



CANADIAN FORCES STANDARD

**SPECIFICATION FOR SHOCK RESISTANT EQUIPMENT ON NAVAL SHIPS AND
SUBMARINES**

PART 1 - SHOCK TEST REQUIREMENTS

(ENGLISH)

(Supersedes D-03-003-007/SG-000 dated 1978-08-16)

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FOREWORD

1. This Canadian Forces Technical Order (CFTO) specification is published in two parts as follows:
 - a. **Part 1 – Shock Test Requirements:** Defines high impact shock requirements and provides prescriptive instruction for high impact shock testing.
 - b. **Part 2 – Design Guidance for Equipment Foundations:** Provides design guidance for equipment foundations subject to high impact shock loads.
2. This specification is UNCLASSIFIED and does not contain Controlled Goods.
3. This specification provides the information required to enable the shock qualification of equipment to be installed onboard Royal Canadian Navy (RCN) ships and submarines. Shock qualification generally means physical testing of equipment within the limitations of commonly available test machines.
4. There are two types of shock testing:
 - a. **High Impact (HI) Shock Testing:** The purpose of high impact shock testing is to verify equipment and foundations function, without causing a hazard to personnel or other equipment, both during and after an underwater explosion event. These tests are relatively high acceleration tests. Standards such as this one, MIL-DTL-901E and MAP 01-470 define HI shock testing requirements.
 - b. **Transportation Shock Testing:** The purpose of transportation shock testing is to verify that equipment will function after transport (i.e. after being subject to shock loads induced by transportation of equipment from the factory to the end user's facility). These tests are relatively low acceleration tests. Standards such as MIL-STD-810H define transportation shock testing requirements.
5. Transportation shock testing results cannot be used as objective evidence that equipment meets high impact shock testing requirements.

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SECTION 1

GENERAL

Applicability

1. This specification is applicable to all Royal Canadian Navy (RCN) combatants and combat support vessels. For the purpose of this specification these vessel types are defined as noted in [Figure 1-1](#).

Ship Role	Definition	Examples
Combat	Vessels intended to operate in harm's way. This includes: <ol style="list-style-type: none"> a. ships or submarines intended to engage in combat; b. ships or submarines intended to deploy combat system(s) for offensive, defensive or surveillance purposes; and c. troop transport vessels. 	Frigates Destroyers Mine Sweepers Patrol Boats Troop Transports Landing Craft Submarines
Combat Support	Vessels expected to operate in harm's way in close support of combat operations. This includes: <ol style="list-style-type: none"> a. fleet replenishment vessels; and b. ships considered to be of tactical or strategic "high value". 	Replenishment Oilers (AOR) Tankers Hospital Ships

Figure 1-1 Definition of Combat and Combat Support Vessels

Scope

2. Vessels complying with this specification are expected to withstand a defined level of high impact shock without suffering operational failure (loss of combat capability or severely compromised ship safety).

3. Vessels complying with this specification must have the following shock tested (or qualified by extension) in accordance with this specification:

- a. All onboard equipment, machinery and systems; and
- b. All piping, cable trays, conduit and waveguides.

4. This specification generally follows MIL-DTL-901E with exceptions and modification to account for the specifics of Royal Canadian Navy ship classes and shock test machines approved by DNPS 2-5.

5. Deviations or waivers to the requirements of this specification may be considered by the RCN. Deviations or waivers must be clearly identified in the approved vessel Design Intent (DI) document.

Priority of documents

6. In the event of any inconsistency between documents, the priority of documents defined in [Figure 1-2](#) shall prevail; highest priority (Priority 1) to lowest priority (Priority 5).

Priority	Document	Notes
1	Design Intent (DI) Report	<p>The approved (signed) RCN DI report for the vessel will define the overarching shock requirements for the vessel. The DI will include statements such as:</p> <ul style="list-style-type: none"> i. The vessel shall comply with all requirements of CFTO D-03-003-007/SG-000. ii. The vessel shall comply with the requirements of CFTO D-03-003-007/SG-000 with the following exceptions: <ul style="list-style-type: none"> · Exception #1 · Exception #2 · Etc. iii. There are shock requirements for the vessel.
2	This CFTO	This specification (CFTO D-03-003-007/SG-000) defines baseline shock criteria and HI shock testing requirements.
3	Contract	<p>The contract as a legal agreement between Canada and the Vendor. Shock related requirements should be stated clearly, completely and unambiguously and shall accurately reflect the requirements defined in Priority 1 & 2 documents.</p> <p>Any differences found between the contractual requirements and those defined by Priority 1 & 2 documents must be remedied. The remedy will be either:</p> <ul style="list-style-type: none"> i. Contract amendment to correct differences (erroneous clauses or omissions). ii. Post contract reparation.
4	Drawings Specifications	Equipment and foundation drawings and specifications shall be included in the vessel's Technical Data Package (TDP). This will include all versions that are relevant to in-service equipment.
5	Samples & Patterns	Patterns and Samples shall reflect approved drawings in the TDP. Any differences found shall result in either (i) updating of drawings, or (ii) rejection of the sample.

Figure 1-2 Priority of Documents

Deviation or waiver

7. The procedure required by D-02-006-008/SG-001 shall be followed in applying for any deviation or waiver from this specification.

8. Any deviation or waiver from this specification must be approved by DNPS 2-5.

Patent infringement warning

9. Attention is drawn to the possibility of patent-infringement if gauges or testing machines fabricated from information contained in this specification. The Government of Canada assumes no responsibility for such use.

References

10. The following references are cited in this specification:

- a. Canada Department of National Defence, "Standard – The Design Change, Deviation, and Waiver Procedure", D-02-006-008/SG-001, 8.Jun.2020.
- b. UK Ministry of Defence, "Shock Manual (Metric)", BR 3021. [UK Restricted].
- c. UK Ministry of Defence, "Shock And Vibration Manual", BR 8470. [UK Restricted].

- d. UK Ministry of Defence, "Shock Design Manual", MAP 01-470, Issue 1, Apr.2012. [UK Restricted].
- e. US Department of Defense, "Test Method Standard – Environmental Engineering Considerations and Laboratory Tests", MIL-STD-810G, 31.Oct.2008.
- f. US Department of Defense, "Detail Specification – Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements For", MIL-DTL-901E, 20.Jun.2017.
- g. US Department of Defense, "Military Specification – Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements For", MIL-S-901D (NAVY), 17.Mar.1989.
- h. US Naval Sea Systems Command, "Shock Design Criteria For Surface Ships", NAVSEA 0908-LP-000-3010, Rev. 1, Sep.1995.
- i. US Naval Sea Systems Command, BUSHIPS Dwg. 10-T-2145-L, Alt. 13, Class HI (High Impact) Shock Testing Machine For Light Weight Equipment. 8.Feb.1961.
- j. US Naval Sea Systems Command, BUSHIPS Dwg. 807-655947, Alt.6, Class HI (High Impact) Shock Testing Machine For Medium Weight Equipment. 16.Oct.1961.
- k. US Naval Sea Systems Command, BUSHIPS Dwg. 645-1973904, Floating Shock Platform, General Arrangement and Details.

Acronyms and abbreviations

11. The following acronyms and abbreviations are used in this specification:

CFTO	Canadian Forces Technical Order
DI	Design Intent
DND	Department of National Defence (Canada)
DNPS	Directorate Naval Platform Systems (Canada)
DNPS 2-5	Sub-section of DNPS responsible for Ship Survivability
ESC#	Equipment Shock Classification Number
FSP	Floating Shock Platform (a HWSM)
HI	High-Impact
HWSM	Heavy Weight Shock Machine
LCMM	Life Cycle Maintenance Manager
LWSM	Light Weight Shock Machine
MWSM	Medium Weight Shock Machine
NAVSEA	Naval Sea Systems Command (US Navy)
RCN	Royal Canadian Navy
STIA	Shock Test Inspection Authority
TDP	Technical Data Package
TNT	Trinitrotoluene (common explosive material)
UK	United Kingdom
US	United States
UUT	Unit Under Test

12. The following units are referenced in the specification:

Hz	hertz (cycle per second)
in	inch

kg	kilogram
kHz	kilohertz
lb	pound
mm	millimeter

SECTION 2

EQUIPMENT CLASSIFICATION

General

1. Shock testing requirements are based on equipment weight and particulars:
 - a. Shock Grade - purpose of equipment,
 - b. Shock Zone - location of equipment onboard,
 - c. Mounting arrangement,
 - d. Assembly type, and
 - e. Orientation of installation.

2. Once the equipment particulars are assigned, the test requirements can be defined and costs estimated. Generally, testing costs increase as the equipment variability increases. For example, an item installed on multiple mounting arrangements and in different orientations will require more testing than the same equipment with one mounting arrangement and orientation.

Equipment Shock Classification Number (ESC #)

3. Each equipment designated for shock qualification testing shall be assigned an Equipment Shock Classification Number (ESC#) as shown in [Figure 2-1](#).

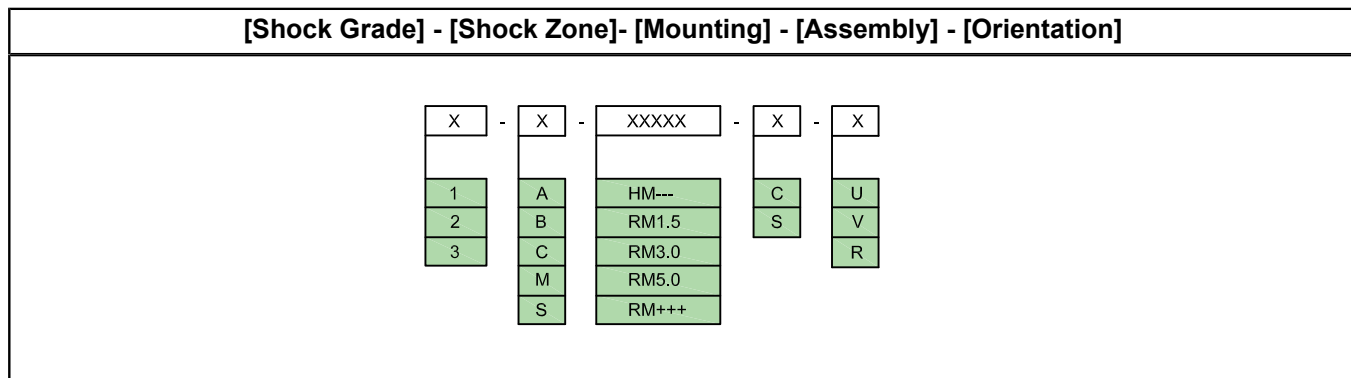


Figure 2-1 Equipment Shock Classification Number (ESC#)

Shock grade

4. The intended purpose of the equipment is used to define the equipment Shock Grade as outlined in [Figure 2-2](#). The testing required is dependent on the Shock Grade assigned.

NOTE

The definition of "Shock Grade" in this specification above is different from that used by the United States Navy (MIL-DTL-901E).

Shock Grade	Description
1	Machinery, equipment and systems essential for the safety and continued combat capability of the ship. Design shall be suitable to withstand Grade 1 shock loadings without significant effect on performance and without any portion of the equipment coming adrift or otherwise creating a hazard to personnel or the ship.
2	Machinery, equipment and systems necessary for all the ship's operational requirements not essential for the safety and continued combat capability of the ship. Design shall be suitable to withstand: <ul style="list-style-type: none"> <li data-bbox="349 436 1235 468">i. Grade 2 shock loadings without significant effect on performance, and <li data-bbox="349 478 1370 600">ii. Grade 1 shock loadings without the equipment or any external portion of the equipment coming adrift or otherwise creating a hazard to personnel or Grade 1 systems. Its securing arrangements and supports shall be calculated to withstand Grade 1 shock.
3	Non-mechanical, electrically uncharged and/or unpressurized ancillary commercial and "housekeeping" equipment which have no effect on the combat or operational performance of the ship and do not seriously affect the habitability of the ship. Grade 1 shock shall be a factor in the design of supports and securing arrangements. Failure to operate even at Grade 2 levels is allowed but it shall not become a projectile under shock conditions. No test is required. Captivity shall be demonstrated by analysis using empirical or numerical methods.

Figure 2-2 Shock Grades

5. Any ancillary system required to support the capabilities of Grade 1 equipment or systems shall also be deemed Grade 1 if that ancillary system is necessary for the effectiveness of the main equipment.

6. All mechanical, pressurized or electrically charged systems shall be tested as Grade 1 or Grade 2 equipment. Some examples of Grade 1 equipment are listed below:






- Propulsion and maneuverability equipment and systems.
- Sonar.
- Communication equipment.
- Radars.
- Navigation equipment.
- Electronic warfare equipment.
- Weapons control.
- Weapons stowage, reloading and firing or launching mechanisms.
- Interior communication systems required for combat or ship safety.
- Emergency and damage control systems.
- Aircraft arming, refueling and controlling.
- Visual reconnaissance.
- Replenishment at sea.

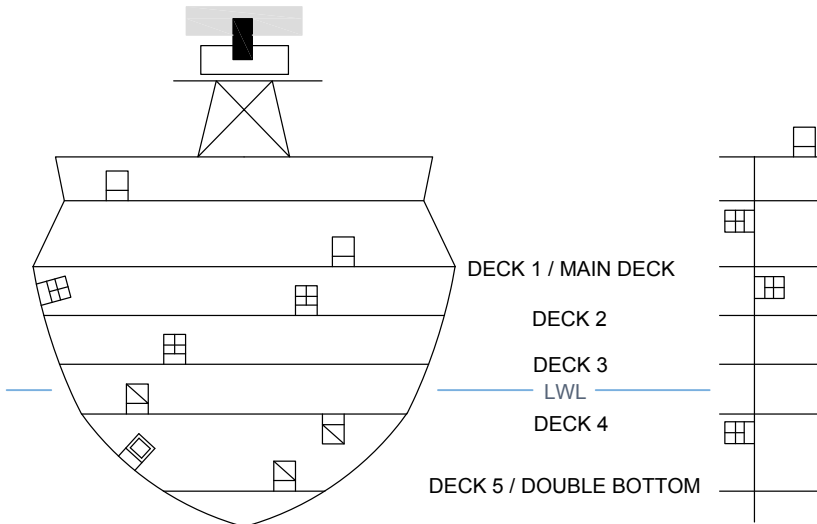
7. The Shock Grade (1, 2 or 3) is the 1st part of the Equipment Shock Classification #:

- a. **[Shock Grade]** - [Shock Zone] - [Mounting] - [Assembly] - [Orientation]

Shock zone

8. The equipment location onboard is used to determine the shock test amplitude. Locations are categorized into the five shock zones as shown in [Figure 2-3](#).

Shock Zone	Legend	Description of Equipment Mounting Location
A		Ship's bottom or decks below the waterline.
B		Bulkheads, decks and ship sides above the waterline.
C		Main deck and superstructure.
M		Mast structure.
S		Ship's side below the waterline. This includes internal and external shell plating, transverse framing and fluid filled tanks along the shell.



DECK 1 / MAIN DECK
 DECK 2
 DECK 3
 LWL
 DECK 4
 DECK 5 / DOUBLE BOTTOM

Figure 2-3 Shock Zones

9. When equipment is installed in multiple shock zones, the most severe zone (zone closest to the keel or shell) shall be assigned.

10. The Shock Zone (A, B, C, M or S) is the 2nd part of the Equipment Shock Classification #:

- a. ESC# = [Shock Grade] - [**Shock Zone**] - [Mounting] - [Assembly] - [Orientation]

Mounting

11. Equipment for use on ships are rarely bolted or welded directly to the ship structure; an equipment foundation or rack is used to support the equipment and provide attachment to the ship. Equipment is either hard mounted as shown in Figure 2-4 or resiliently mounted (e.g. X-mounts, Wire Mounts etc.) to the foundation. Figure 2-5 classifies the various mounting arrangements.

12. For equipment which has multiple mounting arrangements, each of these arrangements will have a unique ESC# and be tested accordingly. Limiting the number of mounting arrangements will reduce testing costs.

13. The Mounting Arrangement (HM---, RM1.5, RM3.0, RM5.0 or RM+++) is the 3rd part of the Equipment Shock Classification #:

a. $ESC\# = [Shock\ Grade] - [Shock\ Zone] - [Mounting] - [Assembly] - [Orientation]$

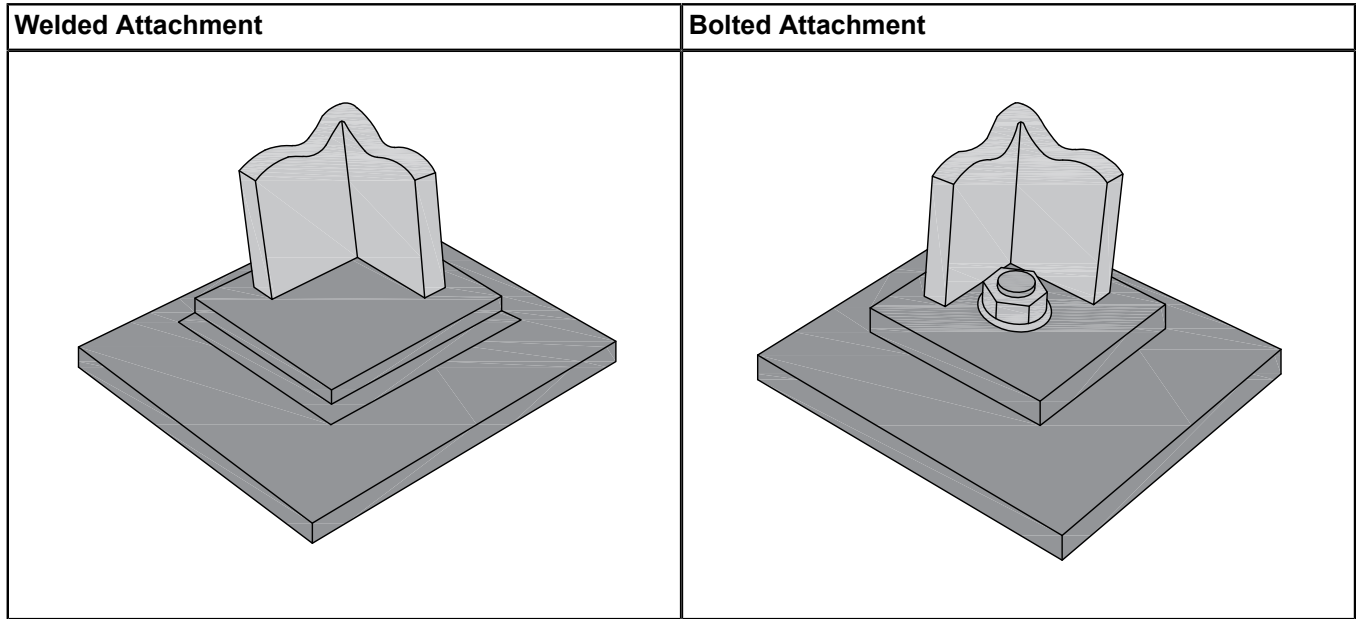


Figure 2-4 Hard Mounting Examples

Mounting Arrangement	Equipment Foundation Description
HM ---	Hard mounted to the bulkhead, shell or deck structure. See Figure 2-4 .
RM 1.5	Resiliently mounted to bulkhead, shell or deck structure with less than 1.5 inches (38 mm) of maximum mount excursion in any direction.
RM 3.0	Resiliently mounted to bulkhead, shell or deck structure with less than 3.0 inches (76 mm) of maximum mount excursion in any direction.
RM 5.0	Resiliently mounted to bulkhead, shell or deck structure with less than 5.0 inches (127 mm) of maximum mount excursion in any direction.
RM +++	Resiliently mounted to bulkhead, shell or deck structure with more than 5.0 inches (127 mm) of maximum mount excursion in any direction.

Maximum X value defines the RM Amplitude (1.5, 3.0, 5.0 or PLUS)

Figure 2-5 Mounting Arrangement Classes

Assembly

14. Equipment is commonly tested as a single primary unit. However, there are cases where a sub-assembly can be tested separately. This may be permitted in cases where the performance of similar equipment has been previously established but new components have been added, or when an equipment is too large for testing as a single unit. Equipment assembly type is defined as per [Figure 2-6](#).

Assembly Type	Description
C	Complete assembly to be mounted and tested as a unit.
S	Allows a sub-assembly to be mounted and tested separately from the equipment.

Figure 2-6 Assembly Type Definition

15. The Assembly Type (C or S) is the 4th part of the Equipment Shock Classification #:

- a. ESC# = [Shock Grade] - [Shock Zone] - [Mounting] - [**Assembly**] - [Orientation]

Orientation

16. There are three installation orientation designations (U, V or R) as shown in [Figure 2-7](#).

- 17. Equipment testing is customized to the onboard orientation of the equipment. Each installed orientation requires a series of tests.
- 18. By restricting the equipment orientation, the amount of testing required (cost) can be reduced.
- 19. The Orientation (U, V or R) is the 5th part of the Equipment Shock Classification #:
 - a. ESC# = [Shock Grade] - [Shock Zone] - [Mounting] - [Assembly] - **[Orientation]**

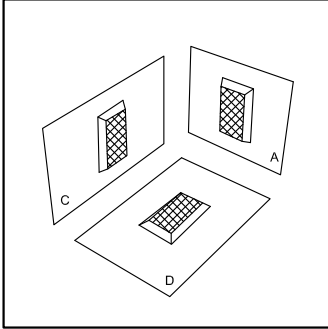
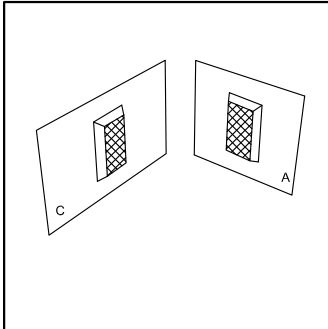
Orientation Designation	Installation Orientation
U	<p>Unrestricted. Installed in any of the three plane orientations (A and C and D)</p> <div style="text-align: center;">  </div>
V	<p>Vertical. Installed in either of two vertical plane orientations (A and C)</p> <div style="text-align: center;">  </div>
R	<p>Restricted. Installed in only one of the vertical plane orientation (A or C or D)</p>

Figure 2-7 (Sheet 1 of 2) Orientation Designation

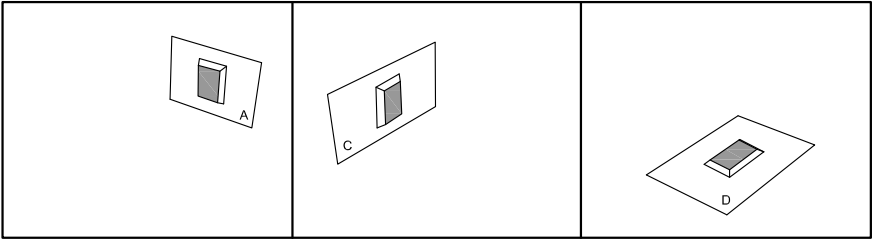
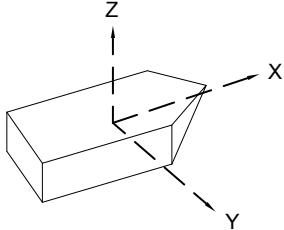
Orientation Designation	Installation Orientation
	
 <p data-bbox="862 659 1224 688">A = Athwartship plane = Y-Z plane</p> <p data-bbox="862 716 1208 745">C = Centerline plane = X-Z plane</p> <p data-bbox="862 772 1154 802">D = Deck plane = X-Y plane</p>	

Figure 2-7 (Sheet 2 of 2) Orientation Designation

SECTION 3

SHOCK TESTS

General

1. A sample of every unique item of equipment, machinery or system for use onboard vessels to which this specification applies must be shock tested (or Qualified by Extension) in accordance with this section.
2. The equipment Vendor shall perform the tests required by this section to the satisfaction of DNPS 2-5.
3. In those cases where the Vendor cannot perform the tests, DND's testing facilities may, at the discretion of the DND, carry out the required tests or may be used to amplify or verify part or all of the Vendor's tests.

Acceptance requirements

4. Equipment capable of withstanding the shock tests specified in this section without significant impairment of function during and after these tests will be identified as complying with this specification. However, the following should be noted:
 - a. Minor damage or distortion may be permitted provided that it does not in any way impair the ability of the equipment to perform its specified functions, or present a hazard aboard ship.
 - b. Momentary malfunction of the equipment shall be considered acceptable if it is automatically self-correcting **and** the momentary malfunction has no consequent derangement, maloperation, or compromise of its capability or the capability of other Grade 1 equipment. For momentary malfunctions to be considered acceptable, the intended use of the component must be well documented and the shock test report must include a description of any momentary malfunctions encountered during testing.
 - c. Maloperation and damage which reduces operation below specification may be cause for rejection of the equipment. This includes momentary malfunctions that are self-correcting.
 - d. Any significant modification of the equipment design which affects its operation or integrity may require all shock tests to be repeated.
5. Equipment shock qualified according to the standards listed below can be considered as having passed the requirements of this specification:
 - a. MIL-DTL-901E
 - b. MIL-S-901D
 - c. NAVSEA 0908-LP-000-3010
 - d. MAP 01-470
 - e. BR 3021
 - f. BR 8470

Shock test machines

6. Testing must be completed on shock test machines approved by the DNPS 2-5. This generally means NAVSEA standard Light-Weight Shock Machine (LWSM), Medium-Weight Shock Machine (MWSM) or Heavy Weight Shock Machine (HWSM). The HWSM is often referred to as the Floating Shock Platform (FSP) or "shock barge".
7. The use of each shock machine is limited by the equipment weight and mounting arrangement as summarized in [Figure 3-1](#).

Test Machine	Weight Limit		Mounting Arrangement
	kg	lb	
LWSM	113	250	HM RM 1.5
MWSM	2,722	6,000	HM RM 1.5 RM 3.0 RM 5.0
HWSM (FSP)	13,608	30,000	HM RM 1.5 RM 3.0 RM 5.0 RM PLUS

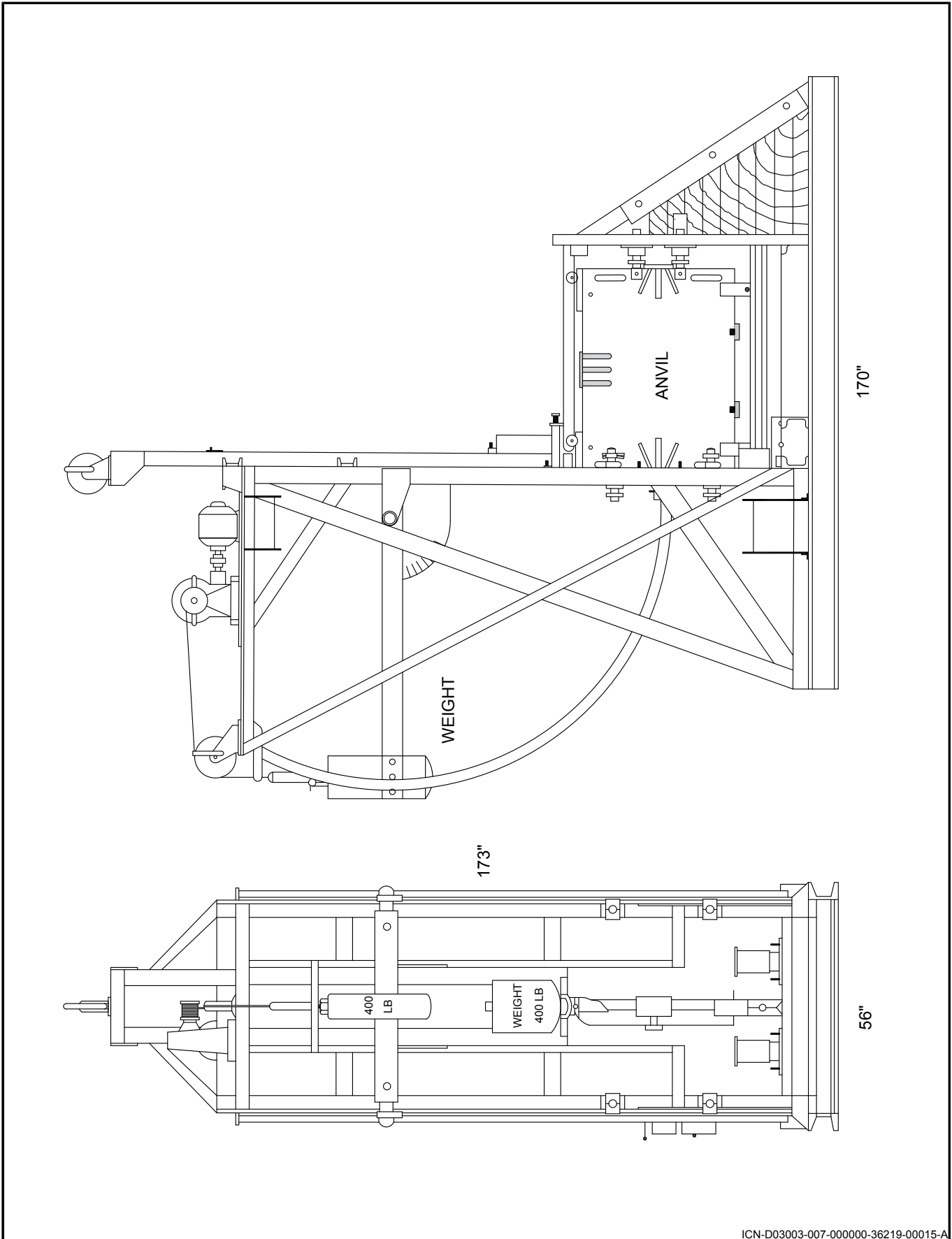
Figure 3-1 Shock Test Machine Limits

8. The weight limits noted in [Figure 3-1](#) refer to the combined weight of the equipment under test, the test fixtures and balancing weights (if required). Generally, the MWSM is suited only for an equipment weight of less than 3,000 lbs.

Light weight test

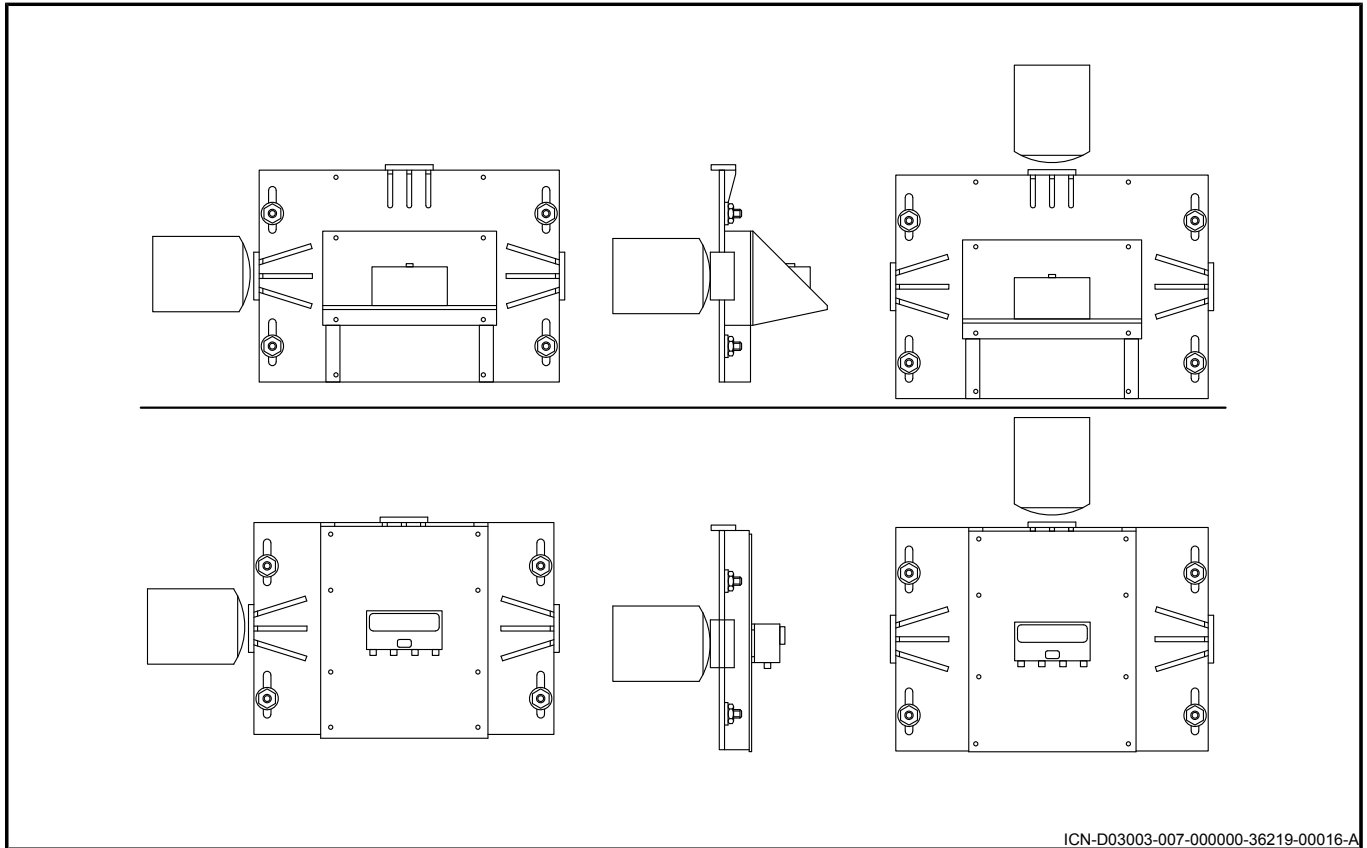
9. For units up to 113 kg (250 lb) and hard or resiliently mounted with less than 1.5 inches of excursion:
- The Unit Under Test (UUT) shall be tested on a LWSM machine similar to that shown in [Figure 3-2](#) (BUSHIPS drawing 10-T-2145-L(13)).
 - Equipment may be mounted directly on the anvil plate of the LWSM, or by means of approved standard fixtures. It is the intent of these standard fixtures to approximate the actual rigidity encountered aboard ship by the particular equipment. A detailed description of the standard fixtures are provided in MIL-DTL-901E.
 - The arrangement on the anvil shall be such that the direction of the blow upon impact shall pass approximately through the centre of gravity of the anvil plus everything mounted on it and also as close as possible through the centre of gravity of the item of equipment.
 - Mounting of the equipment and fixtures is shown in [Figure 3-4](#); it shall be in such a way that the blows are equivalent to shocking the equipment in mutually perpendicular directions:
 - Vertically in the onboard vertical direction;
 - Horizontally in the onboard athwartships direction;
 - Horizontally in the onboard fore/aft direction.
 - The UUT shall not be rotated on the fixture to satisfy the perpendicular shock directions. Instead the anvil plate shall be rotated and hammer direction changed to accommodate the shock direction.
 - The UUT shall be complete with any auxiliary gear which might affect the test, or might itself be susceptible to damage under shock.
 - All appropriate electrical and mechanical connections, required by the equipment for operation, shall be made.
 - For equipment with an orientation designation of U (unrestricted, in any plane), the tests shall normally consist of 9 blows delivered by a weight of 181 kg (400 lb) in three mutually perpendicular planes as shown in [Figure 3-3](#). The 9 blows shall consist of 3 blows parallel to each of the 3 principal axes of the equipment under test with hammer heights listed in [Figure 3-4](#).

- i. For equipment with an orientation designation V (in either vertical plane) or R (restricted to a single plane), the tests shall normally consist of 7 blows as shown in [Figure 3-3](#) with the hammer heights listed in [Figure 3-4](#). The athwartship hammer blows shall be repeated for both onboard athwartship directions.
- j. The UUT shall not be operating at the first lowest hammer blow in each set of blows, but shall be operating at its maximum condition during subsequent blows. If the equipment has more than one operating mode (apart from speed only) the maximum height blow in each direction shall be repeated in the other modes.
- k. For a UUT with electrical connections, a further test of one maximum height blow in each direction shall be repeated with all electrical contacts in the "OFF" position to ensure that they will not momentarily energize the equipment as a result of the shock.
- l. An example test sequence for a 2-mode, V Orientation, Shock Zone A, UUT with electrical connections is shown in [Figure 3-5](#).
- m. Holding down bolts shall be retightened after every blow. Any noticeable retightening movement which may indicate a permanent set in elongation of the bolts shall be noted in the test report.
- n. Holding down bolts shall be of the same material and design as those used in service onboard the vessel.
- o. Separate items (equipment and resilient mounts) can be replaced after 9 blows at the discretion of the contractor.
- p. Any departures from the foregoing requirements will be clearly documented in the test report.
- q. For a UUT containing coils, relays, and overload devices, instructions shall be obtained from DNPS 2-5 regarding test arrangements and conditions for the tests.



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Figure 3-2 Shock Testing Machine For Light Weight Equipment



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Figure 3-3 Mutually Perpendicular Blows On Light Weight Equipment (Deck (top) and Bulkhead (bottom) mounted)

Test Direction	Shock Zone		
	A	B	C
Orientation Designation = U, Unrestricted			
Vertical	381, 762, 1143 mm (15, 30, 60 in)	229, 457, 686 mm (9, 18, 36 in)	
Athwartship			
Fore/aft			
Orientation Designation = V, Vertical or R, Restricted			
Athwartship	381, 762 mm (15, 30 in)	229, 381 mm (9, 15 in)	229 mm (9 in)
Vertical	381, 762, 1 143 mm (15, 30, 60 in)	229, 457, 686 mm (9, 18, 36 in)	229, 457, 686 mm (9, 18, 36 in)
Fore/Aft	381, 762 mm (15, 30 in)	229, 381 mm (9, 15 in)	229 mm (9 in)

Figure 3-4 Light Weight Shock Test Heights

Test Direction	Hammer Height Operating Condition				
Vertical	381 mm (15 in) OFF	762 mm (30 in) ON Mode 1	1143 mm (60 in) ON Mode 1	1143 mm (60 in) ON Mode 2	1143 mm (60 in) OFF
Athwartship Direction 1	381 mm (15 in) OFF	762 mm (30 in) ON Mode 1	762 mm (30 in) ON Mode 2	762 mm (30 in) OFF	
Athwartship Direction 2	381 mm (15 in) OFF	762 mm (30 in) ON Mode 1	762 mm (30 in) ON Mode 2	762 mm (30 in) OFF	

Figure 3-5 Example Hammer Heights and Mode for 2-Mode Equipment Item

Medium weight tests

10. For units between 114 kg and 2,720 kg (250 and 6,000 lb) weight as well as light-weight units (114 kg) mounted on resilient mounts with 38 to 127 mm (1.5 to 5.0 in.) of travel:

- a. The Unit Under Test (UUT) shall be tested on a MWSM machine similar to that shown in [Figure 3-6](#) (BUSHIPS drawing No. 807-655947(5)) with a hammer weight of 1,361 kg (3,000 lb).
- b. Testing will be conducted using standard mountings. The intent of these standard mountings is to approximate the actual rigidity encountered by the equipment when installed onboard.
- c. Resilient mounts shall not exceed 127 mm (5.0 in.) of travel in any direction.
- d. The arrangement on the anvil shall be such that the direction of the blow upon impact shall pass approximately through the centre of gravity of the anvil plus everything mounted on it and also as close as possible through the centre of gravity of the item of equipment.
- e. For each installation orientation, two blows from each of the three Columns (1, 2 & 3) listed in the hammer height schedule shown in [Figure 3-7](#) shall be completed as follows:

Blow #1 The equipment orientation shall be such that the equipment is stressed in the athwartships direction.

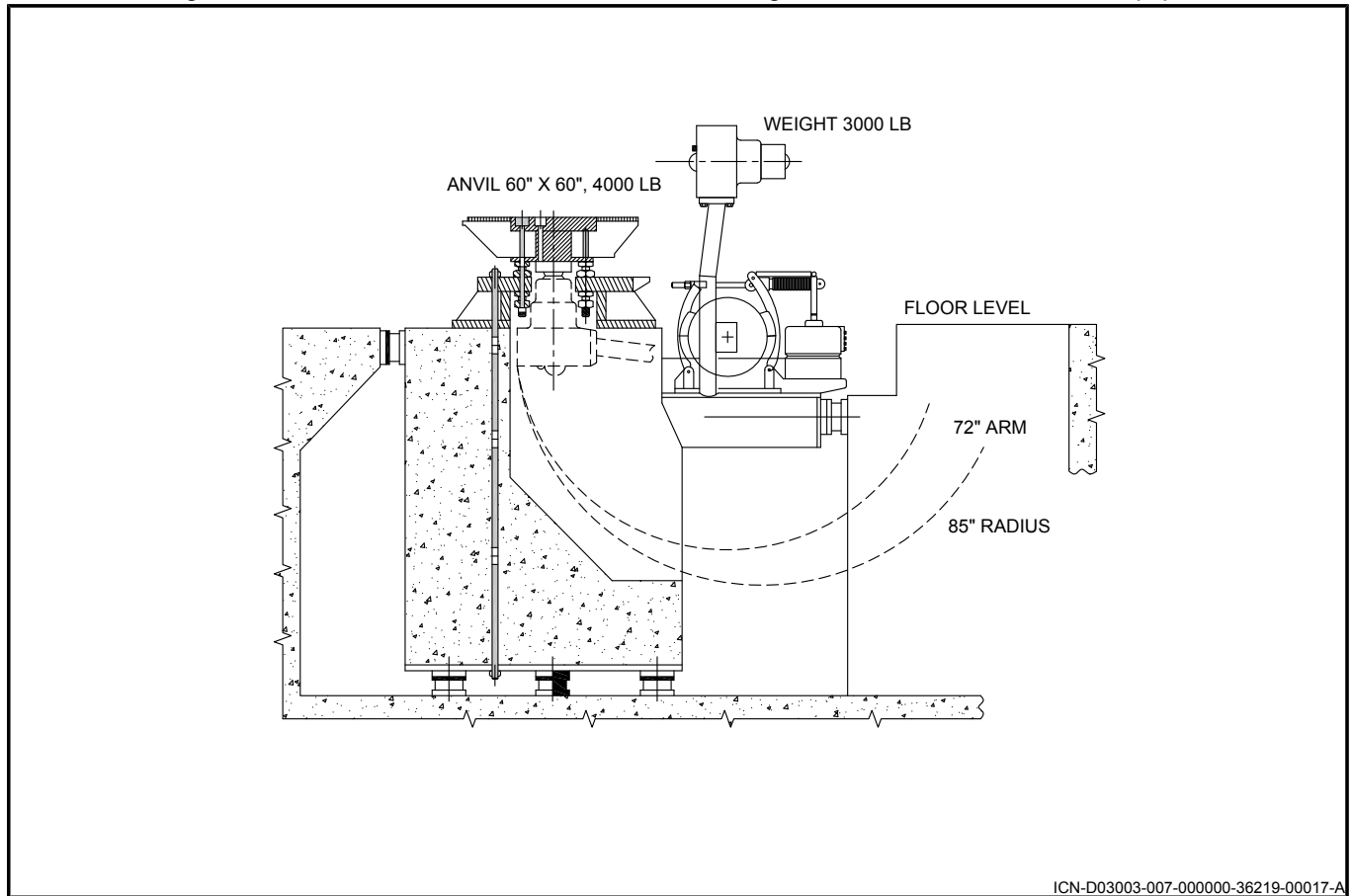
Blow #2 The equipment turned around through 180 °.

NOTE

The installation orientation will determine how many sets of blows listed in [Figure 3-8](#) are required. Restricted orientation will be subject to one set of blows, vertical orientation will be subject to two sets of blows and unrestricted will be subject to three sets of blows. Examples of test arrangements for Restricted, Vertical and Unrestricted orientations are provided in [Figures 3-9, 3-10 and 3-11](#), respectively.

- f. The weight indicated in [Figure 3-7](#) is the total weight including the UUT and all fixtures mounted on the anvil. Total weight on the anvil shall not exceed 3,400 kg (7,500 lb).
- g. The UUT shall not be operating for the Column 1 blows, but shall be operating at maximum condition during the Column 2 & 3 blows. If the equipment has different operating modes (apart from speed only), one Column 3 blow shall be repeated for each mode.
- h. All blows shall be carried out with the UUT on an inclined base support at 30 ° to the horizontal. Normally equipment is designed to operate at up to 20 ° inclination (ship's roll). Any UUT which ceases to function normally at 30 ° may use the 20 ° base support.
- i. An example test sequence for Shock Grade 1 & 2 equipment installed in Shock Zones A, B & C is shown in [Figure 3-8](#). The column numbers (1, 2 and 3) refer to the hammer height schedule column numbers in [Figure 3-7](#). Each table entry notes the operating condition (ON or OFF), number of blows and table travel distance. Where units are mounted on resilient mounts with 3 to 5 inches of travel, Column 3 (Column 2 for Shock Zones B and C) shall be repeated with the table travel set to 5 inches.

- j. Holding down bolts shall be retightened after every blow. Any significant retightening movement which indicates a permanent set of elongation of the bolts, shall be noted in the test report.
- k. Holding down bolts shall be of the same material and design as those used to install the equipment onboard.



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Figure 3-6 Shock Testing Machine for Medium Weight Equipment

Weight		Height of Hammer Drop					
		1		2		3	
kg	lb	mm	in	mm	in	mm	in
113 - 454	250 - 1000	279	11	381	15	610	24
454 - 907	1000 - 2000	330	13	432	17	711	28
907 - 1361	2000 - 3000	356	14	483	19	787	31
1361 - 1588	3000 - 3500	406	16	533	21	864	34
1588 - 1814	3500 - 4000	457	18	584	23	965	38
1814 - 1996	4000 - 4400	508	20	686	27	1143	45
1996 - 2087	4400 - 4600	559	22	737	29	1219	48
2087 - 2177	4600 - 4800	610	24	787	31	1295	51

Figure 3-7 (Sheet 1 of 2) Medium Weight Test Hammer Height Schedule

Weight		Height of Hammer Drop					
		1		2		3	
kg	lb	mm	in	mm	in	mm	in
2177 - 2268	4800 - 5000	660	26	838	33	1397	55
2268 - 2357	5000 - 5200	737	29	940	37	1575	62
2357 - 2449	5200 - 5400	813	32	1041	41	1753	69
2449 - 2722	5400 - 6000	889	35	1143	45	1829	72
2722 - 3402	6000 - 7500	914	36	1168	46	1829	72

Figure 3-7 (Sheet 2 of 2) Medium Weight Test Hammer Height Schedule

Shock Zone	Column	Grade 1	Grade 2
A	1	OFF 2 blows 76 mm (3 in)	OFF 2 blows 76 mm (3 in)
	2	ON 2 blows 38 mm (1.5 in)	ON* 2 blows 38 mm (1.5 in)
	3	ON 2 blows 38 mm (1.5 in)	OFF 2 blows 38 mm (1.5 in)
	3**	ON 2 blows 127 mm (5 in)	OFF 2 blows 127 mm (5 in)
B	1	OFF 2 blows 76 mm (3 in)	OFF 2 blows 76 mm (3 in)
	2	ON* 2 blows 38 mm (1.5 in)	ON* 2 blows 76 mm (3 in)
	2		OFF 2 blows 38 mm (1.5 in)
	2**	ON 2 blows 127 mm (5 in)	ON 2 blows 127 mm (5 in)
C	1	OFF 2 blows 76 mm (3 in)	ON* 2 blows 76 mm (3 in)
	2	ON* 2 blows 76 mm (3 in)	OFF 2 blows 76 mm (3 in)
	2**	ON* 2 blows 127 mm (5 in)	OFF 2 blows 127 mm (5 in)

Notes:
 * Repeated (2 hammer blows) for each operating mode.
 ** Required for equipment mounted on resilient mounts with between 38 and 127 mm (1.5 and 5 inches) of travel.

Figure 3-8 Medium Weight Test Conditions for Each Installed Orientation.

- I. Separate items (equipment and resilient mounts) can be replaced after 6 blows at the discretion of the contractor.
- m. For a UUT containing coils, relays, and overload devices, instructions shall be obtained from DNPS 2-5 regarding test arrangements and conditions for the tests.

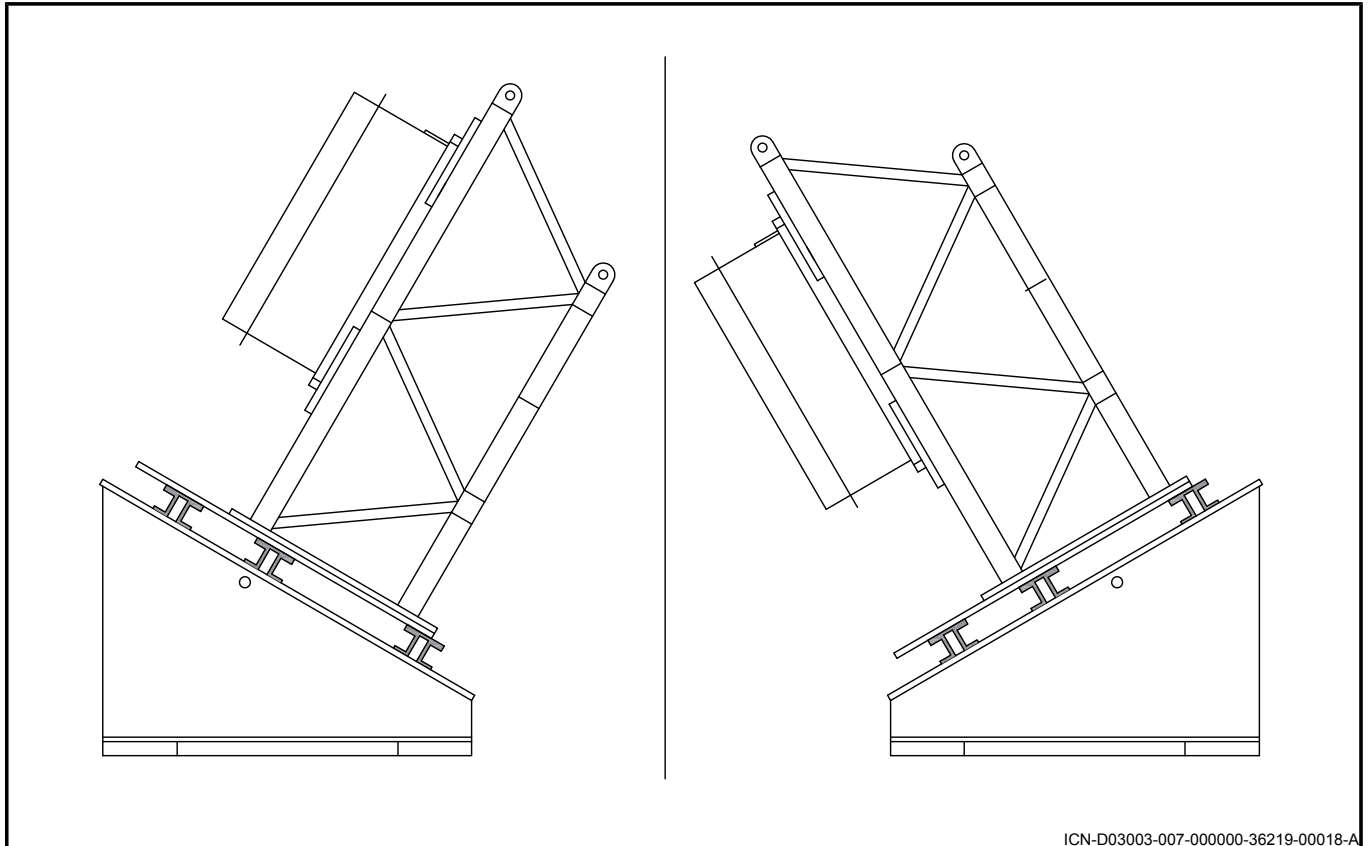
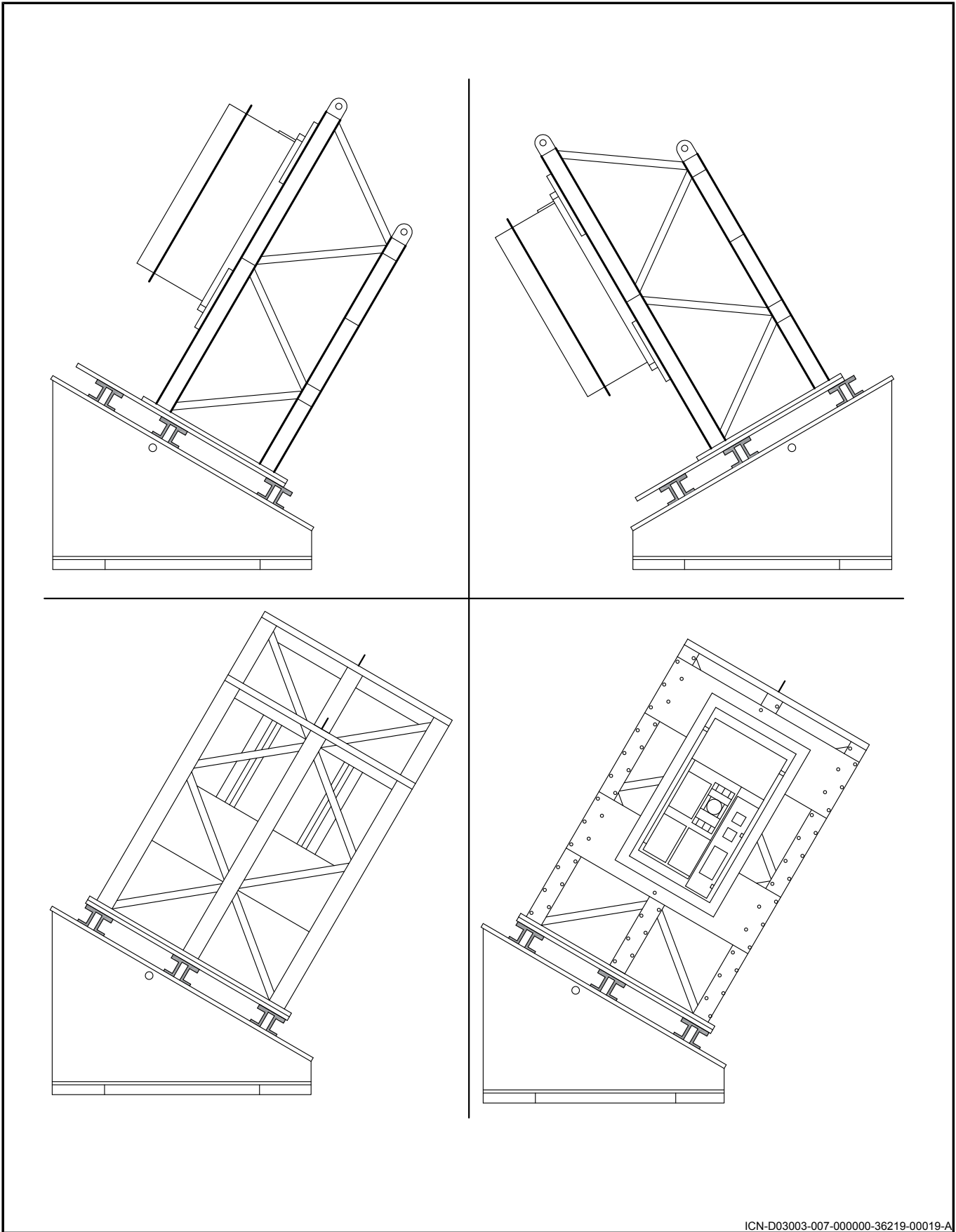
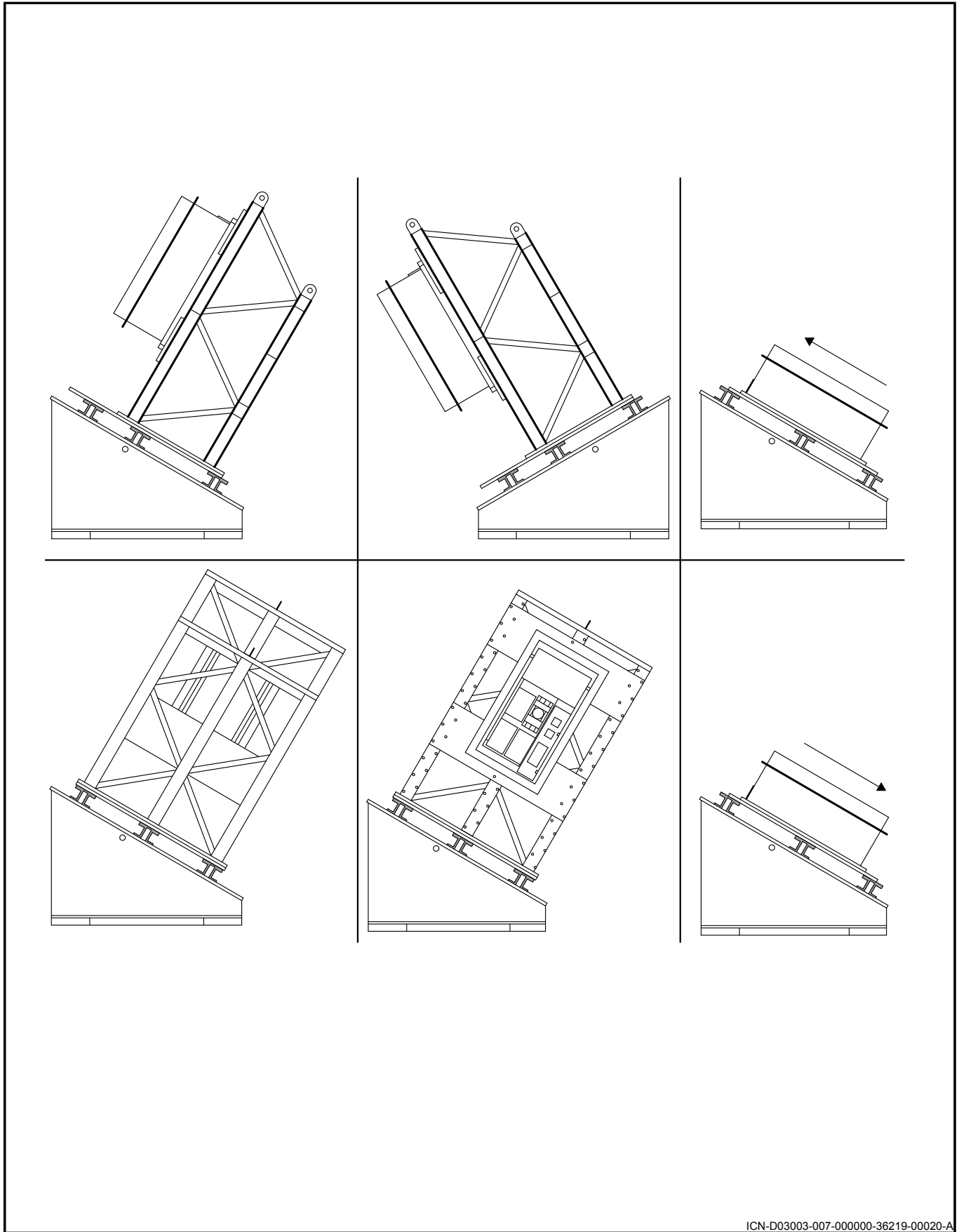


Figure 3-9 Test arrangement for Restricted Orientation set of blows (1).



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Figure 3-10 Test arrangement for Vertical Orientation blow sets (2).

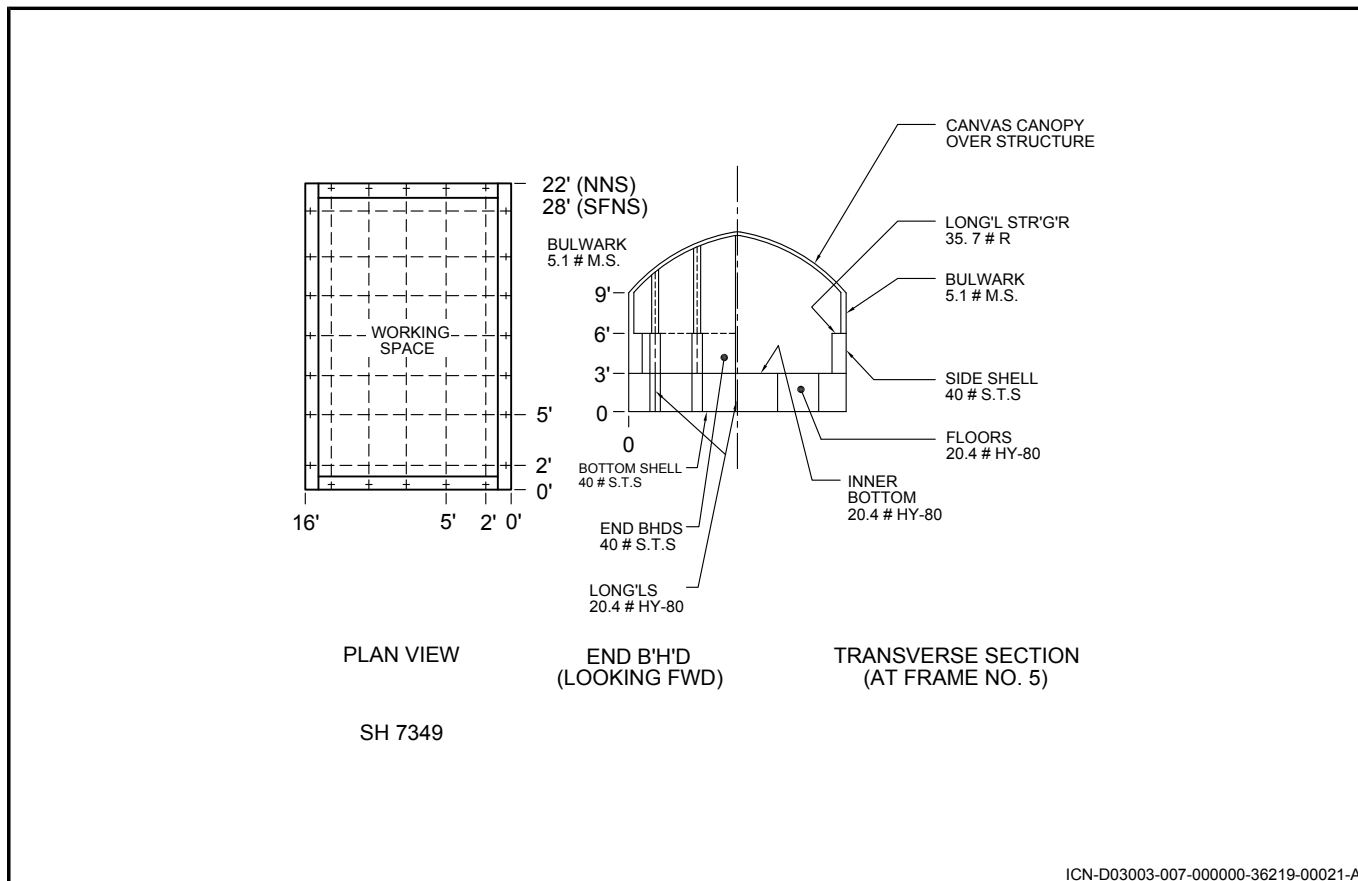


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Figure 3-11 Test arrangement for Unrestricted Orientation blow sets (3).

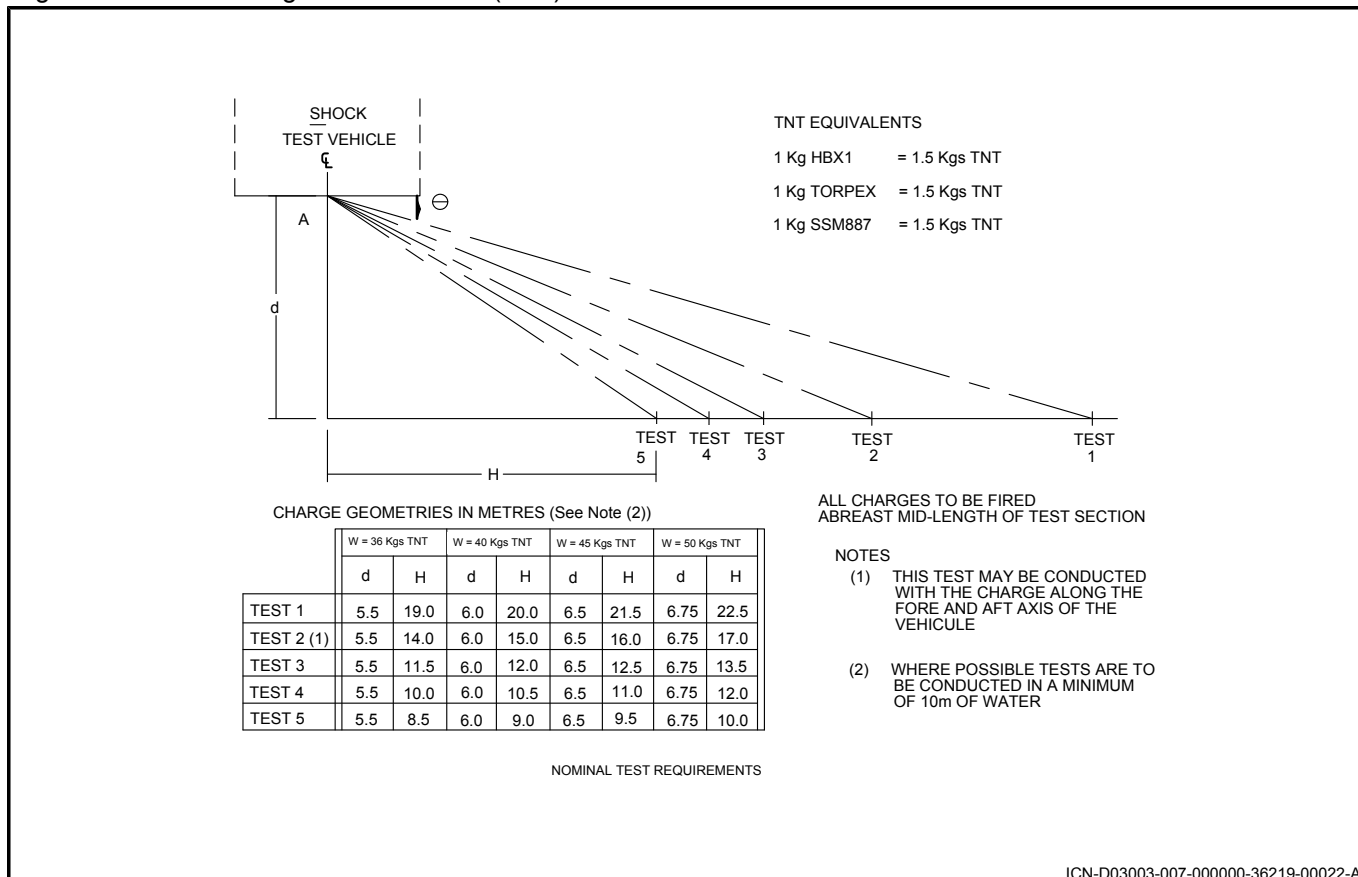
Heavy weight test

11. For equipment weighing between 2,720 and 13,600 kg (6,000 and 30,000 lb) as well as equipment mounted on resilient mounts with greater than 127 mm (5.0 in) of travel:
- a. The Unit Under Test (UUT) shall be tested on a HWSM (FSP) as shown in [Figure 3-12](#) (BUSHIPS Dwg. 645-1973904).
 - b. The UUT on the FSP is to be installed on a seating, foundation or substructure which, as closely as possible, is representative of the manner in which the equipment would normally be installed onboard.
 - c. Holding down bolts shall be of the same material and design as those used in service on the ship.
 - d. When the equipment is to be resiliently mounted onboard it should be fitted on the FSP with the same resilient mounts. These mounts constitute a part of the equipment.
 - e. The equipment shall be in operation during the shock tests.
 - f. The FSP is to be subjected to a series of up to five underwater explosion attacks of increasing severity as defined in [Figure 3-13](#). A charge of 36 to 50 kg of TNT (or its equivalent) is employed for each of these attacks. The explosion severity is governed by the stand-off of the charge from the FSP.
 - g. When equipment has Vertical or Unrestricted Orientations, the equipment is rotated and shot 1 is replaced by additional shot 5 for each orientation. The shot number, shot position and equipment orientation are provided in [Figure 3-14](#).
 - h. The charge size and positions defined by [Figure 3-13](#) are for a Shock Grade 1 equipment in Shock Zones A and S. Grade 1 and 2 equipment installed in Shock Zones B, C and M require a customized definition from DNPS 2-5.
 - i. The equipment is to be thoroughly examined for any evidence of damage and, if possible, its operation is to be checked in detail after each attack and before proceeding to the next more severe attack.
 - j. If necessary, an attack may be repeated to check a result or to confirm the efficiency of repair before proceeding to the next more severe attack.
 - k. Tests at intermediate stand-offs may be employed but such procedure must be clearly and specifically stated in the test report.
 - l. At the discretion of DNPS 2-5 heavy equipment may be dealt with by design only. In this case, detailed calculations shall be submitted to the DNPS 2-5 for approval.
 - m. At the discretion of DNPS 2-5 heavy equipment may be tested as a number of component assemblies. That is, a number of Assembly Type S tests as opposed to a single Assembly Type C test.



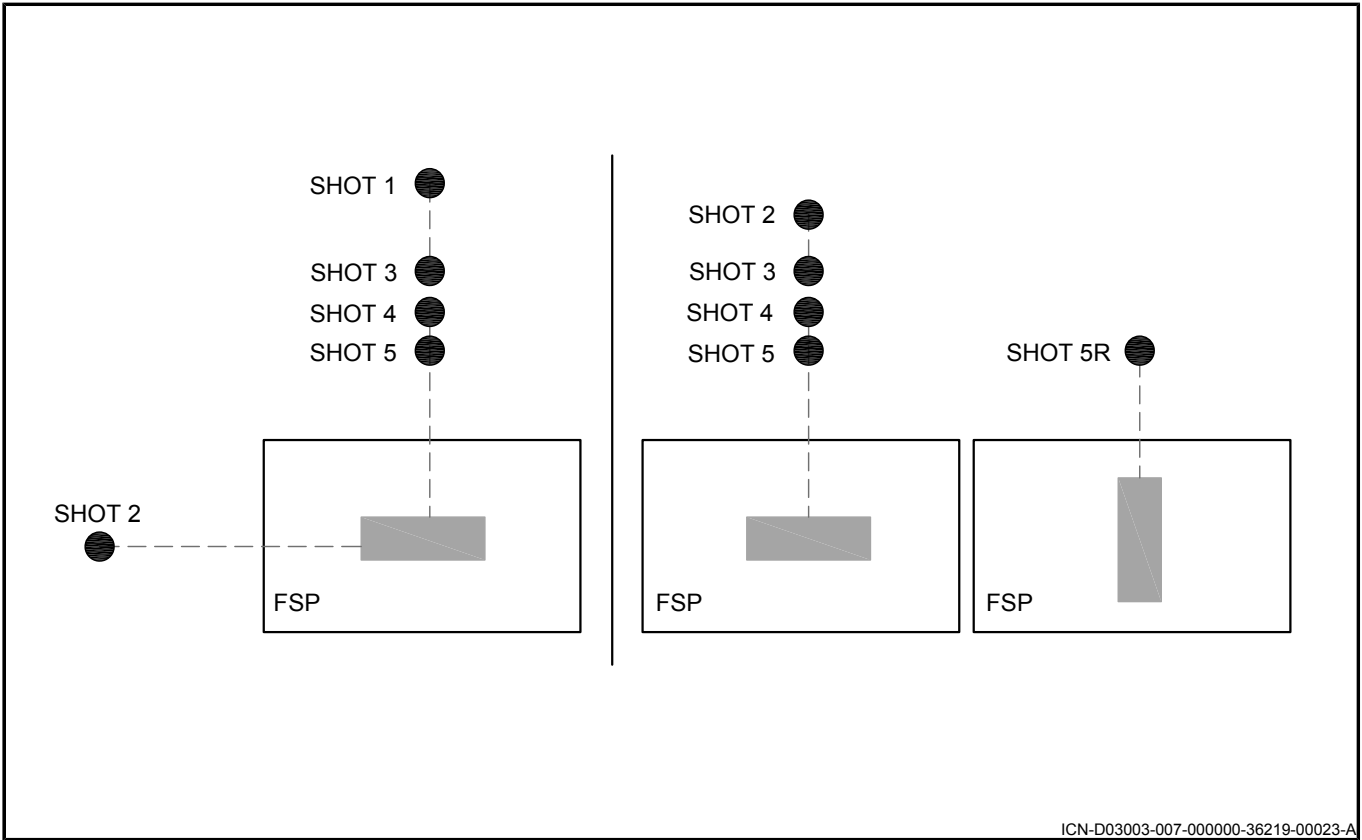
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Figure 3-12 Floating Shock Platform (FSP)



ICN-D03003-007-000000-36219-00022-A

Figure 3-13 FSP Explosives Schedule



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Figure 3-14 Shot position and equipment arrangement for Restricted (left) and Vertical (right) orientations.

Subsequent modifications

12. In the event of failure or damage to the equipment under shock test, the Vendor shall repair and modify the equipment as necessary to pass the test without added cost to Canada.
13. If modifications are made to the design of any equipment after shock testing, for any reason, then a retest may be required. Insignificant changes may be accepted at the discretion of DNPS 2-5.

Shock test inspection

14. Witnessing and inspection of shock tests by the designated Shock Test Inspection Authority (STIA) may be required. Any such requirements will be stipulated in the equipment contract or order.
15. During shock tests, after each blow (or attack), the UUT and its mountings shall be superficially inspected and holding down bolts tightened.
16. During shock tests, after each blow (or attack), the equipment Vendor may sufficiently dismantle the UUT and examine any constituent part. At the discretion of the STIA, the constituent part may be replaced (not modified), before the next blow (or attack).
17. Any failure of UUT to function as designed during and after shock tests shall be clearly recorded in the Test Report. Generally, such failures require a repeat of the shock tests before equipment can be accepted by DND.
18. After completion of tests the UUT shall be dismantled in the presence of the STIA to ascertain whether failure or deformation has occurred. Any crack or deformity out of specification or design drawing tolerances shall be clearly noted in the Test Report.

Use of equipment that has been shock tested

19. Equipment which has been satisfactorily shock tested and reconditioned by the manufacturer to specification, shall normally be accepted for service. Reconditioning shall include replacement of ball or roller bearings.

Test report

20. A test report shall be submitted to DNPS 2-5 giving a description of the equipment and the tests performed. The test report shall include the following details:
- a. Name and address of equipment Vendor and original manufacturer.
 - b. Description of the UUT including details on any differences between the UUT and the equipment to be delivered onboard.
 - c. References to all applicable equipment drawings.
 - d. Weight and general overall dimensions of the equipment as tested.
 - e. Description of any resilient mounting system used to support the equipment during the test including the number of mounts fitted, their load range, their location, the type number and/or name of manufacturer of the mountings.
 - f. Details on the vehicle used for testing (LWSM, MWSM, HWSM).
 - g. A sketch or photographs showing how the equipment was installed in the shock test machine together with any seatings, foundations or substructure fitted.
 - h. Details on the state of the equipment during each shock test performed (i.e. fully operating, partially operating, off) including relevant operational parameter (e.g. electrical load, water or oil pressure, etc.).
 - i. The severity of the tests (e.g. explosive charge and standoff distance, hammer height, etc.).
 - j. Details of any damage or malfunction during or after shock tests. Reporting shall include details of any performance checks and tests performed before and after each component test (i.e. hammer blow or explosive attack).

SECTION 4

QUALIFICATION BY EXTENSION

General

1. There may be cases where shock testing for a new equipment contract/order is not required, examples of this include:
 - a. Equipment is identical to a previously qualified item.
 - b. Equipment is similar to a previously qualified item.
2. In these cases, a submission will be made to DNPS 2-5 for "Qualification by Extension" in lieu of new shock testing of new equipment.
3. DNPS 2-5 will assess requests for Qualification by Extension on a case-by-case basis. If not accepted then shock testing will be required in accordance with Section 3 of this specification.
4. The shipboard mounting location, orientation, and dynamic characteristics intended for the new item shall be no more severe from a shock standpoint than that of the original shock test.

Identical item

5. An item that is "identical" to a previous item must be identical in every detail. There will be no difference in size, weight, centre of gravity, dimensions, materials, construction and configuration between the new and previously tested item. Objective evidence must be submitted to DNPS 2-5 including:
 - a. Shock Test Report from the previous identical item.
 - b. Detailed specification and drawings for the new equipment.
 - c. "Certificate of Identity" from the Vendor.

Similar item

6. An item that is deemed "similar" to a previous item may have minor differences to the previous item but nothing that would affect performance of the item during shock testing. Objective evidence must be submitted to DNPS 2-5 including:
 - a. Shock Test Report from the similar item.
 - b. Detailed specification and drawings for the new equipment.
 - c. Detailed specification and drawings for the similar equipment.
 - d. Details regarding differences in size, weight, centre of gravity, dimensions, materials, construction and configuration.
 - e. A narrative that describes the engineering rationale behind the Vendor's claim that the new equipment has equal or greater shock resistance than the similar item (which has been previously shock tested).

SECTION 5

CONTRACT/ORDER GUIDANCE

General

1. The purchase specification of shock testing requirements is often initially managed by either:
 - a. The equipment Life Cycle Maintenance Manager (LCMM) – upgrading existing equipment or inserting new equipment (capability).
 - b. Project Management Office staff – new platform procurements.
2. Any Contract/Order will have “Priority 3” per [Figure 1-2](#). To avoid unnecessary expense, great care should be taken to ensure contractual shock requirements are accurate and complete. Engagement of DNPS 2-5 is recommended before contract/order is issued.

Ordering equipment

3. End product specifications for equipment, machinery and systems to which this specification applies shall include the following information related to shock testing:
 - a. The ECS# for the equipment as defined in [section 2, paragraph 3](#) of this specification.
 - b. The number of items in any batch to be tested. Normally the first unit only is selected, however, in some cases DND may select other units (e.g. failures of in service units, mid-production run of large quantity order, etc.).
 - c. Mode of equipment operation during the HI shock testing.
 - d. Functional test plan to evaluate equipment during and post HI shock testing. This detail the extent of dismantling and inspection during shock test sequences and after shock tests completed.
4. HI shock testing of equipment is typically completed following vibration and environmental testing. It is acceptable to:
 - a. Test two identical units, one for HI shock and a second for vibration (two units ordered for testing purposes).
 - b. Test the same unit for both vibration and HI shock; refurbishment of the unit after vibration testing and before shock testing is acceptable (one unit ordered for testing purposes).
5. The UUT may be replaced or refurbished after nine (9) and six (6) blows on the LWSM and MWSM, respectively. Similarly on the HWSM, refurbishment is allowed between attacks. Therefore it may be advantageous to order spare units and parts to have on hand during shock testing. Shock requirements shall be clearly defined in the equipment contract/order and be as clear and comprehensive as possible. An example contract or order clause is as follows:

Unit shock requirements are as follows:

- a) *The unit shall be shock tested in accordance with the Canadian Forces Technical Order (CFTO) D-03-003-007/SG-000.*
- b) *The ESC# = 1-C-RM1.5-C-U.*
- c) *The unit to be tested will be delivered to the test facility complete with its resilient mounts.*
- d) *The narrow dimension across the base is athwartships and shall be the direction for the athwartships test.*
- e) *Testing shall be done in two distinct operating modes (i) 100 % load and (ii) 70 % load.*
- f) *Only the first unit shall be tested unless complications arise.*
- g) *Dismantling for inspection shall reveal the main shaft and bearings.*
- h) *If the unit tested passes all shock tests it may be put into service after refurbishment. Refurbishment will include replacement of all roller bearings.*

Test costs

6. The contract/order shall clearly define who is responsible for various shock test related costs:
 - a. Cost of performing tests (i.e. test facility costs) including test set-up, cranes, consumables, mounting fixtures and explosives (if applicable).
 - b. Cost of any ancillary equipment required to conduct tests (e.g. load banks).
 - c. Cost of transportation of equipment to and from test facility.
 - d. Attendance of equipment field technicians if required.
7. The extent of shock testing required may be reduced by limiting the equipment installation orientation and mounting arrangements permitted to a minimum. This can lead to a reduction in testing costs. However, any future installation requiring a different orientation and/or mounting arrangement will require re-testing to qualify the different configuration.
8. The Shock Test Inspection Authority (STIA) shall be designated in the equipment supply contract or order. The STIA shall witness and inspect shock tests as required contractually and/or directed by DNPS 2-5. If requested by DNPS 2-5, the Vendor will accommodate DNPS 2-5 attendance at shock tests.

Test reports

9. Shock Test Reports shall be reviewed by DNPS 2-5. Once accepted, the Report shall be included in the Technical Data Package (TDP) of the vessel where the equipment is installed.

ALPHABETICAL INDEX

NOTE

References are to Part, Section and Paragraph numbers. For example, 2:2:4 refers to Part 2, Section 2, Paragraph 4., and 1:2,3 refers to Part 1, Paragraphs 2 and 3.

If the publication does not contain Parts, 2:4 refers to Section 2, Paragraph 4, and 2:4,5 refers to Section 2, paragraphs 4 and 5.

Acceptance requirements

Acronyms and abbreviations [LA](#)

Applicability

Assembly

Deviation or waiver

Equipment Shock Classification Number (ESC #)

FOREWORD [0](#)

General

General

General

General

Heavy weight test

Identical item

Light weight test

Medium weight tests

Mounting

Ordering equipment

Orientation

Patent infringement warning

Priority of documents

References

Scope

Shock grade

Shock test inspection

Shock test machines

Shock zone

Similar item

Subsequent modifications

Test costs

Test report

Test reports

Use of equipment that has been shock tested

