DEPARTMENT OF THE NAVY
NAVAL SURFACE WARFARE CENTER
CARDEROCK DIVISION

NAVAL SHIP SYSTEMS
ENGINEERING STATION
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From: Commanding Officer, Naval Surface Warfare Center,
Carderock Division, Naval Ship Systems Engineering Station
To: Defense Logistics Agency,
Defense Supply Center Columbus (Code VQP)

Subj: MECHANICAL SHOCK (HI-IMPACT) TEST AND MEASUREMENT GUIDE, QUALIFIED PRODUCTS LIST, TEST SUITABILITY FOR FIBER OPTIC CABLE TOPOLOGY COMPONENTS

Encl: (1) Mechanical Shock, original release, dated 01 September 2006

1. Purpose.

This letter addresses the requirements for performing the mechanical shock test per MIL-S-901 on Fiber Optic Cable Topology (FOCT) components. Proper documentation and performance are required for the following: test laboratory suitability status audits from the Defense Supply Center Columbus (DSCC); proper test performance to FOCT military specifications (such as Qualified Products List or QPL inspections); and review of test procedures and test reports. The applicable FOCT military specifications, that are under DSCC cognizance and require QPL testing, are as follows: MIL-PRF-24623, MIL-I-24728, MIL-PRF-28876, MIL-PRF-29504, MIL-C-83522, MIL-DTL-38999, MIL-PRF-85045. A mechanical shock test and measurement guide, enclosure (1) of this letter, has been prepared to address military requirements and methods of performance.

2. Background.

Naval Surface Warfare Center, Carderock Division, Ship Systems Engineering Station (NSWCCD-SSES) is tasked by the Naval Sea Systems Command (NAVSEA) to provide technical support for qualification and test efforts regarding FOCT components. One subtask is to provide technical support/consultation to DSCC. As part of the subtask, NSWCCD-SSES has supported DSCC in past efforts to qualify component vendors. These efforts include auditing their in-house test facilities, auditing independent, commercial test laboratories, clarifying requirements in military specifications, reviewing documentation (such as test procedures and reports). Development of this mechanical shock test and measurement guide is another type of support being provided.

3. Distribution statement

Distribution Statement A: Approved For Public Release, Distribution Is Unlimited.

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4. Addressees.

This letter is intended for DSCC and other Government agencies/activities, parties in direct support of the Government agencies/activities, vendors, and out-of-house (outside the component's vendor facilities or independent) test laboratories.

5. Point of contact.

DSCC-VQP is to be the initial point of contact for the qualification issues/inquiries that pertain to this matter. Principle point of contact is J. Casto. He can be contacted by telephone: (614) 692-7076 or E-mail: john.casto@dla.mil. Alternative point of contact is Richard Marbais. He can be contacted by telephone: (614) 692-0620 or E-mail: richard.marbais@dla.mil. NSWCCD-SSES point of contact for technical support to DSCC on this matter is E. Bluebond.

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Section E-I

Mechanical Shock

Test Applicability

This section is intended to supplement MIL-S-901 for performing high impact mechanical shock testing on fiber optic components as specified in the applicable component military specification (see below) using the MIL-S-901 lightweight shock machine. Primarily addressed is testing at the level of a subsidiary component (Type B) for fiber optic components; however, aspects for test guidance/requirements on principal units (Type A) is included also. Shock testing of a fiber optic component to the applicable component military specification as part of the process of placing a component on a Qualified Products List (QPL) is considered as testing at the subsidiary component level by the Navy Shock Qualification Activity. Shock testing of a fiber optic component at the level of a subsidiary component is done for the purpose of providing reasonable assurance that the fiber optic component will also pass subsequent Type A tests (when tested as a part of one or more principal units) and to improve opportunities for shock test extension.

Applicable military specifications: MIL-PRF-24623, MIL-I-24728, MIL-PRF-28876, MIL-C-83522, MIL-PRF-85045

Pass/Fail Criteria

1. Mechanical Deterioration. Inability of the launch or detector connectors to properly mate and un-mate during or after the completion of the test shall be cause for failure of the DUT.

2. Physical Deterioration. Evidence of any of the following defects after the test shall be cause for failure of the DUT:

   a. Broken or excessively worn engaging hardware.
   b. Uneven wear or galling of hardware, guide pins, or mating surfaces.
   c. Excessive debris from worn surfaces.
   d. Damage or wear to seals, if applicable
   e. Displaced, bent, broken, or chipped parts.
   f. Scratching of the interface area.
   g. No missile hazard.

   Note: Minor physical damage to the tested item, such as small cracks, minor yielding of structure, out-of tolerance clearances, and similar damage *may* not be cause for shock test disapproval if such damage is accepted by the Defense Supply Center Columbus (DSCC VQP) and unless such damage causes unacceptable impairment of equipment performance, results in a hazard, or results in substantially shortened equipment useful life.
   Note: For Principal units that include the above listed components as part of a system, the following requirements may be applicable for inclusion in the pass/fail criteria: spurious signals to other Grade A equipment, equipment adrift, electrical shorts, electrical shock hazards to personnel, release of flames, smoke, sparks, etc. When applicable, the pass/fail criteria are to be defined explicitly listing the limits and parameters. Refer to 3.1.10 of MIL-S-901 for a listing of the shock test acceptance criteria.

3. Optical performance.

   a. Change in optical transmittance. The maximum allowable change in optical transmittance during or after the test shall is ± 0.5 dB. Power losses exceeding this level shall be cause for failure of the DUT. Note: Some single mode components have a smaller maximum allowable change of ± 0.3 dB.

   b. Optical signal discontinuity. Maximum allowed reduction in the optical signal shall not exceed 0.5 dB for a duration of 50 microseconds or more. A reduction in the optical signal level of 0.5 dB for a duration over 50 microseconds shall be cause for failure unless the requirement is relaxed for the DUT under test.

Note: The following relaxations for various components are specified:

Single mode ST connectors. The maximum allowed reduction in the optical signal shall not exceed 0.5 dB for a duration of 1 second or more.

Multimode ST connectors. For the side axis, the maximum allowed reduction in the optical signal shall not exceed 0.5 dB for a duration of 500 microseconds or more.

4. Accelerometer trace. When specified, an accelerometer trace shall be provided for each impact. The accelerometer shall be calibrated to at least ± 5 percent over the frequency range of 5 to 2000 Hz. The amplitude of the accelerometer shall be calibrated to at least ± 5 percent over the frequency range of 5 to 2000 Hz. The accelerometer selected for a shock sensor should have a fundamental resonant frequency that is not less than 10,000 Hz. The accelerometer shall be rigidly secured and located on the test fixture foundation as near as possible to the DUT, but not on the DUT itself.

Conductance of Test

1. Shock test classification.
    a. Test categories. Test category refers to the type of shock machine or platform in which the test is done. Unless otherwise specified, a lightweight test is performed (on a lightweight shock machine) per MIL-S-901 for testing of fiber optic components. Other categories are medium weight (using a medium weight shock machine) and heavyweight (using a floating shock platform). This Section is written on the premise that a lightweight test is performed. Size, weight and deflection constraints may negate being allowed to perform a lightweight shock test. See items under test equipment for further guidance on this matter.
    b. Shock grades.
        (1) Grade A. Operation of the DUT is essential to the safety and continued combat capability of the ship. The requirements for the pass/fail criteria specified above are to meet Grade A. In general, Shock testing or design of a Grade A DUT shall demonstrate that the DUT will continue to perform its principal function without significant degradation in performance, and that no portion of the DUT will come adrift or otherwise become a hazard during and following application of shock loadings.
        (2) Grade B. Exposure of the DUT to shock cannot result in a missile hazard to personnel or to the ship as a whole. In general, Grade B items are items whose operation is not essential to the safety and combat capability of the ship but which could become a hazard to personnel, to grade A items, or to the ship as a whole as a result of exposure to shock. Failure of a Grade B item to perform its principal function after shock shall not be cause for rejection.
    c. Equipment classes. This classification defines if the resilient mounts are installed between the DUT and the ship structure or shipboard foundation. Class I equipment meets the shock requirements without the use of resilient mountings (between the DUT and the ship structure or shipboard foundation). Class II equipment meets the shock requirements with the use of resilient mountings. Class III equipment meets the shock requirements with and without the use of resilient mountings (thereby required to meet both Class I and Class II requirements). Unless otherwise specified, fiber optic components are considered as Class I equipment.
    d. Shock test types. Fiber optic components, as tested for the applicable component military specifications, are as considered subsidiary components (Type B test) by the Navy Shock Qualification Activity. MIL-S-901 shock testing of Principal units must be coordinated through and approved by the Navy Shock Qualification Approval Activity.
        (1) Type A. The Type A test is a test of a principal unit. Principal units are directly attached to the ship structure or mounted in systems (such as piping and ducting) that are supported buy the ship structure.
        (2) Type B. The Type B test is a test of a subsidiary component. Subsidiary components are items that are the major parts of a principal unit.
        (3) Type C. The Type C test is a test of a subassembly. Subassemblies are items that are a part of a principal unit or a subsidiary component.
    e. Mounting. Unless otherwise specified, fiber optic components shall be bulkhead (hull) mounted (for mounting location) on a 4A mounting fixture. Mounting plane and orientation for the principle axes of the DUT shall be consistent for the top, back and side axes on a lightweight shock machine.
2. Setup.

a. Generic representation. See Section II, General Requirements for test sample configuration.
   (1) Instrumentation. Refer to Sections IV and VI of the Optical Test Measurement Guide for setups pertaining to Change in Optical Transmittance and for Optical Signal Discontinuity, respectively.
   (2) Single ferrule connectors. See figure 1 for connector placement and routing. Refer to 3.b(8)(a) for further details.
   (3) Multiple termini connectors. See figures 2, 3 and 4 for connector placement and routing. Refer to 3.b(8)(b) for further details.
   (4) Cable. See figures 5 and 6 for cable placement and routing. Refer to 3.b(8)(c) for further details.

b. Test equipment (for MIL-S-901, Lightweight Shock Test).
   (1) MIL-S-901 Lightweight Shock Machine. Shock machine used must be one on the approved list in enclosure (1) to NAVSEAINST 9491.1D, Location of Approved Class Hi Shock Testing Facilities. Approval is performed by NSWCCD-SSES Code 623.
   (2) Deflection capability. Test samples shall not be affixed in a manner that allows a deflection that is greater than 1.5 inches for a test performed on a MIL-S-901 lightweight shock machine. Unless otherwise specified, equipment shall be hard mounted (Class I equipment).
      (a) Deflections greater than 1.5 inches. Equipment which would normally be tested on the lightweight shock machine but which is mounted on or incorporates resilient mounts or flexible mounting elements which have deflection capability under shock loading of 1-1/2 inches or more in any direction shall instead be subject medium weight or heavyweight shock testing.
      (b) Deflections greater than 3.0 inches. Equipment which would normally be tested on the medium weight shock machine, but which is mounted on or incorporates resilient mounts or flexible mounting elements which have deflection capability under shock loading in excess of 3 inches in any direction, shall instead be subject to heavy weight shock testing.
   (3) Weight. Weight of test sample and fixtures, excluding anvil plate, must not exceed 300 lb for subsidiary component testing. Note that some ship classes are more restrictive than the general requirement of not exceeding 550 lb per 3.1.2 of MIL-S-901. The equipment (DUT) weight shall not exceed 200 lb. Weight of DUT and fixtures for Principal units testing is addressed in addendum A.
   (4) Mounting fixture. Unless otherwise specified, a type 4A mounting fixture (0.5 inch thick auxiliary mounting panel) shall be used to attach the DUT (or the DUT mounted to supplemental fixtures) to the anvil plate. Width of the 4A plate may be increased from the standard width of 27 inches to a maximum of 36 inches. This width is to be increase only to the extent required for larger equipment. When specified, the following mounting fixtures shown in figures 7 through 12 of MIL-S-901 are acceptable for use: 4C, 6D-1, 6D-2, 6E, 11C.

Lightweight Shock Machine (LWSM) Standard Mounting Fixtures		
Mounting Fixture	DUT Mounting Location	Comments
4A	Bulkhead	Use, unless otherwise specified
4C	Base	
6D-1	Panel	
6D-2	Panel	Use only if specified & 6D-1 not applicable
6E	Controller Components	For contactors, relays, etc.
11C	Base	

   (5) Spacers. For each bolt size, the spacers with the outside diameter and thickness shown in the table below shall be used to secure the DUT or supplemental fixtures containing the DUT to the mounting fixture. One spacer is used for each mounting bolt.

Bolt Size	Outside Diameter	Thickness
¼	¾	3/8
5/16	¾	3/8
3/8	7/8	3/8
½	1-1/4	½
5/8	1-1/2	5/8
3/4	1-3/4	3/4

(6) Resilient mounts. Unless otherwise specified, components shall be hard mounted. Components that would normally be mounted on resilient mounts or on flexible mounting elements may be tested on these mounts provided that the deflection capability in any direction under a shock loading is less than 1.5 inches. If the mounting exceeds this deflection capability, then testing must be done on a medium weight or heavy weight shock machine, as applicable for the deflection capacity.

(7) Retention of position. Once the DUT has been mounted/positioned for test upon a fixture, its position shall not be changed during the course of the test. The same DUT shall be subjected to each series of nine impacts.

(8) Supplemental fixtures. For consistency in testing, supplemental fixtures are standardized for shock testing of fiber optic connectors and cables. Supplemental fixtures are those that hold the DUT and fasten to a mounting fixture (such as a 4A plate).

(a) Single ferrule connector supplemental fixture. Single ferrule connectors shall be tested using a modified MIL-PRF-24728/2 interconnection box as shown in figure 7 as the supplemental fixture. A MIL-PRF-24728/6 patch panel (for an ST connector) or a MIL-PRF-24728/6 style patch panel (for other single terminus connectors) shall be mounted on the interconnection box standard mounting plate (see table below). The appropriate adapter (such as a ST-to-ST adapter for a ST connector) shall be affixed to the patch panel. The cable, from each single ferrule connector, shall be routed within the interior, using tie wraps and tie wrap holders, such that each cable is routed at least three-quarters around the interior of the supplemental test fixture.

Patch Panels for Shock Test Use

Description	CAGE Code	Part Number
ST-to-ST adapter patch panel per M24728/06-001	44291	11254-101
SC-to-SC adapter patch panel, 54 ports, M24728/1 to /3 compatible, without silk screened characters and with captive panel screws	44291	10909 MOD4
SC-to-SC adapter patch panel, 54 ports, M24728/1 to /3 compatible, with silk screened characters and with captive panel screws	44291	10914 MOD4
LC-to-LC adapter patch panel, 48 duplex ports, M24728/1 to /3 compatible, without silk screened characters and with captive panel screws	44291	10909 MOD7
LC-to-LC adapter patch panel, 48 duplex ports, M24728/1 to /3 compatible, with silk screened characters and with captive panel screws	44291	10914 MOD7
Patch panel, blank (without ports or silk screened characters), M24728/1 to /3 compatible, with captive panel screws (Note: user must machine in port configuration for connector being tested)	44291	

(b) Multiple termini connector supplemental fixture. Multiple termini connectors shall be tested using a modified MIL-PRF-24728/2 interconnection as shown in figure 7 as the supplemental fixture. The receptacle shall be mounted to the side of the supplemental fixture via the receptacle mounting plate as shown in figure 2. The receptacle mounting plate shall contain the corresponding through hole and mounting screw holes for the receptacle. The sides of the supplemental fixture shall contain the corresponding through hole and mounting screw holes to interface with the mounting plate. Two receptacles shall be tested at the same time. The receptacles shall be mounted to the interior, sidewalls of the supplemental test fixture. One receptacle shall be mounted near the upper right corner and the other near the lower left corner. The cable, from each receptacle, shall be routed within the interior, using tie wraps and tie wrap holders, such that the cable from each receptacle is routed at least three-quarters around the interior of the supplemental test fixture.

(c) Cable supplemental fixture. The configuration for this fixture shall consist of clamps and a section of a raceway mounted to a 4A plate. Smaller diameter cables (such as 4 and 8 fiber cables) shall be mounted in a rotated 90 degree "S" pattern, as shown in figure 5. Larger diameter cables (such as 31 fiber cables and 7 tube, BOF cables) shall be mounted in an inverted "U" pattern, as shown in figure 6.

(9) Torque for shock machine bolts. Hold down bolts (including screws and other similar fasteners) for affixing the mounting fixture (such as the 4A plate) to the anvil plate and for affixing the supplemental fixture to the mounting plate shall have the specified torque applied (approx 60% of yield per bolt

specifications) for the shock test setup. In general, all type fasteners shall be checked for looseness after each impact and retightened to specified torque values.

(10) Torque for DUT hold down bolts (i.e., foundation bolts for DUT). Hold down bolts (including screws and other similar fasteners) for affixing the DUT to the supplemental fixture shall have the specified (per ship installation) torque applied for the shock test setup. These bolts can be retightened to the specified pre-test torque after the first impact. This retightening is acceptable with no verification (measurement) of bolt yielding or stretching. If retightening is considered to be necessary, the lengths of the bolts are to be measured before DUT installation onto the supplemental fixture (if used) or directly onto the mounting plate, as applicable. After subsequent impacts, it must be verified that the bolts have not lengthened, i.e., any bolt loosening is instead caused by additional seating-in of mating surfaces. This seating-in is defined as a bearing surface minor crushing (such as small deformations of high spots on surface) or a bearing surface being slotted, allowing the bolts to loosen without yielding. If based on measurements, it is determined that that the length of the bolt has increased, retightening is not permitted. The test shall continue with the bolts in the as-found condition. Excessive yielding/stretching (bolt lengthening) or loosening shall be considered a violation of the shock test acceptance criteria. Any or all measurement techniques and results should be incorporated into the final shock test report justifying any retightening of bolts completed after the second impact.

(11) Non-exposed bolts internal to the DUT. Bolts (including screws and other fasteners) are not to have the specified torque applied during shock test setup. Bolts are not to be checked for looseness or retightened to a specified torque value during shock test setup, after the first impact or after each impact. These bolts include the internal, non-exposed, bolts securing resilient mounts from an enclosure to a base plate.

(12) Non-foundation bolts for supplemental test fixtures. Non-foundation bolts on the supplemental test fixture (or any fixture not apart of the application mounting structure) may have the specific torque applied during the shock test setup, retightened to the specified torque value after the first impact, and be checked for looseness after each impact and retightened to the specified torque values. Gross or continued yield of non-foundation bolts for supplemental test fixtures are not acceptable.

(13) DUT cover/inspection panel bolts. In general, non-foundation bolts may be checked and the specified torque applied only during the test setup and, if required for compensation of reseating, after the first blow. Items removed during the test for purposes of performing a visual inspection should be restricted to features designed to permit entry such as inspection panels or covers. Panel/cover bolts are expected to remain tight and not retightened to the specified torque after setup. The exception is when the panel/cover is removed as part of an inspection during the test. This exception to allow entry for visual inspection and apply a torque after inspection is made on a case basis.

(14) Instrumentation bolts. Bolts for securing instrumentation to the DUT, fixtures or other items are to be checked for looseness and retightened to specified torque values during shock test setup, after the first impact and after each impact. This instrumentation includes any accelerometer used and any triaxial mounting block for the accelerometer, if applicable.

(15) Torque the plug coupling ring on multiple termini connectors.

(a) General guidance.

The performance of the connector assembly is based upon the dimensions that exist with the connector tightened properly and the mating components completely seated. This is especially true in connectors that use spring loaded inserts and elastic environmental seals/gaskets that must be properly preloaded/pre-stressed to function according to design parameters. Either the tightening torque should be specified, a final dimension or check mark established, or the connector tightened until no free play exists between the receptacle and the plug portion. Since the condition of "no free play' is somewhat indefinable and usually no marks are provided, the tightening torque specified for the connector must be used. The marking is also critical in determining if the change in measured performance is caused by the connector becoming loose. Shock is a mechanical test and the sudden impact should not create any movement any of the connector components, which could degrade the optical performance of the assembly (including loosening). Usually, accelerometers or other instrumentation is used to determine the response of items under test, however, due to the size and shape of connectors this is difficult to accomplish. Visual observation of alignment marks is an easy and efficient method to determine if the impact is causing an undesirable condition.

Additionally, the connectors should be checked after each impact to measure the effect of the hammer impact for each drop height. It was not intended that the effects be allowed to accumulate over several blows. The increased amount of loosening from the 1st or 2nd blows in each axis may cause a significant anomaly during the next blow, an anomaly that may not have occurred at all had the connector been tightened prior to each impact. For instance if not tightened prior to each blow, a "loose" connector may actually break, instead of just loosening a fraction of turn, because of the increased impact forces.

Consideration should be given to identifying/specifying the amount of looseness that is acceptable. Ideally there should be no loosening whatsoever.

(b) MIL-PRF-28876 connectors. Verify that DUT is sufficiently tight. When mated initially by hand tighten, do not bottom out threads prior to applying torque. Apply torque as specified in the table of appendix D. Torque after each axis. Mark position after torque applied and check/record position after each impact.

MIL-PRF-28876 Coupling Nut Torque Requirements

Shell Size	11	13	15	23
Torque (in-lb)	15	15	25	50

(c) MIL-C-38999 connectors. Initially mate and apply a torque. For shell size 11 (2 termini connector, apply a torque of 1.4 N-m (12 in-lb). Mark position after torque applied and check/record position after each impact. Mating halves contain a ratchet mechanism. Do not tighten after each impact.

(16) Verify mating parts retained on single ferruled connectors. For MIL-C-83522 connectors, COTS ST and SC connectors, verify that the adapters are adequately tightened/fastened to the patch panel. Verify that DUT is sufficiently tight and did not become disconnected/loose after each impact.

c. Measurement equipment.

(1) Ensure that optical equipment is isolated from the shock impact. Surface vibration transmitted from the shock impact can affect instrumentation and connections at the optical ports. One method for isolation is to place optical instrumentation on foam pads or other type of resilient surface.

(2) Accelerometer setup.

(a) Orient accelerometer so it is mounted along the 3 principal axes of the DUT.

(b) Stud mounting accelerometer to supplemental fixture is preferred mounting method. Mount accelerometer to fixture using supplied mounting studs or supplied screws (such as Allen head cap screws). When used, tighten Allen head cap screws to torque specified on the accelerometer parameter sheet.

(c) Clean microdot connector signal pins using isopropyl alcohol. Connect one end to the appropriate accelerometer for axis under test. Connect the remaining end to the charge amp input.

(d) Connect the accelerometer amplifier BNC output to the data acquisition interface box using suitable BNC-BNC cable. Connect to appropriate data acquisition channel.

(e) Set the amplifier sensitivity and set amplifier settings to provide a 2500 g recording capability at 80 percent of the data acquisition card range.

(f) Set the Lower Freq Limit at 2 Hz acc.

(g) Set the Upper Freq Limit at 1 kHz.

(h) Move Power switch to “On”.

(i) Verify that batteries, if used, are charged. Replace or recharge batteries as required.

(3) Data acquisition setup. Ensure acceptable optical signal trace by verifying that no saturation of the optical trace has occurred. Flat horizontal lines in the signal trace close to the baseline (0 dB) or close to optical signal peaks is an indication of amplifier saturation. For example, using a -10 to +10 Volt signal, a data acquisition board would clip (become saturated) at +/- 10 Volts. A flat line signal is a voltage level greater than +10 Volts or less than –10 Volts and is beyond the capability of the data acquisition system to measure it.

3. Test procedure.
   a. Method.
      (1) Multiple terminus connector (M28876, 4.6.6.15, 3.14.16). Mated cable-connector assemblies shall be tested in accordance with MIL-S-901, grade A. Optical discontinuities shall be measured during the test. For connectors of shell sizes 15 and 23, a minimum of four termini shall be monitored for discontinuity. The change in optical transmittance shall be measured after the test. The connector shall be visually examined after the test.
      (2) Cable. (M85045, 4.7.6.13, 3.7.13). A 30-meter minimum length of cable shall be used for this test. The specimen shall be subjected to grade A, type A, class I shocks as specified by MIL-S-901. Not less than 1 meter of the test specimen shall be mounted to simulate shipboard installation in a cable tray (refer to MIL-STD-2003, section 4 for guidance). After completion of the test, the cable shall be visually examined. Signal discontinuity shall be monitored during the test, in accordance with TIA/EIA-455-32, with equipment having a time resolution sufficient to resolve discontinuities of duration not less than 50 **µ**s.
      (3) Single terminus connector (M83522, 4.8.6, 3.5.3.5). Test in accordance with EIA-455 -14. When specified, test shall be in accordance with MIL-S-901, Grade A, Type A, Class 1. Signal discontinuity shall be monitored during the test. Test condition I shall apply.

   b. Test precautions. Verify that the following safety measures are included (also see addendum C).
      (1) Posted sign. Verify that a sign is posted that states: "SHOCK TEST IN PROGRESS". When located in an enclosed facility, sign is to be posted outside the facility entrance. When located in an open area, signs are to be posted along access paths to the area.
      (2) Hearing protection. Verify that personnel are wearing ear protection. When located in an enclosed facility, verify all personnel in the facility are wearing ear protection. When located in an open area, verify all personnel participating in the test, remaining in the area or working in the area are wearing ear protection.
      (3) Missile hazard. Verify that personnel exposure to a missile hazard during the test is minimized. When located in an enclosed facility, verify all personnel in the facility are located outside the plane of the hammer impact. When located in an open area, verify:
         (a) Personnel participating in the test are located outside the plane of the hammer impact,
         (b) Area in which a potential missile hazard may occur is roped off/adequately segregated to personnel working in/transient through.
      (4) Impending hammer impact. Verify that all personnel in the facility are aware of each impending hammer impact/drop prior to the actual impact. When located in an enclosed facility, verify all personnel in the facility acknowledge awareness. A recognized phrase is one method that may be used to alert personnel prior to each impending hammer impact. When located in an open area, a loud-speaker announcement or dedicated audible signal may be more appropriate. If the latter is used, verify that facility personnel recognize purpose of the dedicated signal used.

   c. Test synopsis of hammer impacts/drops.

      (1) Summary. Three impacts (blows) at hammer heights of 1, 3 and 5 feet shall be applied parallel to each of three mutually perpendicular axes of the DUT being tested. This is accomplished by attaching the DUT by fixtures to an anvil plate and striking the anvil plate with top, back and side impacts. The sequence of each axis may vary; however, a sequence of 1, 3 and 5 foot impacts are to be done in each of the three mutually perpendicular axes. When testing connectors, one axis shall be parallel to the longitudinal axis of the connector. If additional testing is required, separate DUT sets may be substituted for each additional set of nine impacts.
      Note: Ensure that the anvil plate is rotated for the side impacts after completing the top and back impacts (or rotated for top and back impacts after completing the side impacts).
      Note: The sequence of the nine impacts is discretionary.
      (2) Items to perform prior to the impact include:
      (a) Post sign stating "SHOCK TEST IN PROGRESS" where appropriate.
      (b) Verify all personnel in the facility are wearing their ear protection in a proper manner.
      (c) Verify that all personnel in the facility are aware of method to be alerted prior to each hammer impact.

(d) Inspect setup to ensure that the hammer and the shock plate are free from optical cable or other obstructions prior to performing the test.
(e) Release the shock machine hammer from the quick release hook. This may be done directly or by an actuator attached to the data acquisition system. If an external actuator is used, ensure that the mechanism does not cause electromagnetic interference in the optical measurement system.

(3) Items to perform after the impact include:
(a) Verify that fixtures and DUT, if applicable, are checked for proper torque value or looseness.
(b) Verify that no missile hazard occurred, no items have become loose/damaged and sufficient optical transmittance is obtained.

4. Calculations.

a. Change in optical transmittance after each impact and the logarithmic power ratio of DUT post impact measurement relative to pre-impact measurement. The computation is as follows: Pre- Log (dB) = 10 log [(P(To)/P(Ro)].

where Pt_o = Power Transmission of item under test measured before start of test/impact.
Pt_i = Power Transmission of item under test measured after impact.
Pt_i/Pt_o = Relative change in power transmission of the item under test after impact.

b. Optical signal discontinuity.

(1) Recorded parameters. Maximum Change in Optical Transmittance during Discontinuity Interval (dB), Time Duration of Discontinuity (Microseconds).
Note: Record, at a minimum, the discontinuity with the maximum duration in with the change in optical transmittance exceeds 0.5 dB (if any). Also record the corresponding maximum value of the change in optical transmittance for the discontinuity with the maximum duration.

(2) Calculated parameters.
Change in optical transmittance after each impact (ΔD) = 10 log (Pti/Pt_0) where:

Pt_0 = Power transmission of test fiber measured before start of test/impact.
Pti = Power transmission of test fiber measured after impact.
(Pti/Pt_0) = relative change in power transmission of test fiber after impact.

Note: Record an increase in optical transmittance (increasing power) as a positive (+) dB.

5. Data sheet.

In addition to the information listed in Section IX of the Optical Test Measurement Guide, the following items are to be included on the data sheet. Test apparatus to include the MIL-S-901 Lightweight Shock Machine and type of Mounting Fixture (i.e., Shock Plate used such as type 4A). Impact/blow direction and hammer drop height plus any additional descriptive test item data. Test Tolerances for the following optical signal discontinuity parameters: Maximum allowed change in optical transmittance (signal level) during shock pulse in dB, Maximum allowed time duration of optical signal discontinuity in microseconds, Maximum allowed relative change in optical transmittance before/after impact in dB. See addendum B for documentation required when performing MIL-S-901 shock testing for a Principal unit.

6. Accelerometer criteria and analysis of accelerometer data.

a. Excitation of shock motion. The Navy high-impact shock machine for lightweight equipment (Lightweight Shock Machine or LWSM) generates a complex shock motion (or spectra). The test is defined in terms of the shock machine used and the mounting method rather than in terms of a specific shock excitation motion (or spectrum). Dominant excitation imparted by a lightweight shock machine is about 100 Hz when test is performed using a type 4A mounting fixture. The dominant excitation may vary for other type mounting fixtures. The lightweight shock machine has a 1.5 inch maximum displacement.

b. Acceptance criteria for accelerometers (acceleration pickup or transducer). Either a piezoresistive or a piezoelectric accelerometer may be used as long as the criteria for sensitivity/frequency response, shock limit and measured frequency range are met and data analysis is not performed to produce a Shock Response Spectrum. For Shock Qualification and/or Shock Response Spectrum analysis purposes, a piezoresistive accelerometer must be used. These acceptance criteria are based on the accelerometer being mounted on a supplemental fixture and not on the anvil plate or mounting fixture.

(1) Sensitivity/frequency response. The ratio of the electrical output over the mechanical input (sensitivity) shall not exceed ± 5 percent over the frequency range from the rated value for sensitivity. This rated (reference) value for sensitivity is specified one frequency. The percent change in sensitivity from the rated value over the frequency range may be referred to as the frequency response or amplitude response.

(2) Shock limits. The maximum limit for the amplitude shall be 2000 g's or greater along the axis of excitation. The resonance frequency shall be at least 10,000 Hz along the axis of excitation.

(3) Frequency range. The range over which the sensitivity does not vary by more than a specified percent from the rated value for sensitivity. The minimum acceptable frequency range is from 5 to 2000 Hz.

c. Accelerometer mounting. Unless otherwise specified, the accelerometer is to be stud mounted with no insulating material between the accelerometer and the mating surface. The accelerometer shall be mounted to align with the orthogonal reference axes of the anvil plate and mounting fixture. Mount the accelerometer on the mounting fixture or supplemental fixtures, as applicable, in a location representative for the mounting of the DUT. In general, verify that mounting efforts for accelerometer eliminate relative motion (between accelerometer and the structure/fixture) in the frequency range of interest and ensure placement is not on an irregular surface.

d. Interpreting the shock pulse. A shock may be defined as the time-history of motion (acceleration) in the equipment support. The equipment may be modeled in terms of a single degree of freedom system. A shock response spectrum may be calculated for a generated shock motion. The maximum acceleration of the mass is plotted against the natural frequency of a single degree of freedom model. This plot is calculated for a particular fraction of critical dampening.

e. Shock response spectrum. Peak values (maximum response) to a shock or impact experienced by a single degree of freedom system for a series of systems, each with a different spring stiffness. A plot is generated of the peak response (in acceleration, velocity or displacement) versus the frequency at the peak response (its natural frequency) for each different spring stiffness. A shock response spectrum, therefore, describes a shock motion in terms of the results it produces.

f. Uses for the shock response spectrum.

Note: For most fiber optic component shock tests, the accelerometer is mounted on the mounting fixture or the supplemental fixture, not the DUT itself. This is due to the small size and shape of these components (accelerometer mounted on DUT would effect response to a shock). Under these constraints, the following uses apply.

(1) DUT. Relative to linear single degree of freedom systems, the shock response spectrum is useful for determining the frequencies at which a shock has the most potential for damage and for developing shock design requirements and performance limits.

(2) Test fixtures. The shock response spectrum is useful for determining the dominant response frequencies in a structure in which the DUT is attached.

g. Limitations of the shock response spectrum.

(1) The appropriate damage potential may not be shown for non-linear failure modes (must be validated).

(2) Obtaining a prescribed shock response spectrum envelope for a particular test configuration may be impossible for some DUT's due to spectrum dip.

(3) Rotational motion, cross-coupled motion and associated failure modes are not addressed.

(4) Shock spectra are time independent; therefore, time dependent failure modes may not be shown (needs validation).

(5) The shock spectrum represents the response of a hypothetical, linear, single degree of freedom system that does not feedback to the foundation. If the shock response spectrum is obtained from the foundation that is affected by a structure reaction, the shock spectrum envelope comparisons can be very misleading.

h. Mounting relative to the equipment's foundation. A measure of equipment's shock severity requires an evaluation of the shock input to the equipment at its base (i.e. the equipment's foundation). As such, an accelerometer is located close to the equipment on its local foundation to monitor the shock input. Note that an accelerometer measurement located at a position on the equipment (e.g. at its center-of-gravity or at a corner on top of the equipment) would not represent the shock input at the base of the equipment located at the equipment–foundation interface. This accelerometer measurement is performed when the objective is to relate test sample failure to severity of the shock input environment. Therefore, if the objective is to quantify the shock severity of the test sample's input via a Shock Response Spectrum derived from an accelerometer record, a measurement of the shock input to the test sample, rather than the test sample response, is required. A different instrumentation approach may be required if the objective is to measure the test sample response directly.

i. Time history curve, information extracted.
   (1) Failure not at peak. Failure does not necessarily map with peak acceleration. A high-frequency acceleration peak that is short in duration may not contribute significantly to the failure. Cumulative accelerations over time up to the failure or that occur throughout the shock pulse contribute to the failure. Shock response spectrum versus frequency is a more appropriate means to pursue for cause of failure. The peak velocity and average acceleration have been shown to correlate to failure in underwater shock testing. The slope of a linear velocity ramp (triangle) is viewed as the average acceleration.
   (2) Integration of data. Accelerometer data is integrated to obtain a velocity time history. Small changes or errors in acceleration data can lead to a drift in velocity values due to computation of the integral, and also will cause incorrect values in the shock spectrum. An accelerometer signal with a response down to direct current is needed to integrate acceleration in time to obtain the velocity. Charge amplifiers used with piezoelectric accelerometers couple alternating current through a capacitor. This restricts the lower frequency bound to several Hertz. Also, an offset occurs at higher shock levels with a piezoelectric accelerometer. For these reasons, a piezoresistive accelerometer must be used when shock spectrum analysis is to be performed.

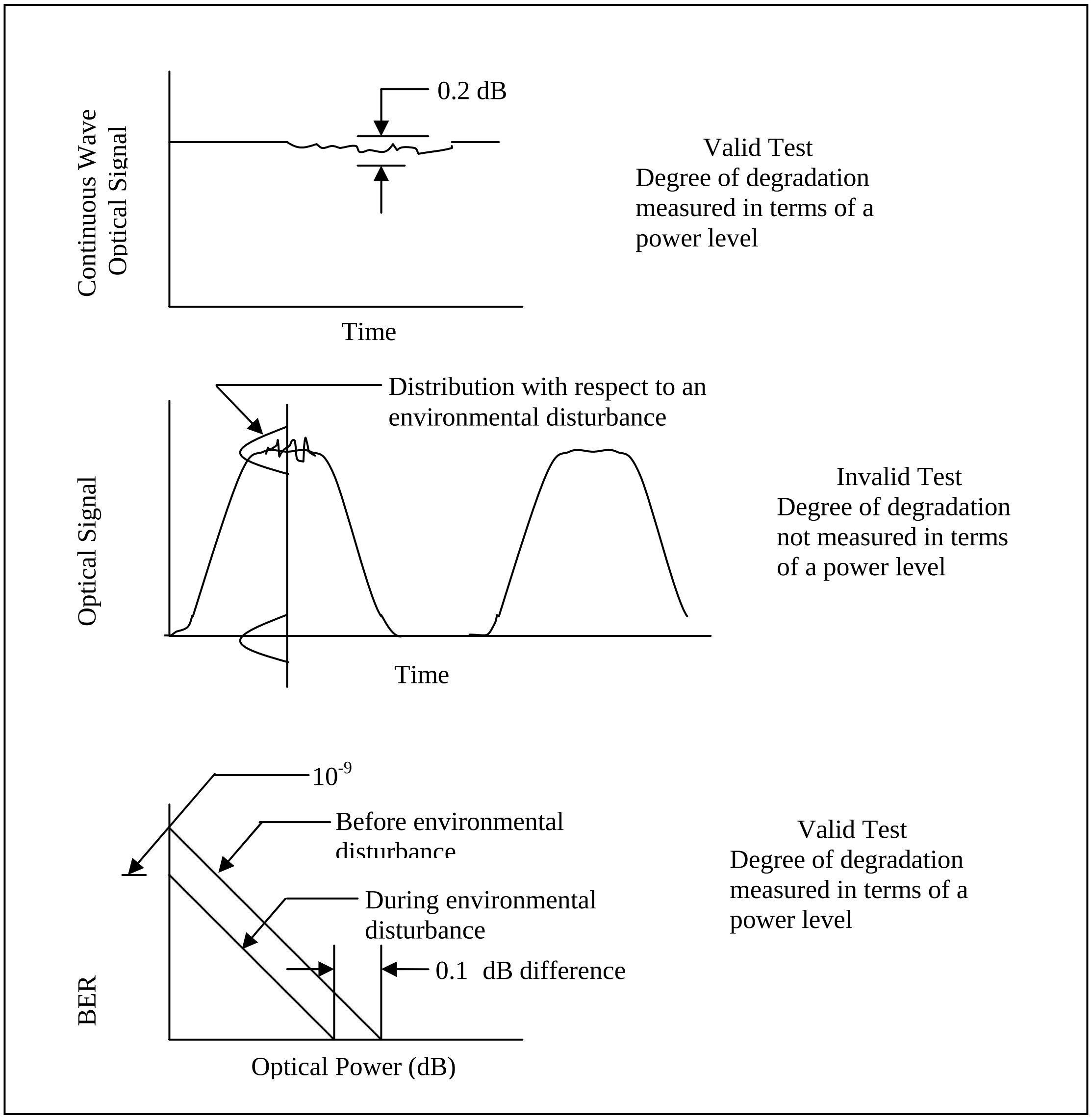
7. Preference of measuring Optical signal discontinuity over Bit Error Rate (BER) test.

   a. Signal characterization. Optical signal discontinuity measurements are done using a continuous wave (CW) signal. The steady state and any drop/gain in the power level are measured for optical signal discontinuity. The magnitude of the modulation of the CW signal (peak-to-valley) can be characterized with respect to an environmental disturbance (such as shock or vibration). BER measurement consists of interpreting the power level output in terms of a zero or one. The exact value of the change of this voltage or power level due to an environmental disturbance is not measured (remains an unknown). As a result, the distribution of the BER signal cannot be characterized with respect to an environmental disturbance.
   b. BER measurement constraints.
      (1) Power level assumed constant. The BER is measured assuming a constant affect or degradation of the power output level that does not vary in magnitude during the extent of the measurement.
      (2) Average degradation measured. The pass/fail criterion is set to measure an average degradation during the test.
      (3) Repeatability of BER test results. The loss at which an error will be registered in typical BER setups is typically several dB. This loss is not really adjustable in a practical sense, it is whatever you happen to get based on the source/detector you use and the cable configuration. This contrasts with the specific 0.5 dB threshold established for change in optical transmittance type test (such as optical signal discontinuity). So the results between different BER test setups will not be comparable nor necessarily representative of the installed system performance.
   c. BER applicability to vibration & shock disturbances.
      (1) Vibration.
         (a) Random. During this test, random levels of amplitudes are introduced at varying frequencies. Each data pulse is measured with a different magnitude of noise or ripple effect. Unless the power output level is set to the worst case output level, the response can be grossly under predicted.
         (b) Swept sine. When stepping through the frequencies one at a time, unacceptable performance at one frequency may be masked if those results are averaged over multiple frequencies.
      (2) Mechanical shock. BER measurements are not applicable for this test since the effects on the output power level are not constant and occur over too short an interval to assess actual performance. The actual response may be grossly under predicted.
   d. Validity considerations to various BER type measurement approaches. In general, a BER measurement at the component level testing for shock and vibration testing is not recommended. If the BER is still of interest, then the alternatives to a direct measurement of BER listed below may be investigated.
      (1) Direct measurement of BER. There is no validity in obtaining an absolute number for the BER. Absolute BER values are a function of the optical power in the system and the measurement

equipment. In addition, averaging occurs during the BER measurement and obtaining a specific value for the BER does not ensure adequate performance.

(2) Approach to BER Measurement in terms of power level. A valid test approach is to measure the degree of degradation in terms of power level and allows for an adequate duration. In this approach, the BER is measured in terms of a power level and not an absolute value. One implementation to this approach is to plot the BER versus the power before and during the test.

(3) Approach to determine change in data packet bits. In order to take out the averaging found in a BER test, an alternate is to run as an error test, where the pass/fail is some specific number of errors. This alternative to performing a BER measurement is a valid approach. A continuous stream of data packet bits is sent during the test. Error checking software determines if there is any change in data packet bits. This check is measured assuming a constant affect or degradation of the power output level that does not vary in magnitude. Passing is considered to be if no data packet bits are changed. The pass/fail criterion is set to measure at an average degradation. To have an accurate representation, the data packet bits must be sent at the worst case power output levels for each system being considered. This approach is qualitative in terms of validating system performance, and generally is not representative of actual system performance.



0.2 dB
Continuous Wave Optical Signal
Time
Valid Test
Degree of degradation measured in terms of a power level
Distribution with respect to an environmental disturbance
Optical Signal
Time
Invalid Test
Degree of degradation not measured in terms of a power level
10-9
Before environmental disturbance
During environmental disturbance
0.1 dB difference
BER
Optical Power (dB)
Valid Test
Degree of degradation measured in terms of a power level

8. Checks on the MIL-S-901 lightweight shock machine. At a minimum, the below listed checks are to be performed as one measure to ensure consistent performance.

   a. Checks before each blow/impact.
      (1) Check fasteners for tightness. This check includes the bolts holding the item to the mounting fixture, the mounting fixture to the anvil plate and the anvil plate to the shock machine.
      Note: If a supplemental fixture is used, this check includes the bolts holding the item to the supplemental fixture and the supplemental fixture to the mounting fixture.
      (2) Check that hammer not in use is secured so that it is not in contact with its anvil pad and will not make contact in course of a blow.
   b. Checks for/during each test.
      (1) Check the clearance between the stops for the forward springs on the Back and Side (Edge) blows. This clearance is to be 1.5 inches (3.8 cm).
      Note: Clearance of the forward springs for Top blows is not controllable. With the static load of the anvil plate and fixture, but without the test item and any supplemental fixture, this clearance should be about 1.5 inches.
      (2) Check the various rollers that guide the anvil plate for the Side blows to ensure that they turn freely. This check may be performed when the anvil plate is being reoriented for the Side blows or reoriented for the Back and Top blows.
   c. Periodic checks.
      (1) Check for cracks in the welds on the anvil plate. Welds in the vicinity of the anvil pads and bottom guide rollers are particularly susceptible. A visually detected crack must be repaired (such as chipped out and re-welded).
      (2) Check for deformation in the anvil pads. Apply a straightedge along the anvil pad. If the gap between the center of the anvil pad and the straight edge is more than 0.5 inch (1 cm), the anvil pad (and most likely part of its support structure) is to be removed and replaced.
      (3) Check to verify that the pivot bearings of the swing hammer are greased periodically.
      Note: Lubrication is not mandatory on the guides for the vertical hammer. There is sufficient clearance between the vertical hammer and the guides (0.06 to 0.12 inch [0.15 to 0.30 cm]) to minimize the effectiveness of any lubrication.
      (4) Check the forward and rebound springs for possible deformation or breakage.
         (a) Back and Side springs. These springs are visible and easy to inspect.
         (b) Top springs. These springs are enclosed. One procedure to check these springs is when the anvil plate is oriented for the Back and Top blows. First verify that the total height is about 9 inches (23 cm) when the top springs support only the weight of the bare anvil plate. Next, lower the vertical hammer until it rests on the top anvil pad. The height of the Top springs should shorten by no more than 0.5 inches (1.3 cm). If a discrepancy is observed, the Top spring assembly should be disassembled and inspected.
      (5) Check the mounting fixture and any supplemental fixture to ensure it is not excessively bowed or deformed.

Addendum A – Principal Unit Weight Restrictions: Shipboard Applications.

Shock test requirements for Principal units can vary between ship classes, therefore shock test requirements should be consulted prior to test for each ship class that the component is being tested. In general, MIL-S-901 refers to the high impact shock test requirement for the respective ship class identified in the paragraphs and table below for surface ships, submarines and submarine overhauls.

1. Surface ships. Shock testing requirements for surface ship equipment are established by each class' respective Ship Specification. Generally surface ship specifications require equipment, systems and structures to be shock tested in accordance with MIL-S-901D, Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment and Systems, Requirements for, dated 17 March 1989.

2. Submarines. The following table establishes the baseline submarine high impact shock testing requirements for each submarine class.

Submarine Class	High Impact & Wetted Surface Shock
SSN 688 (LOS ANGELES) Class	MIL-S-901C as modified by NAVSEA T9SSN-XG-SBS-010 "Specifications for Building Submarines, SSN 688 Class" Section 9400-1, Table 1
SSBN 726 (OHIO) Class	MIL-S-901C as modified by NAVSEA 0902-LP-027-7010 "Specifications for Building Submarines, SSBN Trident Class" Section 9400-1, Table 1
SSN 21 (SEAWOLF) Class	Project Particular Document No. 802-6335704* "Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment, and Systems, Requirements for"
SSN 774 (VIRGINIA) Class	MIL-S-901D, Amended by Interim Change #1** "Shock Tests, High Impact Shipboard Machinery, Equipment, and Systems, Requirements for"
SSGN Conversion of SSBN 726	MIL-S-901C as modified by NAVSEA 0902-LP-027-7010 "Specifications for Building Submarines, SSBN Trident Class" Sect. 9400-1, Table 1 and "SSGN Conversion Ship Specification Addendum", Sect. 9400-1
* As modified by paragraph 072k of Specifications for Building Submarines, SEAWOLF Class. ** As modified by paragraph 072k of Specifications for Building Submarines, New Attack Submarine Class.	

3. Submarine overhaul. The requirements for overhaul of in-service submarine (SSN-688, SSBN-726, SSGN-726 (Non-SSGN Conversion)) equipment are augmented by NAVSEA 0902-018-2010 General Overhaul Specifications for Deep Diving SSBN/SSN Submarines; dated 1 July 1992. NAVSEA S9070~AA~MME-010/SSN/SSBN Technical Requirements Manual For Temporary Submarine Alterations, THIRD REVISION; dated 18 January 2005 augments the requirements for temporary alterations installed aboard all submarine classes.

Addendum B – Principal Unit Documentation Requirements: Shipboard Applications.

Data Item Description (DID) DI-ENVR-80708 and DI-ENVR-80709 should be utilized as guidance when developing the shock test report and shock test procedures, respectively.

DI-ENVR-80708 Adopted for MIL-S-901D Interim Change #1, Sept 1994, Shock Test Report.
DI-ENVR-80709 Adopted for MIL-S-901D Interim Change #1, Sept 1994, High-Impact Shock Test Procedures.

Submission of a shock test procedure for approval prior to performance of the LWSM shock test is not require (but is required for a HWSM shock test). The risk assumed in the event the LWSM shock test is performed without a prior test procedure submission and the test is considered invalid due to improper test performance, the test may need to be redone. A few items that have invalidated previous tests performed and should be addressed before performing a LWSM shock test used for Shock Qualification are as follows:

1. Mounting considerations.
   a. Interface. The component's mounting on the LWSM must be done in the same manner as in the shipboard installation. Any fixture, stand-offs or other type interface used in the application must

be included in mounting the DUT on the LWSM shock test. In general, verify that the DUT is mounted directly to the bulkhead without the use of any interface (but with required spacers).

b. Non-standard fixture. Test procedure approval, by the NAVSEA 05 Delegated Approval Authority (DAA), is required prior to start of testing when a non-standard test fixture is used. An example of using a non-standard fixture could be in the testing of a drawer level component in lieu of testing the component in its shipboard configured rack. The non-standard fixture could be in form of bookend interface. This non-standard fixture would be used as an interface between the mounting fixture (such as the types 4A, 4C or 11C) and the DUT. Evidence must be provided that the non-standard fixture provides the same shock characteristics as the mounting configuration used in the shipboard application.

c. Attachment hardware. The same bolt (i.e., size, material, grade, etc.) stud or other mounting hardware used to secure the DUT to the bulkhead, deck, etc. must be used to secure the DUT to the LWSM. Bolt torque should also be specified.

2. Pass/fail criteria. All criteria for DUT performance during the shock test must be defined, tested and verified to be within specification limits. For instance, testing must include performance of battle short conditions if those type requirements exist.

3. Accelerometer data. Shock Qualification for testing performed on a LWSM is not required to be instrumented with accelerometers to record the shock input. There is one exception. Shock Qualification testing performed that may later be used for Shock Qualification Extension should be instrumented with accelerometers. NAVSEA DAA approval should be obtained prior to the start of testing for the accelerometer instrumentation and the accelerometer mounting method, orientation and locations if data is needed to support the shock extension.

Addendum C – Safety Considerations.

1. Regulations. It is recommended that the test laboratory follow safety practices pertaining to this test for personnel and equipment. For each product or stressor, the applicable personnel protective equipment (PPE) should be considered.
   a. Hearing conservation. Federal standards include 29 CRF 1910.95. Also, the military must be in compliance with the applicable documentation such as OPNAV 5100.23F, Ch 18. For the product/stressor of “noise”, the PPE of circumaural muffs or circumaural muffs with ear plugs should be considered.
   b. Eye protection. Federal standards include 29 CRF 1910.133. Also, the military must be in compliance with the applicable documentation such as OPNAV 5100.23F, Ch 20. For the product/stressor of “impact”, the PPE of impact resistant goggles or safety glasses should be considered.
   c. Hand protection. Federal standards include 29 CRF 1910.138. Also, the military must be in compliance with the applicable documentation such as OPNAV 5100.23F, Ch 20. For the product/stressor of “getting your fingers smached/splintered” while placing/reorienting fixtures, the PPE of heavy duty gloves should be required.
   d. Lifting equipment/hoists. Navy standards include NAVFAC P307. Also, each military Activity must be in compliance with their internal standard (such as NAVSSES 5100.14F, Ch 25). Hoists and other heavy lifting equipment should require routine maintenance, inspection and safety checks.

2. Considerations. Consideration should be given to implement test precautions (see 3.b) and safety measures cited in the test synopsis (see 3.c) as part of the specified laboratory safety procedures.

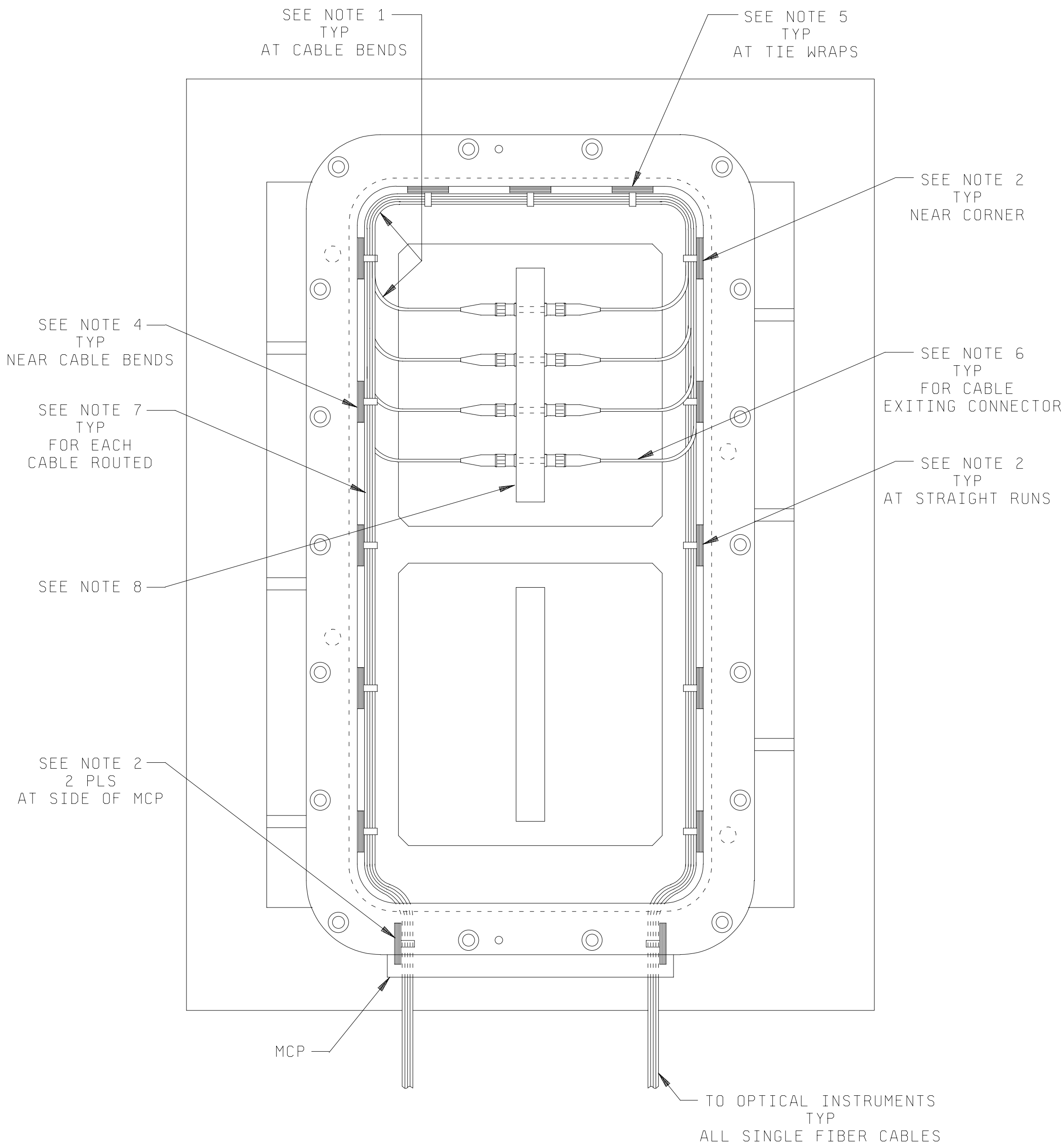


Figure 1: <u>Supplemental test fixture with single ferrule connectors: cable routing and tie-downs</u>.

NOTES:

1. Maintenance of bend diameter. Each cable bend is not to exceed (be smaller than) the long term, minimum bend diameter of cable inside the interconnection box.
2. Mounting of tie wrap holders. On the inside of the interconnection box, tie wrap holders are to be placed as shown around the sides of the box. Place a tie wrap holder near the corners of the box, near cable bends and towards the middle for lengths of straight runs (about three on the top, four to five on both the left and right sides, and one on each side of the MCP). Tie wrap holders must be secured in place using epoxy. The adhesive on the tie wrap holder is not adequate to secure the tie wrap during the shock.
3. Type of tie wrap holder. Use the following type tie wrap holder or equivalent: Mounting base, tie down, electrical, Thomas & Bettz P/N TC5347A. Four way configuration (versus two way) and with adhesive is optional.
4. Type of tie wrap. For most applications, 4-inch long tie wraps are used. SAE-AS33671 electrical tie down straps, adjustable, plastic, Type I, Class 1, miniature, 18 lb. minimum tensile strength (such as P/N MS3367-4-9, NSN 5975-00-727-5153 or P/N MS3367-4-0, NSN 5957-00-903-2284) or other equivalent commercial self-locking cable ties.
5. Degree of tightness. Tie wraps are to be snug so that movement of the cable is restricted, but tie wrap exerts no to minimum pressure on the cables.
6. Straighten cable at exit to connector. Cable that is exiting the connector is to be kept straight to maximum length practical before placement into the first bend while still maintaining requirement stated in note 1.
7. The cable from each single ferrule connector shall be routed within the interior, using tie wraps and tie wrap holders, such that each cable is routed at least three-quarters around the interior of the supplemental test fixture.
8. Patch panels, single ferrule connector supplemental fixture. A MIL-PRF-24728/6 patch panel (for an ST connector) or a MIL-PRF-24728/6 style patch panel (for other single terminus connectors) shall be mounted on the supplemental fixture standard mounting plate (see table below). The blank patch panel shall be used with the appropriate cutouts made for single ferrule connectors not listed. The appropriate adapter (such as a ST-to-ST adapter for a ST connector) shall be affixed to the patch panel.

Patch Panels for Shock Test Use

Description	CAGE Code	Part Number
ST-to-ST adapter patch panel per M24728/06-001	44291	11254-101
SC-to-SC adapter patch panel, 54 ports, M24728/1 to /3 compatible, without silk screened characters and with captive panel screws	44291	10909 MOD4
SC-to-SC adapter patch panel, 54 ports, M24728/1 to /3 compatible, with silk screened characters and with captive panel screws	44291	10914 MOD4
LC-to-LC adapter patch panel, 48 duplex ports, M24728/1 to /3 compatible, without silk screened characters and with captive panel screws	44291	10909 MOD7
LC-to-LC adapter patch panel, 48 duplex ports, M24728/1 to /3 compatible, with silk screened characters and with captive panel screws	44291	10914 MOD7
Patch panel, blank (without ports or silk screened characters), M24728/1 to /3 compatible, with captive panel screws (Note: user must machine in port configuration for connector being tested)	44291	

9. Dimensions are in inches.

Figure 1: <u>Supplemental test fixture with single ferrule connectors: cable routing and tie-downs</u> - Continued.

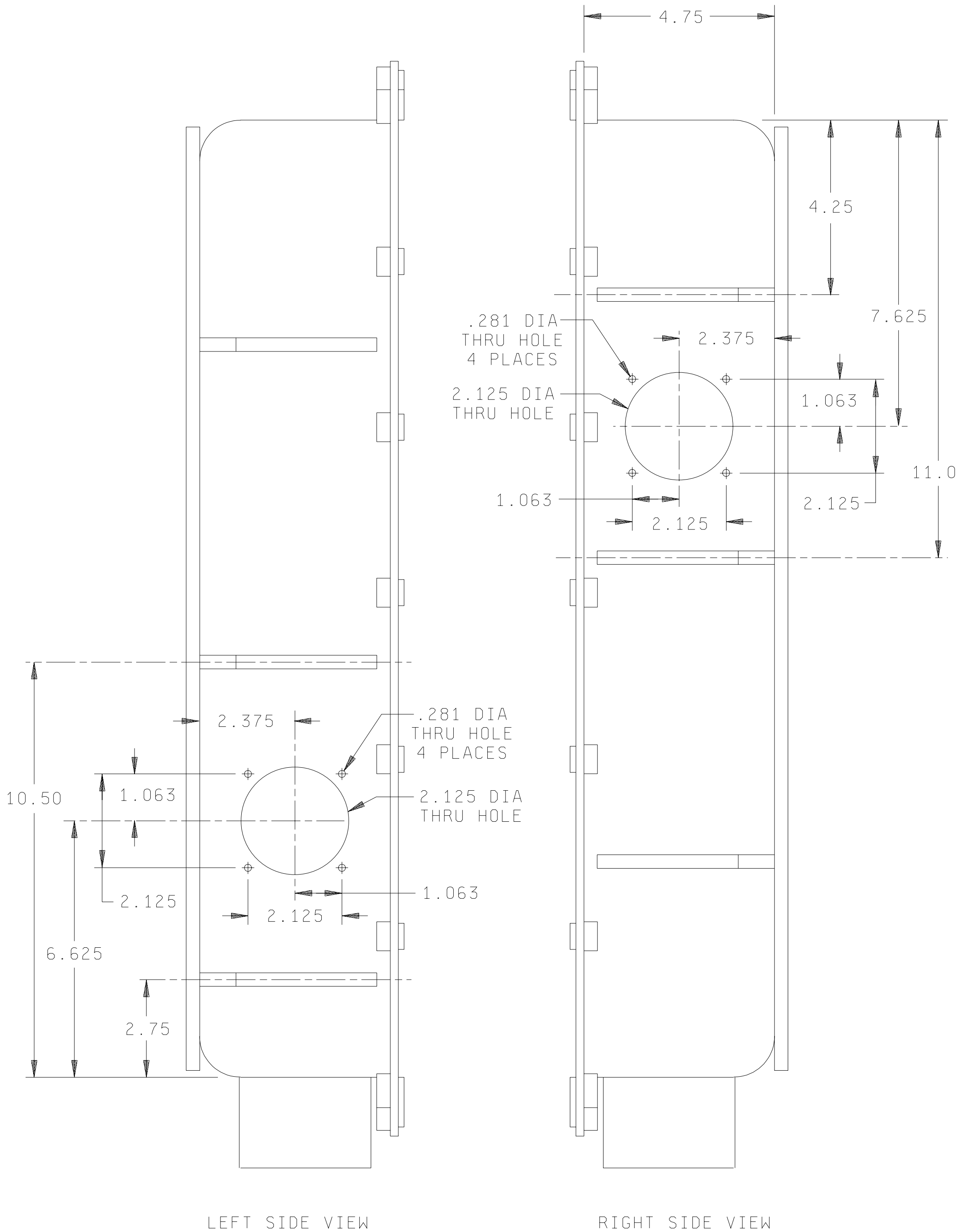
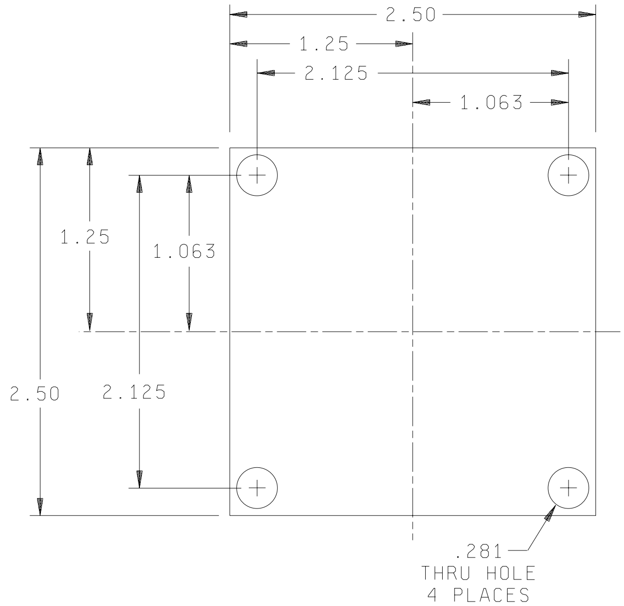
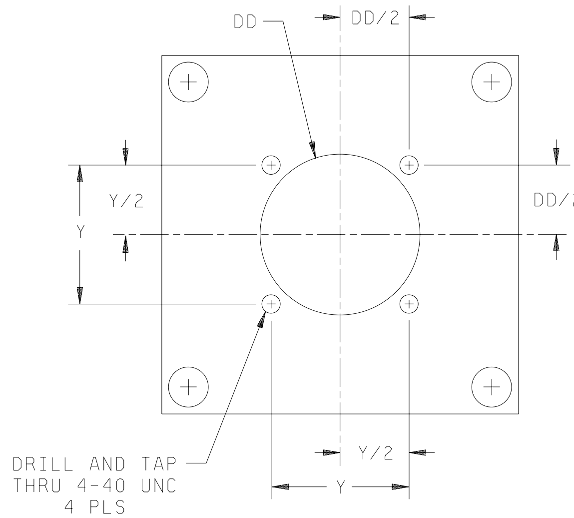


Figure 2: Mounting plate locations and plate configurations for multiple termini connectors supplemental test fixture.





Master Adapter Plate
1/8inch steel

Inch	mm
0.281	7.14
1.063	27.00
1.25	31.75
2.125	53.98
2.375	60.36
2.50	63.50
2.75	69.85
4.25	107.95
6.625	168.28
7.625	193.68
10.50	266.70
11.00	279.40

MIL-PRF-28876 and MIL-PRF-NGCon adapter plate. Use master adapter plate for common dimensions & material

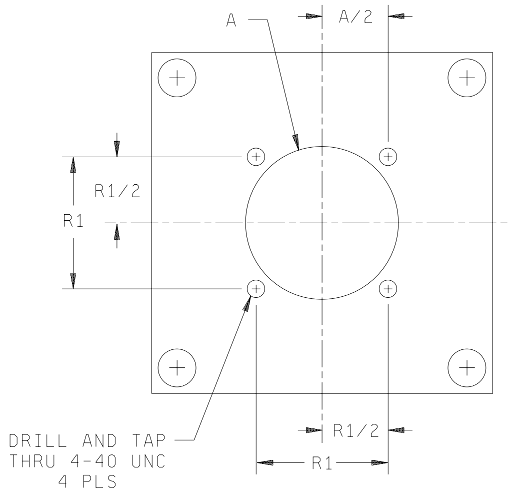
TABLE I. MIL-PRF-28876 and NGCon adapter plate dimensions.

Shell Size	Y	DD dia +/- .010
11	0.750 (19.05)	0.812 (20.62)
13	0.843 (21.41)	0.937 (23.80)
15	0.968 (24.59)	1.124 (28.55)
23	1.281 (32.54)	1.562 (39.68)

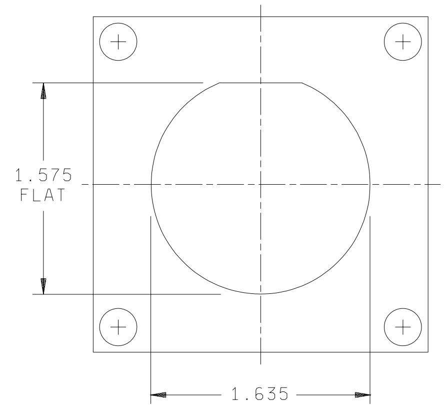
NOTES:
1. Adapter plates are used for affixing various multiple termini connectors to supplemental test fixture.
2. Dimensions are in inches.
3. Metric equivalents (mm) are in parenthesis.
4. Metric equivalents are given for general information only.

Detail A. Master plate and adapter plate configurations

Figure 2: Mounting plate locations and plate configurations for multiple termini connectors supplemental test fixture - Continued.



MIL-DTL-38999 connector adapter plate
Use master adapter plate for
common dimensions & material



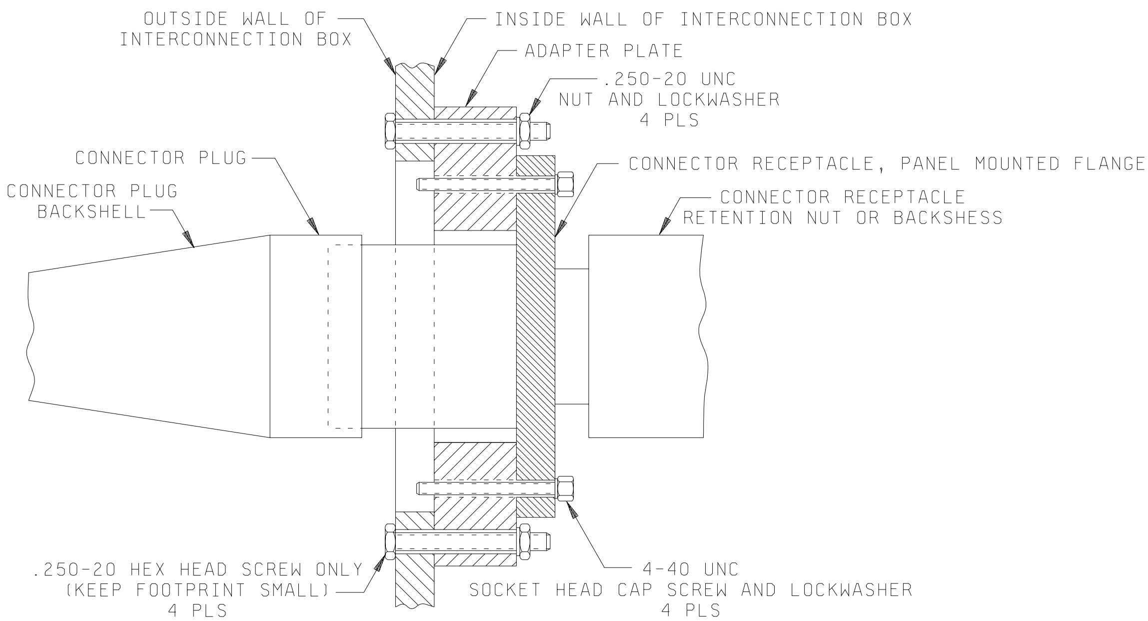
Hermaphroditic connector adapter plate
Use master adapter plate for
common dimensions & material

TABLE II. MIL-DTL-38999 adapter plate dimensions.

Shell size	A	R1
09	.656 (16.66)	.719 (18.26)
11	.796 (20.22)	.812 (20.62
13	.922 (23.42)	.906 (23.01)
15	1.047 (26.59)	.969 (24.61)
17	1.219 (30.96)	1.062 (26.97)
19	1.297 (32.94)	1.156 (29.36)
21	1.422 (36.12)	1.250 (31.75)
23	1.547 (39.29)	1.375 (34.93)
25	1.672 (42.47)	1.500 (38.10)

Detail A. Master plate and adapter plate configurations - Continued

Figure 2: Mounting plate locations and plate configurations for multiple termini connectors supplemental test fixture - Continued.

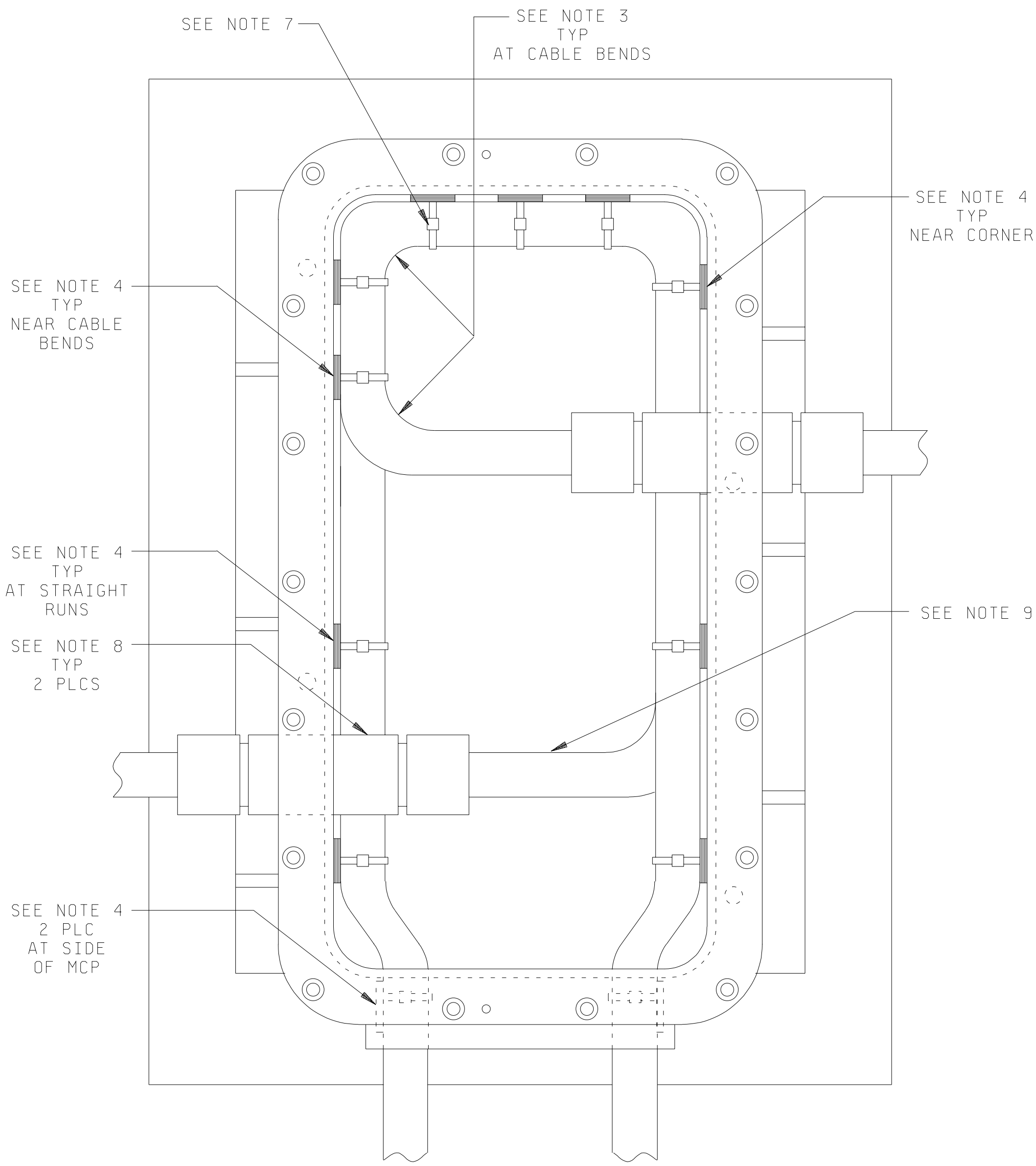


NOTES:

1. This detail shows the configuration to mount the applicable adapter plate to a multiple termini connector, and mounting the connector with adapter plate to the supplemental test fixture (i.e., side of the interconnection box).
2. Verify hardware used and direction hardware mounted are in accordance with this detail.
3. For tightening connector plug to connector receptacle with a strap wrench, keep hardware footprint small on the outside of the interconnection box.

Detail B. Master Adapter Plate Mounting to IC Box fixture

Figure 2: Mounting plate locations and plate configurations for multiple termini connectors supplemental test fixture - Continued.



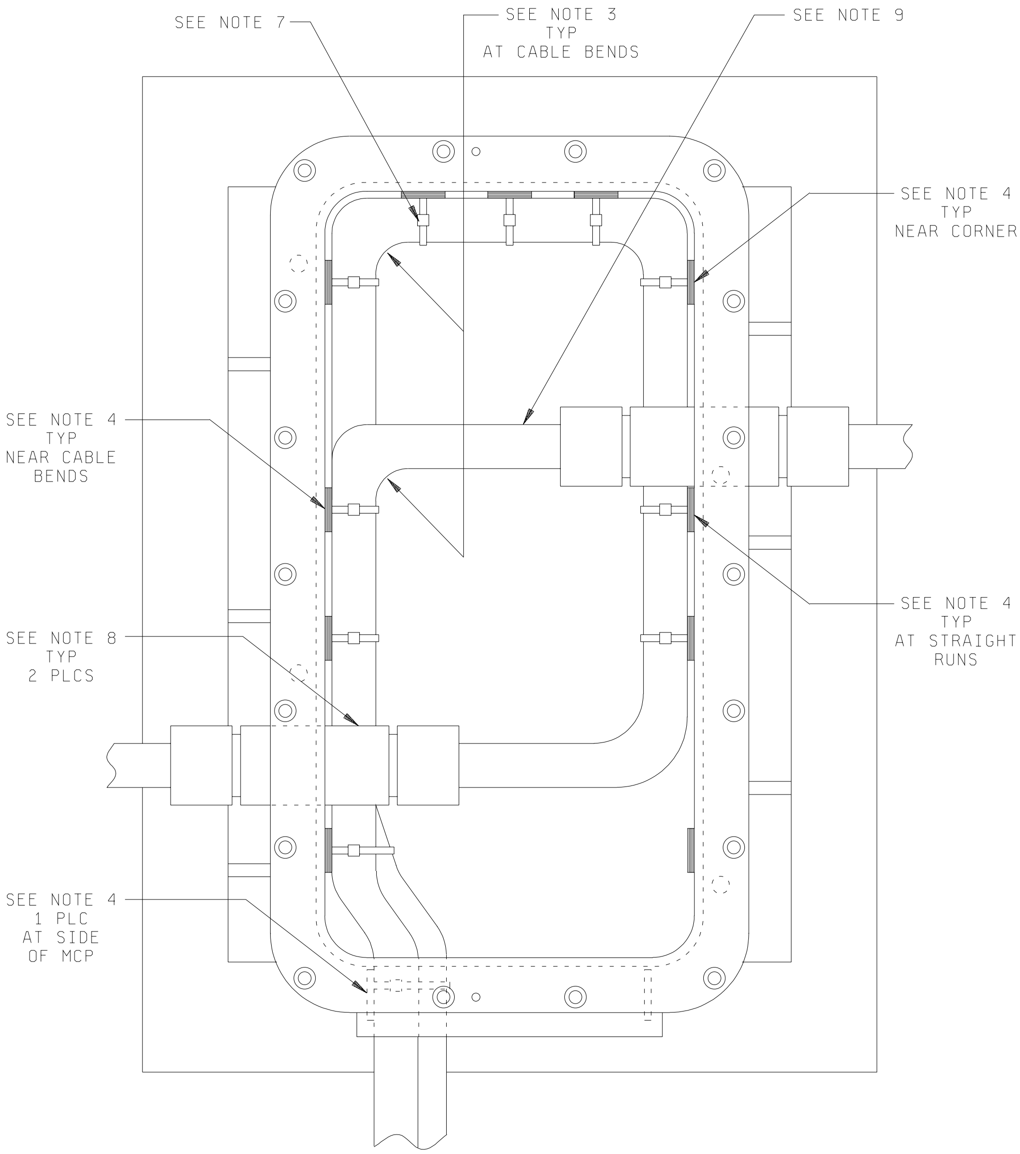
See Note 1

Figure 3: Supplemental test fixture with multiple terminus connectors: cable routing and tie-downs, smaller cable diameter.

NOTES:

1. Test fixture applicability. If 13.5 – B $\leq$ 3 where “B” is in inches, use supplemental test fixture in Figure 4 (See note 2).
2. Bend diameter. B = Long term, minimum bend diameter of cable under test.
3. Maintenance of bend diameter. Each cable bend is not to exceed (be smaller than) the long term, minimum bend diameter of cable inside the interconnection box.
4. Mounting of tie wrap holders. On the inside of the interconnection box, tie wrap holders are to be placed as shown around the sides of the box. Place a tie wrap holder near the corners of the box, near cable bends and towards the middle for lengths of straight runs (about three on the top, four to five on both the left and right sides and one on each side of the MCP). Tie wrap holders must be secured in place using epoxy. The adhesive on the tie wrap holder is not adequate to secure the tie wrap during the shock.
5. Type of tie wrap holder. Use the following type tie wrap holder or equivalent: Mounting base, tie down, electrical, Thomas & Bettz P/N TC5347A. Four way configuration (versus two way) and with adhesive are optional.
6. Type of tie wrap. For most applications, 4-inch long tie wraps are used. SAE-AS33671 electrical tie down straps, adjustable, plastic, Type I, Class 1, miniature, 18 lb. minimum tensile strength (such as P/N MS3367-4-9, NSN 5975-00-727-5153 or P/N MS3367-4-0, NSN 5957-00-903-2284) or other equivalent commercial self-locking cable ties.
7. Degree of tightness. Tie wraps are to be snug so that movement of the cable is restricted, but tie wrap exerts no to minimum pressure on the cables.
8. Connector receptacle mounted to side from inside the interconnection box.
9. Straighten cable at exit to connector. Cable that is exiting the connector is to be kept straight to maximum length practical before placement into the first bend while still maintaining requirement stated in note 3.
10. Dimensions are in inches.

Figure 3: Supplemental test fixture with multiple terminus connectors: cable routing and tie-downs, smaller cable diameter - Continued.



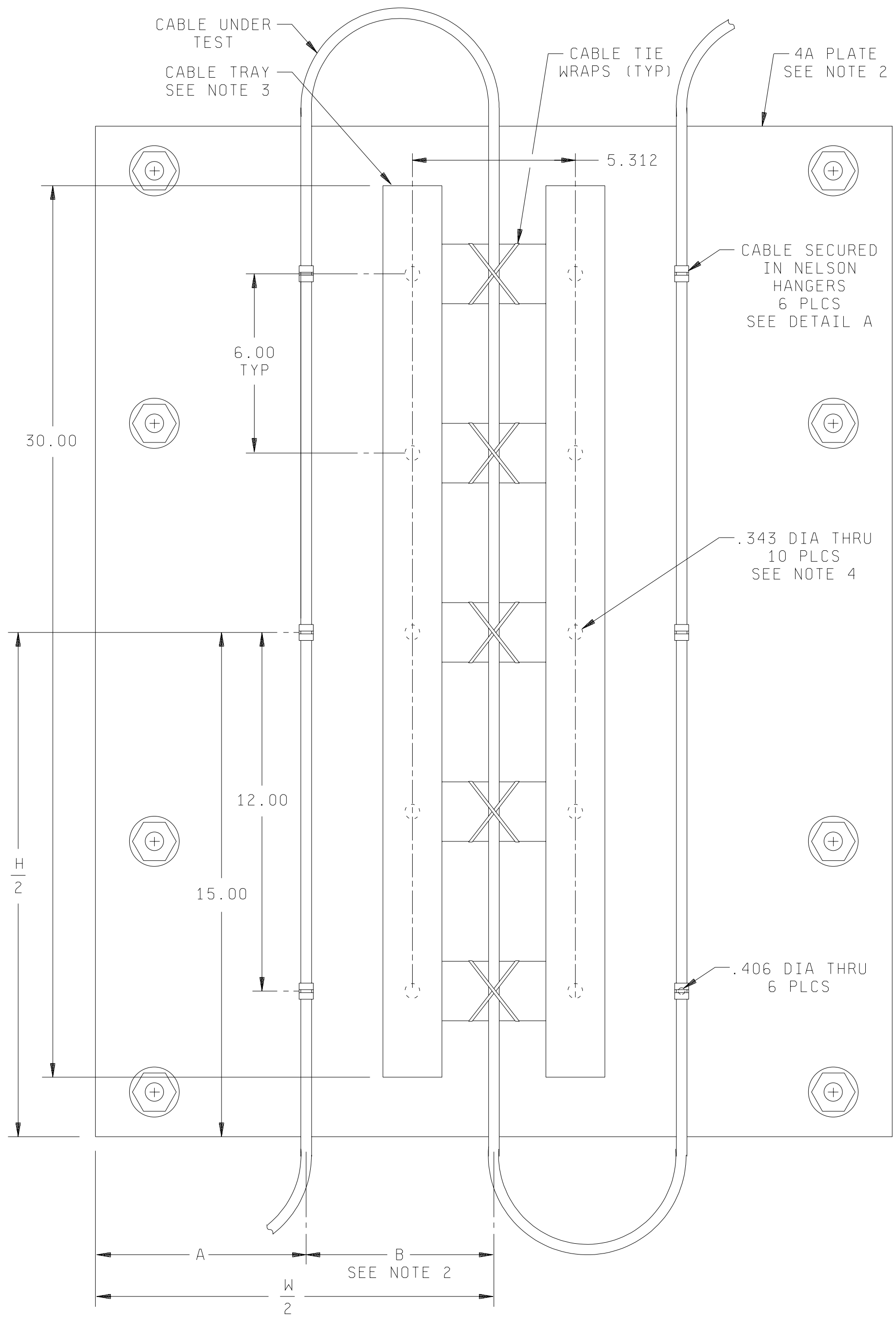
See Note 1

Figure 4: Supplemental test fixture with multiple terminus connectors: cable routing and tie-downs, larger cable diameter.

NOTES:

1. Test fixture applicability. If 13.5 – B > 3 where "B" is in inches, use supplemental test fixture in Figure 3 (See note 2).
2. Bend diameter. B = Long term, minimum bend diameter of cable under test.
3. Maintenance of bend diameter. Each cable bend is not to exceed (be smaller than) the long term, minimum bend diameter of cable inside the interconnection box.
4. Mounting of tie wrap holders. On the inside of the interconnection box, tie wrap holders are to be placed as shown around the sides of the box. Place a tie wrap holder near the corners of the box, near cable bends and towards the middle for lengths of straight runs (about three on the top, four to five on both the left and right sides and one on each side of the MCP). Tie wrap holders must be secured in place using epoxy. The adhesive on the tie wrap holder is not adequate to secure the tie wrap during the shock.
5. Type of tie wrap holder. Use the following type tie wrap holder or equivalent: Mounting base, tie down, electrical, Thomas & Bettz P/N TC5347A. Four way configuration (versus two way) and with adhesive are optional.
6. Type of tie wrap. For most applications, 4-inch long tie wraps are used. SAE-AS33671 electrical tie down straps, adjustable, plastic, Type I, Class 1, miniature, 18 lb. minimum tensile strength (such as P/N MS3367-4-9, NSN 5975-00-727-5153 or P/N MS3367-4-0, NSN 5957-00-903-2284) or other equivalent commercial self-locking cable ties.
7. Degree of tightness. Tie wraps are to be snug so that movement of the cable is restricted, but tie wrap exerts no to minimum pressure on the cables.
8. Connector receptacle mounted to side from inside the interconnection box.
9. Straighten cable at exit to connector. Cable that is exiting the connector is to be kept straight to maximum length practical before placement into the first bend while still maintaining requirement stated in note 3.
10. Dimensions are in inches.

Figure 4: Supplemental test fixture with multiple terminus connectors: cable routing and tie-downs, larger cable diameter - Continued.

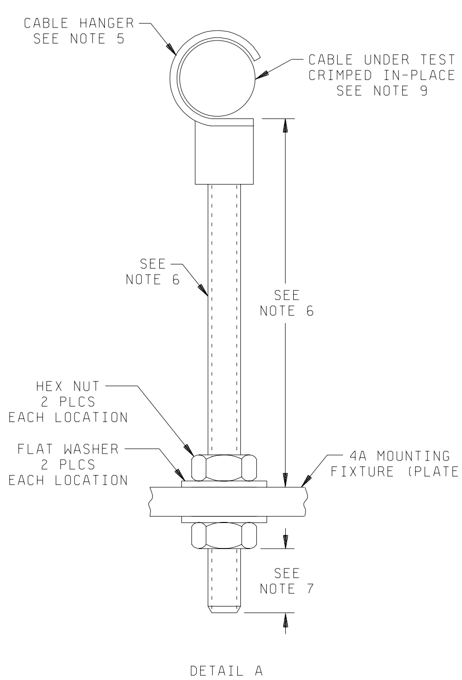


See Note 1

Figure 5: Supplemental Test Fixture For Cable of Small Diameter.

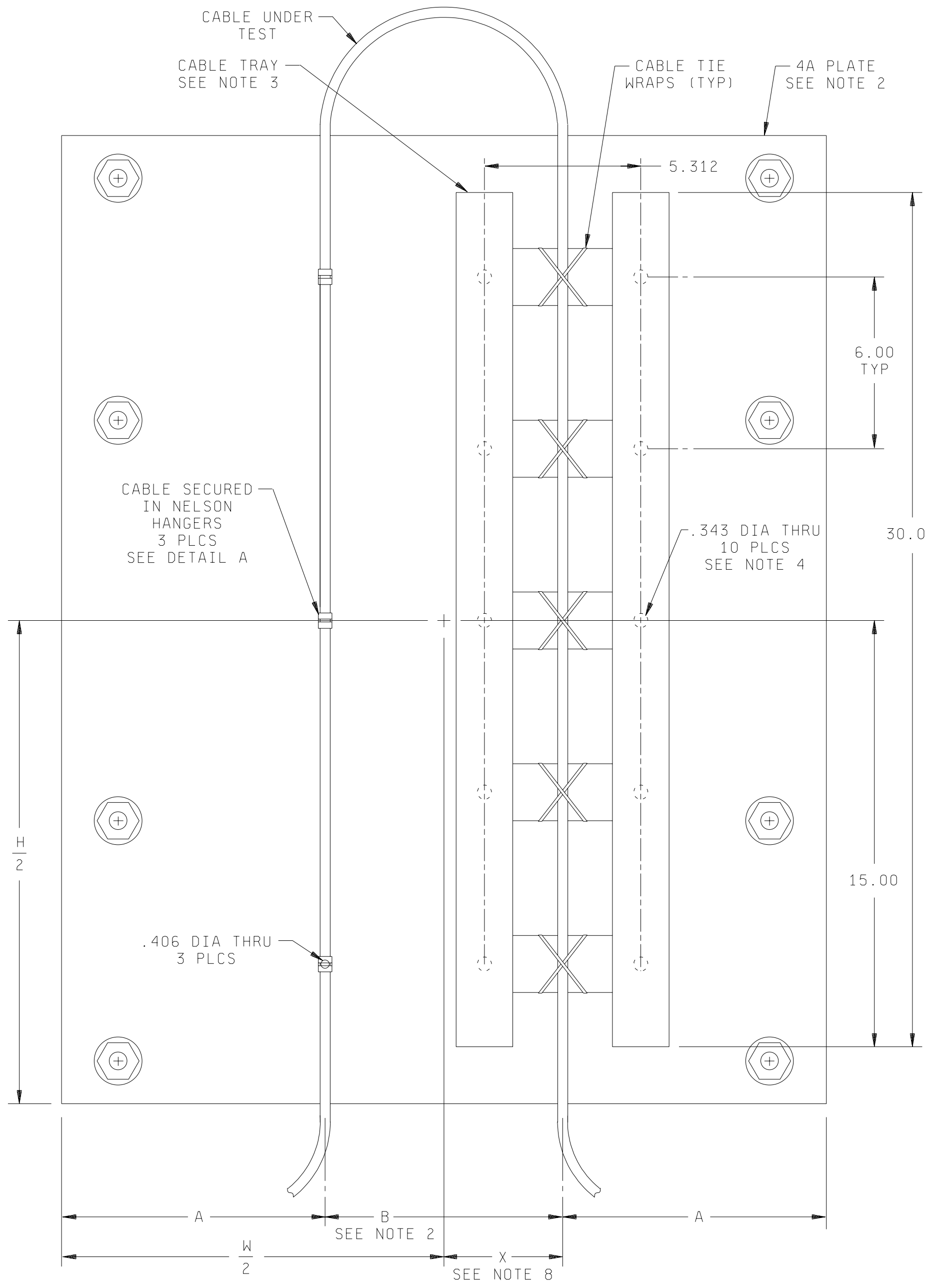
NOTES:

1. If W/2 – B $\leq$ 3, use supplemental test fixture in Figure 6 (See note 2).
2. B = Long term, minimum bend diameter of cable under test. W = 27 inch, using 4A mounting fixture (plate) with standard width per MIL-S-901.
3. Metallic cable tray system, straight section, 3 inch NEMA/4.20 inch outside, 9 inch rung spacing, 12 inch width, aluminum, Cooper B-Line Product Catalog # 34A09-12-240 (where 240 is for 20 ft section) or equivalent cable tray.
4. Cable tray mounting holes. Minimum size to be used for mounting hardware is 5/16 diameter.
5. Single cable hanger, Nelson CrimpLoc style, Nelson Stud Welding, Inc. Part # SL091AA-TXL where AA is to be replaced by the designators for the applicable cable diameter or equivalent single cable hanger.
6. Use 3/8-16 all-thread (B7 or B16) for raising the single cable hanger to the same height as the cable tray, typically 4-1/8 inch for dimension shown. See detail A for installation.
7. Protruding thread length, 3 threads minimum.
8. Dimensions are in inches.
9. Degree of tightness: Cable shall be crimped into cable hanger in a manner that the cable is snug (movement restricted, but cable hanger exerts no to minimum pressure on the cable). Additional guidance may be obtained in DoD-STD-2003-4 (such as Figure 4C7).
10. Recommended cable hanger crimping instructions. Use channel-lock pliers to compress the clip portion of the cable hanger. Start by gripping both the tip (i.e., the open end or the fingers) and the base of the cable clamp with the channel-lock pliers – squeeze pliers to close the hanger until it contacts the cable jacket. Then, use the pliers as necessary to close/form the fingers so that the hanger conforms to the cable outside diameter and clamps evenly around the circumference without crushing the cable jacket. Degree of tightness to achieve is stated in note 9.



Detail A . Nelson hanger for cable test setup.

Figure 5: <u>Supplemental Test Fixture For Cable of Small Diameter</u> – Continued.

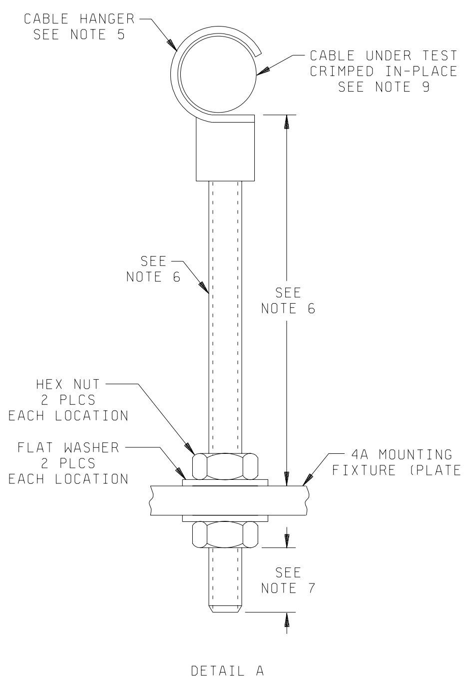


See Note 1

Figure 6: <u>Supplemental Test Fixture For Cable of Larger Diameter</u>

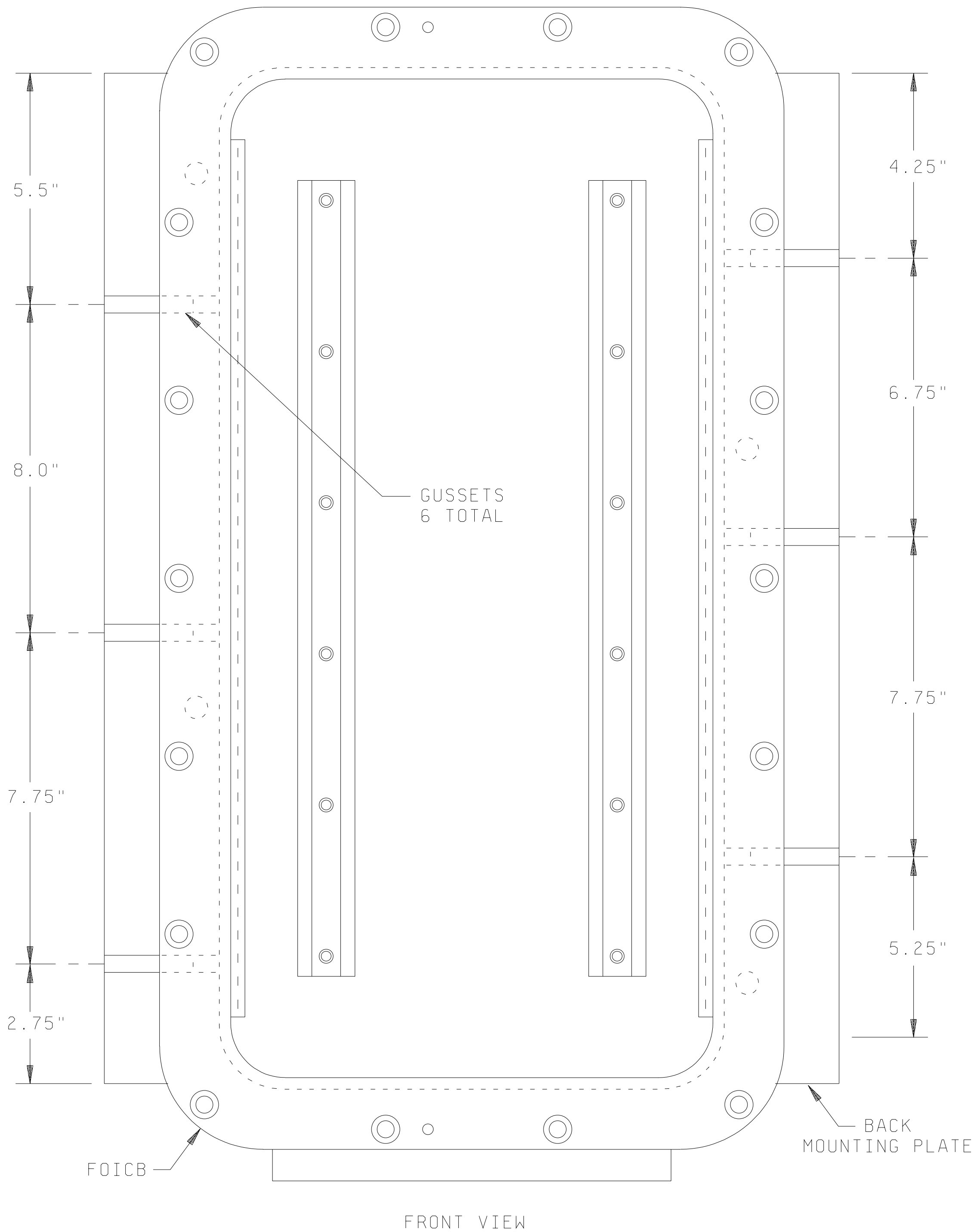
NOTES:

1. If W/2 – B > 3, use supplemental test fixture in Figure 5 (See note 2).
2. B = Long term, minimum bend diameter of cable under test. W = 27 inch, using 4A mounting fixture (plate) with standard width per MIL-S-901.
3. Metallic cable tray system, straight section, 3 inch NEMA/4.20 inch outside, 9 inch rung spacing, 12 inch width, aluminum, Cooper B-Line Product Catalog # 34A09-12-240 (where 240 is for 20 ft section) or equivalent cable tray.
4. Cable tray mounting holes. Minimum size to be used for mounting hardware is 5/16 diameter.
5. Single cable hanger, Nelson CrimpLoc style, Nelson Stud Welding, Inc. Part # SL091AA-TXL where AA is to be replaced by the designators for the applicable cable diameter or equivalent single cable hanger.
6. Use 3/8-16 all-thread (B7 or B16) for raising the single cable hanger to the same height as the raceway, typically 4-1/8 inch for dimension shown. See detail A for installation.
7. Protruding thread length, 3 threads minimum.
8. Center dimension B on vertical centerline of the 4A plate so that W = B + 2A (See note 2).
9. Degree of tightness: Cable shall be crimped into cable hanger in a manner that the cable is snug (movement restricted, but cable hanger exerts no to minimum pressure on the cable). Additional guidance may be obtained in DoD-STD-2003-4 (such as Figure 4C7).
10. Recommended cable hanger crimping instructions. Use channel-lock pliers to compress the clip portion of the cable hanger. Start by gripping both the tip (i.e., the open end or the fingers) and the base of the cable clamp with the channel-lock pliers – squeeze pliers to close the hanger until it contacts the cable jacket. Then, use the pliers as necessary to close/form the fingers so that the hanger conforms to the cable outside diameter and clamps evenly around the circumference without crushing the cable jacket. Degree of tightness to achieve is stated in note 9.
11. Dimensions are in inches.



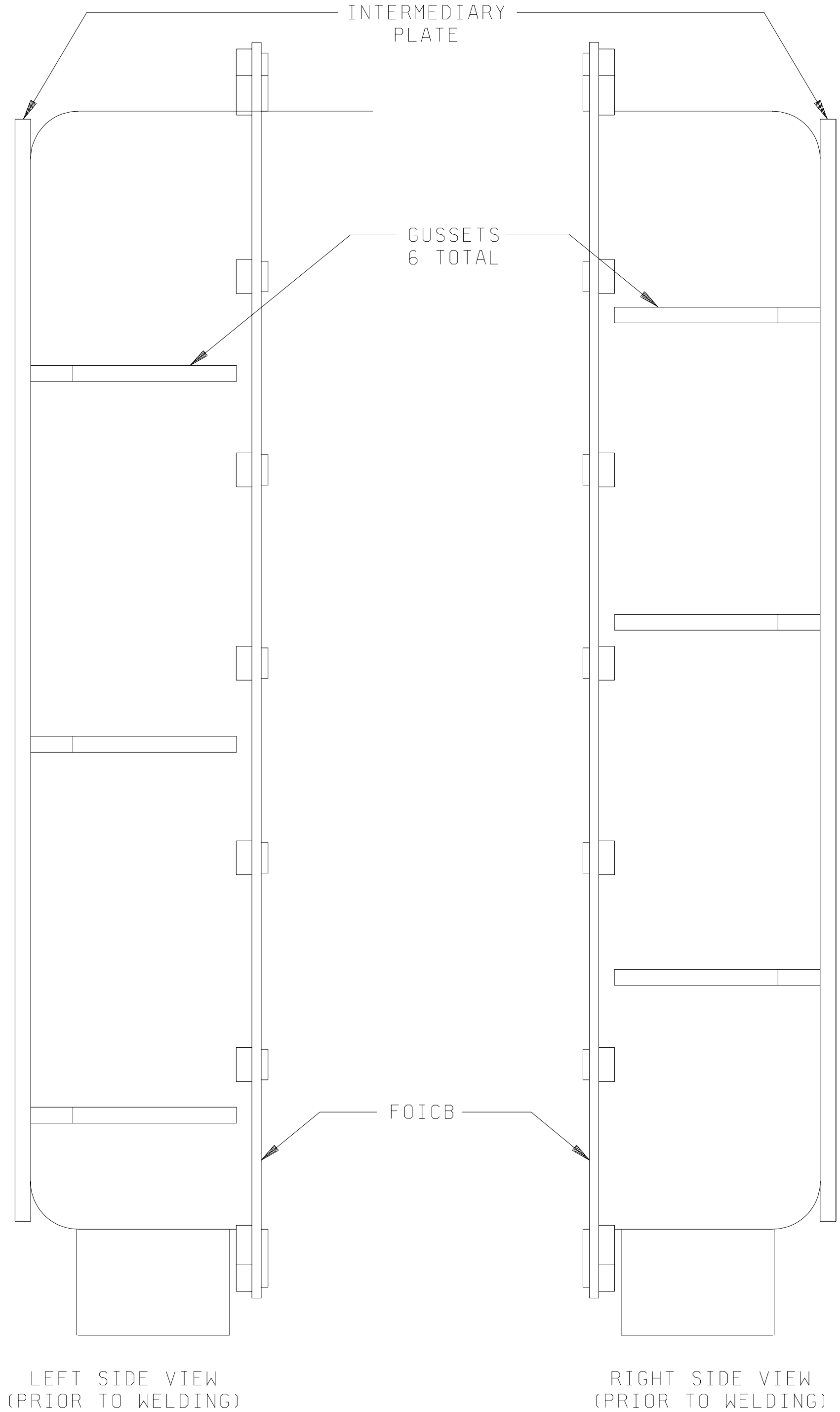
Detail A . Nelson hanger for cable test setup.

Figure 6: Supplemental Test Fixture For Cable of Larger Diameter – Continued.



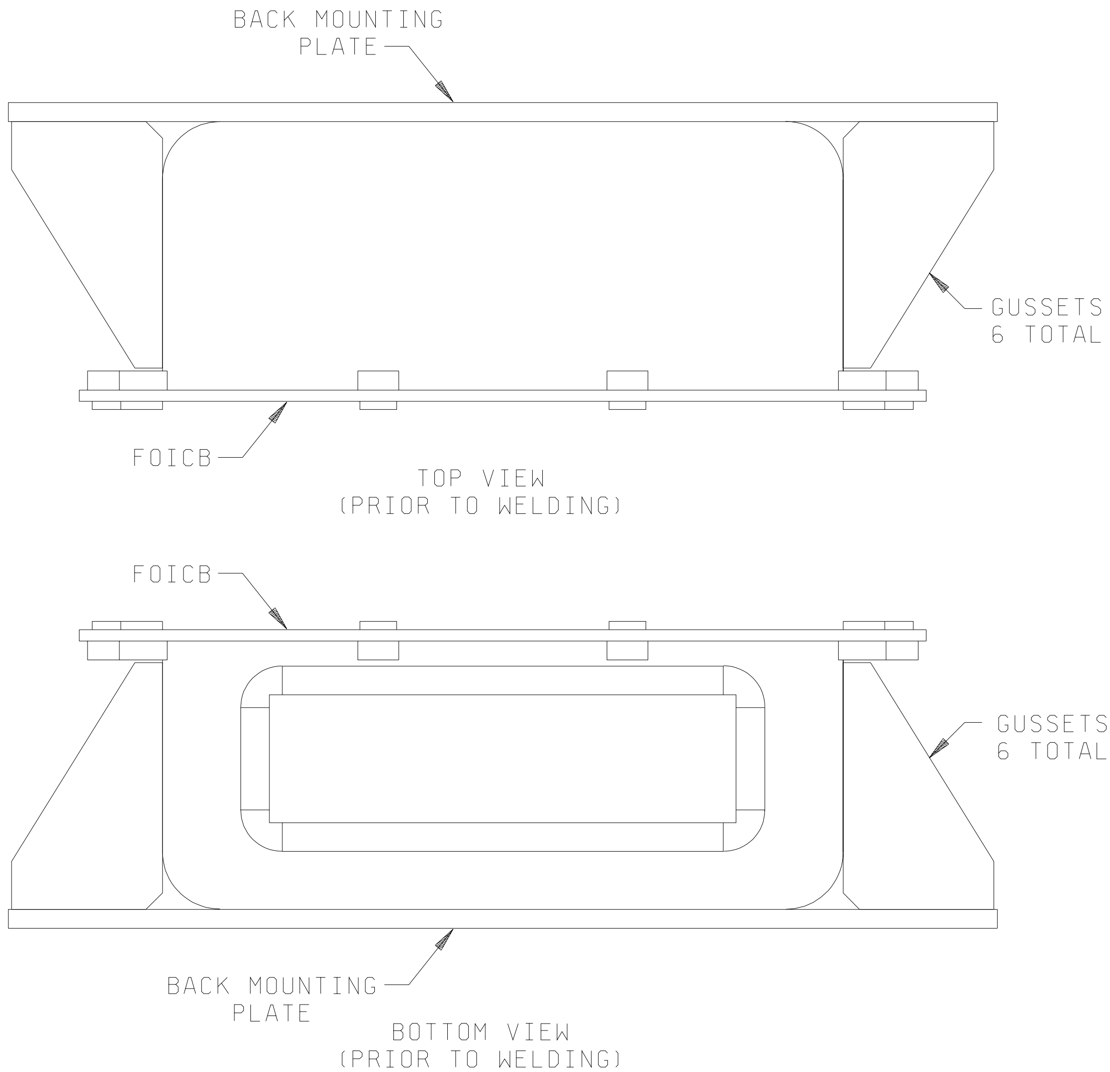
Front view

Figure 7. Supplemental fixture for connectors, fabrication drawing.



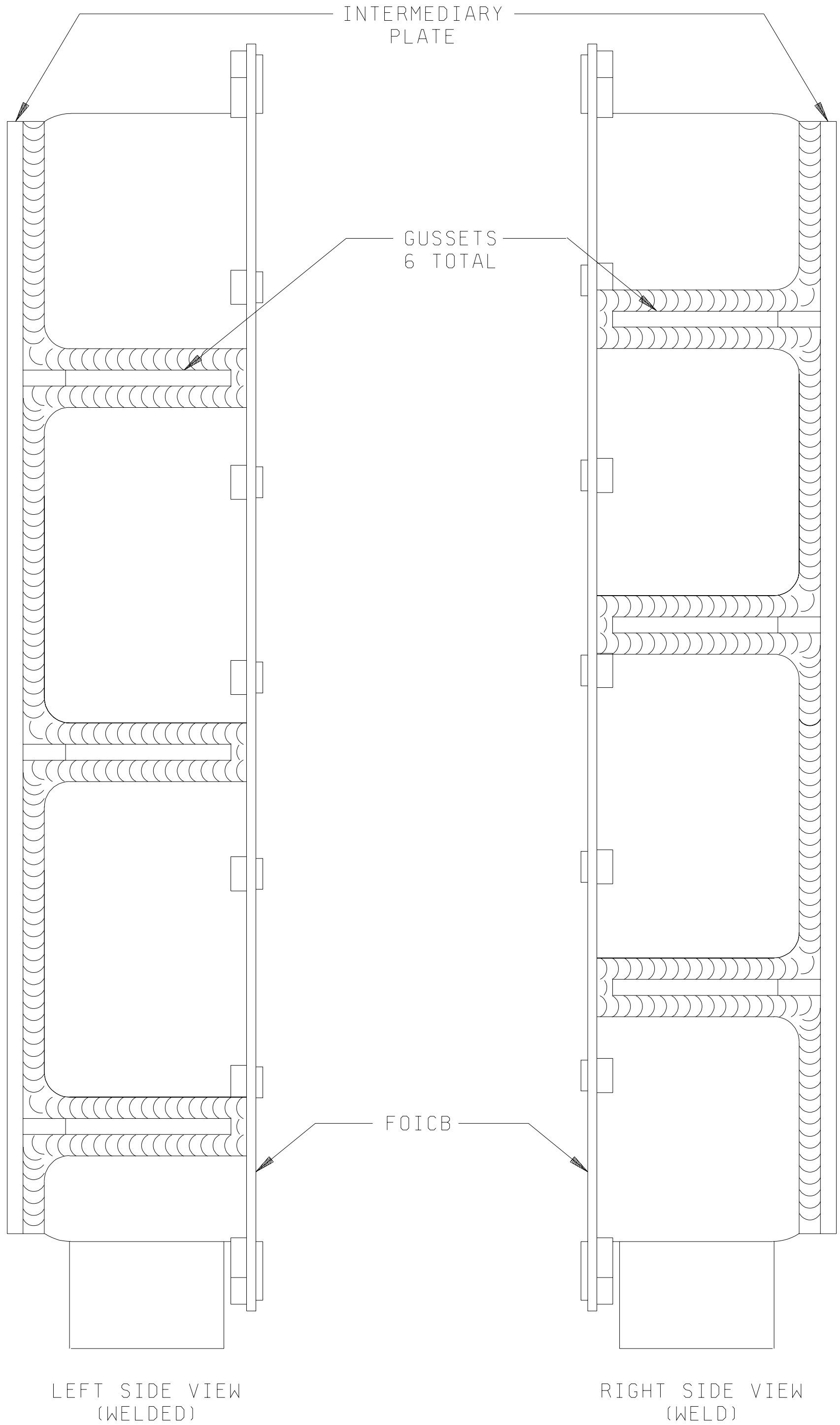
Left and right view prior to welding

Figure 7. Supplemental fixture for connectors, fabrication drawing - Continued.



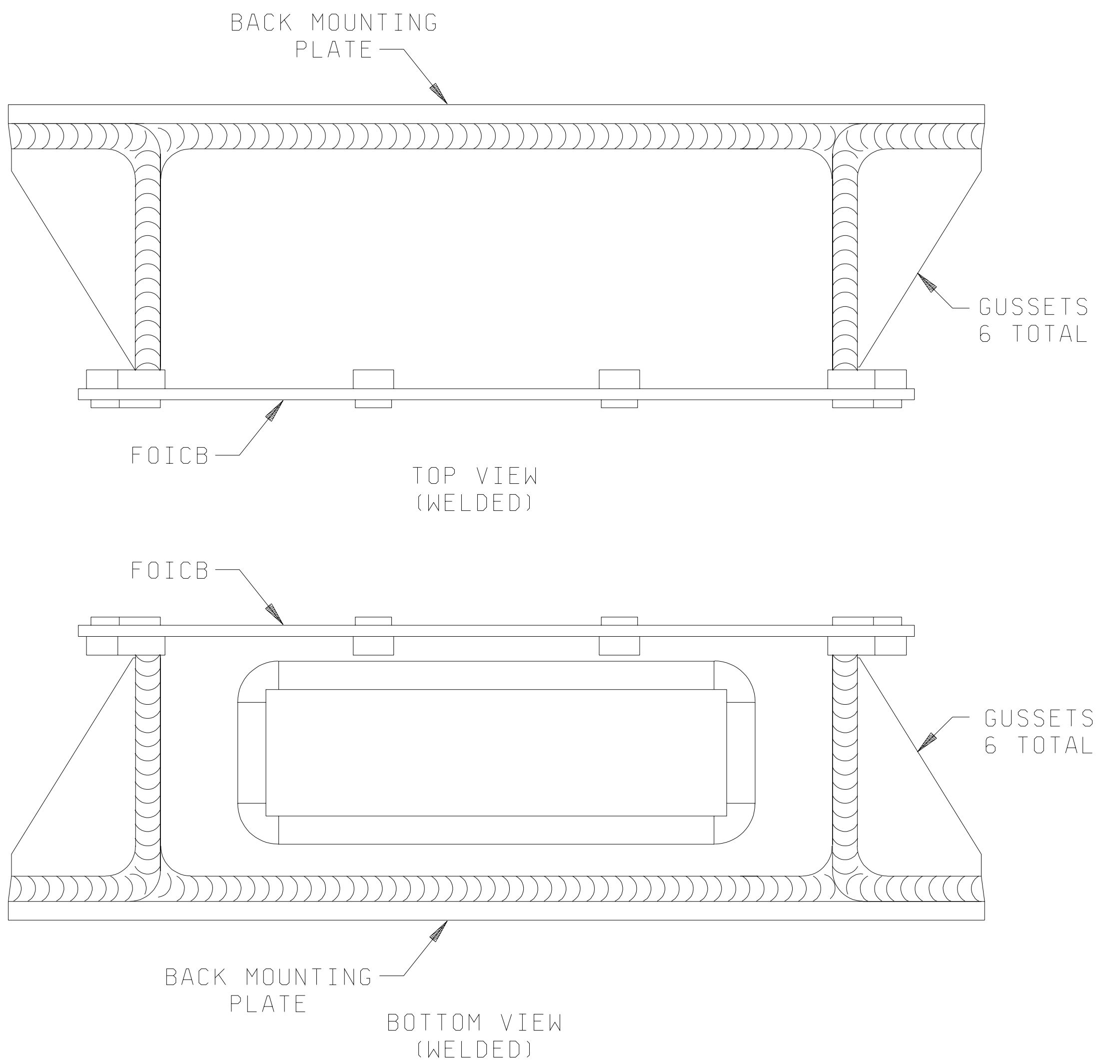
Top and bottom view prior to welding

Figure 7. Supplemental fixture for connectors, fabrication drawing - Continued.



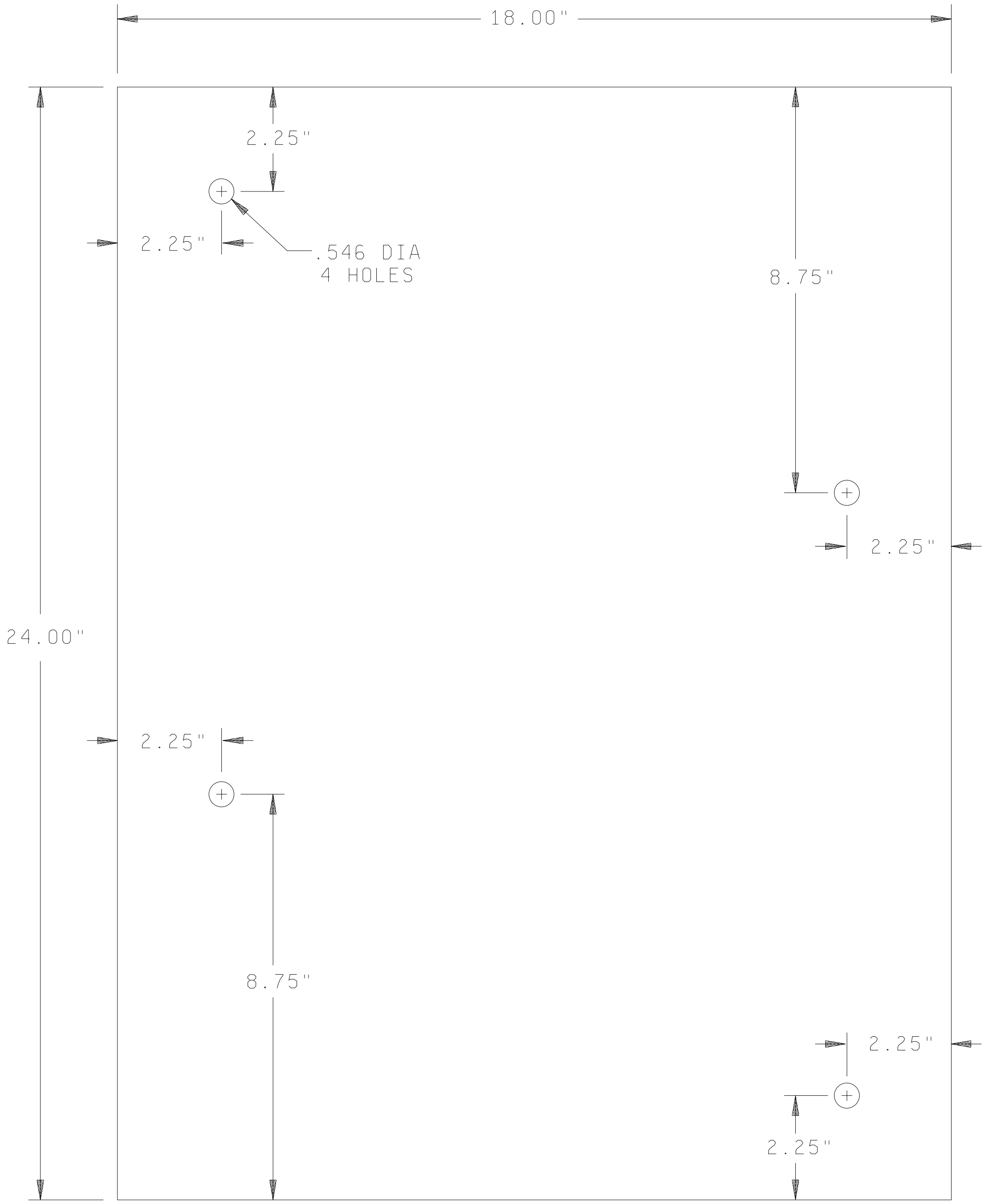
Left and right view welded

Figure 7. Supplemental fixture for connectors, fabrication drawing - Continued.



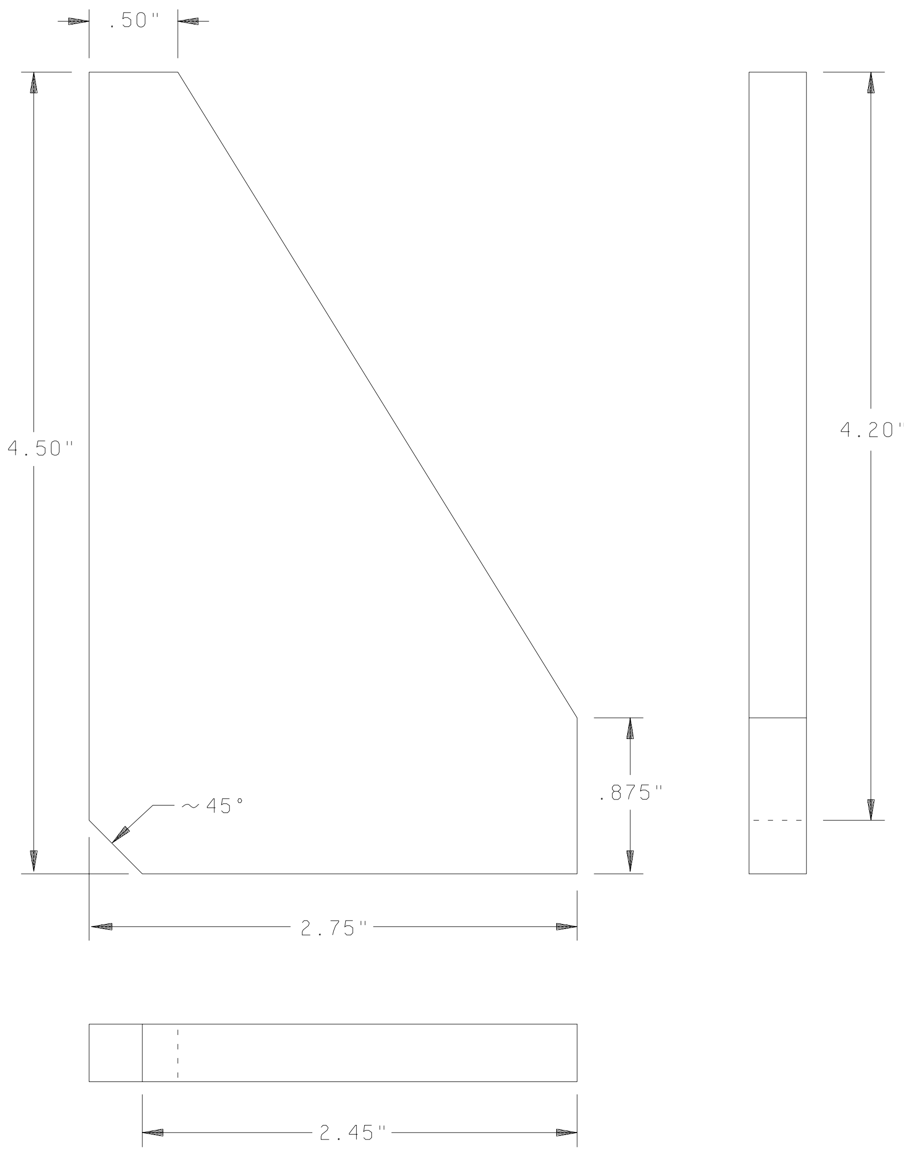
Top and bottom view welded

Figure 7. Supplemental fixture for connectors, fabrication drawing - Continued.



Intermediary plate

Figure 7. Supplemental fixture for connectors, fabrication drawing – Continued.



Gusset

Figure 7. Supplemental fixture for connectors, fabrication drawing - Continued.