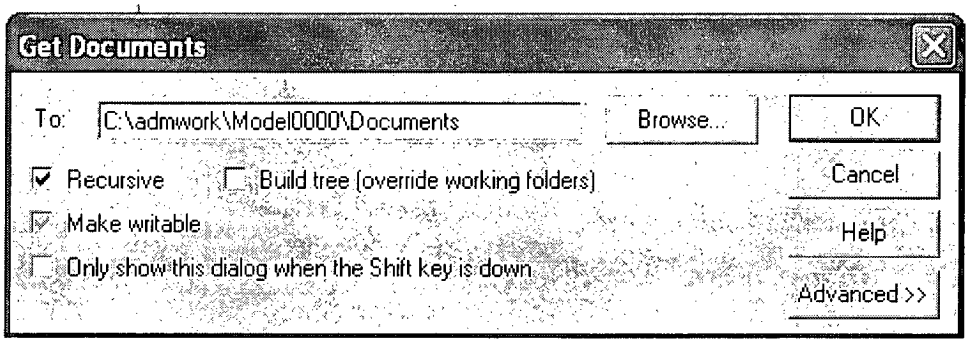


Illustration 18: Adding Folder - Step 2

You will then be prompted with a dialogue box to create the folder. If the folder name or path is incorrect, call for assistance immediately. It should say "C:\...." and never "\\eqss-server-01\..."

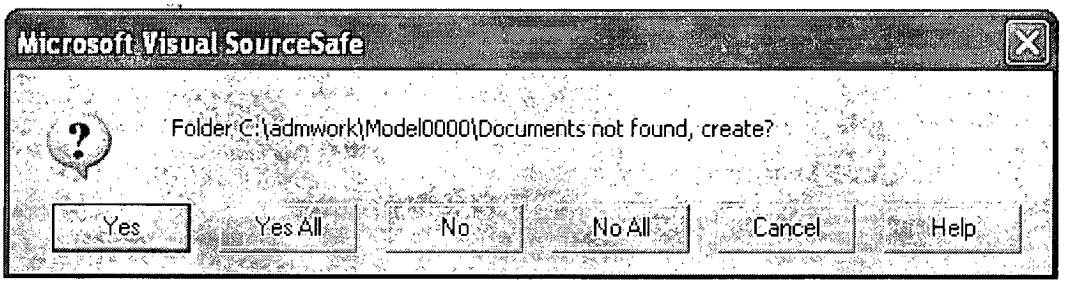


Illustration 19: Adding Folder - Step 3

Press Yes to create the folder on your computer.

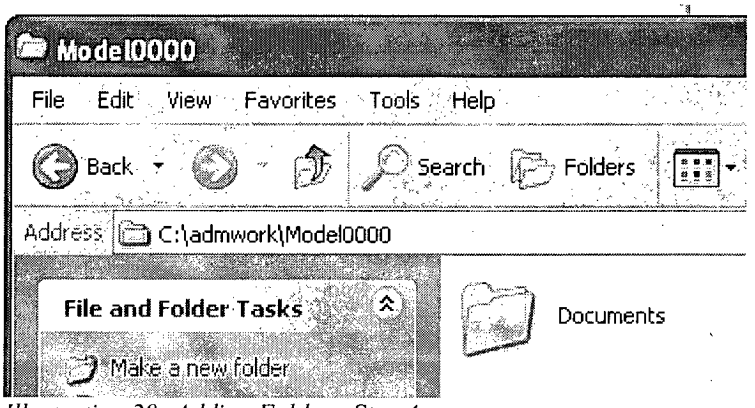


Illustration 20: Adding Folder - Step 4

Using windows explorer you can verify that the folder was created correctly.

To add a file

Suppose I have a text document called example.txt and I create / place the file in the documents folder:

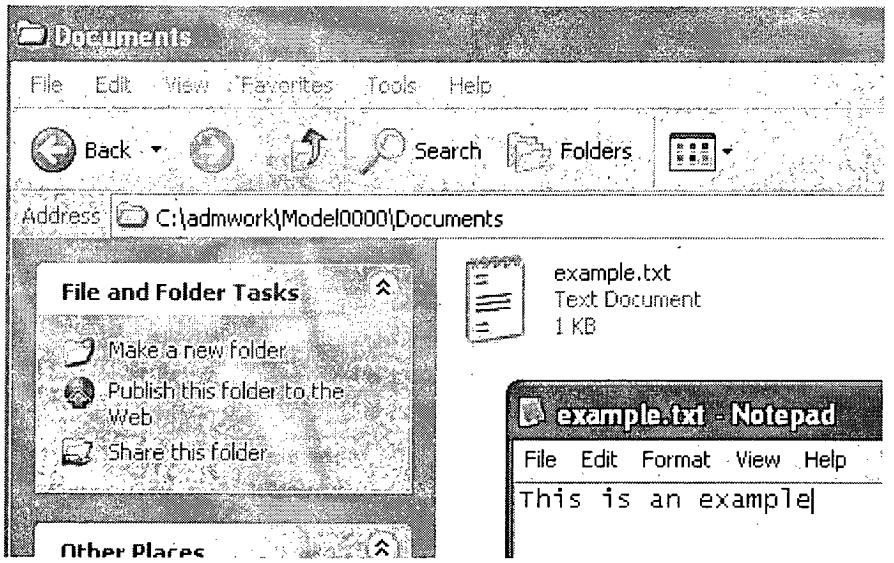


Illustration 21: Add File - Step 1

The file contains some text. "This is an example"

Now to add the file to VSS:

Make sure the file is closed, and you are not currently editing it.

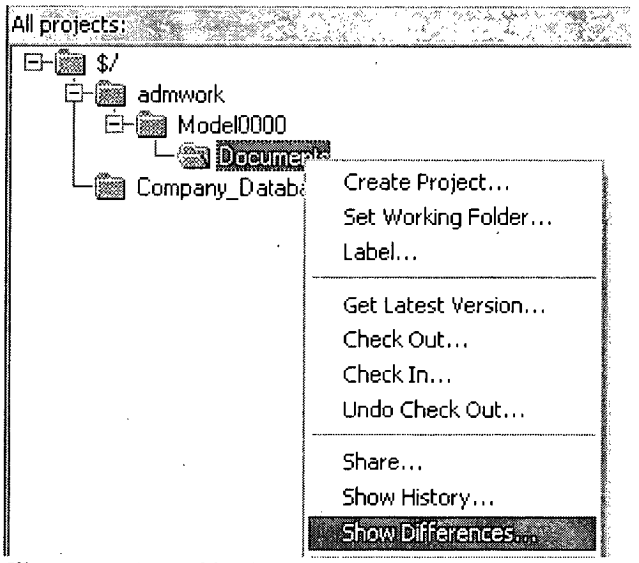


Illustration 22: Add File - Step 2

Right click on the documents folder in VSS and select, “Show Differences”

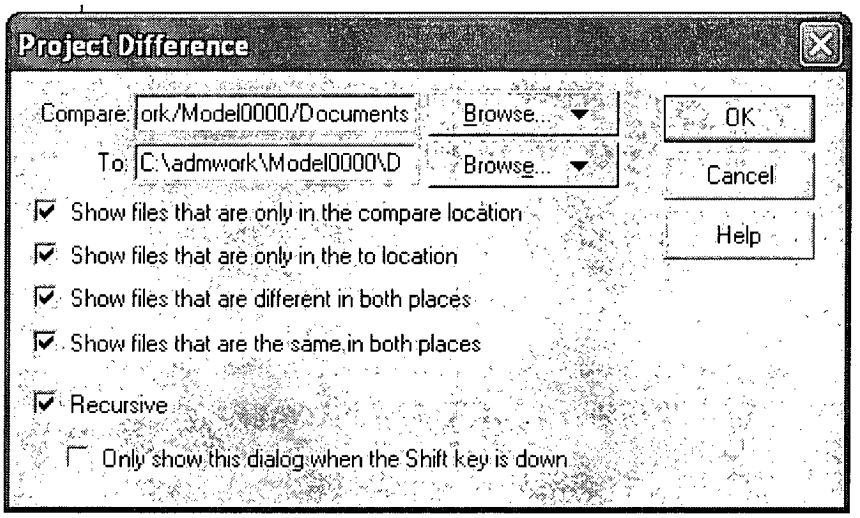


Illustration 23: Add File - Step 3

Ensure that the “Recursive” check box is ticked and select OK.

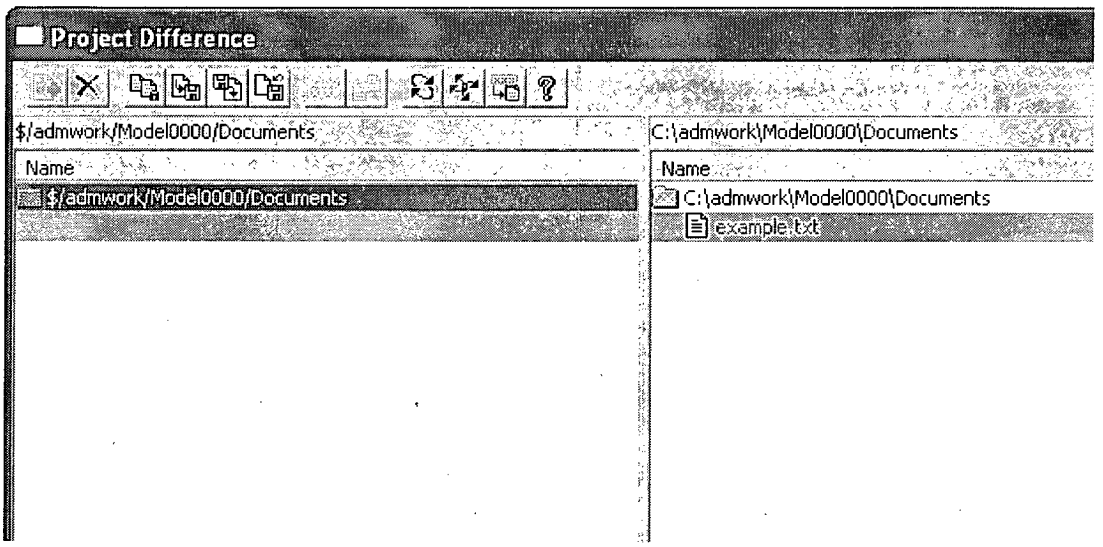


Illustration 24: Add File - Step 4

You will be presented with a dialogue box. The items that appear on the right hand side and are highlighted in green are not in VSS.

Right click on the file you wish to add and select "Add Files"

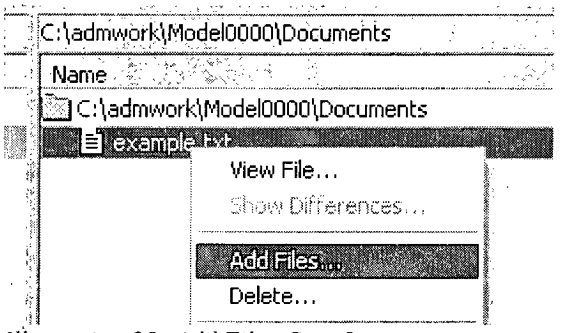


Illustration 25: Add File - Step 5

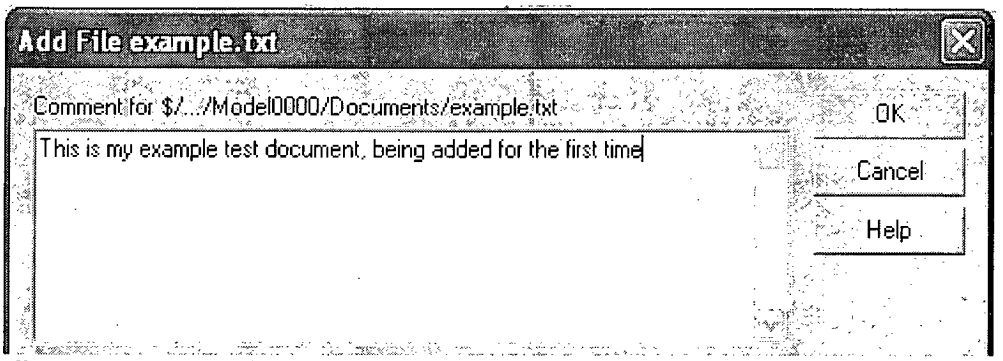


Illustration 26: Add File - Step 6

You will need to add a comment to the file, every file should have a comment.

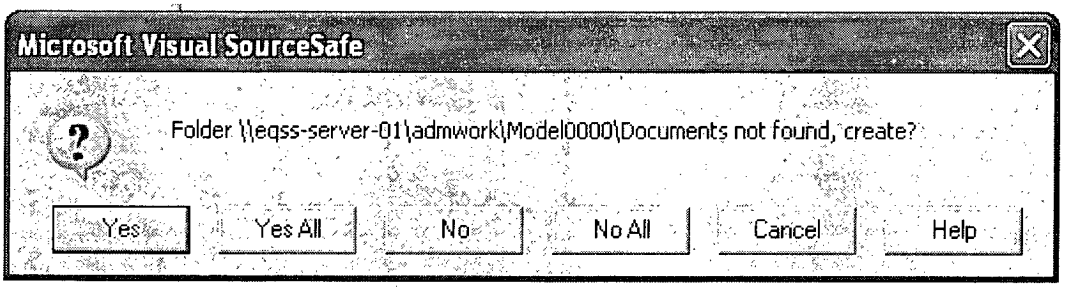


Illustration 27: Add File - Step 7

You will most likely be presented with another dialogue box. This is for the shadow copy of the database on the server.

Select YES.

Close the “Project Difference” dialogue.

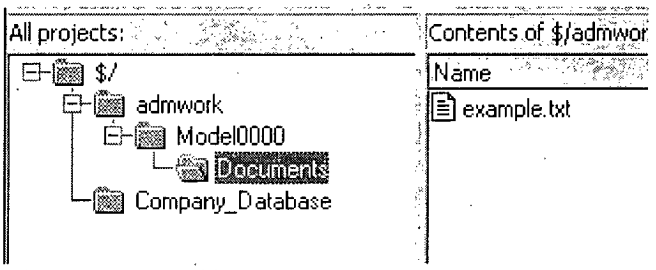


Illustration 28: Add File - Step 8

In the documents folder in VSS you will see the example text file.

Checking Out

You've just added your document to the document folder in the project you've created in VSS. You would like to make a change to the document. Currently because you have the file checked in, it is read-only on your computer and you can not edit it.

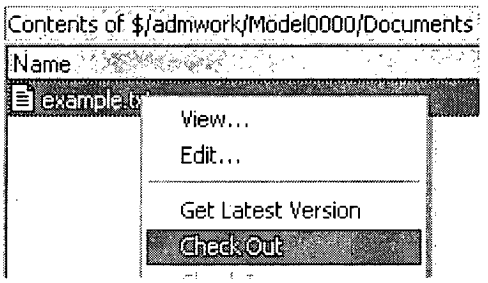


Illustration 29: Check Out - Step 1

Select the file, right click and then select “Check Out”

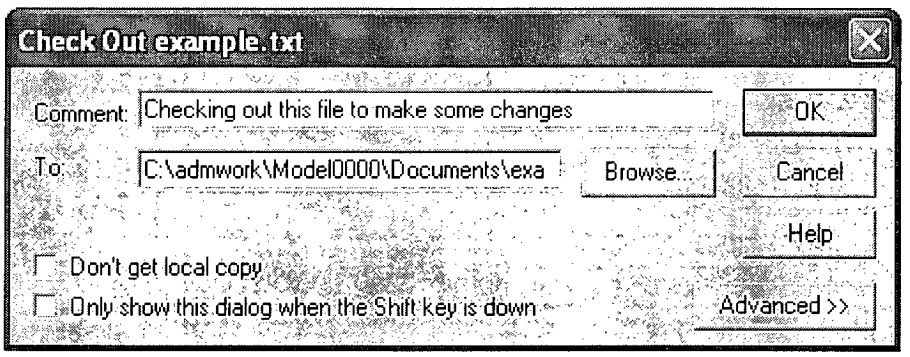


Illustration 30: Check Out - Step 2

You may add a comment if you wish and then select OK.

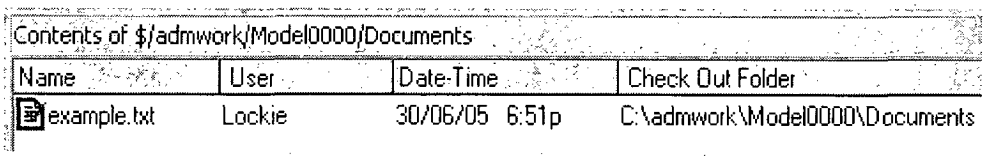


Illustration 31: Check Out - Step 3

You will then see the document has changed to red, the user of the document is "lockie" and it is checked out to a folder on my local machine. I am now free to edit the file, and no-one else can edit the file as it is read-only on their machines.

Checking Back In

I have just edited the file using my favourite editor. The file now looks like:

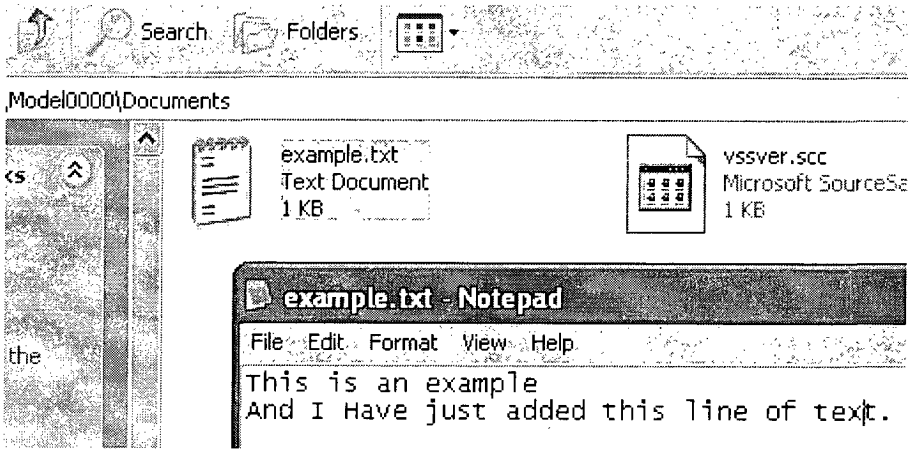


Illustration 32: Check In - Step 1

I have finished editing the file and I wish to check the file back in, so it can become part of the project. I may never need to edit the file again.

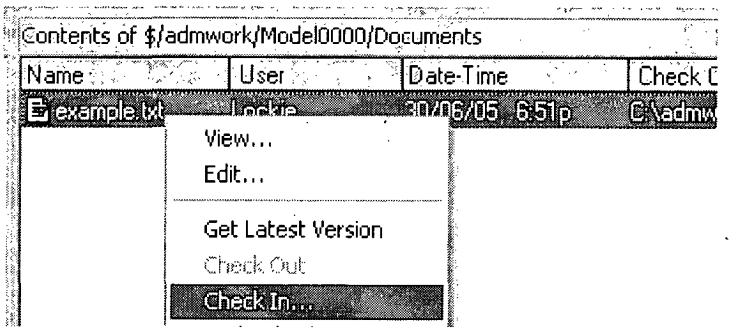


Illustration 33: Check In - Step 2

Select the file, right click and select “Check In”

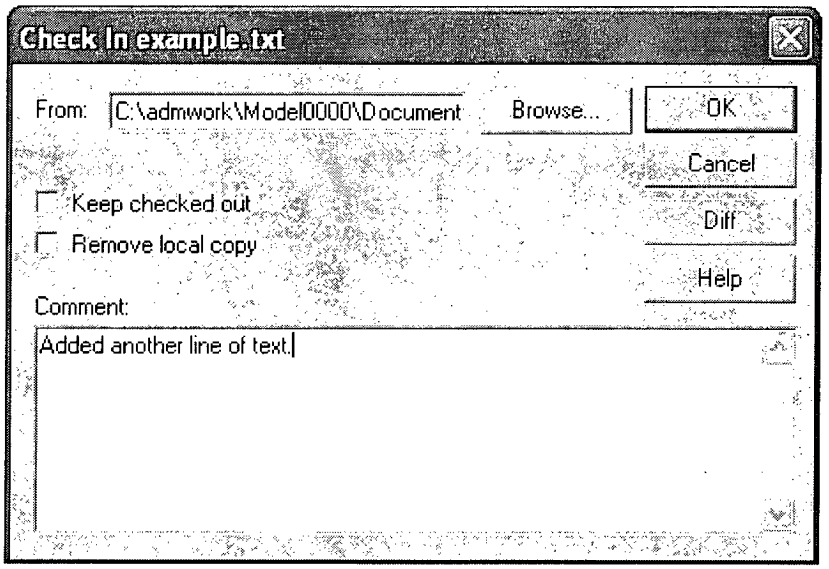


Illustration 34: Check In - Step 3

You must add a comment stating what you have changed. Select OK when you are done. The file is now checked into VSS and is safe.

Version History

You can view the version history of a file by selecting the file and showing its history.

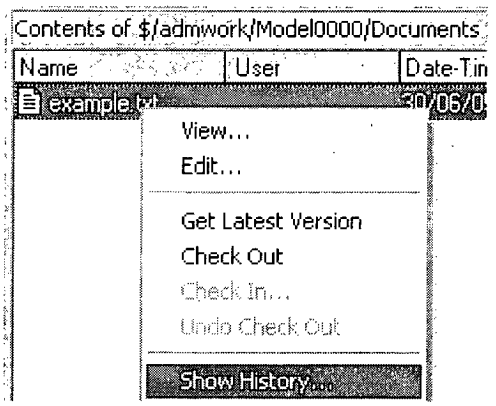


Illustration 35: Version History - Step 1

Click on "Show History

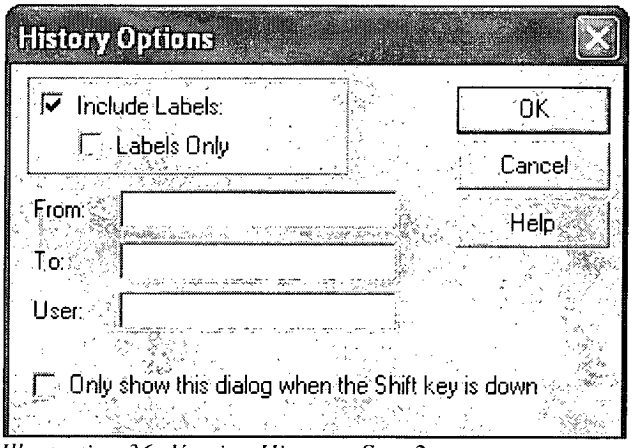


Illustration 36: Version History - Step 2

Just click on OK in the dialogue box. You will then be presented with the history of the file, including what was changed, and who changed it.

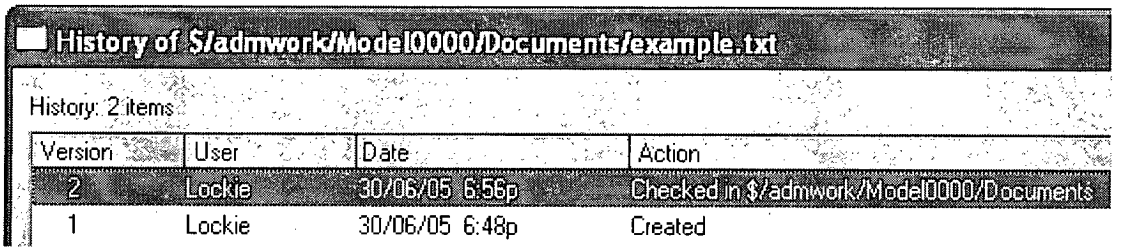


Illustration 37: Version History - Step 3

You can see that version 1 of the file was created at 6:48, and version 2 of the file was checked back in at 6:56pm. You can view more advanced information about what occurred to a file by selecting the file and choosing "Details"

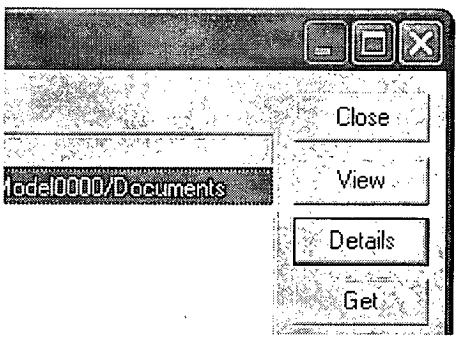


Illustration 38: Version History - Step 4

Choose "Details"

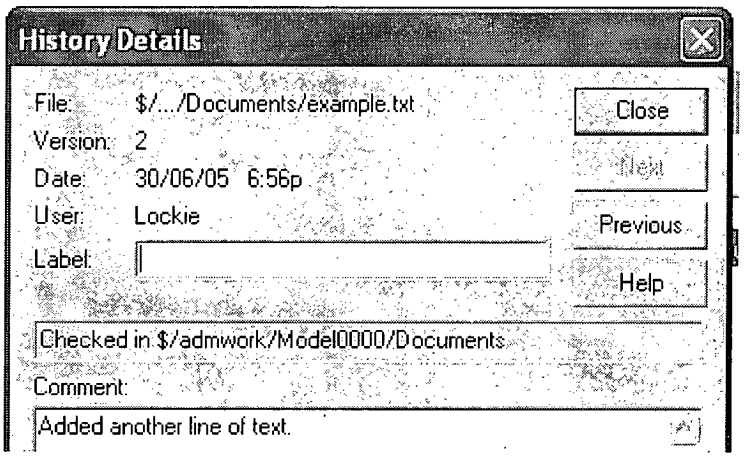


Illustration 39: Version History - Step 5

You can see that file version 2 was checked in at 6:56pm by Lockie and the comment I made was "Added another line of text."

Labels

Labels are the most important aspect of VSS. An entire project can be given a label. VSS automatically labels every file in the project with the same label, making it very easy to step back to a particular point in the project.

Label Format

The suggested format for labels is:

model_number.discipline.number

Where:

Model_Number = The current model number you are working on.

Discipline =

- HW – Hardware
- SW – Software
- MEC – Mechanical
- VHDL – VHDL
- FW – Firmware
- DOC – Documentation.

Number = An incrementing number.

ECN Process

Proper documenting of Engineering Change Notices (ECN's) is essential to ensure that the contract manufacturer (CM) and ADM are on the exact same page on what is being built. Not only does an ECN need to be produced as a formal request for change, but it also has to be tracked and stored with the appropriate project and parts which are affected. An ECN also needs appropriate company wide approval before being implemented to ensure that there are no issues which may be created by the change in the product.

Relevant parties that may be needed to seek approval are:

- R&D Hardware Manager
- R&D Software Manager
- Manufacturing Manager
- Support Manger
- Marketing Manager
- Regulatory Manager
- Finance Manager[6]
- CEO/ Managing Director[7]

An ECN may be triggered because of a query from the CM i.e. They have found an equivalent material for a cheaper price; from a supplier i.e. A particular component is being replaced with another one; or by the R&D team i.e. Interfacing with support it has been discovered that the most common fault with the system is 'x' and therefore a slight modification to this area would alleviate the problem.

An ECN will be created for **ANY** change that happens to **ANY** part of the product or manufacturing process.

There is a standard ADM ECN template document which must be used when an ECN is being produced. This helps ensure that all relevant information is being collected, and also helps for traceability in the future.

There are two options for an ECN a 'hard roll' or a 'soft roll'. A hard roll may occur when the change must go into manufacturing immediately and therefore any components that were used previously will be scrapped. This may occur for example if it was realized that a electronic component used actually had a fault associated with it and therefore it was decided to move to another brand of component. A soft

6 Usually only in the case when the ECN will bring about either a large cost increase, or scrapping of a large amount of components (and thus wasting a large amount of money)

7 Usually only in the case when the ECN will bring about either a large cost increase, or scrapping of a large amount of components (and thus wasting a large amount of money)

roll might occur if it was found that another manufacturer of the same component could supply it to us cheaper, and therefore all the components already bought should be used up before switching to the new component.

Once the ECN is issued to the CM they need to acknowledge it and state when it is planned to be implemented. When it does get implemented they need to report back the last serial number before the change, and the first serial number after the change so that this information can be recorded against the ECN.

Document Distribution

Work In Progress.

Document Legibility

Work In Progress.

External Documents

Work In Progress.

Obsolete Documents

Control of Records

A very critical component in the Quality System is the control of records.

In general records (evidence) of activities relating to the requirements of the Quality Management System must be kept and in easily accessible and maintainable format.

To assist in this task, many templates and electronic services have been implemented to ensure that all employees (where applicable) have access and the ability to control their records.

VSS Database

To assist in the storage and management of the records, a Visual Source Safe database has been implemented.

Database Location

The database can be found in:

\\eqss-server-01\vss_records

Database Folders

Documentation Standards

Introduction

This section details the necessary information to produce and manage a document. Any document used in; or related to, a final product must follow these documentation standards. Upon completion of a document, the nominated QA officer will check the documents compliance with this set of standards. In general all documents will be produced using the OpenOffice suite of tools.

Requirements

This section details the specific requirements for each document as per the guidelines set out in AS9001:2000

Structure Requirements

The table above lists the structural requirements for each document. The overall structure of each document will differ slightly based on the content of the document, however in general, all documents must include this information.

Item	*Requirement*
1.	Front Page 1. Must contain the company letter head at the top of the page. This must include the companies ABN. 2. Must contain the major category heading using the style "heading" 3. Must contain the minor category heading using the style "sub_heading" 4. May contain a graphic of the product or process being described.

Item	*Requirement*
2.	Second Page 1. Must contain the document identifier (document file name) 2. Must contain the location of the document as per the users local working folder from VSS 3. Must contain the contributors and details of how to contact them 4. Must contain a brief abstract of the document which must be set as a section for linking outside of the document. 5. Must contain the documents revision status. 6. Must contain the warning notice about controlled documents, together with information about obtaining the latest version.
3.	Third Page 1. Must contain a revision history table. The table entries must be in reverse chronological order. This table must be manually updated.
4.	Fourth Page 1. Must contain a list of the documentation conventions, this includes graphical symbols, text, etc. This list must be linked to the companies documentation conventions document and must not be manually entered.
5.	Fifth Page 1. May contain any legal notices
6.	Sixth Page 1. Must contain the table of contents. This table of contents must be automatically generated and must not be manually entered.
7.	Last Page 1. Must contain an index of illustrations (if used) 2. Must contain an index of tables (if used) 3. Must contain an alphabetical index (if used) 4. Must contain a table of references (if used) 5. All indexes must be automatically generated (except for references) and must not be manually entered.
8.	Document Header / Footer 1. Generally the header must remain blank 2. The footer must contain the current page, page count and a confidentiality notice in red if necessary.

Table 16: Document Structural Requirements

Document Headings

Document headings are used in documents to clearly differentiate major and minor headings.

The table above describes the table headings used in a document.

Item	*Requirement*
1.	Heading Level 1 1. Must use style "heading 1" 2. Must not be numbered 3. Must be Arial, 26, Bold, Blue 4. All Level 1 headings must be on a new page designated by a manual page break.
2.	Heading Level 2 1. Must use style "heading 2" 2. Must not be numbered 3. Must be Arial, 20, Bold, Blue 4. Must be indented 5mm 5. Where Practical all level 2 headings must be on a new page designated by a manual page break.
3.	Heading Level 3 1. Must use style "heading 3" 2. Must not be numbered 3. Must be Arial, 16, Bold, Blue 4. Must be indented 10mm
4.	Heading Level 4 5. Must use style "heading 4" 6. Must not be numbered 7. Must be Arial, 14, Bold, Blue 8. Must be indented 15mm
5.	Subsequent Headings 1. Generally must be avoided, re-work the document if you have too many levels deep.

Table 17: Document Headings

Captions

Captions are used for identifying resources within a document. These resources include tables, illustrations and graphics.

The table above lists the requirements for captions.

Item	*Requirement*
1.	All Tables, Illustrations, Graphics, Pictures, Notes, etc. must contain a caption.
2.	Captions must be placed at the bottom of the item and must be left justified.
3.	Captions must be used to generate the indexes as per item 7 in Structure Requirements

Table 18: Structure Requirements - Captions

Cross References

Cross references are used for referencing objects in a document to in-line text. References are required to maintain documents that can be easily maintained.

Item	*Requirement*
1.	1. Cross References must be used when referring to any item in a document. 2. Cross References must be set in the document for each and every item that requires referencing within the documents text. 3. Cross References must not be manually entered

Table 19: Structure Requirements - Cross References

Equations

Equations such as $y = mx + c$ or symbolic numbers such as ^{137}Cs must be formatted in equation writer. Equation writer ensures that all text of a mathematical nature is presented in the same format and ensures consistency across our documents.

Document Templates

In general all documents should be based on a template. Various templates exist for both the styles and layout of a document exist. Templates are to be used for all documents to ensure conformity with the above listed requirements. A change in the template will result in a change in all documents based on that template.

List Of Templates

To be Revised.

Indexes and Tables

Indexes and tables are designed to automatically collate and tabulate the information contained in the headings, captions and bibliography.

The following requirements relate to the use of indexes and tables.

Item	*Requirement*
1.	Table Of Contents 1. Must appear in the first few pages of a document 2. Must show all heading levels
2.	Table of Illustrations 1. All illustrations must be automatically tabulated in a table of illustrations
3.	Table of Tables 1. All tables in a document must be automatically tabulated in a table of tables
4.	Bibliography 1. Any text in a document where a reference to an external source is made must be added to a bibliography. 2. The bibliography must be stored in a database for the current project.

Table 20: Bibliography's

Alphabetical Index

Where practical an alphabetical index must be maintained for all documents.

Images

Any images placed in documents must be linked into the documents, and not inserted. The link must point back to the path of the image (say from an model rendering).

Management Responsibility

This section describes the responsibility of upper management with respect to maintaining the integrity of the Quality Management System.

Requirements

These requirements have been extracted from the AS9001:2000 document, and referenced accordingly.

Management Commitment[8]

Please see Management Commitment on page 63

Item	*Requirement*
1.	Top management shall provide evidence of its commitment to the development and implementation of the quality management system and continually improving its effectiveness by communicating to the organization the importance of meeting customer as well as statutory and regulatory requirements.
2.	Top management shall provide evidence of its commitment to establishing the quality policy
3.	Top management shall provide evidence of its commitment to ensuring that quality objectives are established
4.	Top management shall provide evidence of its commitment to conducting management reviews
5.	Top management shall provide evidence of its commitment to ensuring the availability of resources

Table 21: Management Commitment - Requirements

Customer Focus[9]

Please See Customer Focus on page 66

Item	*Requirement*
1.	Top management shall ensure that customer requirements are determined and are met with the aim of enhancing customer satisfaction

Table 22: Customer Focus - Requirements

8 Referenced Directly From AS9001:2000
9 Referenced Directly From AS9001:2000

Quality Policy[10]

Item	*Requirement*
1.	Top management shall ensure that the quality policy is appropriate to the purpose of the organization
2.	Top management shall ensure that the quality policy includes a commitment to comply with requirements and continually improve the effectiveness of the quality management system
3.	Top management shall ensure that the quality policy provides a framework for establishing and reviewing quality objectives
4.	Top management shall ensure that the quality policy is communicated and understood within the organization
5.	Top management shall ensure that the quality policy is reviewed for continuing suitability

Table 23: Quality Policy – Requirements

Planning Quality Objectives[11]

Item	*Requirement*
1.	Top management shall ensure that quality objectives, including those needed to meet requirements for product [see 7.1 a)], are established at relevant functions and levels within the organization.
2.	The quality objectives shall be measurable and consistent with the quality policy.

Table 24: Planning - Quality Objectives

Quality Management System Planning[12]

Item	*Requirement*
1.	Top management shall ensure that the planning of the quality management system is carried out in order to meet the requirements given in 4.1, as well as the quality objectives
2.	Top management shall ensure that the integrity of the quality management system is maintained when changes to the quality management system are planned and implemented

Table 25: Planning - Quality Management System Planning

10 Referenced Directly From AS9001:2000
11 Referenced Directly From AS9001:2000
12 Referenced Directly From AS9001:2000

Responsibility & Authority[13]

Please see Responsibility, Authority and Communication on page 67

Item	*Requirement*
1.	Top management shall ensure that responsibilities and authorities are defined and communicated within the organization

Table 26: Responsibility, Authority & Communication - Responsibility & Authority Requirements

Management Representative[14]

Please see Management Representative on page 67

Top management shall appoint a member of management who, irrespective of other responsibilities, shall have responsibility and authority that includes

Item	*Requirement*
1.	Ensuring that processes needed for the quality management system are established, implemented and maintained.
2.	Reporting to top management on the performance of the quality management system and any need for improvement
3.	Ensuring the promotion of awareness of customer requirements throughout the organization.
4.	The responsibility of a management representative can include liaison with external parties on matters relating to the quality management system.

Table 27: Responsibility, Authority & Communication - Management Representative Requirements

Internal Communication[15]

Item	*Requirement*
1.	Top management shall ensure that appropriate communication processes are established within the organization and that communication takes place regarding the effectiveness of the quality management system.

Table 28: Responsibility, Authority & Communication - Internal Communication Requirements

13 Referenced Directly From AS9001:2000
14 Referenced Directly From AS9001:2000
15 Referenced Directly From AS9001:2000

Management Review Requirements

General[16]

See Management Review on page 68

Item	*Requirement*
1.	Top management shall review the organization's quality management system, at planned intervals, to ensure its continuing suitability, adequacy and effectiveness. This review shall include assessing opportunities for improvement and the need for changes to the quality management system, including the quality policy and quality objectives.
2.	Records from management reviews shall be maintained (see 4.2.4).

Table 29: Management Review - General Requirements

Review Input[17]

The input to management review shall include

Item	*Requirement*
1.	Results of audits
2.	Customer feedback
3.	Process performance and product conformity
4.	Status of preventive and corrective actions
5.	Follow-up actions from previous management
6.	Changes that could affect the quality management
7.	Recommendations for improvement

Table 30: Management Review - Review Input Requirements

16 Directly Referenced From AS9001:2000
17 Directly Referenced From AS9001:2000

Review Output[18]

The output from the management review shall include any decisions and actions related to

Item	*Requirement*
1.	Improvement of the effectiveness of the quality management system and its processes
2.	Improvement of product related to customer requirements
3.	Resource needs

Table 31: Management Review - Review Output Requirements

18 Directly Referenced From AS9001:2000

Management Commitment

Introduction

This section describes and documents the commitment management has to its Quality Policy in the following areas.

1. Improving the quality of its management system
2. Establishment of the quality policy
3. Ensuring quality objectives are being met
4. Ensuring management reviews are conducted
5. Ensuring that management makes the necessary resources available.

QMS Development & Implementation

The quality management system has been developed and implemented within A&DM. A&DM recognises the importance of a Quality Management System and as such, has put the infrastructure and resources in place to ensure that everyone covered by the scope of the QMS has access to the necessary resources.

These include:

- Electronic web access to parts database, assembly lists, customers and supplier databases, materials, etc.
- Electronic access to a revision control system which ensures the correct documentation is delivered to the correct parties.
- Electronic web access to an always "up to date" copy of the Quality System Manual which can be accessed by all staff.
- An assigned person to maintain the quality management systems, including infrastructure and training.

Quality Policy Establishment

The quality policy has been established within the guidelines of AS9001:2000.

Management Reviews

Management reviews are scheduled to take placed every 6 – 12 months to ensure that the quality management system is functioning correctly and to ensure it gets updated accordingly.

Resource Availability

A&DM makes available a dedicated staff member to control and maintain the Quality Management System. Please see Management Representative on page 67 for further details.

Customer Focus

Privacy Policy

Collection and Storage – Personal Information

In the course of our business, personal information such as names, addresses, may be collected and held, for use in fulfilling the primary purposes intended. This includes information required to provide customers and others with products and services. Information retained on our database is also used to inform stakeholders and customers of relevant developments in procedures or products which we believe is either necessary or will assist in the use of the product or service we offer.

Unless we are informed otherwise, we will continue to use the information collected in this manner. Accuracy of information is important to us and changes or corrections to information held will be welcomed at any time.

Normally we collect information from the persons concerned and they are under no obligation to provide it. However without certain information we may be unable to provide the products and services, or facilitate the preferred payment method. Most personal information is stored in-house.

All reasonable steps are taken to protect the security of the personal information held, be it stored in electronic or hard copy form.

Customer Satisfaction

Customer satisfaction is important in ensuring the product or service being delivered meets the requirements it was designed for. As a result A&DM has procedures in place to ensure customer satisfaction data can be gathered and added into the next revision of the product.

The following items are measured:

- Direct communication with the customer to gain feedback
- Feedback via warranty and returns
- Feedback from service department
- Feedback via technical help desk
- Feedback from advertising material, such as web site hits and magazine response forms.
- Feedback via performance data systems in embedded software / hardware.

Responsibility, Authority and Communication

Introduction

This section describes who is responsible person for the quality management system, who has authority and the functional position requirements.

Management Representative

Lachlan Grogan has been appointed the management representative for A&DM for the purposes of Quality Assurance. Lachlan Grogan has been appointed this position due to his vast experience and knowledge gained through upper management positions.

Please see position descriptions for details of QA officers requirements.

The following duties are required of the management representative:

QMS General

This requirement sees the management representative ensure that the quality system is established, implemented and maintained and reviewed on a regular basis.

Throughout A&DM the management representative has to meet the following requirements.

Item	*Requirement*
1.	Ensuring that the quality system is established and meets the requirements of this manual.
2.	Ensuring that throughout the company that the quality system is implement and all staff are aware of the quality requirements.
3.	Ensure that the quality manual is maintained.

Table 32: Management Representative - QMS Requirements

Reporting

This requirement ensures that the management representative reports to top management the performance and quality of the management system and what improvements need to be maintained.

QMS Awareness

This requirement ensures that the management representative ensures that everyone throughout the organisation is aware of the Quality System.

Management Review

This section discusses the requirements by senior management to review A&DM's quality management system.

General

The management review of the quality system shall:

1. Be conducted at regular intervals no greater than 6 months apart.
2. Be conducted when ever there is a contention or lack of information in the quality manual
3. Be conducted as a result of changing project demands.
4. Be conducted as a result of a large rate of change in business activity.

Review Input

In general the inputs to a management review shall include

1. Results of any previous audits on the quality system, including any outside audits.
2. Customer Feedback
3. Process performance and product conformity,
4. Status of preventive and corrective actions,
5. Follow-up actions from previous management reviews,
6. Changes that could affect the quality management system
7. Recommendations for improvement.

Review Output

The output from the management review shall include any decisions and actions related to:

1. Improvement of the effectiveness of the quality management system and its processes
2. Improvement of product related to customer requirements
3. Resource needs.

Resource Management

Requirements

Provision Of Resources[19]

Item	*Requirement*
1.	The organization shall determine and provide the resources needed to implement and maintain the quality management system and continually improve its effectiveness
2.	The organization shall determine and provide the resources needed to enhance customer satisfaction by meeting customer requirements.

Table 33: Provision of Resources – Requirements

Human Resources[20]

Item	*Requirement*
1.	Personnel performing work affecting product quality shall be competent on the basis of appropriate education, training, skills and experience.

Table 34: Human Resources - General Requirements

19 Referenced Directly From AS9001:2000
20 Referenced Directly From AS9001:2000

Competence, Awareness & Training[21]

Item	*Requirement*
1.	Determine the necessary competence for personnel performing work affecting product quality
2.	Provide training or take other actions to satisfy these needs,
3.	Evaluate the effectiveness of the actions taken
4.	Ensure that its personnel are aware of the relevance and importance of their activities and how they contribute to the achievement of the quality objectives
5.	Maintain appropriate records of education, training, skills and experience (see 4.2.4).

Table 35: Human Resources - Competence, Awareness & Training Requirements

21 Referenced Directly From AS9001:2000

Company Structure & Authority

Organizational Information

Responsibility

Analogue and Digital Measurements Pty. Ltd (A&DM) implements its quality assurance programme as normal operation in the following areas:

Area	*Description*
1 – Design	Ensuring that all design work is carried out in a controlled manner, using proven tools and methodologies by competent engineers.
2 - Manufacture	Ensuring that all design information is conveyed to the parties responsible for manufacturing, and that each party ensure adherence to the manufacturing requirements.
3 – Testing	Ensuring that the design, and any subsequent designs are tested in accordance with the competent authorities regulations.
4 - Documentation	Ensuring that all documentation related to the items listed in this table is written and maintained to a strict set of standards.
5 - Use	Ensuring that the use of any product or service covered by this quality system is documented correctly as per the guidelines covered in this quality system.
6 - Maintenance	To ensure that any maintenance work performed on critical components is performed to a set of documented standards.
7 - Inspection	

Table 36: QA Programme - Target Areas

The management of A&DM is responsible for the continued implementation of this programme on all current and future projects.

Authority

A&DM has an established organisational structure with procedures which ensures that in all areas of quality assurance, the assignment and responsibility for each area, is:

Item	*Details*
1.	Achieved and maintained by appropriately qualified and trained personnel
2.	The the conformance of Item 1 (above) is verified by individuals or groups not directly responsible for work performed
3.	That quality verification and reporting to management heir achy precludes conflict of interest (i.e. Independent from costing and scheduling), in management areas of responsibility.
4.	All personnel involved with Quality Assurance have the authority and responsibility, in writing, to stop at any time, the further process of any non conformal material, work, shipment, delivery or installation with direct recourse to upper management.
5.	QA managers have the further responsibility, in writing, to supervise further processing after corrections, for any procedural reason, have been made.

Table 37: QA Programme - Authority

Structure

The current organisational structure of A&DM is detailed below. This includes both direct and indirect lines of communication.

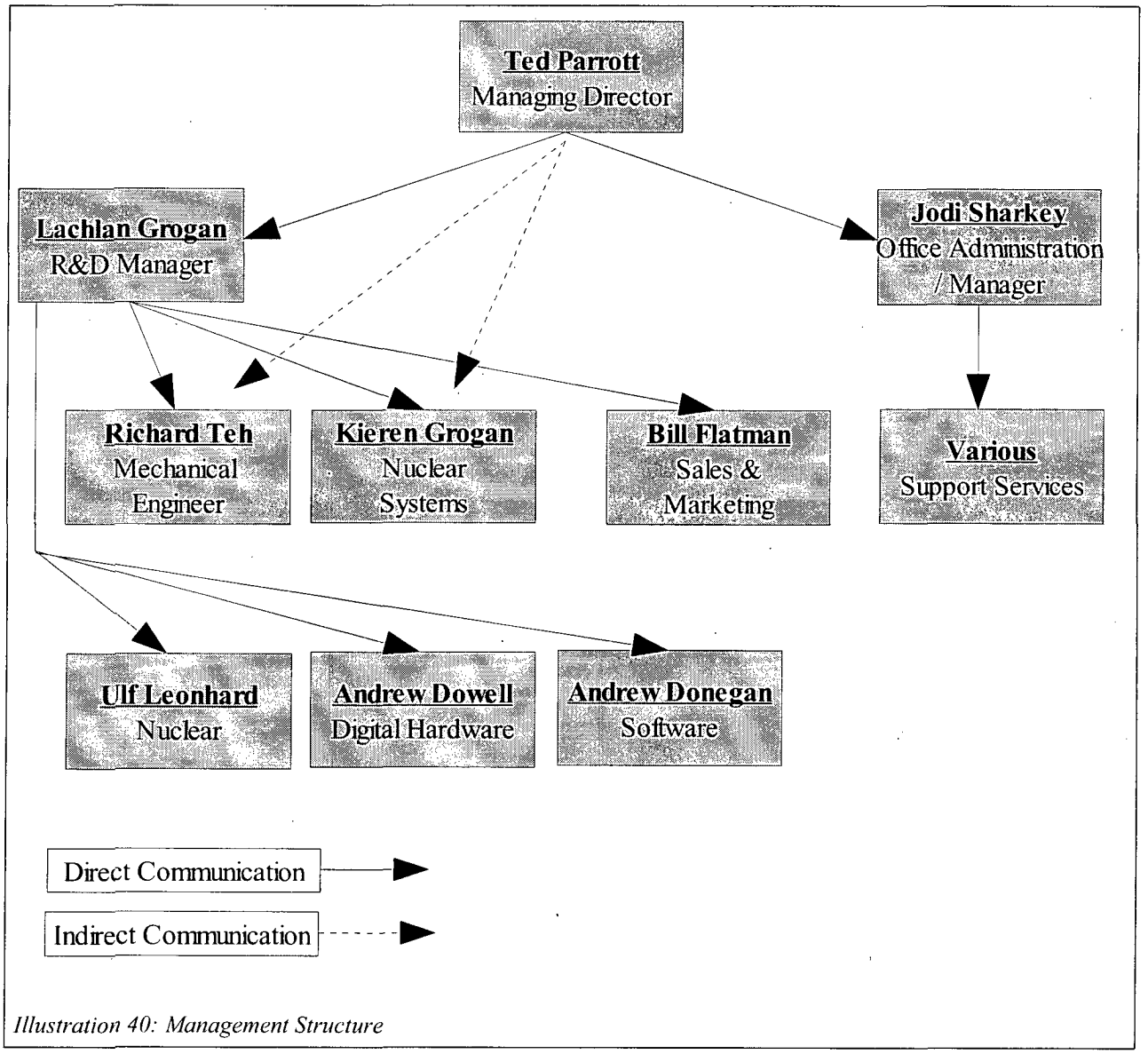


Illustration 40: Management Structure

Position Descriptions

Each employee in A&DM has a position description which clearly describes their roles, responsibilities and rights within the organisation.

Ted Parrott – Managing Director

As the sole owner, is responsible for the financial status of the company

CHARACTERISTICS OF POSITION

Key Responsibilities

The Managing Director will manage and lead the company managers to design, develop and maintain the Companies software and hardware systems.

- Ensure there is sufficient resources to carry out the day to day activities of the company.
- Carry out all legal responsibilities for the operation of the company as set down by ASIC.
- Interface with the Australian Tax Office.
- Ensure company and company staff licensing meet the state regulator requirements.
- Maintain both local and international contacts for sales and purchasing
- Interface with regulators for equipment approvals and supervise perpetration of submission documents.
- Back up support for the engineering staff.
- Sales for both ADM Nuclear and eQss. Preparation of quotations and contracts.
- Design of Industrial Source Holders.
- Design of Type A transport packages.
- Design of Type B(U) transport packages.
- Design of storage casks.
- Make final decisions for the commitment and continued investigation of development issues as outlined by the R&D manager and his support staff.

Skills

- 45 Years experience with radiation measurement and isotopes.
- 50 years experience with load cells and associated technologies.
- 30 year experience with operating a business.
- 40 years experience with the design and manufacture of electronic. measuring equipment.

Decision Making Authority

- the Managing director has ultimate authority in all aspects of the company operation.

Lachlan Grogan – R&D Manager

CHARACTERISTICS OF POSITION

Key Responsibilities

The Research & Development Manager will manage and lead the team to design, develop and maintain the Companies software and hardware systems.

A key participant in the company for innovation, excellence and quality, the individual will help identify and document customers requirements and perform any other duties as required by the Managing Director.

- Responsible for determining Company direction, product development and sales strategies for the eQSS product range.
- Coordinates technical support, development and construction
- Responsible for billing technical support related activities to customers
- Overall responsibility in the absence of Managing Director
- Responsible for all aspects of employees directly under his control.
- Assist when necessary in meeting our commitments with our Nuclear Division

Key Relationships

- Reports internally to the Managing Director
- The individual will need to interact directly and responsibly with other employees, suppliers and customers

Decision Making Authority

- Right to hire personnel authorised by the M.D
- Right to dismiss personnel that do not meet the program requirements
- Lead employees to develop sales and technical strategies
- Provide management, leadership and direction in technical design and implementation decisions
- Authorised for the purchase of hardware, software and components related to Development and Manufacturing.

- Authorized to give instructions to all A&DM employees
- Authorized to bill customers for technical support and other support activities

Problem Solving Responsibilities

- Work through employee problems and relationship issues with employees
- Identify key issues from a variety of information
- Propose and develop alternate solutions for customer requirements that are based on logical assumptions and factual information that take in to consideration constraints, business drivers, technology available, etc.
- Work through challenging technical issues

MINIMUM COMPETENCIES REQUIRED

Experience

- At least 5 years experience developing intelligent hardware systems
- Experience managing and leading other employees

Skills

- Project Management and leadership skills
- Hardware analysis and design
- Software Systems Design
- Excellent communication and interpersonal skills
- Quality Systems Awareness

Education

- Bachelor of Electrical/Computer Systems Engineering

Kieren Grogan – Nuclear Systems Engineer

Characteristics Of Position

Key Responsibilities

The Product Support Engineer (Radiation) is a key participant in the company for innovation, excellence and quality. The individual will help identify and document customers requirements, provide technical support, service, training, development and perform any other duties as required by the Managing Director. Your key responsibilities are outlined below, however you are to provide a backup for the development and ongoing support to the eqss program, at which time you will be on loan to eQSS and Responsible to the R&D Manager.

- Product installation, testing and maintenance
- Servicing customers equipment (particularly equipment with Isotopes)
- Development of Radiation Transport Container & Source Holder Products
- Promotion & Implementation of our Wipe Test Service
- Promotion & Implementation of Radiation Management Plans
- Develop equipment to enhance the operation of Blood Product Irradiators
- Develop an Instrument to measure & categorise Isotopes that may be evident in or on persons entering a building.
- Build & Promote a Calibration Rig for Calibration of Survey Meters
- Coordinate technical support and customer service
- Technical documentation including product manuals, installation procedures, test information and service reports
- Responsible for smooth running of downstairs Workshop
- Wherever possible handle the repairs & maintenance that require you, to go on site
- Transport of Radioactive Materials, to the Code of Practice.

eQSS

- When on loan to eqss you will be required to assist in the design and testing of both hardware and software for the crane computer as directed by the R&D Manager.

Key Relationships

- Reports directly to the Managing Director
- When on loan to eQSS reports to the R&D Manager.
- The individual will need to interact directly and responsibly with other employees, suppliers and customers

Decision Making Authority

- Identify and implement the best possible outcomes, taking into consideration occupational health and safety, constraints, technology available etc.
- Interact with and supervise sub contractors building equipment for both Radiation and eQSS divisions.
- Initiate orders to procure the parts or Services necessary to meet your commitments
- Balance the needs & allocate time between the two divisions.

Problem Solving Responsibilities

- Identify key issues from a variety of information
- Work through challenging technical issues

Skills

- Hardware and software design and analysis
- Excellent communication and interpersonal skills

Education

- Bachelor of Electrical/Computer Systems Engineering (or similar).
- Radiation Safety Management.

Bill Flatman – Sales and Marketing

CHARACTERISTICS OF POSITION

Key Responsibilities

The Sales & Marketing Engineer will be responsible for handling the sales and marketing requirements of the 3 company categories being:

- Nuclear Products and Services
- Equipment Safety Products and Services
- Instrumentation

You are key participant in the company for customer interfacing, quality and business development. You will help identify and document company procedures, develop customer relationships and perform any other duties as required by the R&D Manager.

Your specific responsibilities include:

- *Business Development:* You are responsible for further developing the business of A&DM by liaising with potential principle companies, identifying target markets, identifying new products, procedures and technologies. You are expected to spend a minimum of 0.5 days a week exploring new business avenues for the company.

- Documentation: You are required to ensure that all your work is documented as per our quality systems requirements and that no deficits exist in your documentation, database's or activity diaries.

- Company Databases: You are responsible for maintaining the company database lists of customers, suppliers, etc., that relate to your job function. The database's will need you to identify any related target markets and follow up on these markets by way of mail outs (either in electronic or paper format) or by way of phone conversations.

- Document Preparation: From time to time you will be required to review documentation relating to our products and correct the documents for formatting, presentation, etc. You will be responsible to prepare customer documents (printing, binding, etc.) and to ensure

that these documents are presented to the customer in a professional manor.

- *Customer Interface:* You are responsible for interfacing with the customers in a professional manor. When you are required on a customers site you need to ensure that all relevant health and safety regulations are met.

- Inquiry Handling: You are responsible for responding to the majority of customer enquiries for products or services. You must make yourself aware of the products and services that the company has to enable you to respond to any inquiry in a timely and professional manner.

- Marketing: You will need to devote a large amount of your time to marketing the companies products and services. The marketing process starts by entering the target customer in the company database and then preparing the necessary information pack to send out. You will need to make verbal communication with almost every customer before sending marketing information.

- Planning: You will need to maintain a working plan of your sales and marketing strategies and ensure that this plan is visible to the company at all times. You should seek input from other employees for continual enhancement to this plan.

- Quality Systems: The company has a comprehensive set of quality systems which are continually being developed, you will be required to use your skills and experience to add to this quality documentation from time to time.

Key Relationships

- Reports internally to the R&D Manager.
- The individual will need to interact directly and responsibly with other employees, suppliers and customers

Decision Making Authority

- Provide management, leadership and direction in the areas of sales and marketing.
- Authorized to give instructions to A&DM employees on issues related

to your position description.

Problem Solving Responsibilities

- Identify key issues from a variety of information
- Work through any technical or non technical issues that may arise.

MINIMUM COMPETENCIES REQUIRED

Experience

- At least 5 years experience in sales, marketing and quality systems.
- Electronics, Mechanical and management skills.
- Experience communicating with employees and suppliers.

Skills

- Software skills including, MS Office products and CAD Tools.
- Excellent communication and interpersonal skills.

Andrew Dowell – Digital Hardware Engineer

CHARACTERISTICS OF POSITION

Key Responsibilities

The Digital Hardware Engineer will be responsible for the day to day requirements of our electronics activities including design, development, testing, repairs & maintenance, documentation and safety. A key participant in the company for safety, quality and technology, the individual will help identify and document company procedures, develop customer relationships and perform any other duties as required by the R&D Manager.

Your specific responsibilities include:

- *Business Development:* You are responsible for further developing the business of A&DM by liaising with potential principle companies, identifying target markets, identifying new products, procedures and technologies. You are expected to spend a minimum of 0.5 days a week exploring new business avenues for the company.
- Documentation: You are required to ensure that all your work is documented as per our quality systems requirements and that no deficits exist in your documentation or database's for our nuclear based activities. This also means that a complete paper trail must be kept for every nuclear activity.
- Production: You are required to assist where possible in the production of the companies products and services. This may require you to lean new skills or procedures to enable you to complete this requirement.
- Company Databases: Responsible for maintaining the company database lists of customers, suppliers, etc. The database's will need you to identify any related target markets and follow up on these markets by way of mail outs (either in electronic or paper format).
- Document Preparation: From time to time you will be required to review documentation relating to our products and correct the documents for formatting, presentation, etc. You will be responsible to prepare customer documents (printing, binding, etc.) and to ensure that these documents are presented to the customer in a professional manor.
- *Customer Interface:* You are responsible for interfacing with the customers in a professional manor. When you are required on a customers site you need to ensure that all relevant health and safety regulations are met.
- Reporting: Responsible for the generation of reports based on current jobs or activities when required by your manager.

Key Relationships

- Reports internally to the R&D Manager.
- The individual will need to interact directly and responsibly with other employees, suppliers and customers

Decision Making Authority

- Provide management, leadership and direction in the areas of nuclear activities and related systems.
- Authorized to give instructions to A&DM employees on issues related to your position description.

Problem Solving Responsibilities

- Work through employee problems and relationship issues with employees
- Identify key issues from a variety of information
- Work through any non technical issues that may arise.

MINIMUM COMPETENCIES REQUIRED

Experience

- At least 10 years experience in digital electronics design.
- Radiation and health safety training.
- Experience communicating with employees and suppliers.

Skills

- Software skills including, MS Office products and CAD Tools.
- Excellent communication and interpersonal skills.

Ulf Leonhard – Nuclear

CHARACTERISTICS OF POSITION

Key Responsibilities

The Nuclear Systems Engineer will be responsible for the day to day requirements of our nuclear activities including source handling, repairs & maintenance, documentation, safety and design. A key participant in the company for safety, quality and technology, the individual will help identify and document company procedures, develop customer relationships and perform any other duties as required by the R&D Manager.

Your specific responsibilities include:

- *Business Development:* You are responsible for further developing the business of A&DM by liaising with potential principle companies, identifying target markets, identifying new products, procedures and technologies. You are expected to spend a minimum of 0.5 days a week exploring new business avenues for the company.
- Documentation: You are required to ensure that all your work is documented as per our quality systems requirements and that no deficits exist in your documentation or database's for our nuclear based activities. This also means that a complete paper trail must be kept for every nuclear activity.
- Production: You are required to assist where possible in the production of the companies products and services. This may require you to lean new skills or procedures to enable you to complete this requirement.
- Company Databases: Responsible for maintaining the company database lists of customers, suppliers, etc. The database's will need you to identify any related target markets and follow up on these markets by way of mail outs (either in electronic or paper format).
- Document Preparation: From time to time you will be required to review documentation relating to our products and correct the documents for formatting, presentation, etc. You will be responsible to prepare customer documents (printing, binding, etc.) and to ensure that these documents are presented to the customer in a professional manor.
- *Customer Interface:* You are responsible for interfacing with the customers in a professional manor. When you are required on a customers site you need to ensure that all relevant health and safety regulations are met.
- Reporting: Responsible for the generation of reports based on current

jobs or activities when required by your manager.

Key Relationships

- Reports internally to the R&D Manager.
- The individual will need to interact directly and responsibly with other employees, suppliers and customers

Decision Making Authority

- Provide management, leadership and direction in the areas of nuclear activities and related systems.
- Authorized to give instructions to A&DM employees on issues related to your position description.

Problem Solving Responsibilities

- Work through employee problems and relationship issues with employees
- Identify key issues from a variety of information
- Work through any non technical issues that may arise.

MINIMUM COMPETENCIES REQUIRED

Experience

- At least 10 years experience in the Nuclear Industry
- Radiation and health safety training.
- Experience communicating with employees and suppliers.

Skills

- Software skills including, MS Office products and CAD Tools.
- Excellent communication and interpersonal skills.

Jodi Sharkey – Office Management

CHARACTERISTICS OF POSITION

Key Responsibilities

The Office Administration individual will manage the day to day operations of the companies office. A key participant in the company for management, organization and quality, the individual will help identify and document company procedures, develop customer relationships and perform any other duties as required by the R&D Manager.

Your specific responsibilities include:

- *Office Communications:* Responsible for ensuring that all incoming phone calls are answered and, if necessary, directed to the relevant parties. Responsible to ensure that all fax and email communications are collected and followed up by any relevant parties.

- MYOB: Responsible to ensure that that the day to day MYOB tasks are handled correctly and diligently. This includes purchasing, invoicing and following up on monies owed. You are also to ensure that as you develop (or change) any office procedures that they are documented and added to our procedures manual. You may also be required to handle the payroll requirements of the company.

- Purchasing: Responsible for purchasing parts and materials as required by our engineering teams, and ensuring that the records of such purchases are maintained as per our quality systems. You will also be required to handle any overseas orders, including follow up's and general communication with principles.

- Company Databases: Responsible for maintaining the company database lists of customers, suppliers, etc. The database's will need you to identify any related target markets and follow up on these markets by way of mail outs (either in electronic or paper format).

- Document Preparation: From time to time you will be required to review documentation relating to our products and correct the documents for formatting, presentation, etc. You will be responsible to prepare customer documents (printing, binding, etc.) and to ensure that these documents are presented to the customer in a professional manor.

- *Jobs:* Responsible to ensure that current jobs are managed from initial communication with the customer through to billing, and to ensure that our internal job lists (including reporting) and procedures are maintained and enforced.

- Reporting: Responsible for the generation of reports based on current jobs, profits / losses, stock on hand, monies owing, etc.

- Responsible for all aspects of employees directly under your control, including those that are contracted (i.e. Building maintenance, etc.).

Key Relationships

- Reports internally to the R&D Manager.
- The individual will need to interact directly and responsibly with other employees, suppliers and customers

Decision Making Authority

- Provide management, leadership and direction in the areas of office administration and its related systems.
- Authorised for the purchase of hardware, software, components and services as required by other employees within the company procedures guidelines.
- Authorized to give instructions to A&DM employees on issues related to your position description.

Problem Solving Responsibilities

- Work through employee problems and relationship issues with employees
- Identify key issues from a variety of information
- Work through any non technical issues that may arise.

MINIMUM COMPETENCIES REQUIRED

Experience

- At least 5 years experience in an office environment.
- Experience managing an office and communicating with employees and suppliers.

Skills

- Software skills including, MS Office products and MYOB.
- Excellent communication and interpersonal skills.

Richard Teh – Mechanical Engineer

CHARACTERISTICS OF POSITION

Key Responsibilities

- To Support both ADM nuclear and eQss with the design and manufacture of mechanical assemblies or parts that make up the company products.
- To report directly to the managing director

Decision Making Authority

- Preparation of construction programme for radiation holders and other sundry parts.
- Supervision of sub contractors
- Coordinates QA programmes with subcontractors
- Purchase of materials and services
- Maintenance of QA records

Skills

- Efficient use of computer programs and design tools as required by the R&D manager

Education

- Bachelor of engineering (Mechanical)

Andrew Donegan – Software Engineer

Key Responsibilities

The Software Engineer will be responsible for the day to day requirements of our software activities including design, development, testing, repairs & maintenance, documentation and safety. A key participant in the company for safety, quality and technology, the individual will help identify and document company procedures, develop customer relationships and perform any other duties as required by the R&D Manager.

Your specific responsibilities include:

- *Business Development:* You are responsible for further developing the business of A&DM by liaising with potential principle companies, identifying target markets, identifying new products, procedures and technologies. You are expected to spend a minimum of 0.5 days a week exploring new business avenues for the company.
- Documentation: You are required to ensure that all your work is documented as per our quality systems requirements and that no deficits exist in your documentation or database's for our nuclear based activities. This also means that a complete paper trail must be kept for every nuclear activity.
- Production: You are required to assist where possible in the production of the companies products and services. This may require you to lean new skills or procedures to enable you to complete this requirement.
- Company Databases: Responsible for maintaining the company database lists of customers, suppliers, etc. The database's will need you to identify any related target markets and follow up on these markets by way of mail outs (either in electronic or paper format).
- Document Preparation: From time to time you will be required to review documentation relating to our products and correct the documents for formatting, presentation, etc. You will be responsible to prepare customer documents (printing, binding, etc.) and to ensure that these documents are presented to the customer in a professional manor.
- *Customer Interface:* You are responsible for interfacing with the customers in a professional manor. When you are required on a customers site you need to ensure that all relevant health and safety regulations are met.
- Reporting: Responsible for the generation of reports based on current jobs or activities when required by your manager.

Key Relationships

- Reports internally to the R&D Manager.
- The individual will need to interact directly and responsibly with other employees, suppliers and customers

Decision Making Authority

- Provide management, leadership and direction in the areas of nuclear activities and related systems.
- Authorized to give instructions to A&DM employees on issues related to your position description.

Problem Solving Responsibilities

- Work through employee problems and relationship issues with employees
- Identify key issues from a variety of information
- Work through any non technical issues that may arise.

MINIMUM COMPETENCIES REQUIRED

Experience

- At least 2 years experience in software design.
- Radiation and health safety training.
- Experience communicating with employees and suppliers.

Skills

- Software skills including, MS Office products and CAD Tools.
- Excellent communication and interpersonal skills.

Minimum Job Qualifications

From time to time A&DM is required to increase its staffing levels on a demand basis. A set of minimum job qualifications have been detailed to ensure that any staff, including temporary staff have enough qualifications to safely and accurately carry out their job function.

Minimum job qualifications are posted with each position description.

Product Realization

Introduction

This section covers the necessary requirements and processes to produce a product or service. This section discusses the necessary life cycles for product planning, design & development as well as meeting the needs of the customer.

Requirements

The requirements for this section can be found in the individual sections below.

Product Planning

This section discusses the requirements for planning a product.

Planning

The organization shall plan and develop the processes needed for product realization. Planning of product realization shall be consistent with the requirements of the other processes of the quality management system.

Item	*Requirement*
1.	quality objectives and requirements for the product
2.	the need to establish processes, documents, and provide resources specific to the product
3.	required verification, validation, monitoring, inspection and test activities specific to the product and the criteria for product acceptance
4.	records needed to provide evidence that the realization processes and resulting product meet requirements
5.	The output of this planning shall be in a form suitable for the organization's method of operations.
6.	A document specifying the processes of the quality management system (including the product realization processes) and the resources to be applied to a specific product, project or contract, can be referred to as a quality plan.

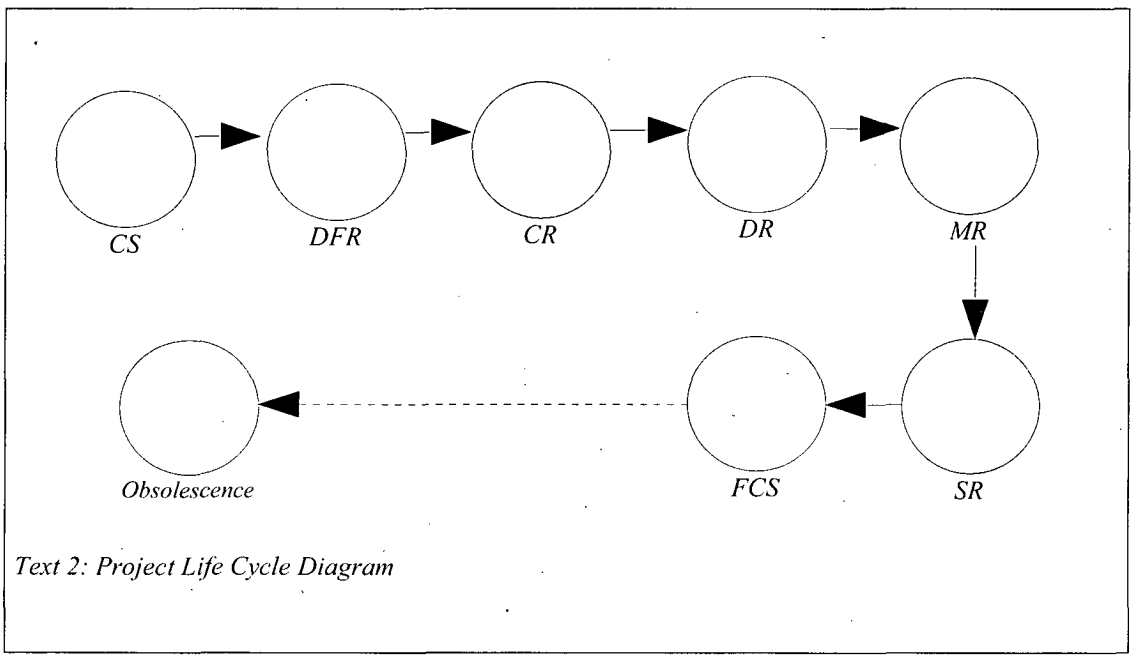
Table 38: Product Planning Requirements

Introduction

This section describes the compulsory product planning procedures which covers the project life-cycle from concept right through to customer supply.

Project Life Cycle

Every project should follow the correct project life cycle procedure as documented below:



Text 2: Project Life Cycle Diagram

CS

A candidate project will go through a 'Concept Selection' where it is chosen above all other possible projects that the company has in its funnel, based on what is the best fit for the companies roadmap, customer requests, and companies resources. There are key actions that need to be completed before a candidate project passes though this milestone.

DFR

When moving into the Definition Release milestone the project is formally recognised throughout the company. R&D resources are quickly brought into the project to scope the technical aspects and attempt to de-risk any questionable areas and Marketing start defining the market potential. Key functional blocks and components are identified and checked for availability (when sourcing them from another company). Marketing objectives are set, sketches, mock drawings, mock models, mock brochures are constructed defining the products and its operation. A project plan is created to allow visibility in what needs to be done to get to the Commitment Release (CR) milestone.

CR

This is the commitment release of the project, and it defines when the company commits to put all necessary resources behind the project to get it to DR. At this point:

- Product Requirements are finalized
- R&D engineering specifications are completed
- project plan is in place
- high level architecture has been fleshed out
- time lines are completed
- project test specification and plan has been developed
- product launch plan is specified
- project financial viability plan has been created
- project manufacturing plan has been created
- project manufacturing test plan has been created
- regulatory requirements plan has been created
- support product plan has been created
- documentation plan has been created

Dollar estimates and resource estimates for the project are completed and management has signed off and agreed to spend the money.

DR

Design release occurs when all new components in the project have been developed and integrated in. It does not mean that development has finished, rather that R&D are in a consolidation phase rather than an exploration phase. System QA is now run over the system and non optimal workings, functional blocks which haven't had all their functionality developed yet and bugs are worked on and fixed. There is a clear path in what the project has to achieve to get to MR i.e. All bugs fixed, functionality as per the R&D specification.

MR

When all of the CR plans have been executed i.e. Documents have been created, support is ready to go, the product meets the R&D specification, the prototype product has been reviewed against any regulatory requirements, and where necessary a first pass has occurred to ensure that there is high confidence in passing regulatory requirements when the real product is built, manufacturing are ready to receive the product, the company has the necessary resources in place to

launch, the Manufacturing Release can be declared. This is a formal handover of the project from R&D to Manufacturing. No development is expected to be necessary from now on, unless issues are found in the field. Manufacturing are expected to be able to build the product to a consistent standard due to the design now being solidified, and ensure that it meets the quality standards by executing the manufacturing test plan.

A project review should happen at this point to work out what went well, what went wrong, what could be improved etc. Also a review on any IP that has been developed in the project, and strategies that should be undertaken to protect it i.e. Patents.

SR

Depending on how ready manufacturing are, and how well R&D handed over the product Shipment Release can happen almost immediately after Manufacturing Release. Shipment Release is declared when manufacturing are able to build the product in the necessary volumes demanded by customers. A pre production run has been completed, and appropriate testing and checking has occurred.

FCS

The First Customer Shipment milestone can occur when the product is fully certified against any regulatory requirements. This may have happened back at MR if the prototype was being built in the same way as the now finished product, and there has not been any changes. FCS occurs when the first product is shipped to the customer.

Discontinuance and Obsolescence

Discontinuance is generally a plan of how to get to obsolescence. Referring to the companies roadmap it can be decided that a product is no longer necessary for a variety of reasons. Before this milestone occurs customer and market requirements need to be fully understood, and any 'fallout' due to removing this product from the market need to be deemed acceptable. An understanding of warranties and servicing for products that are already out in the field has to be undertaken.

Model Number Allocation

Every project, regardless of weather it is a minor test tool or a product in mass production, must have a model number if you wish to sell it to a customer.

Company Categories

There are three main company categories for products, Crane Related, Measurement Related and Nuclear Related. We have 3 trading names to suit.

Company Category	*Trading Name*
Crane Related Products	EQSS (eQuipment Safety Systems)
Measurement Related Products	ADM (Analogue And Digital Measurements)
Nuclear Related Products	NS (Nuclear Stuff)

Table 39: Company_Categories

Series Numbers

All products belong to a series of products. The Series numbers are in increments of 100. For Example:

Series	*Description*
Series 6200	Processor based crane measurement
Series 6300	Crane Sensors

Table 40: Example Series Numbers

Each company category will have a different set of series, therefore regardless of the company category, each product will be uniquely identifiable.

Model Numbers

A model number in a series starts at 00 and continues on until 99 at which point a new series must be started (its unlikely we will reach 99 products in a series) For Example:

Model Number	*Description*
6201	Pipe Layer Computer
6242	Crane Safety Appliance.

Table 41: Model Numbers - Example

A spread sheet of model numbers exists for each company category. The Visual Source Safe Databases have been created for each category; For Example:

Category	*Path To Model Number Spreadsheet*
EQSS	\eqsswork\Documents\Model_Number_Allocation\
ADM	\admwork\Documents\Model_Number_Allocation\
NS	\nuclearwork\Documents\Model_Number_Allocation\

Table 42: VSS databases

Please note that \eqsswork\, \admwork\ and \nuclearwork\ are all VSS databases.

Serial Numbers

All products leaving our doors that we manufacture must carry our standard serial number in the format listed below.

Format

The format for a serial number is as follows:

MODEL_NUMBER–S**BN**-DATE_CODE–SEQUENCE_NUMBER

Model Number

The model number is the model number of the product, for example Model 4100 – GM Switch would be written as 4100-X1.

Date Code

The date code is in ISO standard format: YYMM

Marker	*Description*
YY	2 Digit Year Code
MM	2 Digit Month Code

Table 43: Date Code Table

Sequence Number

The sequence number starts at 000 and goes through to 999. It is unlikely that we will produce more that 999 of a particular model of product.

Example

The Third Model 6215 Windicator, built in March 2005 would be numbered **6215-0503-003**

The second Model 6242 CSA built in April 2005, but has been adapted to a specific customers requirements (SBN) will be: **6242-R1-0504-002**

Serial Number Spreadsheet

For every product that is sold the following information must be maintained in a spreadsheet, located in the documents directory of the EQSS, ADM or NS VSS databases:

Item	*Requirement*
1.	Serial Number
2.	VSS version label (product version)
3.	Customer Job Number
4.	Any relevant notes.

Table 44: Serial Number Spreadsheet Requirements

The spreadsheets have been created and are available for you to edit.

You will need to check the spreadsheet out of VSS to edit it. For details on VSS please see Changes and Revision Control on Page 30

Special Cases

There are special cases where the recommended serial number format can not be used. One such example is the data plates fitted to source holders.

The format of radiation source holders data plate format is specified in the code of practice. Therefore the serial number format must be broken up.

Example:

Product is an ASHF2-A1, with sequence number 045, built in march 06

Our serial number would be ASHF2-A1-0603-045

The marking on the data plate would be:

Model = ASHF2-A1

Serial Number = 045

Date of Manufacture = Mar. 06

Terminology

Item	*Name*	*Description*
1.	Product	The physical end product that will be manufactured from a range of materials and assemblies containing components
2.	Assembly	An assembly is a collection of components or other assemblies.
3.	Component	A component is the smallest entity in an assembly.

Table 45: Product Number Allocation Terminology

Product Number Allocation

A product number is a descriptive number assigned to each product. Generally speaking product numbers fall into categories; series numbers and physical names. It is open as to what format you would use.

For Example:

Product number 6242 is the crane computer display.

Likewise ASHF2 is also a product number, from the ASHF series.

Product numbers also carry a configuration and revision identifier. Please see below.

Configuration And Revision Identifier

Each product number will also have a configuration and revision identifier as part of the product number. The configuration identifier is generally a character in the range of A – W, while the revision identifier is a number in the range 1-9.

Products that do not have different configurations, or that carry generic components or assemblies shall use an "X" as the configuration.

Products that are of prototype nature must carry a ZERO as the revision identifier.

For Example:

The product number is ASHF2

The configuration is "E"

The revision is 2

Therefore the product number is ASHF2-E2

Assembly & Component Numbering

As mentioned previously, groups of components form assemblies and assemblies form products. Each component and assembly in a product must carry a unique number to identify it in the current product, and also in the case of future revisions.

All assembly numbers start from 000 and range through to 099

All component numbers start from 100 and range through to 999.

The Product Number – Revision & Configuration Identifier is appended to the start of each assembly of component number.

For Example:

The top level assembly in the ASHF2-E2 product would have the number:

ASHF2-E2-000

While the first component in the product (regardless of where it sits in an assembly) will have the number:

ASHF2-E2-100

Logging Spreadsheet

It is a basic requirement of this standard that a spreadsheet be kept which details what components and assemblies have been created for a particular product. The spreadsheet should be kept in the same folder as the product.

The format of the spreadsheet is open.

Drawing Numbering

All drawings must carry the product number, configuration / revision identifier, the component or assembly number for the component being described together with a sequential number starting at 00.

An example drawing number would be:

ASHF2-E1-023-00

Autodesk® Inventor™ Specific Requirements

This section details the specific requirements for developing products using Inventor™.

Document Storage

Storage and retrieval of documents created in Inventor™ is of utmost importance to the success of the product. Generally speaking simple products[22] will be stored in a folder labelled with the product number and configuration & revision identifier.

Advanced products[23] will need to have their common component and assemblies stored in a common folder, while the different configuration options reside in sub folders.

Suggested Directory Structure

It is suggested that a common directory structure be created for each project to facilitate the efficient storage of documents for each product.

A folder called "Autodesk_Inventor" should be created under the product folder.

A further set of directories under the "Autodesk_Inventor" folder should be created to detail the various configurations and revisions of the particular product.

Each configuration should have directories for "Components", "Assemblies", "Drawings", "Presentations", etc.

22 Simple products are defined as products that have fewer than 20 components and only one configuration.
23 Advanced products contain many components, and have multiple different configurations and revisions

Example Storage System (Simple Product)

Product AXYZ is produced and does not have any variants. The product is sent into manufacture immediately after being checked and no prototype version was built.

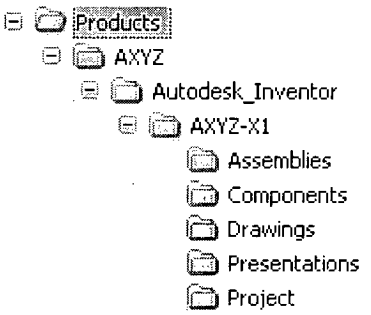


Illustration 41: Example Storage System (Simple)

As can be seen from Illustration 41 (above) a folder called "Autodesk_Inventor" is created under the main folder for our example product.

A folder is then created under "Autodesk_Inventor" with the name that matches the current product number and configuration / revision identifier.

Further folders are created, their contents are documented below.

Item	*Folder Name*	*Contents*
1.	Assemblies	This folder contains assemblies with the ".iam" file extension.
2.	Components	This folder contains only components used for the current configuration. All components in this directory carry the ".ipt" file name extension.
3.	Drawings	This folder contains only drawing files for the current product configuration. All drawings in this folder must contain the ".idw" extension. It is permissible to have another folder under this directory called "PDF" which contains the exported files in Adobe Acrobat format.
4.	Presentations	This folder contains presentations of any component or assembly for the current product configuration. This directory should only contain ".ipn" files. Do not confuse presentations with drawings. A presentation is not a drawing until you create a drawing with the presentation embedded in the drawing.

Item	Folder Name	Contents
5.	Project	This folder contains the project file for the current configuration. This folder is optional, however it is highly recommended that a project file be created correctly for each product configuration.

Table 46: Product Folders

Example Storage System (Advanced Product)

Product BCDE has a range of common components and assemblies, it also has various configurations. The image below details the expected directory structure.

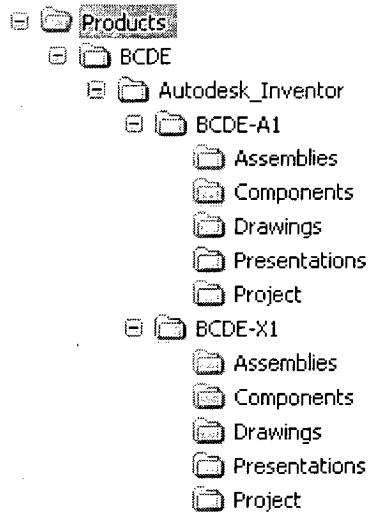


Illustration 42: Example Storage System (Advanced Product)

Customer Processes

Requirements

Determination of Customer Requirements[24]

Item	*Requirement*
1.	Determine the requirements specified by the customer, including requirements for delivery and post delivery activities
2.	Determine requirements not stated by the customer by necessary for the specified or intended use, where known.
3.	Determine the statutory and regulatory requirements related to the product.
4.	Determine any additional requirements required by the organisation.

Table 47: Determination Of Customer Requirements

Review of Customer Requirements

Customer Communication

24 Referenced Directly From AS9001:2000

Design and Development

This section describes the design and development processes related to product realization.

Requirements

Design & Development Planning[25]

Item	*Requirement*
1.	The organization shall plan and control the design and development of product
2.	During the design and development planning, the organization shall determine 1. the design and development stages 2. the review, verification and validation that are appropriate to each design and development stage 3. the responsibilities and authorities for design and development.
3.	The organization shall manage the interfaces between different groups involved in design and development to ensure effective communication and clear assignment of responsibility.
4.	Planning output shall be updated, as appropriate, as the design and development progresses.

Table 48: Design & Development Planning Requirements

25 Referenced Directly From AS9001:2000

Design & Development Inputs[26]

Item	*Requirement*
1.	Inputs relating to product requirements shall be determined and records maintained (see 4.2.4). These inputs shall include 1. functional and performance requirements 2. applicable statutory and regulatory requirements 3. where applicable, information derived from previous similar designs 4. other requirements essential for design and development.
2.	These inputs shall be reviewed for adequacy.
3.	Requirements shall be complete, unambiguous and not in conflict with each other.

Table 49: Design & Development Inputs - Requirements

Design & Development Outputs[27]

Item	*Requirement*
1.	The outputs of design and development shall be provided in a form that enables verification against the design and development input and shall be approved prior to release.
2.	Design and development outputs shall 1. meet the input requirements for design and development 2. provide appropriate information for purchasing, production and for service provision 3. contain or reference product acceptance criteria 4. specify the characteristics of the product that are essential for its safe and proper use.

Table 50: Design & Development Outputs – Requirements

26 Referenced Directly From AS9001:2000
27 Referenced Directly From AS9001:2000

Design & Development Review[28]

Item	*Requirements*
1.	At suitable stages, systematic reviews of design and development shall be performed in accordance with planned arrangements (see 7.3.1)
2.	Evaluate the ability of the results of design and development to meet requirements
3.	Identify any problems and propose necessary actions.
4.	Participants in such reviews shall include representatives of functions concerned with the design and development stage(s) being reviewed. Records of the results of the reviews and any necessary actions shall be maintained (see 4.2.4).

Table 51: Design & Development Review - Requirements

Design & Development Verification[29]

Item	*Requirement*
1.	Verification shall be performed in accordance with planned arrangements (see 7.3.1) to ensure that the design and development outputs have met the design and development input requirements.
2.	Records of the results of the verification and any necessary actions shall be maintained (see 4.2.4).

Table 52: Design & Development Verification - Requirements

28 Referenced Directly From AS9001:2000
29 Referenced Directly From AS9001:2000

Design & Development Validation[30]

Item	*Requirement*
1.	Design and development validation shall be performed in accordance with planned arrangements (see 7.3.1) to ensure that the resulting product is capable of meeting the requirements for the specified application or intended use, where known.
2.	Wherever practicable, validation shall be completed prior to the delivery or implementation of the product. Records of the results of validation and any necessary actions shall be maintained (see 4.2.4).

Table 53: Design & Development Validation - Requirements

Control of Design & Development Changes[31]

Item	*Requirement*
1.	Design and development changes shall be identified and records maintained.
2.	The changes shall be reviewed, verified and validated, as appropriate, and approved before implementation.
3.	The review of design and development changes shall include evaluation of the effect of the changes on constituent parts and product already delivered.
4.	Records of the results of the review of changes and any necessary actions shall be maintained (see 4.2.4).

Table 54: Control of D & D Changes - Requirements

30 Referenced Directly From AS9001:2000
31 Referenced Directly From AS9001:2000

Development Planning

This section describes the planning requirements for a project. The planning stage can only be commenced based on the requirements stated in Project Life Cycle on page 97

Document Storage

Consideration must be given to the types of documents (files) that will need to be stored during the life of the project.

Generally speaking, all documents storage locations should be developed as per the guide lines in General Consideration on page 24

Project Planning

In general every project must be started with a basic project plan, which evolves during phases of the project to eventually be able to track manufacturing and shipment.

The project plan contains:

1. Resources required for the project
2. List of phases
3. List of activities
4. Any relevant mile stones.

As a general guide, A&DM uses Open Workbench (as opposed to Microsoft Project) for maintaining its project plans.

Project Task Websites

A&DM's intranet has a series of sites set up to track each project, its tasks and resources. Once a new project is started the QA officer is required to set up a new task site.

Development Inputs

The development inputs are defined as per the commitment release phase of the project life cycle. Details can be found in CR on page 98.

Evidence that the criteria has been met must be documented and stored in the projects documents folder.

Further Inputs

Further inputs to the project may be in the form of:

- Regulatory Requirements
- Reference Designs
- Prototype Platforms
- Australian or ISO standards
- Drawings
- Specifications
- Competing Products

Where practical documentation must be produced for these inputs and stored in the project's folder.

Qualitative Acceptance

Each input into the design should be accepted based on several criteria, including

- Past performance
- Acceptable To the application(s)
- Cost

The project's description and time line may be changed based on the acceptance of various inputs, even if the quality of such inputs is not immediately realised.

Development Outputs

This section describes the outputs that are to be created during development of a product.

Revision Control

All development outputs must be controlled as per Changes and Revision Control on page 30

Autodesk® Inventor™ Specific Outputs

Drawing Layout

The layout for an Inventor drawing must contain at least 2 pages.

Page 1 must contain:

Item	Description
1	Revision Table
2	Isometric View Of the Component Or Assembly Being Described

Page 2 onwards must contain:

Drawing Requirements

All drawings produced for development / production use must conform to the prescribed company standard. The standard is in place to ensure all drawings carry the minimum amount of detail necessary for someone to re-produce the component or assembly. Drawings that carry the correct information will help expedite manufacture.

The table below details the specific requirements for a drawing.

Item	*Detail*	*Description*
1.	File Name	A drawing must be named correctly as per the file name specification.
2.	Template	A drawing must be produced from the supplied drawing template. Only A3 drawings are acceptable, except in the case of requirements of a competent authority
3.	Parts List[32]	A drawing must contain a list of components / assemblies that are present in the drawing The parts list must contain material information where applicable.
4.	Drawing Revision History Table	Each drawing must contain a revision history table detailing what has been modified on every edit of the drawing. The first revision is revision is revision 1 and should be described as "Initial Revision"
5.	Revision Number	The drawing revision number must be modified to reflect the most current revision entry in the revision table.

Table 55: Drawing Specific Requirements

Drawing Specifics

Autodesk Inventor Drawing templates exist to ensure that all drawing outputs produced in this software package are of an acceptable standard.

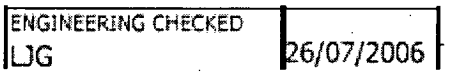
The user editable information is to be configured so as the title block contains relevant and accurate information about the component or assembly being displayed.

DRAWN LJG	26/07/2006	**eQuipment Safety Systems Pty. Ltd.** http://eqss.com.au			
ENGINEERING CHECKED LJG	26/07/2006	Project / Model	**6242R1.2**		
DRAWING QA CHECK LJG	26/07/2006	Component Number	**6242R12-DISP1-105**		
TOLERANCE (UNLESS SPECIFIED)	0.2mm	Component Description	Front Insert		
		Drawing Description	Layout For Acetal Insert		
		SIZE A3	SCALE N.T.S	DWG NO	SHEET 1 OF 1	REV 1

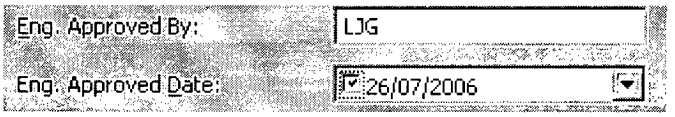
The title block contains the relevant information for a drawing to meet the QA requirements.

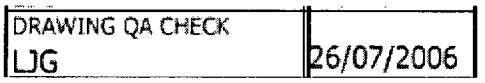
32 Parts list describes a generic list which could describe components, assemblies or library components.

The "Drawn" box contains the initials of who initially drew the document, and the date in which it was drawn. This is automatically entered by Inventor and generally should not be changed.

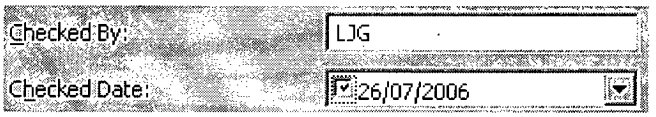


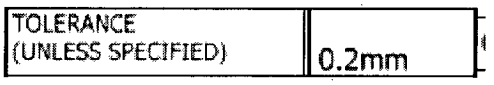
The "Engineering Checked" box contains the initials of the competent person whom checked the drawing (component & assembly) for technical accuracy and completeness. Once approved, this information may be entered into the iProperties of Inventor.



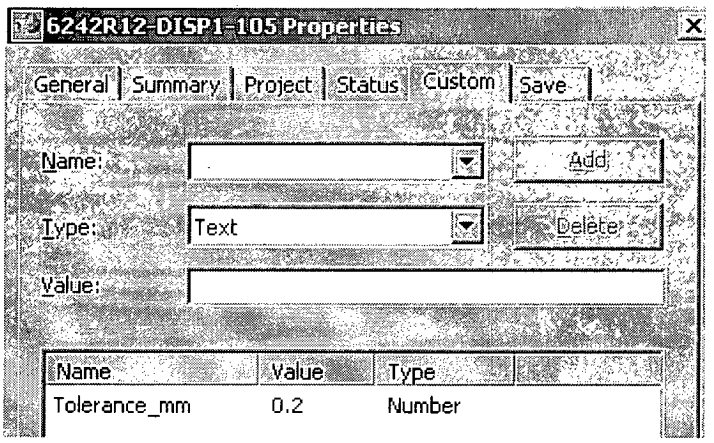


The drawing QA check is to be completed by the QA officer prior to converting the document to PDF and then stamping.





The tolerance statement is set up with the template, this must be added to old drawings via the drawings iProperties.



Development Review

The development review is critical in ensuring the project remains on track and the design outputs (as they progress) will converge towards the final design goal.

Review Frequency

Generally formal design reviews happen once a week, or more frequently during critical phases of the design and development.

Design reviews may be conducted via email which aids in the tracking of vital information.

Review Outputs

In general, each design review should be documented and its outcomes posted to all relevant team members. This can be achieved by means of meeting minutes, or via electronic means, such as email.

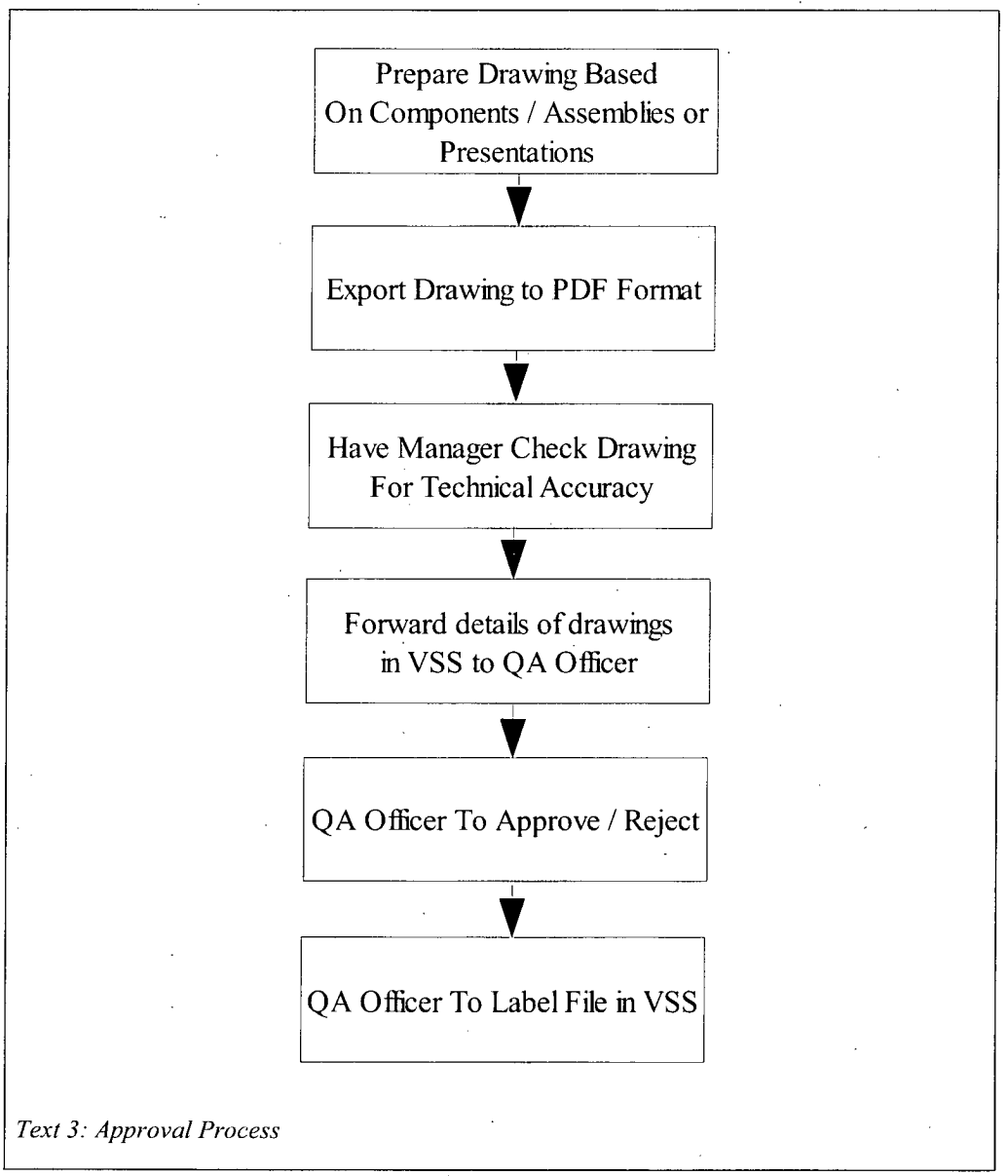
Development Verification

Once the development outputs are in progress, several stages of verification occur to ensure the outputs will function in the greater scheme of things.

Approval of Drawings

Drawings that are produced must be approved before they are release for manufacture. Generally speaking the Quality Assurance officer is responsible for approving drawings.

The approval process is as follows:



Text 3: Approval Process

Control of Development Changes

Development changes are controlled via several means, these include:

- Software, hardware and document / drawing revision numbers
- Version control software
- Reflections in model numbering.

Purchasing

This section describes the requirements and procedures for the purchasing of products, materials or services.

Requirements

Purchasing Process Requirements[33]

Item	*Requirement*
1.	The organization shall ensure that purchased product conforms to specified purchase requirements. See: Verification of Purchased Product on page 131
2.	The type and extent of control applied to the supplier and the purchased product shall be dependent upon the effect of the purchased product on subsequent product realization or the final product.
3.	The organization shall evaluate and select suppliers based on their ability to supply product in accordance with the organization's requirements.
4.	Criteria for selection, evaluation and re-evaluation shall be established.
5.	Records of the results of evaluations and any necessary actions arising from the evaluation shall be maintained.

Table 56: Purchasing Process - Requirements

33 Referenced Directly From AS9001:2000

Purchasing Information[34]

Item	*Requirements*
1.	Purchasing information shall describe the product to be purchased, including where appropriate 1. requirements for approval of product, procedures, processes and equipment, 2. requirements for qualification of personnel, and 3. quality management system requirements. See: Purchasing Process on page 127
2.	The organization shall ensure the adequacy of specified purchase requirements prior to their communication to the supplier.

Table 57: Purchasing Information - Requirements

Verification Of Purchased Product[35]

Item	*Requirements*
1.	The organization shall establish and implement the inspection or other activities necessary for ensuring that purchased product meets specified purchase requirements.
2.	Where the organization or its customer intends to perform verification at the supplier's premises, the organization shall state the intended verification arrangements and method of product release in the purchasing information.

Table 58: Verification of Purchased Product - Requirements

34 Referenced Directly From AS9001:2000
35 Referenced Directly From AS9001:2000

Supplier Selection Criteria

Supplier Selection will be based on the following parameters

Item	*Parameter*
1.	Past Trading History
2.	Relative Geographical Distance From Our Offices
3.	Past Quality Performance
4.	Documented Standards / Quality Certification
5.	Ability to perform the required task
6.	Ability to deliver the required task in a timely manor

Table 59: Supplier Selection Criteria

Performance Records

A record of each suppliers performance must be kept and reviewed as necessary. Generally a review will take place when the QMS is reviewed, or if a QA problem is found with the supplier.

Performance records will exist for each supplier and are stored in Visual Source Safe under vss:\\records\suppliers\performance_records\

A template for performance records exists under vss:\\records\templates\performance_records\

An example of a performance record entry is shown below:

Company Name Name Here

Date	**01/01/06**
Measure	
Past Trading History	0
Geographical Distance	0
Quality Performance	0
Documented Standards	0
Ability To Perform Work	0
Ability To Deliver Work	0
SCORE / 10	**0**

Purchasing Process

This section describes the processes for the purchase of a product, service or material.

Material Purchase

Materials that are purchased (such as Stainless Steel Plate used in Transport Casks) must be correctly identified and records of the purchase must be kept. To simplify this process two procedures are in place.

The first procedure relates to a material ID for components designed in Autodesk Inventor. (See: Materials on page 136).

The second procedure related to actually purchasing the material and the check list's that must be adhered to. The steps described below will assist in purchasing a material and controlling the records of that purchase.

Step 1 – Material Description

The description of the material(s) to be purchased can only come from a Autodesk Inventor drawing[36]. The drawing must meet the following requirements:

Item	*Requirement*
1.	The drawing is provided to the purchasing officer in electronic format.
2.	The engineer requesting the purchase of the material has provided a written request for the materials to be purchased. The description of the material must exactly match the description of the material as stated on the drawing.
3.	The electronic format of that document is PDF format.
4.	The PDF document contains a "Green Stamp" stating that it has been approved for manufacture
5.	The PDF document has not expired, and does not contain any corrections.

Table 60: Material Description

Once the drawing is provided to the purchasing officer, it is up to the purchasing officer to generate a written purchase order in the companies format and to ensure that the details of the material being purchased is exactly that as stated on the supplied documents.

36 In some situations it may be a requirement of the supplier that they reproduce a drawing in their own format which is a representation of the supplied drawing. In such a case, both our original drawing and the suppliers reproduced drawing must be provided.

Example

The example below shows an email written to the purchasing officer stating a request for materials, and an accompanying drawing.

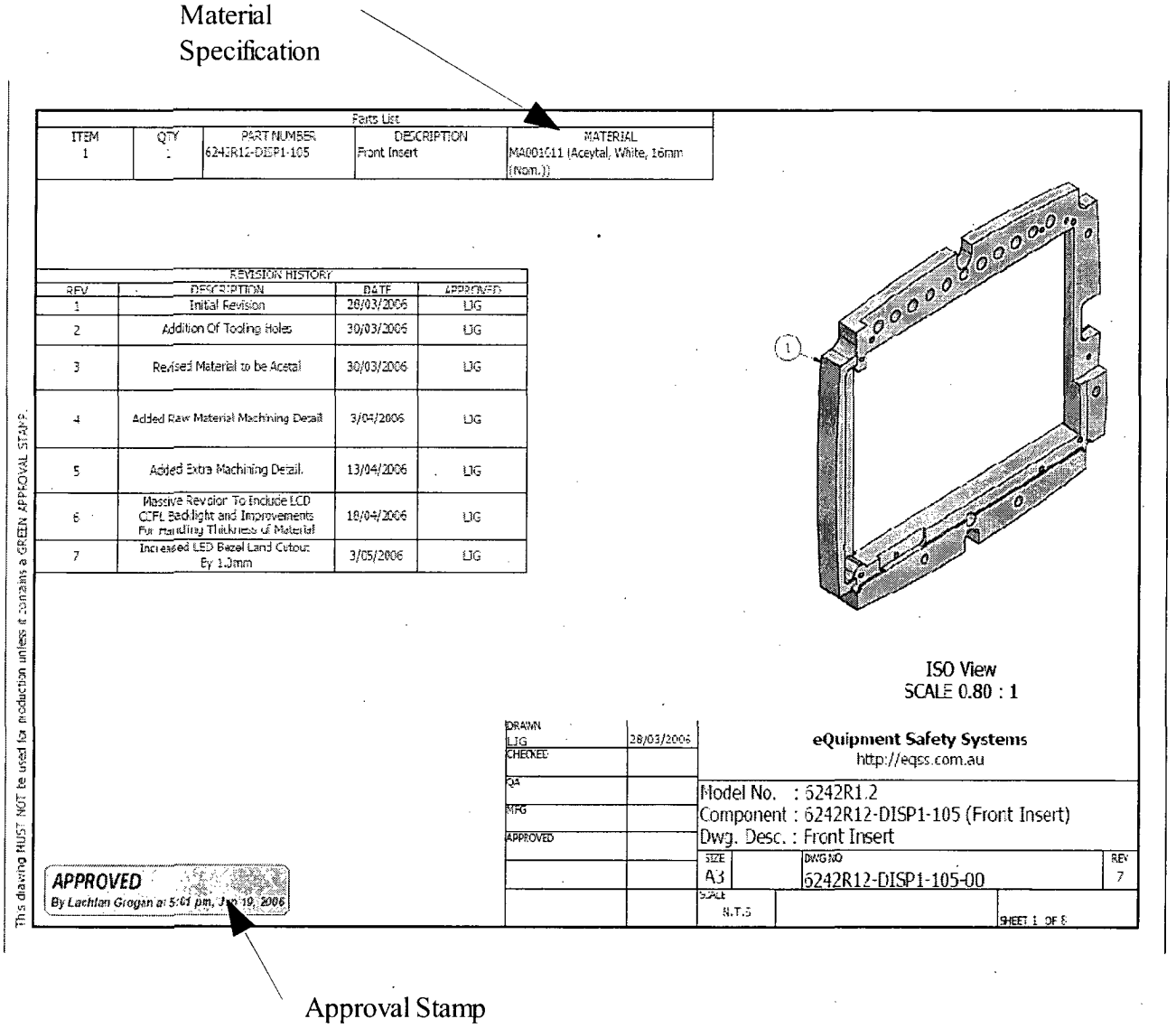


Illustration 43: Example Drawing Format

Step 2 – Purchase Order

Once the purchase order has been completed it must be re-produced in electronic PDF format. The purchase order, along with the electronic copies of the documents must be forwarded to the QA officer at which point if the documentation is correct, the QA officer will issue a green stamp on the purchase order. At this point the purchase order may be sent to the supplier.

The line numbers on a purchase order must reflect the PR number as detailed below.

An example purchase order is shown below that meets the requirements.

PURCHASE ORDER # 00004607

A Noble & Sons
135 South Gippsland Highway

SHIP TO:

Analogue & Digital Measurements Pty Ltd
27 Cumberland Drive
Seaford, 3198
Victoria Australia

SALESPERSON	YOUR NO.	SHIP VIA	SHIP DATE	TERMS	DATE
	----------			Net 30th after EOM	20/06/20

LINE NUMBER	QTY	DESCRIPTION	UNIT PRICE	DISC %	PRICE
PR001	1	STAINLESS STEEL POCKET	$500.00		$500.00
PR002	5	STUDS	$12.50		$62.50
PR003	10	SWITCH BODIES	$25.00		$250.00
PR004	2	STICKERS	$60.00		$120.00

Text 4: Example Purchase Order

Step 3 – Storage Of Records

Once the QA officer has issued a green stamp on the purchase order, the details of each item in each purchase must be stored in an appropriate folder from within Visual Source Safe.

The next step is to allocate a unique purchase record number to each line item in the purchase order. A spreadsheet has been set up for this purpose and can be found under vss:\\vss_records\purchasing\number_allocation\

An example line entry for the records spread sheet is located below.

PR Number	P.O Number	Line Number	Date	Supplier Name	Description
PR000	1234	1	19/06/06	Lachlan Grogan	Test Entry

Once the Purchase Record number has been allocated in the spread sheet, a folder must be created using the format Prxxx, where xxx is the sequence number.

Copies of the purchase order, along with the files that were used to generate the purchase order must be placed in this folder and checked into Visual Source Safe.

Verification of Purchased Product

Once a product, material or service has been purchased, it is important to verify that the purchased product meets the requirements as stated in the purchase order and that records are kept as evidence.

There are two methods for verification:

1. When the material from a supplier is delivered directly to another supplier (i.e. Plate steel delivered to the laser cutter).
2. When material is delivered directly to our premises.

Verification Records

Records for the verification of purchased products must be kept.

Templates exist for record keeping, and a template MUST be used at all times. When a template does not exist, it is the policy of this quality manual that a review takes place and a new template is created.

Once the Quality Record Template is filled in (either by us, or the supplier), the information must be returned, scanned, and stored in Visual Source Safe in the purchase record number (PR) folder for which the verified product was ordered.

Verification Of Materials

A Quality Record Template (QRT) exists for verification of materials. The details of the QRT Are:

Item	*Description*
QRT Number	QRT001
Location	VSS:\\records\\templates\quality_record\templates\

Identification

Purchased materials must be labelled in a manor where the label can not inadvertently be destroyed.

Internal Part Number Allocation

When a product, service or material is brought in from the outside it is allocated an internal Brought In Part number.

This number allows us to use a product, service or material in a product and not only ensure continuity with the supplier but to ensure that the purchased product meets the requirements of the engineering department.

Part Number Database

A record of the internal part number allocations is recording in a database which can be accessed via the Company Web internal website

Access The Database

To access the database open up a web browser and go to the company web, by typing "company web" into the address bar.

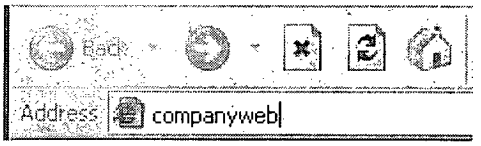


Illustration 44: Access Company Web

From the Links column on the right of the page select "Parts Database"

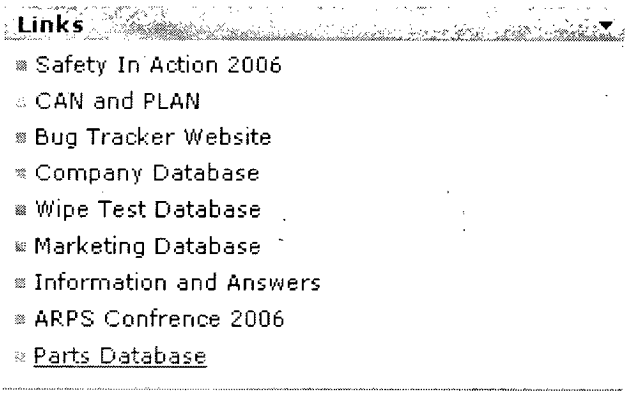


Illustration 45: Access Parts Database

This will open the parts database interface.

Add a Part

To add a new part to the database select "Add Part" from the left column.

The main window will open with a new part record.

Enter a part number as described below in Number Format.

Fill in the remaining details and click Update to store the new part to the database.

Find a Part

To find a part in the parts database select "View Parts" from the left column.

The main window will open a table listing all part records.

Select the desired part category from the Part Type drop down box.

Select the part from the table to view or modify the part details.

Delete a Part

Only delete a part if it was created in error, such as a wrong Part Number was assigned, or if it will no longer be used.

To delete a part open up it's part record window and click delete. A window will pop up asking you to confirm the deletion.

You can not delete a part if it is included in an assembly's bill of materials. Remove the part from all BOM's then delete it.

Number Format

Each brought in part (which differs from a product part number) will be assigned a part number with the following attributes

- category prefix – As described below in Component Categories
- 3 digit version / revision number
- 3 digit ID which is unique to each category

Example

An example of a fastener is

FA001037

With category prefix FA revision number 001 and unique ID 037.

Component Categories

Prefix	*Description*
FA	Fasteners and related hardware including bolts, nuts, washers, roll pins, set screws, etc.
BE	Bearings
LC	Load Cell Transducers including load cells, pressure, strain, etc.
SE	General sensors including length, angle, etc.
MA	Materials
CA	Capacitors
CN	Connectors
EN	Enclosures
OP	Optical Components, LEDS, Displays, etc.
PO	Power Components
RE	Resistors
SE	Sealing Components, O-Rings, etc.
IC	Semiconductors
SW	Switches
HW	Miscellaneous Hardware
PB	Printed Circuit Board
CB	Cable
ME	Mechanical
MT	Manufacturing
AU	Audio Components
DO	Documentation and Manuals

Table 61: Part Number Category Prefixes

Materials

Materials (especially when defined in Autodesk Inventor) are virtual components, meaning that they are assigned a reference, but there is no specific component associated with the material.

Each material used in Autodesk Inventor must be assigned a unique material ID (From the parts database), and that ID must be entered in the style library and the parameters of the material correctly adjusted.

Assemblies and Bill Of Materials

When a new product is created from a set of brought in parts, it must be recorded in the parts database as a new assembly.

This will generate a Bill Of Materials (BOM) for that assembly, which is used in purchasing components.

Add an Assembly

To add a new assembly to the database select "Add Assembly" from the left column.

The main window will open with a new assembly record.

Enter the Assembly Number as described above in Number Format except with the prefix 'AS'. All assemblies must have the prefix 'AS'.

Fill in the remaining assembly details and click 'Update'.

Find an Assembly

To find an assembly in the parts database select "View Assemblies" from the left column.

The main window will open a table listing all assembly records.

Select the assembly from the table to view or modify the assembly details or the assemblies Bill Of Materials.

Bill Of Materials

Each assembly has a bill of materials which lists the parts and sub-assemblies it is made of.

The bill of materials can be accessed by open the assembly record and clicking 'Bill Of Materials'.

The Bill Of Materials page contains a list of all the items that belong to that assembly.

Listed for each item is

- Item Number – Either Part Number or Sub-Assembly Number
- Quantity – The amount of the item in the assembly
- Description – A listing of the description field for each item
- Type – Whether the item is a part or a sub-assembly

Add Item

When an assembly is first created it's BOM is empty, to add items to the assembly click either 'Add Part' or 'Add Sub-Assembly'.

The item record screen will not list items that are already listed in the assembly's BOM.

Add Part

Clicking on the 'Add Part' button will open the part records screen, allowing you to add a new part to the BOM.

Select the desired part type from the drop down box and navigate through the records using the page numbers at the bottom of the page.

Once the part has been found click it to add it to the BOM.

Add Sub-Assembly

Clicking on the 'Add Sub-Assembly' button will open the sub-assembly records screen.

This will list other assemblies which can be added to the assembly as a sub-assembly.

Sub-assemblies that would result in a Circular Reference Error if they were added to the assembly are not listed.

Navigate through the sub-assembly records using the page numbers at the bottom of the page, once the sub-assembly has been found click it to add it to the BOM.

Modify Quantity

Once an item has been added to the BOM it's quantity is set to 1. If there is more one of this item in the assembly change it's quantity field to the proper amount and press Enter.

Remove Item

To remove an item from the BOM set it's quantity to 0 and press Enter. Once the page has finished loading the item will disappear.

Save As CSV

To generate a top level BOM for all parts in the assembly and all sub-assemblies click 'Save As CSV' and a file download window will pop-up.

This will generate a Comma Separated Values (CSV) file which can be opened with most spreadsheet programs.

If the download window does not have an Open button then the windows file associations have not been set-up for CSV. The following instructions assume that the file associations for CSV have been set as described in Setting Windows File Associations.

Click Open to open the file with OpenOffice Calc. A Text Import window will open up, click OK to continue.

The CSV BOM consists of 5 columns and a variable number of rows.

The first row contains the assembly number for this BOM.

The remaining rows list the parts in the BOM.

Each row contains the following columns

- Number – This is the Part Number of the component
- Description – This is the part description, according to the part record
- Quantity – This is the total quantity of the part including sub-assemblies
- Cost (Each) – This is the cost of the part, according to the part record
- Cost (Total) – This is the cost of the part given the quantity specified

The last row lists the total number and cost of the parts that make up this assembly.

Setting Windows File Associations

To set the file association for CSV file to open in OpenOffice, follow the procedure below.

1. Open up windows explorer by holding Win + E or another method.
2. Select Tools -> Folder Options...
3. Select the File Types tab
4. Click New
5. Enter CSV into the File Extension field and click OK
6. Select CSV from the extensions column and click Change...
7. Click Select the program from a list and click OK
8. Find and select OpenOffice.org 2.0 in the programs list and click OK
9. Click Close and close windows explorer.
10. The file association has now been set.

Circular Reference Error

When a BOM is generated for an assembly, the procedure below is followed.

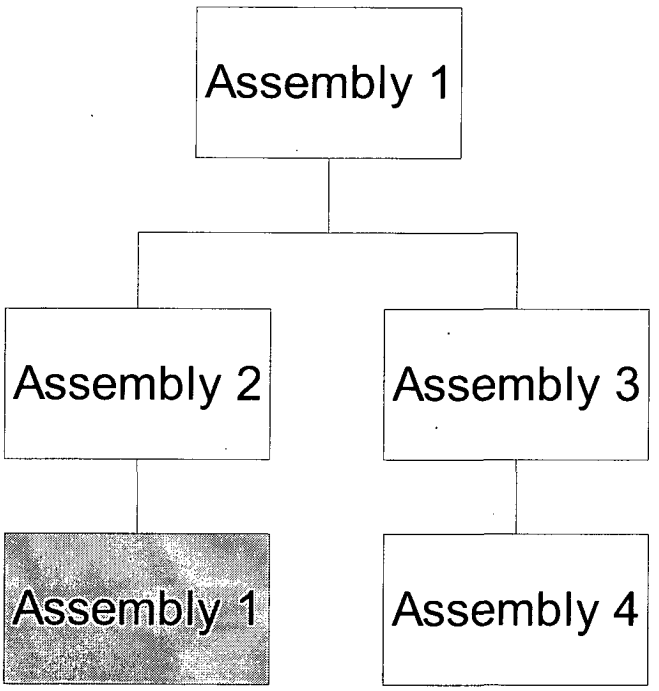
1. First the parts of the assembly are added to the BOM list
2. If the assembly has sub-assemblies, the parts of each sub-assembly are added to the BOM list.
3. If those sub-assemblies have sub-assemblies of their own, the parts of those sub-assemblies are added to the BOM list.
4. Step 3 is repeated until there are no more sub-assemblies

A circular reference error occurs when an upper level assembly is added to a lower level assembly. When a BOM of parts is generated it continues to count the number of parts going round in a circle from the upper level assembly to the lower level assembly then back up to the top level assembly.

The parts database stops this from happening by hiding all upper level assemblies from an assembly.

The example below illustrates the circular reference problem.

The following drawing shows the structure of 4 assemblies.



Drawing 1: Circular Reference Example

From the drawing it can be seen that Assembly 2 can add as sub-assemblies Assembly 3 and Assembly 4 but not assembly 1 which would cause a circular reference as shown by the red Assembly 1 box.

It should also be noted that Assembly 4 can add Assembly 2 as a sub-assembly

since it is not a direct upper assembly.

However if Assembly 2 was added to Assembly 4, Assembly 2 could no long add Assemblies 3 and 4 as sub-assemblies.

Production And Service

Requirements

Control of Production and Service Provision[37]

The organisation shall plan and carry out production and service provision under controlled conditions. Controlled conditions shall include, as applicable

Item	*Requirement*
1.	The availability of information that describes the characteristics of the product.
2.	The availability of work instructions, as necessary.
3.	The use of suitable equipment,
4.	The availability of monitoring and measuring devices.
5.	The implementation of monitoring and measurements
6.	The implementation of release, delivery and post delivery instructions.

Table 62: Requirements - Control of Production and Service

37 Referenced Directly From AS9001:2000

Validation of Processes for Production and Service provision[38]

The organisation shall validate any processes for production and service provision where the resulting output cannot be verified by subsequent monitoring or measuring. This includes any processes where deficiencies become apparent only after the product is in use or the service has been delivered.

Validation shall demonstrate the ability of these processes to achieve planned results.

Item	*Requirement*
1.	Defined criteria for review and approval processes
2.	Approval of equipment and qualification of personnel
3.	Use of specific methods and procedures
4.	Requirements for records. See Control of Records on Page 51
5.	Revalidation

Table 63: Requirements - Validation or Processes

Identification and Traceability[39]

Item	*Requirement*
1.	Where appropriate, the organisation shall identify the product by suitable means throughout the product realisation process.
2.	The organisation shall identify the product status with respect to the monitoring and measuring requirements.
3.	Where traceability is a requirements, the organisation shall control and record the unique identification of the product as per Control of Records on Page 51

Table 64: Requirements - Identification & Traceability

38 Referenced Directly From AS9001:2000
39 Referenced Directly From AS9001:2000

Customer Property[40]

The organisation shall exercise care with customer property while it is under the organisations control or being used by the organisation. The organisation shall identify, verify, protect and safeguard customer property provided for use or incorporation into the product. If any customer property is lost, damaged or otherwise found to be unsuitable for use it shall be reported to the customer and records maintained as per Control of Records on Page 51.

Customer property can include intellectual property.

Preservation of Product[41]

The organisation shall preserve the conformity of the product during internal processing and delivery to the intended destination. This preservation shall include identification, handling, packaging, storage and protection. Preservation shall also apply to the constituent parts of a product.

40 Referenced Directly From AS9001:2000
41 Referenced Directly From AS9001:2000

Control of Monitoring and Measuring Devices[42]

Item	*Requirement*
1.	The organisation shall determine the monitoring and measurement to be undertaken and the monitoring and measuring devices needed to provide evidence of conformity of product to determined requirements.
2.	The organisation shall establish processes to ensure that monitoring and measurement can be carried out and are carried out in a manner that is consistent with the monitoring and measurement requirements.
3.	Where necessary to ensure valid results, measuring equipment shall: 1. Be calibrated or verified at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded. 2. Be adjusted or re-adjusted as necessary. 3. Be identified to enable the calibration status to be determined 4. Be safeguarded from adjustments that would invalidate the measurement result. 5. Be protected from damage and deterioration during handling, maintenance and storage.
4.	In addition, the organisation shall assess and record the validity of the previous measuring results when the equipment is found not to conform to the requirements. The organisation shall take appropriate action on the equipment and any product affected. Records of the calibration and verification shall be maintained.
5.	When used in monitoring and measurement of specified requirements, the ability of computer software to satisfy the intended application shall be confirmed. This shall be undertaken prior to initial use and reconfirmed as necessary.

Table 65: Requirements - Control of Measuring devices

42 Referenced Directly From AS9001:2000

Quality Assurance Inspection, Component Failure

Realization of Component Failure

Any component that does not meet the Quality Assurance dimensions, or specific requirements as nominated by its corresponding Green Stamp Approved technical drawing fails QA.

An A&DM Quality Assurance Failure certificate is be filled with the component drawings attached to the rear of the certificate. The certificate, drawings and component are to be placed in a zip lock bag and moved to the nominated component quarantine area where a course of action is formulated by the QA officer

Course of Action

When a component is in QA quarantine it is the duty of the QA officer to determine the course of action. There are three possibilities to consider

1. Remedial work is carried out by A&DM. This is limited to minor work such as de-burring, thread depth correction, minor hole diameter correction etc.

2. Deficiencies are discussed with the subcontractor, and methods of correction are discussed and a plan of action formulated. After rework is finished the parts are QA'd with special attention to the specific areas of correction.

3. If a parts QA criteria can not be accommodated with rework by A&DM or the subcontractor, or if the cost of rework out weighs the cost of the component. The component is condemned and disposed of. The reason for the failure of the component to meet the quality standard is analysed and the production processes that require variation are determined, and technical drawings are modified to reflect the changes.

QA Component Failure Certificate

Analogue & Digital Measurements P/L
ABN: 57 005 531 484

http://admeasure.com.au
sales@admeasure.com.au

27 Cumberland Drive
Seaford, 3198
Victoria Australia

Ph: 03 8770 6500
Fax: 03 8770 6590

QA COMPONENT FAILURE CERTIFICATE

This Quality Assurance component failure certificate is to be used for components that do not meet the QA dimensions or specific requirements as nominated by its corresponding green stamp approved technical drawing.

DATE OF INSPECTION	**COMPONENT SERIAL NUMBER**
QA INSPECTOR	
	COMPONENT DRAWING NUMBER
INSPECTOR SIGNATURE	

REASON FOR COMPONENT FAILURE

SUGGESTED ACTION

Rework by A&DM.	
Rework by Subcontractor.	
Dispose of Component.	

Note 1. The component drawings are to be attached to the rear of this certificate.

Note 2. Component, Certificate & Drawings to be sealed in zip lock back.

Note 3. To be placed in the A&DM component quarantine area.

Customer Property

As a matter of policy A&DM does not accept any customer property without:

1. A purchase order stating what work or function the customer's property is to have conducted on it.
2. Where A&DM is required to hold customers property which is radioactive (storage) in nature, special agreements are formed on a per contract basis.

Customer property may be in the form of intellectual property. In this case electronic security measures are in place to safeguard and control this information.

Preservation Of Product

This section discusses the necessary steps for:

- Identification and storage of materials
- Identification and storage of components.

Materials

Materials which are purchased for use in the manufacture of products must be correctly identified and stored while on our premises. It is up to the supplier of a material to ensure that their control methods are adequate.

In general, all materials which are delivered to our premises must be labelled with the purchase record (PR) number on which they were ordered.

Details of the PR numbering may be found in Purchasing Process on page 127

Service Testing

Currently Being Reviewed.

Measuring Devices

Requirements

Control of Monitoring and Measuring Devices[43]

Item	*Requirement*
1.	The organisation shall determine the monitoring and measurement to be undertaken and the monitoring and measuring devices needed to provide evidence of conformity of product to determined requirements.
2.	The organisation shall establish processes to ensure that monitoring and measurement can be carried out and are carried out in a manner that is consistent with the monitoring and measurement requirements.
3.	Where necessary to ensure valid results, measuring equipment shall. 1. Be calibrated or verified at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded. 2. Be adjusted or re-adjusted as necessary. 3. Be identified to enable the calibration status to be determined 4. Be safeguarded from adjustments that would invalidate the measurement result. 5. Be protected from damage and deterioration during handling, maintenance and storage.
4.	In addition, the organisation shall assess and record the validity of the previous measuring results when the equipment is found not to conform to the requirements. The organisation shall take appropriate action on the equipment and any product affected. Records of the calibration and verification shall be maintained.
5.	When used in monitoring and measurement of specified requirements, the ability of computer software to satisfy the intended application shall be confirmed. This shall be undertaken prior to initial use and reconfirmed as necessary.

Table 66: Requirements - Control of Measuring devices

43 Referenced Directly From AS9001:2000

Measurement, Analysis and Improvement

Requirements

General[44]

The organisation shall plan and implement the monitoring, measurement, analysis and improvement processes needed

Item	*Requirement*
1.	To demonstrate conformity of the product
2.	The ensure conformity of the quality management system
3.	The continually improve the effectiveness of the quality management system
4.	Include determination of applicable methods, including statistical techniques and the extent of their use.

Table 67: Requirements - General

44 Referenced Directly From AS9001:2000

Monitoring and Measurement

As one of the measurements of the performance of the quality management system, the organisation shall monitor information relating to customer perception as to weather the organising has met customer requirements. The methods for obtaining and using this information shall be determined.

Internal Audit

The organisation shall conduct internal audits at planned intervals to determine whether the quality management system conforms to the planned arrangements and to the quality management system requirements established by this organisation; and is effectively implemented and maintained.

Monitoring and Measurements

Customer Satisfaction

Please see Customer Focus on page 66.

Internal Audits

Internal audits are conducted at regular intervals by all levels of the company to ensure that the products and services being offered meet the stated design requirements and that any changes to standards covering these products or services are addressed.

The companies procedures are audited, along with any industry specific regulations or contractual requirements.

Basic Procedures

The basic procedures for an internal audit of a product, service or quality management system is:

1. Organise a meeting between management parties (either face to face or electronically).
2. Discuss and resolve any current concerns about products, services or quality level objectives that are not being met.
3. Discuss what changes need to be made to the QMS
4. Document and record results.

Monitoring and Measurement of Processes

Many of the processed used at A&DM require the use of outside labour or machinery or services.. These include:

- Mechanical machining
- Mechanical Assembly
- PCB assembly
- Automated PCB loading
- Web hosting and data services
- Plastic Moulding
- Supply of various materials

The quality procedures for each outside process ensures that problems that may occur can be dealt with.

Monitoring and Measurement of Product

Critical to the success of the company, is the performance of its products to meet its customer's expectations.

Improvement

This section covers the improvements to a product or service that may be gained as a result of an effective QMS.

Continual Improvement

Corrective Action

There are many situations when corrective actions need to be performed after a product is manufactured. These fall into the categories of:

1. Hardware Failures
2. Software Failures
3. Documentation Deficiencies
4. Operational Deficiencies

Hardware Failures

In general, hardware failures are among the most common failures in products that A&DM designs and manufactures.

Hardware failures fit into the following groups

1. Minor feature failure, such as a blown light globe
2. Major defect, such as a faulty PCB
3. Wiring failure, such as a damaged cable and connector.

Whenever A&DM learns about a hardware failure the following items take place.

1. The design team is alerted to the problem
2. The design team will try and re-create the problem on its simulation platforms.
3. The the defect can be repaired by the customer an instruction will be issued on a per customer basis.
4. The details on the defect and possible solutions will be added to the "trouble shooting" section of the manual.
5. Future thought will be placed to avoiding the defect in future manufacturing runs.

Software Failures

Software failures usually result in total or partial loss of functionality of the product or service on offer. Software failures are generally a result of:

1. Customer setting invalid configurations
2. A software bug
3. Software not performing to its stated objectives.

When A&DM learns about a software failure its design team will.

1. Re-create the failure on its simulation platform.
2. Attempt to fix the software
3. Update the customer with new firmware
4. Update the necessary technical documentation.
5. Ensure that all products leaving A&DM will contain the future revision of software.

Documentation Deficiencies

Documentation Deficiencies are generally found by the customer. When a documentation deficiencies is found, A&DM will move quickly to update the customer (generally via electronic means) with enough information to prevent them from incurring any further delays.

A&DM will then move quickly to update its documentation, including web references if necessary.

Customers on a documentation list will also receive updates.

Preventative Action

By default, A&DM takes large amounts of preventative action to ensure that the quality of its products always remains high.

The following methods are used:

1. Past performance data, (design revisions)
2. Mechanical simulation of components, Finite Element Analysis, to detect early failures of products
3. Software and hardware co-simulation to test hardware systems over various conditions (temperature and power fluctuations) before the product is built.
4. Testing of new designs in the factory, followed by pre-production systems being delivered to customers for trial.

Management Of Non-Conformities

currently being reviewed

Indexes

Alphabetical Index

A
ABN (Australian Business Number) 52
Allocation
Allocation - Model Numbers 100
Approval
Approval Requirements Document 27
C
Changes
Changes and Revision Control 30
Circular Reference 141
Control
Control of Documents 23
D
Documentation
Document - Approval Requirements 27
Documents
Document Control 23
M
Model Numbers
Model Number Allocation 100
O
Open Standards
Open Standard Policy 23
R
Revision Control
Changes and Revision Control 30
Visual Source Safe 30
V
Visual Source Safe 30
VSS (Visual Source Safe) 53

Illustration Index

Illustration 1: Web Site Image 18
Illustration 2: Standard Directory Structure 25
Illustration 3: Visual Source Safe Administration 26
Illustration 4: Example Approval Mark 27
Illustration 5: Connecting to VSS Database 31
Illustration 6: Set Working Directory - Step 1 32
Illustration 7: Set Working Directory - Step 2 32
Illustration 8: Set Working Directory - Step 3 33
Illustration 9: Create Project - Step 1 34
Illustration 10: Create Project - Step 2 34
Illustration 11: Create Project - Step 3 35
Illustration 12: Create Project - Step 4 35
Illustration 13: Create Project - Step 5 35
Illustration 14: Create Directory - Step 1 36
Illustration 15: Create Directory - Step 2 37
Illustration 16: Create Directory - Step 3 37
Illustration 17: Adding Folder - Step 1 37
Illustration 18: Adding Folder - Step 2 38
Illustration 19: Adding Folder - Step 3 38
Illustration 20: Adding Folder - Step 4 38
Illustration 21: Add File - Step 1 39
Illustration 22: Add File - Step 2 39
Illustration 23: Add File - Step 3 40
Illustration 24: Add File - Step 4 40
Illustration 25: Add File - Step 5 41
Illustration 26: Add File - Step 6 41
Illustration 27: Add File - Step 7 41
Illustration 28: Add File - Step 8 42
Illustration 29: Check Out - Step 1 42
Illustration 30: Check Out - Step 2 42
Illustration 31: Check Out - Step 3 43
Illustration 32: Check In - Step 1 43
Illustration 33: Check In - Step 2 43
Illustration 34: Check In - Step 3 44
Illustration 35: Version History - Step 1 44
Illustration 36: Version History - Step 2 45
Illustration 37: Version History - Step 3 45
Illustration 38: Version History - Step 4 45
Illustration 39: Version History - Step 5 46
Illustration 40: Management Structure 74
Illustration 41: Example Storage System (Simple) 109
Illustration 42: Example Storage System (Advanced Product) 110

Illustration 43: Example Drawing Format..... 128
Illustration 44: Access Company Web..... 133
Illustration 45: Access Parts Database..... 133

Index of Tables

Table 1: Document Revision History 3
Table 2: Issue Control History 4
Table 3: QMS - General Requirements 16
Table 4: General Requirements 19
Table 5: Quality Manual Requirements 20
Table 6: Control Of Documents - Requirements 21
Table 7: Control Of Records - Requirements 22
Table 8: General Considerations - Document Types 24
Table 9: Distribution Control - Requirements 26
Table 10: Document Approval Requirements 27
Table 11: Approval Check List 28
Table 12: VSS Databases 31
Table 13: VSS Working Directories 32
Table 14: VSS Shadow Folders 33
Table 15: VSS - Example Directory Structure 36
Table 16: Document Structural Requirements 53
Table 17: Document Headings 54
Table 18: Structure Requirements - Captions 55
Table 19: Structure Requirements - Cross References 55
Table 20: Bibliography's 57
Table 21: Management Commitment - Requirements 58
Table 22: Customer Focus - Requirements 58
Table 23: Quality Policy - Requirements 59
Table 24: Planning - Quality Objectives 59
Table 25: Planning - Quality Management System Planning 59
Table 26: Responsibility, Authority & Communication - Responsibility & Authority Requirements 60
Table 27: Responsibility, Authority & Communication - Management Representative Requirements 60
Table 28: Responsibility, Authority & Communication - Internal Communication Requirements 60
Table 29: Management Review - General Requirements 61
Table 30: Management Review - Review Input Requirements 61
Table 31: Management Review - Review Output Requirements 62
Table 32: Management Representative - QMS Requirements 67
Table 33: Provision of Resources - Requirements 70
Table 34: Human Resources - General Requirements 70
Table 35: Human Resources - Competence, Awareness & Training Requirements 71
Table 36: QA Programme - Target Areas 72
Table 37: QA Programme - Authority 73
Table 38: Product Planning Requirements 96

Table 39: Company_Categories.....100
Table 40: Example Series Numbers.....100
Table 41: Model Numbers - Example.....101
Table 42: VSS databases.....101
Table 43: Date Code Table.....102
Table 44: Serial Number Spreadsheet Requirements.....103
Table 45: Product Number Allocation Terminology.....105
Table 46: Product Folders.....110
Table 47: Determination Of Customer Requirements.....111
Table 48: Design & Development Planning Requirements.....112
Table 49: Design & Development Inputs - Requirements.....113
Table 50: Design & Development Outputs - Requirements.....113
Table 51: Design & Development Review - Requirements.....114
Table 52: Design & Development Verification - Requirements.....114
Table 53: Design & Development Validation - Requirements.....115
Table 54: Control of D & D Changes - Requirements.....115
Table 55: Drawing Specific Requirements.....119
Table 56: Purchasing Process - Requirements.....124
Table 57: Purchasing Information - Requirements.....125
Table 58: Verification of Purchased Product - Requirements.....125
Table 59: Supplier Selection Criteria.....126
Table 60: Material Description.....127
Table 61: Part Number Category Prefixes.....136
Table 62: Requirements - Control of Production and Service.....143
Table 63: Requirements - Validation or Processes.....144
Table 64: Requirements - Identification & Traceability.....144
Table 65: Requirements - Control of Measuring devices.....146
Table 66: Requirements - Control of Measuring devices.....150
Table 67: Requirements - General.....151

Bibliography

IAEA requirement	A&DM response	ARPANSA comment
QUALITY ASSURANCE PROGRAMMES		
Organization and structure of the quality assurance programme		
The quality assurance programme should be prescribed in a document describing • the structure and overall composition of the quality programme	See ADM Quality Manual Quality Management System on page 15 See Also: Model 1860 Transport Cask Manual "Quality Assurance Programme" section "Structure Composition"	
• The document should include or make reference to the necessary procedures and/or instructions, and describe the way in which they combine to form the overall quality programme	See ADM Quality Manual Quality Management System on page 15 See Also: Model 1860 Transport Cask Manual "Quality Assurance Programme" section "QAP – Design" and onwards	
• the program should cover all activities of the company related to the safe transport of radioactive materials and compliance with the IAEA Regulations.	See Also: Model 1860 Transport Cask Manual "Quality Assurance Programme" also see "Radiation Protection Programme"	
Included in the quality assurance programme must be the company's quality policy statement which clearly reflects the commitment of senior management to the attainment and continuous improvement of quality, and to compliance with applicable regulations.	See ADM Quality Manual Quality Management System on page 15 See Also: Model 1860 Transport Cask Manual "Quality Assurance Programme"	
Documenting the quality assurance programme		
All constituent parts of the quality assurance programme developed and maintained by the company should be systematically produced in the form of appropriate written documents.	See ADM Quality Manual Accessing the Quality Manual on page 18 See Also: Model 1860 Transport Cask Manual "Quality Assurance Programme"	
Review and evaluation of the quality assurance programme		

Provision should be made by the company management for periodic review and evaluation of the quality assurance programme. These reviews should ensure that the quality assurance programme continues to be effective and appropriate to the company's activities, and that the quality policy objectives continue to be met. The results of such reviews should be documented and appropriate action taken by company management.	See ADM Quality Manual Management Reviews on page 64	

IAEA requirement	A&DM response	ARPANSA comment
ORGANISATION		
Responsibility and authority		
A clearly defined and documented organizational structure, complete with functional responsibilities, levels of authority and lines of internal and external communication, should be established. The organizational structure and functional assignments should recognize that application of a quality assurance programme is the responsibility of management, of those performing the work and of those verifying the effectiveness of the management processes involved. It is binding on everyone and is not the sole domain of any single group. The organizational structure and the functional assignments should be such that: • Attainment of quality objectives is accomplished by those who have been assigned responsibility for performing the work; this may include examination, checks and inspections of the work by the individuals performing the work; and • When verification of conformity to established requirements is necessary, it is carried out by those who do not have direct responsibility for performing the work.	See ADM Quality Manual Resource Management on page 70 See Also: Model 1860 Transport Cask Manual "Quality Assurance Programme" section "Responsibilities of the Engineers"	Structure and functional responsibilities defined in the application,
The persons and organizations ensuring that an appropriate quality assurance programme is established and effectively applied should have sufficient authority and organizational freedom to identify quality problems, to review all pertinent information and to initiate, recommend or provide solutions. Such persons or organizations should also have the authority to initiate actions to control further processing, delivery, installation or use of an item, package, process, or part of the quality assurance programme which is non-conforming, deficient or unsatisfactory until proper compliance has been achieved. They should be sufficiently independent of cost and schedule considerations.	See ADM Quality Manual on page See Also: Model 1860 Transport Cask Manual "Quality Assurance Programme" section "Responsibilities of the Engineers"	
Contract review		
Documented procedures should be established to ensure that contracts, orders or tenders placed between those different participating organizations in transport are reviewed for their adequacy and accuracy; any subsequent changes should be similarly reviewed and passed to the relevant parts of those organizations concerned.	See ADM Quality Manual Management Review on page 68 See Also: Management Commitment on page 63 See Also: Management Review on page 68	Contractors issue addressed in the application

Organisational interfaces		
The quality assurance programme and associated procedures should provide for the documented recognition and control of interfaces, both internal and external, wherever they occur.	See Resource Management on page 70	
Where several organizations are involved in a transport operation, the responsibility of each organization should be clearly established, and interfaces and co-ordination among organizations should be achieved by appropriate measures, with provision made for regular review and amendment when necessary.	See Model 1860 Transport Cask Manual. "Quality Assurance Programme" section "organisational interfaces"	

IAEA requirement	A&DM response	ARPANSA comment
DOCUMENT CONTROL		
Document preparation, review and approval		
The preparation, review, approval and issue of documents essential to the performance and verification of the work, such as instructions, procedures and drawings (these may be held in hard copy or other media such as computer disk or microfilm), concerned with all activities affecting quality of design, manufacture, use, etc., of the packaging and transport operations, should be subject to control. Instructions, procedures and drawings should include appropriate qualitative and quantitative acceptance criteria for determining that important activities have been satisfactorily accomplished. Documents should be independently (of the original author) reviewed to ensure they meet the company's technical and quality requirements, and should be approved prior to release. Individuals and organizations responsible for document review and approval should be clearly identified and should have the necessary authority.	See ADM Quality Manual Documentation Requirements on page 19 See Also: Document Approvals on page 27	Verification of work described in the application
Document release and distribution		
Measures should be provided for ensuring that those participating in an activity are aware of, and use, appropriate and up to date documents for performing the activity.	See ADM Quality Manual Document Control on page 23 See Also: Distribution Control on page 26 See Also: Document Awareness on page 23	
A document release and distribution system should be established to make the documents readily available by means of up to date distribution lists or other methods appropriate to the complexity of the company and its activities.	See ADM Quality Manual Distribution Control on page 26	
Document change control		
Changes to documents should be identified and recorded, and should be subject to review and approval, in accordance with documented procedures, by the original document review and approval functionaries or other designated persons or organizations having access to the relevant information. Distribution of revised documents, and information concerning their status, should be prompt and timely. Care should be taken to ensure that out of date, redundant documents are destroyed or clearly marked as such to prevent further use. When necessary an original document file should be established to maintain the history and to assure traceability; these documents should be marked as obsolete to prevent any further use.	See ADM Quality Manual Approval Check List on page 28 See Also: Changes and Revision Control on page 30	Change control described in the submitted QA documentation

IAEA requirement	A&DM response	ARPANSA comment
DESIGN CONTROL		
Design control measures should be established and documented to ensure that all design requirements are identified, specified and met by the final design.	See ADM Quality Manual Product Planning on page 96 See Also: Project Life Cycle on page 97 See Also: 1860 Transport Cask Manual: *"QAP – Design"*	
Where the design process involves more than one organization or function, appropriate interfaces and responsibilities should be established and documented in order to maintain the required design control. Design planning	See 1860 Transport Cask Manual: "Quality Assurance Programme " section "Organisational Interfaces"	
The organization responsible for the design process should establish and review appropriate plans for those design activities to be carried out, assigning responsibilities, personnel and resources as necessary	See ADM Quality Manual Development Planning on page 116 See Also: 1860 Transport Cask Manual: "QAP - Design"	
Design input requirements such as regulatory requirements, quality requirements, design bases, codes, standards, specifications, drawings, results of contract reviews, etc., should be identified, documented and reviewed to ensure that they are sufficient for the final design. They should include, where applicable, quantitative and qualitative acceptance criteria	See ADM Quality Manual Development Inputs on page 117 See Also: 1860 Transport Cask Manual: "QAP – Design" section "Regulatory Authority Compliance"	
Measures should also be established for the selection and for the review for suitability of materials, parts, equipment and processes that are essential to the function of the packaging, subassembly, systems or components relative to their operating environments.	See Verification of Purchased Product on page 131 See Also: 1860 Transport Cask Manual: "QAP – Design" section 'Design Flow Control"	
Design output, as the final product of the design process, should be documented to demonstrate its conformance to the agreed design input requirements and to the defined acceptance criteria. It should be reviewed and approved by the defined level of management in the company or organization responsible for the design. Design output documents may include drawings, specifications, handling and maintenance instructions, etc., and can be in the form of hard copy, electronic data or other acceptable media. Other parties such as the end user, customer, manufacturer or the regulatory body may comment on design output and influence its final approval.	See ADM Quality Manual on page See Also: 1860 Transport Cask Manual: "QAP – Design" See Also: 1860 Transport Cask Manual: "Detailed Design"	

Design control measures should be established and documented for verifying the adequacy of design, by the performance of design review(s). Design reviews and verification can be supported by the use of alternative calculation methods, or by the performance of a suitable test programme in accordance with the requirements of the IAEA Regulations as appropriate.	See ADM Quality Manual on page See Also: 860 Transport Cask Manual: "QAP - Design"	
Design verification and review should involve all functions or personnel concerned with the final design quality and/or the design phase under consideration.	See ADM Quality Manual on page See Also: 1860 Transport Cask Manual: "QAP - Design"	
Design validation activities should be carried out as necessary to confirm that the finished item, packaging or service conforms to the end user's requirement. This can be done by means of commissioning tests, package handling trials or similar methods.	See ADM Quality Manual on page See Also: 1860 Transport Cask Manual: "QAP - Design"	
The results of all these design activities should be appropriately recorded in order to demonstrate control throughout the design process and confirm that the finished design meets all requirements.	See Customer Focus on page 66 See Also: 1860 Transport Cask Manual: "QAP – Design" See Also: 1860 Transport Cask Manual: "Detailed design"	
Procedures should be established for effecting design changes, including in-service changes or modification, in a manner consistent with the design control measures for the original design. Design changes should be approved by the original design organization/function or a technically qualified substitute. The full impact of changes should be carefully considered and the need, justifications and required actions recorded. Written information concerning the changes should be sent to all affected persons and organizations in a controlled and timely manner.	See 1860 Transport Cask Manual: "QAP - Design"	

IAEA requirement	A&DM response	ARPANSA comment
PROCUREMENT CONTROL		
Procurement control measures should be documented and ensure that purchased items and services meet defined requirements and performance criteria.	See ADM Quality Manual, Purchasing on page 124	
Items or services may be procured to different levels of quality, depending on their importance and impact on safety. A graded approach to quality, as described in Safety Series No. 113, may be used in the procurement of such items and services.	See 1860 Transport Cask Manual: "QAP – Manufacture - Purchasing"	
Purchasing documents should contain data clearly describing the product or service required; such documents should be reviewed and approved before release. These data may include reference to applicable regulatory requirements, standards or codes, drawings, specifications, quality and other requirements as necessary.	See ADM Quality Manual, Purchasing Process On page 127 See Also: 1860 Transport Cask Manual: "QAP – Manufacture - Purchasing"	
Purchasing verification measures should provide for agreement between the supplier and the purchaser on methods used to verify that all purchasing requirements will be met. Where verification of the purchased product will be performed at the subcontractor's premises, the verification arrangements should be clearly specified in the purchasing documents. The supplier, competent authority (when necessary), or their representatives, should have access to plant facilities, items, materials and records for inspection and audit and have appropriate records forwarded when required for review or approval. These records should be retained for an appropriate time.	See Verification of Purchased Product on page 131 See Also: 1860 Transport Cask Manual: "QAP – Manufacture"	
Verification that the purchased product conforms to the requirements is the prime responsibility of the supplier. In the case of a purchased packaging, the purchaser should obtain adequate documented evidence that the packaging has been designed, manufactured and tested to meet specified requirements and that acceptable national or international standards on quality assurance have been applied throughout. Where the customer, end user or competent authority verify the product at the subcontractor's or the supplier's premises, this verification should not replace responsibility of the supplier for effective control	See See ADM Quality Manual, Verification of Purchased Product on page 131	
Documented procedures should be established to ensure that any material or equipment provided by the purchaser, for use in the final product or service, is suitably protected and controlled by the supplier.	See See ADM Quality Manual, Verification of Purchased Product on page 131	

IAEA requirement	A&DM response	ARPANSA comment
MATERIAL CONTROL		
Measures should be established and documented for the identification and control of packagings, package contents, associated transport equipment, materials and components; these measures should cover all relevant phases of transport including the entire production process, handling, loading, labelling and despatch, carriage, receipt, servicing and maintenance, storage, etc.	See ADM Quality Manual Preservation Of Product on page 151 Also See 1860 Transport Cask Manual: "QAP – Manufacture" section "Procedure for ordering materials and vendor parts"	
Similar measures should provide for sufficient traceability throughout the transport cycle, and also prevent damage, deterioration, loss, or the use of time expired material. Records of identification and traceability should be appropriately maintained, detailing batch or individual item identity when required.	See ADM Quality Manual Preservation Of Product on page 151	

IAEA requirement	A&DM response	ARPANSA comment
PROCESS CONTROL		
All processes involved in design, manufacture, use or servicing activities should be subject to documented control procedures. These process controls should be developed where the absence of such procedures would have an adverse effect on quality or where the required quality cannot be verified by post-process examination. The training and qualification of personnel, when relevant to the process, should be specified or referenced in these control procedures. Where processes are verified by statistical sampling or similar techniques, the application of these techniques should be in accordance with documented procedures.	See ADM Quality Manual Product Planning on page 96 Also See 1860 Transport Cask Manual: "QAP – Manufacture" section "Construction procedures"	
Control of the transport operation as a process should be accomplished by documented procedures or quality plans. These procedures should cover, when applicable, identification and control of contents, packing, handling, labelling, despatch, carriage, receipt, cleaning, storage, servicing and maintenance, etc., and any special process controls, including monitoring of leak tightness, radiation and contamination levels relating to package material. These measures should also identify relevant interfaces and their controls, prevent damage, deterioration or loss of contents, and enable compliance with the relevant regulations for packages or consignments to be confirmed.	See 1860 Transport Cask Manual: "Requirements And Controls For Transport" also see 1860 Transport Cask Manual: "Radiation Protection Programme" also see 1860 Transport Cask Manual: "Emergency Response Plan"	
Processes affecting the finished product/service quality, where the required quality cannot be verified by post-process examination alone, and where pre qualification of the process is necessary, e.g. welding or heat treatment, should be controlled in accordance with documented procedures. Such procedures should refer to relevant codes, standards, specifications or dedicated requirements. Where specified, measures should be taken to ensure that these processes are accomplished by qualified personnel, procedures and equipment	See 1860 Transport Cask Manual: "Quality Assurance Programme" also see 1860 Transport Cask Manual: "Production Manual A- F"	

IAEA requirement	A&DM response	ARPANSA comment
INSPECTION AND TEST CONTROL		
Documented procedures should provide for in-process, final, and in-service inspection carried out during all phases of testing, production, transport and maintenance against specified requirements. These procedures should include provision for measuring and test equipment used to be calibrated, adjusted and maintained at defined intervals.	See 1860 Transport Cask Manual: "Maintenance and Inspection Manual"	
Test and inspection status of packagings or their parts should be identified by the use of markings, stamps, tags, labels, routing cards, inspection records, security seals or other appropriate means to indicate the acceptability or non-conformity of items. The identification of the inspection and test status should be maintained as necessary throughout manufacturing, use, servicing and maintenance of the item, to ensure that only items that meet the specified requirements are used.	See 1860 Transport Cask Manual: "Maintenance and Inspection Manual"	
Receipt inspection, in-process inspection, and final inspection measures should be planned and carried out to meet the requirements specified in regulations, standards, design and manufacturing documents, transport, servicing, maintenance, and operating procedures, instructions, applicable quality plans, etc. Essential criteria to be included in such inspection measures can be found in Safety Series No. 113	See 1860 Transport Cask Manual: "Maintenance and Inspection Manual"	
All testing required to demonstrate that the package, and its components, will perform satisfactorily in continued service should be carried out in accordance with documented procedures. Such testing may include prototype qualification and regulatory proof testing, production, operational, servicing and maintenance tests, etc. These procedures, incorporating the requirements and acceptance criteria specified in design documents, should be carried out by trained personnel using properly calibrated instrumentation and equipment. All test results should be recorded and evaluated to confirm that the defined requirements have been met.	See 1860 Transport Cask Manual: "Maintenance and Inspection Manual" See Also: See 1860 Transport Cask Manual: "Test Procedures" also see ANSTO Engineering Report	

Documented measures should ensure that tools, gauges, instruments, test software and other inspection, measuring and test equipment, and other devices used in determining conformity to acceptance criteria, are of the proper range, type, accuracy and precision. They should be properly handled and stored, controlled, calibrated and adjusted at specified intervals to maintain accuracy. Records of calibration should be maintained and be adequate for traceability of measurement, to national or international standards, when necessary. When deviations beyond prescribed limits are detected, an evaluation should be made of the validity of previous measurements and tests, and acceptance of tested items reassessed	See ADM Quality Manual "Measuring Devices"	

IAEA requirement	A&DM response	ARPANSA comment
NON-CONFORMITY CONTROL		
Documented measures should control items such as packagings, package contents, services and processes which do not conform to requirements, in order to prevent their inadvertent use before or during transport. These measures should also ensure that non-conforming items be identified by marking, tagging and/or by physical segregation, where practical, in order to control further processing, delivery or assembly. Such items should be reviewed and rejected, modified, repaired, reworked or accepted without modification. The responsibility for review and authority for disposal or acceptance of non-conforming items should be defined.	See: Model 1860 Transport Cask. "Maintenance and Inspection" Also see Dispatch Inspection Check-list Also see Dispatch Documentation check-list	

IAEA requirement	A&DM response	ARPANSA comment
CORRECTIVE ACTIONS		
Documented procedures should provide for corrective and preventive action to ensure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective or incorrect material and equipment, and any other non-conformities, are promptly identified, corrected and prevented from recurring. Such procedures should provide for: • investigation and determination of the root causes of non-conformities and of corrective actions required to prevent their recurrence; • processing of customer, regulator or other complaints, and appropriate responsive or corrective action; • controls to ensure that corrective action is promptly implemented and effective; • detection of potential quality failures and the identification of appropriate preventive action.	See ADM Quality Manual, Measurement, Analysis and Improvement on page 154 See: Model 1860 Transport Cask Manual: "Emergency Response Plan" Also "Maintenance And Inspection"	
Corrective and preventive action reports should be documented and provided to appropriate levels of management in order to support management review and quality improvement	See ADM Quality Manual, Measurement, Analysis and Improvement on page 154 See: Model 1860 Transport Cask Manual: "Emergency Response Plan" Also "Maintenance And Inspection"	

IAEA requirement	A&DM response	ARPANSA comment
RECORDS		
Documented procedures for the identification, collection, indexing, filing, storage, maintenance, retrieval and disposal of pertinent quality documentation and records should be established. Records should demonstrate that the product or service has met the specified requirements, and that the quality assurance programme is operating effectively. Such records should be retained for defined periods, be readily retrievable and maintained in good condition. They may take the form of hard copy, electronic data or any other acceptable media.	See: ADM Quality Manual " Documentation Requirements – Requirements – Control Of Records"	
Records relating to appropriate radioactive material packagings should be established and maintained to record the complete manufacturing, operational and service/maintenance history of such packagings.	See Model 1860 Transport Cask Manual *"Radiation Protection Programme"*	

IAEA requirement	A&DM response	ARPANSA comment
STAFF AND TRAINING		
All personnel responsible for performing activities affecting quality should be suitably trained and qualified to perform their specifically assigned tasks.	See: Model 1860 Transport Cask Manual "Training" See: Model 1860 Transport Cask Manual "Radiation Protection programme" section "Radiation Protection Safety Control"	
Documented procedures should provide for the identification of training needs and training programmes, including, when necessary, specialist qualification training; records of training should be maintained	See: Model 1860 Transport Cask Manual "Training" See: Model 1860 Transport Cask Manual "Radiation Protection programme" section "Radiation Protection Safety Control"	

IAEA requirement	A&DM response	ARPANSA comment
SERVICING		
Documented measures should be established to control all servicing and maintenance activities relative to packaging, transport related equipment and other items, in order to ensure continued compliance with specified requirements. Servicing and maintenance schedules should be based on design input and experience, and also take account of normal or harsh operating conditions. The measures should provide for the identification of specified requirements, confirm that they have been met, and produce the necessary records.	See 1860 Transport Cask Manual. "Maintenance & Inspection"	

IAEA requirement	A&DM response	ARPANSA comment
AUDITS		
Documented procedures should ensure that internal audits are carried out on a regular basis to verify compliance with all aspects of the quality assurance programme and to confirm its continuing effectiveness. Similarly, when conducting external audits, to verify the quality arrangements of suppliers, they should be planned and carried out in accordance with written procedures. Audits should be conducted by qualified persons selected for their independence from the activity under audit.	See ADM Quality Manual, Internal Audits on page 156	
The documented audit results should be brought to the attention of the management personnel responsible for the activity audited. The responsible management should take timely improvement or corrective action in response to the audit findings. Verification of the effective implemented corrective action should be established and recorded.	See ADM Quality Manual, Internal Audits on page 156	
Further guidance on the various phases of audits such as audit programme elements, audit scheduling, team selection, pre- and post-audit meeting, reporting and response, and follow-up action can be found in Safety Series No. 113	Model 1860 Transport Cask Manual "Quality Assurance Programme"	